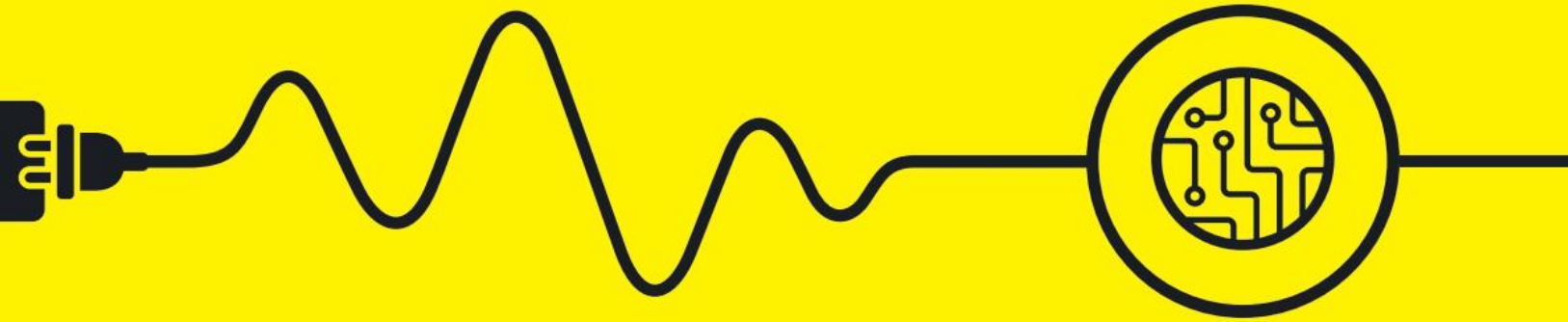
NELSON
CENGAGE Learning

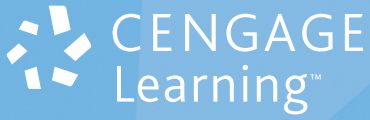
3rd edition

INFORMATION AND SOFTWARE TECHNOLOGY

A project-based approach



David GROVER Heather KNIGHTS Eamon GORMLEY



COPYRIGHT NOTICE

Copyright in this work is owned by Cengage Learning Australia ("the work"). A condition of purchase of this electronic version of the work is that you agree to respect the copyright in the work, abide by the *Copyright Act 1968* and specifically agree not to transfer, sell, assign, misuse, copy or transmit an electronic or other version of the work to any third party.

Please note: This product is accompanied by a licence (single user, network or adoption) governing the terms and conditions of its use.

This is a legal agreement between the you, (the "Customer") and Cengage Learning Australia Pty Limited (ABN 14 058 280 149) (the "Licensor") which provides the terms and conditions of this non-exclusive licence and the limited warranty for the Product. Use of the Product indicates an acknowledgement that the Customer has read and agreed to be bound by the terms and conditions of this Agreement. If you do not agree to these terms and conditions, return the Product to the place of purchase within 15 days of the date of purchase (with proof of purchase) for a full refund

1. **Licence Grant**
   You do not receive title to the Product. Copyright in the Product (which includes all images, photographs, video, animations, audio, music and text incorporated in the Product, including all of the accompanying printed material) is owned by the Licensor and/or its suppliers and is protected by Australian copyright laws. The Licensor grants you a non-exclusive licence to use the Product subject to the restrictions and terms set out in this Agreement.

2. **A Licence allows you to:**
   Use the Product on your computer. The Customer represents that they shall in no way place the Product in the public domain or in any way compromise our copyright in the Material. You agree to take reasonable steps to protect our copyright.

3. **You may not:**
   Alter, modify, translate, reverse engineer, decompile, or adapt the software or create derivative works based on the Product.

   Make further copies by any means technological, electronic, digital whatsoever without the written permission of the Licensor.

   Rent or transfer all or any part of your rights under this Agreement. Remove or alter any copyright or other proprietary notice or label attached to the software.

4. **Termination**
   Any failure to comply with the terms and conditions of this agreement will result in the automatic termination of this licence. Upon termination of this licence for any reason, the Customer must destroy or return to the Licensor all copies of the software and accompanying documentation.

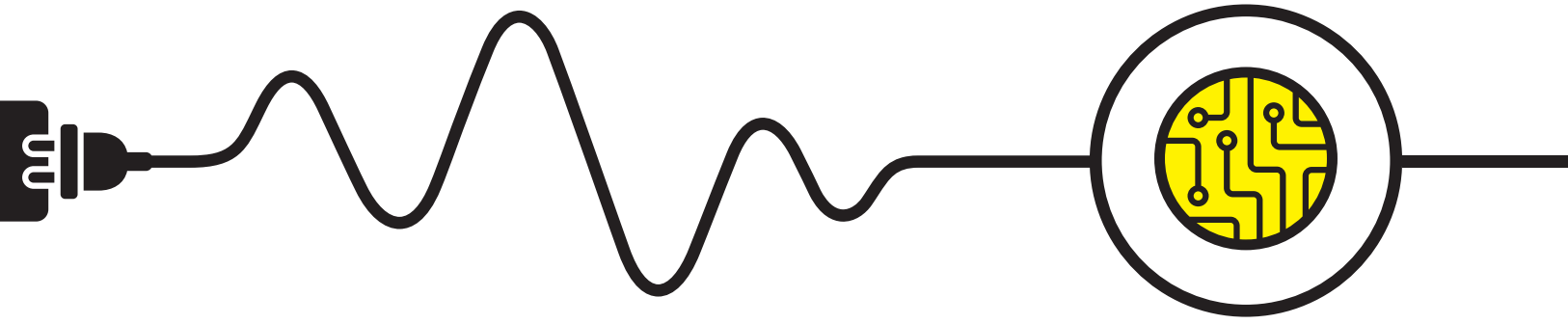
5. **Warranties**
   To the extent permitted by law, the Licensor's liability for any breach of the warranty or any term implied by law into this licence is limited to the lowest cost of replacing the goods, acquiring equivalent goods or having the goods repaired.

David **GROVER** Heather **KNIGHTS** Eamon **GORMLEY**

3rd edition

INFORMATION AND SOFTWARE TECHNOLOGY

A project-based approach



NELSON CENGAGE Learning

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States

NELSON
CENGAGE Learning

Information and Software Technology: A project-based approach
3rd Edition
David Grover
Heather Knights
Eamon Gormley

Publishing editor: Sarah Craig
Project editor: Aynslie Harper
Editor: Stephen Roche
Indexer: Max McMaster
Cover designer: Luana Keays
Text designer: Julie Hally
Art direction: Luana Keays
Permissions researcher: Jan Calderwood and Wendy Duncan
Production controller: Erin Dowling
Typeset by: Cenveo Publisher Services
Cover image: Shutterstock/Blan-k

Any URLs contained in this publication were checked for currency during the production process. Note, however, that the publisher cannot vouch for the ongoing currency of URLs.



Text © 2015 David Grover, Heather Knights, Eamon Gormley
Design and illustrations © 2015 Cengage Learning Australia Pty Limited

Copyright Notice
This Work is copyright. No part of this Work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without prior written permission of the Publisher. Except as permitted under the *Copyright Act 1968*, for example any fair dealing for the purposes of private study, research, criticism or review, subject to certain limitations. These limitations include: Restricting the copying to a maximum of one chapter or 10% of this book, whichever is greater; providing an appropriate notice and warning with the copies of the Work disseminated; taking all reasonable steps to limit access to these copies to people authorised to receive these copies; ensuring you hold the appropriate Licences issued by the Copyright Agency Limited ("CAL"), supply a remuneration notice to CAL and pay any required fees. For details of CAL licences and remuneration notices please contact CAL at Level 15, 233 Castlereagh Street, Sydney NSW 2000,
Tel: (02) 9394 7600, Fax: (02) 9394 7601
Email: info@copyright.com.au
Website: www.copyright.com.au

For product information and technology assistance,
in Australia call **1300 790 853**;
in New Zealand call **0800 449 725**

For permission to use material from this text or product, please email **aust.permissions@cengage.com**

National Library of Australia Cataloguing-in-Publication Data
Grover, David, author.
Information and software technology : a project-based approach /
David Grover, Heather Knights, Eamon Gormley.

9780170365987 (paperback)
Includes index.
For secondary school age.

Information technology--Study and teaching (Secondary)
Computer programming--Study and teaching (Secondary)
Computer software--Problems, exercises, etc.
Software maintenance--Textbooks.

004

Cengage Learning Australia
Level 7, 80 Dorcas Street
South Melbourne, Victoria Australia 3205

Cengage Learning New Zealand
Unit 4B Rosedale Office Park
331 Rosedale Road, Albany, North Shore 0632, NZ

For learning solutions, visit **cengage.com.au**

Printed in China by China Translation & Printing Services.
1 2 3 4 5 6 7 19 18 17 16 15

CONTENTS

To the students vii
About this book viii
How to use this book x
About the authors xii

CORE

1 Projects: design, produce, evaluate 2
1.1 Defining and analysing the problem 4
1.2 Designing possible solutions 6
1.3 Producing and evaluating solutions 8
1.4 Project management 10

2 Hardware 14
2.1 Input, output and storage 16
2.2 Processing and control 20
2.3 Classification of systems 22
2.4 Hardware solutions 24

3 Software 26
3.1 Software systems 28
3.2 Types of application software 30
3.3 Features of application software 32
3.4 Interface design 34
3.5 Features of a graphical user interface 36
3.6 Operating system software 38
3.7 Hardware requirements 40

4 Data handling 42
4.1 Data and information 44
4.2 Data forms 46
4.3 Data types 48
4.4 Data storage 50
4.5 File types and data compression 52
4.6 Data transmission and security 54

5 Past, current and emerging technologies 56
5.1 Past information and software technologies 58
5.2 Current and emerging technologies 60
5.3 Exploring current and emerging technologies for each option 64
5.4 The impact of technology on the environment 70

6 People 72
6.1 Roles and responsibilities 74
6.2 Careers in information and software technology 76

7 Issues 78
7.1 Legal issues 80
7.2 Ethical issues 82
7.3 Social issues 84

OPTIONS

8 Artificial intelligence, simulation and modelling 86
8.1 Artificial intelligence 88
8.2 Areas of artificial intelligence 90
8.3 Requirements of artificial intelligence 96
8.4 Modelling and simulations 98
8.5 Requirements of models and simulations 100
8.6 Advantages and limitations of models and simulations 102
8.7 Using modelling and simulation programs 104
8.8 Project development and additional content 108

9 Authoring and multimedia 112
9.1 A digital revolution 114
9.2 Types of multimedia products 116
9.3 Multimedia data types 122
9.4 Multimedia hardware 128
9.5 Authoring software systems 130
9.6 Developing a multimedia product 136
9.7 Project development and additional content 142

10 Database design 146
10.1 Database development 148
10.2 Collecting, organising and storing data 154
10.3 Processing and analysing data 160
10.4 Presenting information 166
10.5 Integration 168
10.6 Project development and additional content 170

11 Digital media 174
11.1 The purpose of digital media 176
11.2 Types of digital media products 180
11.3 Data types for digital media products 194
11.4 Digitisation of data types 200
11.5 Digital manipulation techniques 206
11.6 Display and distribution 214
11.7 Project development and additional content 216

12 The Internet and website development 220
12.1 The Internet 222
12.2 A historical perspective on the Internet 224
12.3 Features and uses of the Internet 228
12.4 Accessing information using search engines 238
12.5 Internet software 242
12.6 Types of Internet protocols 246
12.7 The World Wide Web 248
12.8 Control of access to information 250
12.9 Website development 254
12.10 Project development and additional content 256

13 Networking systems 260
13.1 Communications networks 262
13.2 Network protocols 266
13.3 Data transmission modes 268
13.4 Data transmission rates 270
13.5 Data transmission media 272
13.6 Types of networks 274
13.7 Components of networks 276

13.8 Security of information 280
13.9 Network topology 282
13.10 Network operating systems 284
13.11 Choosing transmission media 286
13.12 Project development and additional content 288

14 Robotics and automated systems 290

14.1 Robotics 292
14.2 Types of robots 294
14.3 The purpose of robots 298
14.4 The use of robots 300
14.5 The function of robots 304
14.6 Automated control 308
14.7 Sensing devices 312
14.8 Actuators and controlling devices 316
14.9 Project development and additional content 318

15 Software development and programming 320

15.1 What does a computer program look like? 322
15.2 Basic programming ideas 326
15.3 Data types 334
15.4 Operators and assignment statements 336
15.5 Functions 338
15.6 Algorithms 340
15.7 Desk checking and subprograms 346
15.8 GUI layout 350
15.9 Programming languages 352
15.10 Data structures 354
15.11 Testing program code and detecting errors 356
15.12 Correcting errors and program documentation 358
15.13 Project development and additional content 360

Index 364

TO THE STUDENTS







The world of information and software technology you will explore using this student book is an amazingly creative, exciting, challenging and rapidly changing one.

It is a world that truly offers something for everyone. If you are bursting with creative energy, you can explore digital media and multimedia. If you are a born organiser, you can contribute to this revolution by building a website or a database of your own. If you like to find out how things work, then topics such as artificial intelligence, networking and operating systems will fascinate you. If you love to be in control, robotics will give you a chance to design and program your own robots. Finally, the topic of programming offers to hand control over to you as you learn to write software yourself.

This book emphasises a project-based approach to information and software technology. Each topic is built around a practical project where you design, produce and evaluate your own solution to a given problem, either working on your own or as part of a team.

Most students know enough about computers to complete basic daily tasks, such as word processing, browsing the Internet or playing a computer game. However, as you learn about information and software technology you will learn far more than this. You will discover why the computer has been called the most complex and versatile device ever built, and you will learn about a digital revolution that is only just beginning.

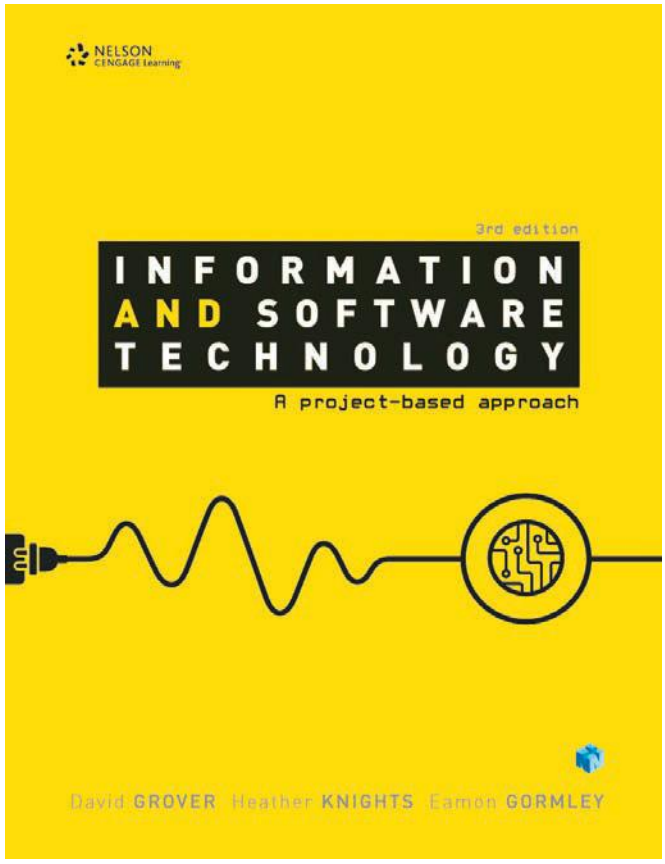






ABOUT THIS BOOK

STUDENT BOOK



This new edition of *Information and Software Technology: A project-based approach* has been fully updated to cover emerging technologies and practices. Retaining all of the best-loved features from the second edition, the third edition includes new topics such as 3D printing, cloud computing and HTML5, as well as an extended section on augmented reality. Chapter 15: Software development and programming has been completely reworked to meet the demands of teaching and learning in this course.

The student book provides a clear project development focus in line with the spirit of the syllabus. It presents an in-depth coverage of the core topics, which provide a ready reference when studying the options. The double-page spread format allows for easy navigation through the topics, and the text features updated activities at the end of each section and a wealth of questions throughout to ensure student engagement.

Key features

- A clear, logical design makes the book easy to navigate.
- The inclusion of new content reflects current computing technology advances and ensures students are engaging in the most up-to-date technological landscape.
- Chapter opening pages list syllabus outcome numbers and outline the syllabus outcomes and key terms used in that chapter.
- Each chapter begins with an 'In action' section that presents a real-life application of the following content.
- Core alerts in the option chapters identify sections that are closely linked to core material.
- New case studies present students with challenging material and highlight relevant examples of the theory.
- Infobits provide snippets of interesting information to stimulate curiosity.
- Issues boxes explore legal and social concerns.
- People sections focus on profiling individuals working with technology.
- Engaging, hands-on group and individual tasks and projects are balanced with theory.
- Project sections at the end of the option chapters have been completely updated to be more user-friendly and engaging.

NELSONNET BOOK



The *Information and Software Technology* NelsonNetBook is an interactive ebook that can be used online or offline. It is compatible with interactive whiteboards, computers and tablets, and with optional Web 2.0 functionality for class groups. Students can add highlights, annotations, audio and video clips and weblinks, and teachers can use it to share their personalised version with the class.

NELSONNET WEBSITES



NelsonNet is your portal to a wealth of extra digital resources.

The student version includes:

- review questions
- links to online tutorials and videos
- weblinks
- examples of multimedia work.

The teacher version includes:

- everything contained in the student version
- chapter PDFs of the student book
- a core topics/options matrix showing the links between the option chapters and core content
- student book answers
- chapter tests and answers
- approaches to developing projects
- detailed project worksheets, including marking matrices
- further project ideas for each option
- teaching program suggestions
- recommended resources and software.

Access to the NelsonNetBook and NelsonNet student website is available free to students for 26 months if your school has booklisted *Information and Software Technology*. Please note that complimentary access to the NelsonNetBook and NelsonNet teacher website is only available to teachers who use the accompanying student book as a core educational resource in their classroom. Contact your sales representative for information about access codes and conditions.

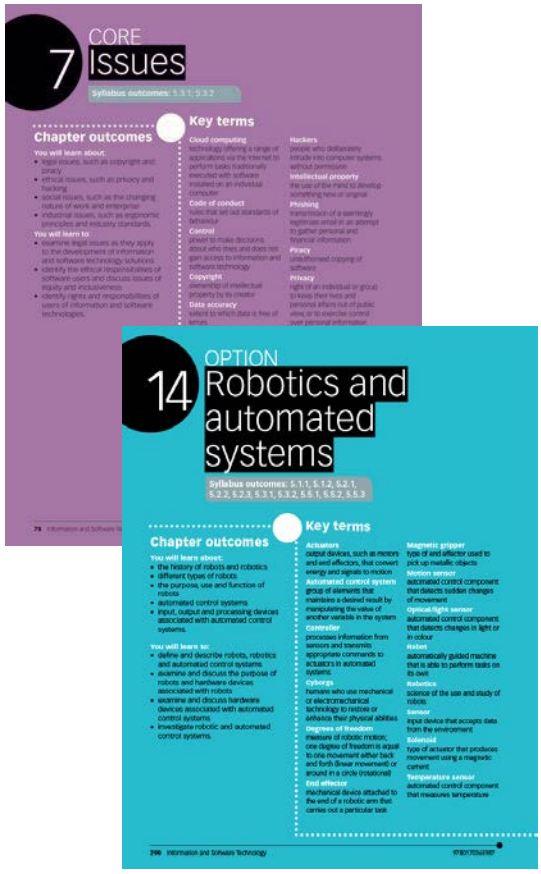
www.nelsonnet.com.au

HOW TO USE THIS BOOK

Information and Software Technology: A project-based approach, 3rd edition, addresses the requirements of the New South Wales Years 7–10 Information and Software Technology syllabus.

The book is divided into two colour-coded sections, corresponding to the **core** content and the **options**.

The course should integrate the study of core content within the context of the options delivered through projects.

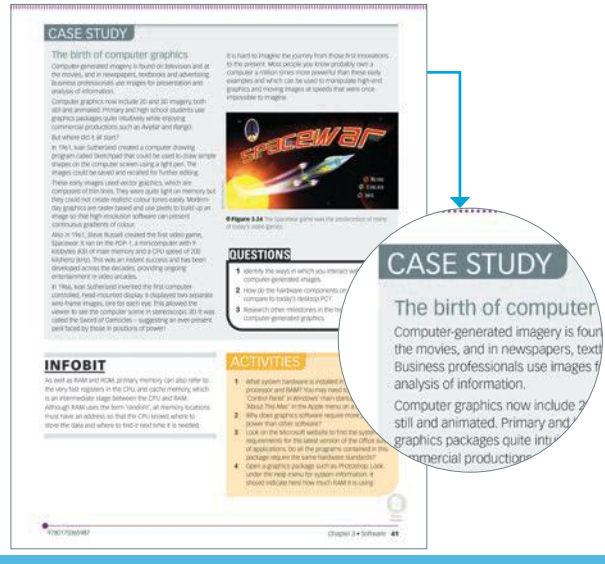


There are 15 chapters in this book, each with the following features.

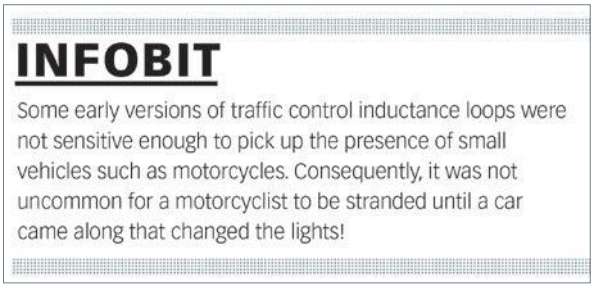
- **Chapter opening pages** list syllabus outcome numbers and outline the syllabus outcomes and key terms used in the chapter. The chapter begins with an 'In action' section that presents a real-life application of the chapter content.



- **Case studies** highlight relevant, real-life examples of the theory.



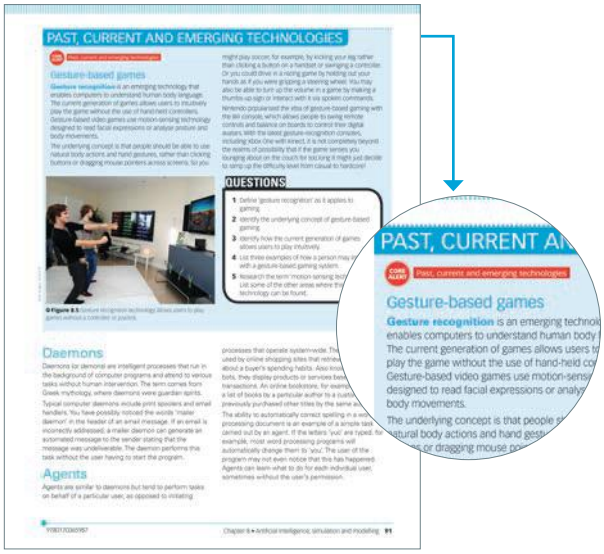
- **Infobits** provide snippets of interesting information to stimulate curiosity.



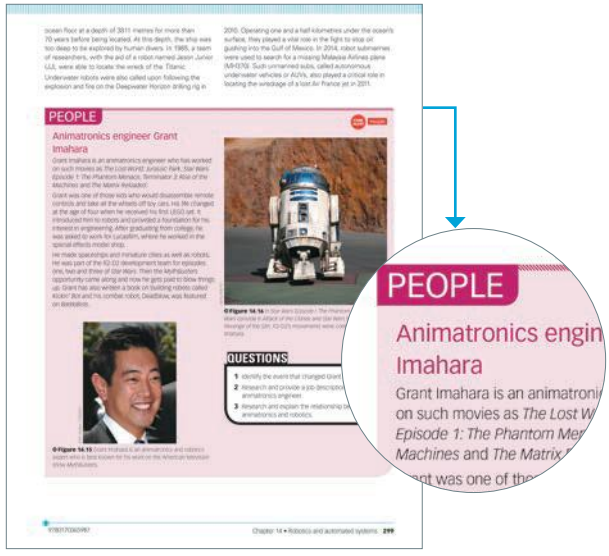
- **Issues** boxes explore legal and social concerns.



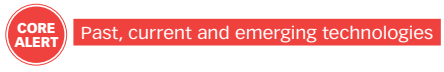
- **Past, current and emerging technologies** boxes look at past technology as well as present and where technology is heading.



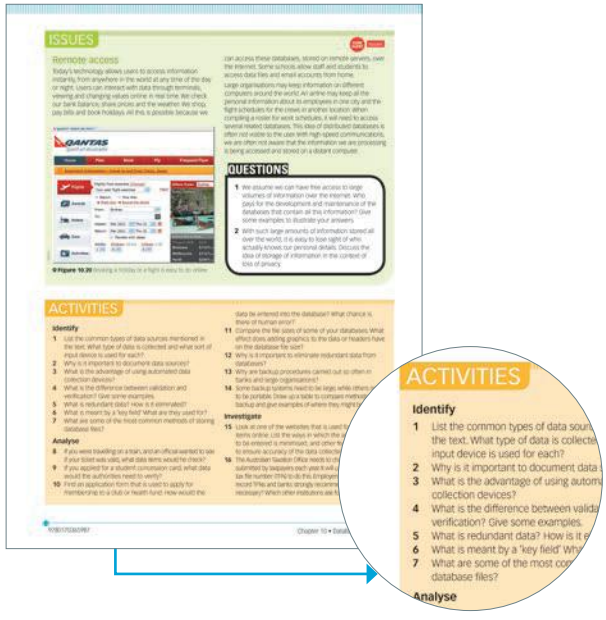
- **People** sections focus on profiling people working with technology.



- **Core alerts** in the option chapters identify sections that are closely linked to core material.



- **Activities** at the end of each section in the option chapters are broken down under a selection of the following headings:
  - Identify: comprehension and recall questions that check understanding
  - Analyse: extension questions where students are required to apply their knowledge
  - Investigate: higher order activities requiring more critical thinking.



ABOUT THE AUTHORS

David Grover

David Grover has been Head Teacher of Computing at Chatswood High School, New South Wales, and is the author of a number of texts and resources in secondary computing. He conducts many popular workshops for teachers of computing and has been a senior marker for HSC computing. He has had many years' experience in the training of computing teachers at a number of tertiary institutions.

David recently conducted research in the educational applications of augmented reality (AR) for Macquarie University and at present is enjoying combining AR with his 3D printer! He loves sharing his excitement for emerging technologies with his students and many have gone on to enjoy successful careers in animation, games design, robotics and programming. He has established a reputation for expertise in interactive digital education, recognised in various teaching awards and a NSW Premier's Scholarship where he studied New and Emerging Technologies around the globe.

Heather Knights

Heather Knights was Learning Technologies Coordinator and Head of the TAS (Technological and Applied Studies) Department for many years at Meriden Anglican School in Strathfield, New South Wales. Her passion for delivering innovative and sound computing applications in the classroom was complemented by her eagerness to support all members of staff and students in their personal journeys of discovery.

Previous to this, Heather taught Computing Studies to HSC level at Knox Grammar School, New South Wales. She holds postgraduate qualifications in ICT and was involved in HSC marking for a number of years.

Heather has run workshops at senior school, university and primary school level, and continues to develop her interest and involvement in emerging technologies, particularly in regard to computer programming for primary school students.

Eamon Gormley

Eamon Gormley is a high school Computing Studies teacher in Sydney's inner city. He holds postgraduate qualifications in eLearning and his current professional interest is the effective use of technology in a distance education setting. He has delivered professional learning workshops to help teachers embed technology into their teaching practice, with a particular focus on virtual learning tools and how they can enable students to connect and learn outside their classroom and school.

CORE

1 Projects: design, produce, evaluate

Syllabus outcomes: 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- defining and analysing a problem
- designing possible solutions
- producing solutions
- evaluation
- project management
- communication techniques
- collaboration and group work.

You will learn to:

- identify factors that impact on solutions
- generate ideas using a range of methods
- model possible solutions
- apply set criteria to choose an appropriate solution
- establish evaluation criteria
- communicate ideas and solutions
- collaborate in a group situation.

Key terms

Analyse
identify components and the relationships between them

Collaboration
working together in a group to share ideas and expertise

Communication
sharing of information with people

Concept map
graphic that shows how ideas are related

Criteria
elements that must be included in a project and the standards by which it will be evaluated

Design, produce, evaluate
the three stages of successful project work, following defining and analysing the problem

Evaluation
comparison of the solution and original expectations

IPO table
input, output and processing of data needed for a solution

Project management
overseeing of a project to ensure it is completed on time and on budget

Prototype
simple version of how the final project might look

Resources
time, finances and people needed for a solution

Storyboard
simple sketches of screen design and navigation

IN ACTION

Managing projects in the digital media industry

Project management of a team of professionals requires a wide range of personal and professional qualities. Leading a multidisciplinary and often multicultural team requires ethical and social understanding. Communication with a wide range of people, from technical experts to company directors, includes the need to collect and present information as well as working through conflicts. Strong organisational skills are needed for producing project plans, performing cost modelling and schedule controls. Above all, a project manager has to encourage and sustain among staff an ethic of working as a team, with openness, curiosity and a desire to meet new challenges.

Weta Digital is a world-leading visual effects company based in Wellington, New Zealand. It provides a full suite of digital production services for feature films and high-end commercials, from concept design to cutting-edge 3D animation.

Some of Weta Digital's projects include providing digital effects for box office hits such as *Avatar* and *Dawn of the Planet of the Apes*. Work on films like these involves developing software technologies and production techniques in order to reach a new level of creative and technological excellence.

Completing a project on time and bringing it in on budget are important factors in maintaining a company's reputation and this keeps Weta Digital in high demand among some of the world's leading film studios.

Further challenges include effective management of human resources. With the need for a vast range of digital media skills, Weta Digital employs people such as:

- animators with expert knowledge of 3D modelling and animation programs such as Maya®
- motion editors who can edit and integrate close-ups of facial movements with the main action
- programmers with an expert knowledge of motion physics so that they can create effects such as the movement of small particles or insect swarms
- artists who can render computer-generated scenes realistically.

At Weta Digital, effective project management is crucial. The crew works in a relaxed atmosphere but they have an intense work ethic and sense of professionalism. The creative skills and commitment of the team keep this New Zealand-based company at the forefront of digital film-making, in Hollywood and around the world.

QUESTIONS

1. What is the main focus of Weta Digital? Identify some of the company's most successful projects.
2. What are the components of project management that contribute to the success of companies such as Weta Digital?
3. How could these components be important in other projects in the IT industry?



Picture Media/Photoshot/LFI (left); Picture Media/Reuters/20thCentury Fox/Weta (right)

Figure 1.1 Andy Serkis plays the apes' leader, Caesar, in *Dawn of the Planet of the Apes*. The digital make-up is overlaid onto performances by actors in special suits.

1.1 Defining and analysing the problem

In all walks of life, from the classroom to national and international affairs, people are involved in projects. Some are tasks that can be completed in a matter of days, while others may take several years to complete. However, the common thread is that all projects are designed to address a specific issue or problem. The degree of success of the project will largely depend on how well the process has been managed.

In this course, you will complete several projects using information and software technology. This provides exciting opportunities for exploring and developing new applications. As your ideas and ambitions become more complex, you will need to talk to fellow students and adults about what you want to achieve and any problems you have.

Identifying the problem

One of the first tasks that must be done before we can solve any problem is to identify the need for a solution or work out exactly what the problem is. We might also question whether the problem does in fact need to be solved at all. If your friend rang you one evening asking for help because she could not do her Maths homework, you would need to know whether it was because she didn't understand Maths or because she was going to the movies and didn't have time to do it. You need to identify the problem. You can then decide whether to tell her you are busy or find out more about her problem.

You will already be familiar with the completion of projects in many areas of your study at school. At higher levels of education and in the workforce, these projects become more demanding in terms of creativity and documentation.

The processes that you go through – both physical and intellectual – will be an education in themselves. Learning to solve problems is a valuable lesson in any walk of life!

It is often useful to keep written records of what was done and when, so that everyone knows how the project is developing. You will find that documentation is essential in large business projects.

Read the scenario in the case study opposite, which we will follow throughout this chapter. Take some time to consider the problem and discuss your ideas within your class groups.

Factors that impact on problem solving

In any project, there are various factors that might impact on any planned solution. These fall into five categories – time, technical, operational, financial and ethical.

- Time factors are crucial and can affect the success of a project significantly. If the project is not finished in time, there can be severe financial consequences and other related projects may be badly affected as well.
- Technical factors might include whether the available hardware or software is adequate for the task. Is there other hardware that could be used to input information into the system?
- Operational factors need to be considered to determine how the new plans would fit into the existing system or workplace. Will the staff be comfortable using a new system or should training opportunities be offered?
- Financial factors will influence the budget. How much will the whole project cost to set up and maintain? Will it save money and increase profits eventually?
- Ethical factors influence ideas about data access and marketing practices. What information should be stored on the system and who will be allowed access to it?



Figure 1.2 Once you understand the problem, there are then three stages that you should work through in all projects – **design, produce, evaluate**.

CASE STUDY

Implementing a computer system

Defining and analysing the problem

Denis is the owner of a local hardware shop and has been running his business the same way for 20 years. Recently, customers have complained about being incorrectly charged for items and his stock often being out of date. He also suspects that he has a large stock of items that have been sitting in the storeroom for years. Perhaps it is time he sold the shop and retired, or maybe he should replace his assistant Lisa, who has difficulties using the computer system properly.

Susan is a business colleague of Denis. She asks if perhaps the computer system he is using is a little outdated. More modern hardware and software might be easier to use, so mistakes would occur less often and some stock analysis could be implemented. It should be possible to solve the problem with just a little thought and planning.

Denis and Susan begin to **analyse** the problem. They write down exactly what the problem is and several ideas on how it can be solved. They soon realise that there are a few factors that might affect some of their plans. For example, they know they will need some new software, and probably hardware. How much money can they afford to spend on the project and how will Lisa, the assistant, react to a new computer system?

Case study continues in next section …



Alamy/Adrian Arbib

Figure 1.3 Organising stock in a hardware shop

QUESTIONS

1. What is the problem that Denis is having with his hardware shop?
2. What are some of the solutions Denis has thought of? Do you think they are reasonable?
3. Which of the five factors listed in the text are considered in this scenario by Denis and Susan?
4. What other factors should be considered? Why are these important?



Figure 1.4 Factors that influence problem solving

INFOBIT

A recent study by a leading project management consultancy in the United Kingdom found that only 20 per cent of projects were considered to be truly successful and the reason in each case was effective project management.

ACTIVITIES

1. Identify the three main stages of project work. What needs to be done even before the first stage?
2. What projects have you been involved in at school? Do you feel you approached them in an organised way? What were the most important factors you needed to consider?
3. What would be the most important factors to be considered when working on a large project?
4. Investigate some large projects that have been completed around the world; for example, building venues for sports events or developing online health systems. Prepare a report that describes the nature of the project and its success or otherwise in terms of completion times and budget.

1.2 Designing possible solutions

The first major stage in project development is the design phase, in which we create several possible solutions for the project. It is important to write down the **criteria** that the solutions must meet in order to keep the ideas on track. Think about the target audience, and the time frames and **resources** available.

Generating ideas

Generating ideas can be a creative and spontaneous pursuit. It is useful to document ideas so that you can revisit them later or share them with other people. You might choose to use a **concept map** – see figure 1.5. There are computer programs, such as Inspiration®, that can help you to draw these diagrams. A concept map helps to formulate your ideas in a logical and connected way. Use words such as 'how', 'why', 'who', 'when' and 'where' to help brainstorm issues.

One of the most important steps in design is to consult the users of a system. Surveys, interviews and observation are all tools that can be used for this. After all, users are the ones for whom projects are created!

Observing other people's solutions can be useful to create ideas. If your project involves multimedia or website development, look carefully at professional examples on television, in magazines or on the Internet. How is a particular mood or idea conveyed? What colours, layout or images have been used? You may not use all these ideas immediately, but they may be helpful in a future project.

Researching information has been made an easier task with the introduction of technology into the classroom. Using search engines, examining websites or emailing companies and individuals can be a great way to stimulate ideas. Libraries or newspapers and magazines can also be very helpful resources. Information you use from printed or digital media needs to be summarised in any research you do for a project. Make sure you write down where you found your ideas. You will need to acknowledge these sources of information formally at the end of your project or you may want to revisit them later.

Design techniques

Once you have several ideas in front of you, you may want to try them out to see how they work. Depending on the type of project you are working on, you may want to build a **prototype** or draw up a **storyboard** to help you decide on the overall look of the project solution.

Software developers working on a new project often use a prototype to test their ideas. A prototype is a simple version of the final product. It will not have every detail working, but it can be used to gain feedback from typical users. For example, if a program was needed to produce an online quiz for students, the initial prototype could be used to judge whether instructions to the user were clear, or if all the modules connected with each other as planned. You could receive useful feedback by giving the user a list of questions to rate their opinions, or just by observing how they use the quiz.

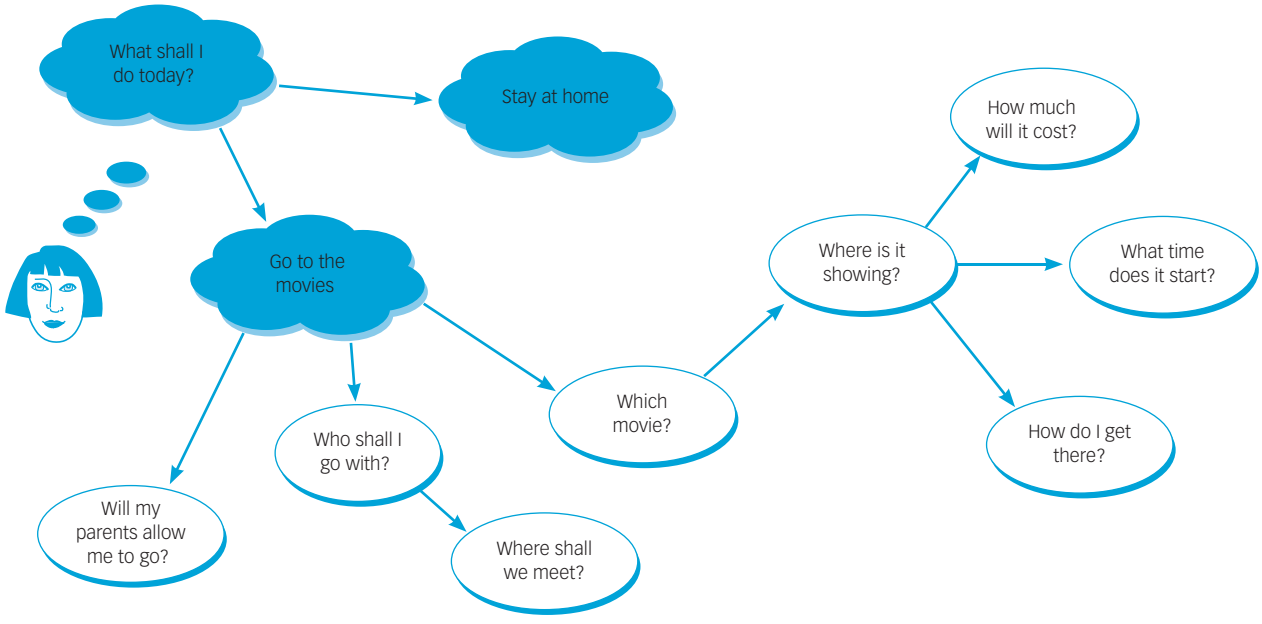


Figure 1.5 Planning a trip to the movies

Software developers may also use an input, processing, output (IPO) table to document their plans. An **IPO table** shows how data input to the program is processed to become output. In the same example of our student online quiz, it is important to identify exactly what the program is designed to produce (output), the data it needs to create that result (input), and what work needs to be done in between (processing).

Input	Processing	Output
• Username • User responses to questions	• Find highest scorer • Compare to correct answer • Increase score for each correct answer	• List of highest scorers • User score • Answers to questions that were answered incorrectly

Figure 1.6 An IPO table for an online quiz

CASE STUDY

Implementing a computer system *(cont.)*

Designing possible solutions

Our friends in the hardware shop write down some clear ideas on the time frame, budget and requirements for the new system. They start to use a database program to see how the information about stock and suppliers can be organised. Susan has seen a website that might give them some ideas for giving customers online access to information. She suggests that they could also collect details about their regular customers and introduce some marketing ideas such as loyalty reward schemes and special discounts.

A storyboard is a suitable means for designing many projects, such as an animation, a movie or a complete website. Simple sketches of screen layouts will help to keep graphic design elements and navigation controls consistent (see figure 1.7). For example, in an interactive presentation it is important to ensure there is a link to the main menu on all pages, and that company logos and user instructions are placed appropriately on each page.

Storyboards allow members of a team to understand the various parts of the production. During the design stage, a storyboard makes it easy to rearrange scenes, change descriptions and modify, add or delete parts while creating the complete story.

Susan sketches out a storyboard to document her ideas about the website design.

Case study continues in next section …

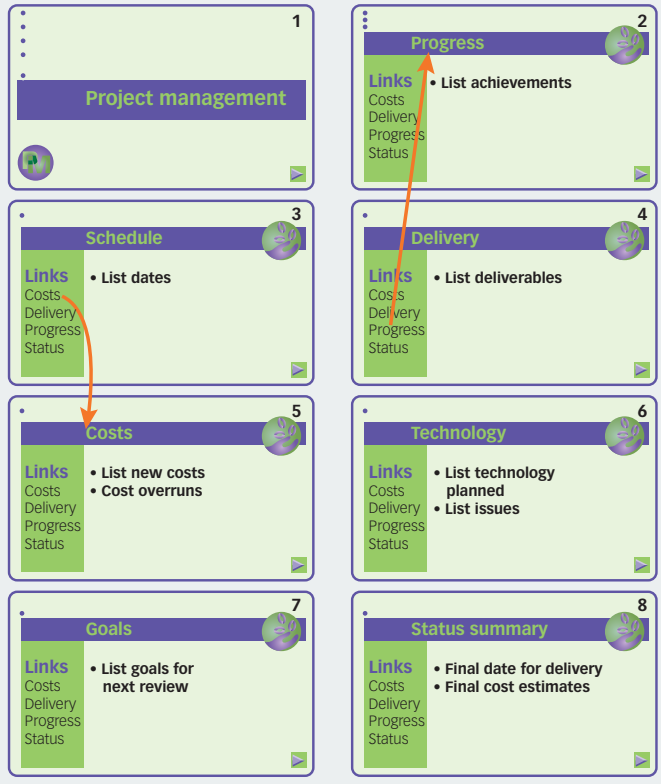


Figure 1.7 A storyboard for a multimedia presentation about project management. Consistency in design means layout, colour and fonts are similar on all slides.

QUESTIONS

1. Sketch a storyboard for a possible design of a website for this hardware shop.
2. What other activities should Denis and Susan be considering at this stage?

ACTIVITIES

1. You want to include a video clip in a presentation you are making to your local sports club. What are the possible ways you could do this and what might be some of the problems? Brainstorm some ideas and draw up a concept map of possible solutions.
2. What is a prototype? What is its main purpose?
3. Draw up an IPO table for the purpose of calculating a budget for a holiday you are planning.
4. Access a website that incorporates an online quiz. Sketch the storyboard for the site. Does it have clear instructions and navigation links?

1.3 Producing and evaluating solutions

Having spent a significant amount of time generating and documenting ideas, the next stage of your project will be to actually produce a solution and evaluate its success.

There are guidelines that must be followed while you produce your solution, and standards that must be reached by which you will be evaluated. If these guidelines and standards are clearly documented, it can help you achieve your goals.

Producing solutions

At an early stage in any project, there will need to be some agreement on the style and scope of the finished product. This will involve the establishment of criteria, which are the standards to which the solution must conform. There may be a particular audience that needs to be targeted, or a particular software application that must be able to run the solution.

Criteria

Your documentation should indicate clearly the criteria that need to be met, and you may have to eliminate some of your ideas if they do not qualify. If, for example, you have to make a presentation on a subject you have researched, you need to ensure your material is not too technical for your audience. You may need to restrict your ideas to graphics that are free of copyright, and not too complex to be understood by your audience. Remember that you may need to explain how the criteria have been met in a later stage of the project.



Alamy/Sagaphoto.com/Stephane Gautier

Figure 1.8 Recycling old hardware can reduce the impact of technology on the environment.

Basic rules and innovation

During this course, you will use many different software applications to produce some exciting projects. There will be frequent opportunities to think outside the square and investigate different methods of development. It is important, however, to remember some basic rules. It is better to have a simple product that works, rather than a complex and sophisticated program that is full of bugs. Also, losing your work at a crucial moment can be frustrating, so regular and secure backups are essential. Keep an open mind and ask for constructive feedback from your peers. Discovering new techniques can be the best part of project work and can encourage innovative solutions.

Evaluating

The **evaluation** of a project includes looking carefully at the criteria that were originally specified for the solution, and explaining how they have been met. If, for example, you have created a digital media presentation for an advertising agency, it may be more important to use quality graphic design principles than to include lots of busy animations and sound effects. Similarly, file sizes may be critical for a website design.

Functionality and quality

Evaluating functionality means deciding whether the application works in the way we expect. Thorough testing needs to be carried out to ensure there is no potential for misunderstanding by the user. For example, in a multimedia presentation, if an icon needs to be clicked to play a movie clip, it is a good idea to prompt the user to do it.

Quality of information in any project is important. Information must be accurate, otherwise errors can be made in processing data or making decisions. Also, it must be relevant to the project, otherwise it is useless and it will take up valuable space. It may also be confusing to the user.

Integrity of information is a measure of its reliability and so it should be collected only from a trusted source. Finding information in a newspaper or on the Internet does not guarantee that it is true. Information can also become out of date; for example, clients can move house or change jobs.

Ethics and the environment

Ethics and respect for the environment will also be important criteria for evaluating projects. For example, there is a reasonable expectation that clients' personal details will be protected from hackers and that any statistics produced from stored data will be presented in a fair and honest manner.

In addition, we must all take responsibility for protecting our environment, both close to home and across the world. Excessive use of paper and inconsiderate disposal of old hardware can have a major impact on our environment (see figure 1.8). Issues such as the placement of communication towers and clean methods of delivering power to our computers are further examples of such environmental concern.

Methods of evaluation

We have looked at a range of criteria that should be used to evaluate our projects. Here again the users of the project are most important. We can also use different groups of users to test those criteria. Initially, of course, we must take time to step back and consider our own work.

Asking for feedback from peers as well as teachers is a valuable experience. Try to reflect on any comments so that you can modify your work to meet the criteria more effectively, and also to improve on performance in future projects. If the project is targeted at a particular group of people or a specific end user, it would make sense to gain regular feedback from these people during the development of the project. It might be useful to write down some specific questions for them to answer, rather than expect just vague comments on all aspects of your work.

CASE STUDY

Implementing a computer system *(cont.)*

Producing a solution

Denis and Susan gave the prototype database that they had developed to the assistant, Lisa, to see if it worked successfully. Although she was quite an experienced computer user and keen to use the new system, Lisa seemed to have a problem understanding how it all worked. There was obviously a need for some training and online user help. In light of Lisa's comments, Denis and Susan decided they would be better off hiring a computer professional to manage the whole project. The time plan and financial analysis that they had carried out earlier confirmed this decision.

Evaluating

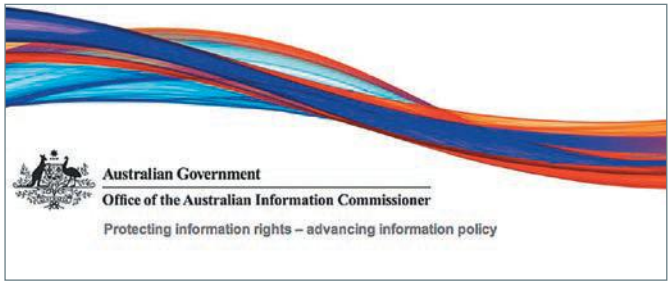
Denis and Susan hired Andrew, a computer project manager, to complete the solution for the hardware shop. They gave him all the documentation they had created, and Andrew discussed with them some other factors that they had not yet considered, such as data security and backup. Andrew was also able to advise them on the legal implications of collecting and storing information about people.

The National Privacy Principles website has information about privacy issues you must consider when collecting data about people.

Case study continues in next section …

QUESTIONS

1. Why do you think Denis and Susan decided to use a computer professional to complete the project?
2. What factors would have been important in making this decision?
3. What other issues do you think should be considered at this stage?
4. Find out about the National Privacy Principles and the laws about collecting information about people.



OAIC website, http://www.oaic.gov.au/

Figure 1.9 The Office of the Australian Information Commissioner can help people understand their right to privacy.

ACTIVITIES

1. What is meant by criteria? What criteria have you needed to consider in some of your projects?
2. List the criteria by which all projects should be evaluated. Give an example of how these would be met in the hardware shop example discussed throughout this chapter.
3. Identify four qualities that information should have. Give an example to illustrate the importance of each in the context of a database system suitable for a doctor's surgery.

1.4 Project management

We have seen how to use specific criteria to develop successful projects and will look now at other factors that contribute to a satisfactory outcome. The bigger the project, the more important the planning will be.

Project management

It is estimated that there is an 80 per cent failure rate on projects in the information and communication industry due to lack of **project management**. This can become very expensive and frustrating for the workers and the client. Project managers have specialised jobs in the information technology field. They are responsible for the overall success of projects and must therefore carefully plan the use of resources such as time, finances and people.

Having a clear time schedule is essential for completing a project on time. Remember that problems may arise while you are developing your solution, so it is a good idea to work well ahead of deadlines. Resources such as people, printers and computers all have the potential to let you down at the most inconvenient moments. Also, making secure backups of your work will pay dividends and save you time.

Draw up a table of tasks that need to be done and allocate a realistic time frame to complete them. Figure 1.10 shows the stages of a typical project. You will need to list specific tasks in your time schedule. Keep the documentation up to date. It will be much easier to edit an existing document at the last minute than try to create it all from scratch the night before your project is due.

Resources

Money is always an important issue, no matter how big the project. Trying to predict how much a project will cost is a difficult task, but estimates and limits can be determined by examining other similar projects. Keeping track of how much has been spent, and on what, is an easy exercise using a spreadsheet. Complex analysis and predictions can be carried out and graphs can be used for comparisons and trends in spending.

Organising a team of people calls for special talents. A big project may need to be serviced by a variety of people, each with their own area of expertise. Their availability and correct understanding of needs will have to be coordinated by the project manager. Their costs and work location are issues that need to be negotiated. Perhaps some tasks could be outsourced (sent to people outside the company for completion) so that expertise and office accommodation costs can be optimised.

Communication techniques

Communication within a team or with a client is an essential factor in the success of a project. There are various ways to communicate information and to present projects: verbally, in written format, and with or without graphical and visual aids.

Verbal

Verbal communication can be difficult if you are in an uncomfortable situation. If you need to express something clearly, take time beforehand to make a note of the main idea you wish to convey. Remember that the more you practise this skill, the easier it will become. Oral presentations of projects bring their own challenges. If you are presenting to an audience, make sure all equipment is working as you would expect. Practise the presentation on the actual hardware you will use on the day. Any visual aids you use must be large enough for all your audience to see. A detailed animation will be difficult if your audience is too far away. Graphics should be clear and appropriate. Try not to read your script too much and never insult (or bore!) your audience by reading word for word from a screen.

Written

Written documentation is an essential part of any project. It is a good idea to write a diary of events so that you can reflect on the progress you have made. This is even more important for larger projects. There are now opportunities for people to work collaboratively on documents online. Copies of documentation and research findings should be clearly named and dated, and submitted with the final project so that they are easily accessed. Always acknowledge your sources of information and anyone who helped you with the project.

Graphical

Throughout this course, you will have the opportunity to incorporate many graphical images and visual aids into your projects. These can add impact and capture audience interest. However, you must ensure they are appropriate to the theme of the project and that issues of copyright are not violated. Another option for presenting your project might be to publish it on the Internet or your school's intranet. Your audience would have the flexibility of accessing your presentation in their own time, and you could ask for feedback from them by email or questionnaire.

Task	Week 1	Week 2	Week 3	Week 4	Week 5
Research ideas					
Create prototype					
Test prototype					
Produce solution					
Evaluate solution					
Documentation					

Figure 1.10 Time management – a schedule of tasks to be completed

	A	B	C	D
1	Budget			
2	Train fare	$3.80		
3	Movie ticket	$13.00		
4	Snacks	$8.00		
5	Total:	$24.80		
6				
7				
8				
9				
10				

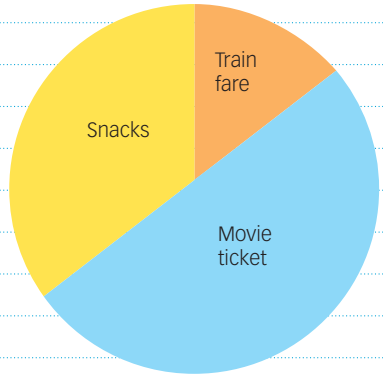


Figure 1.11 A simple spreadsheet shows the budget for a trip to the movies. Include formulas to automatically calculate totals.

INFOBIT

Project team members often use social networking to keep up to date with progress of tasks. Blogs and wikis are often used, as well as Facebook, Twitter and Yammer.

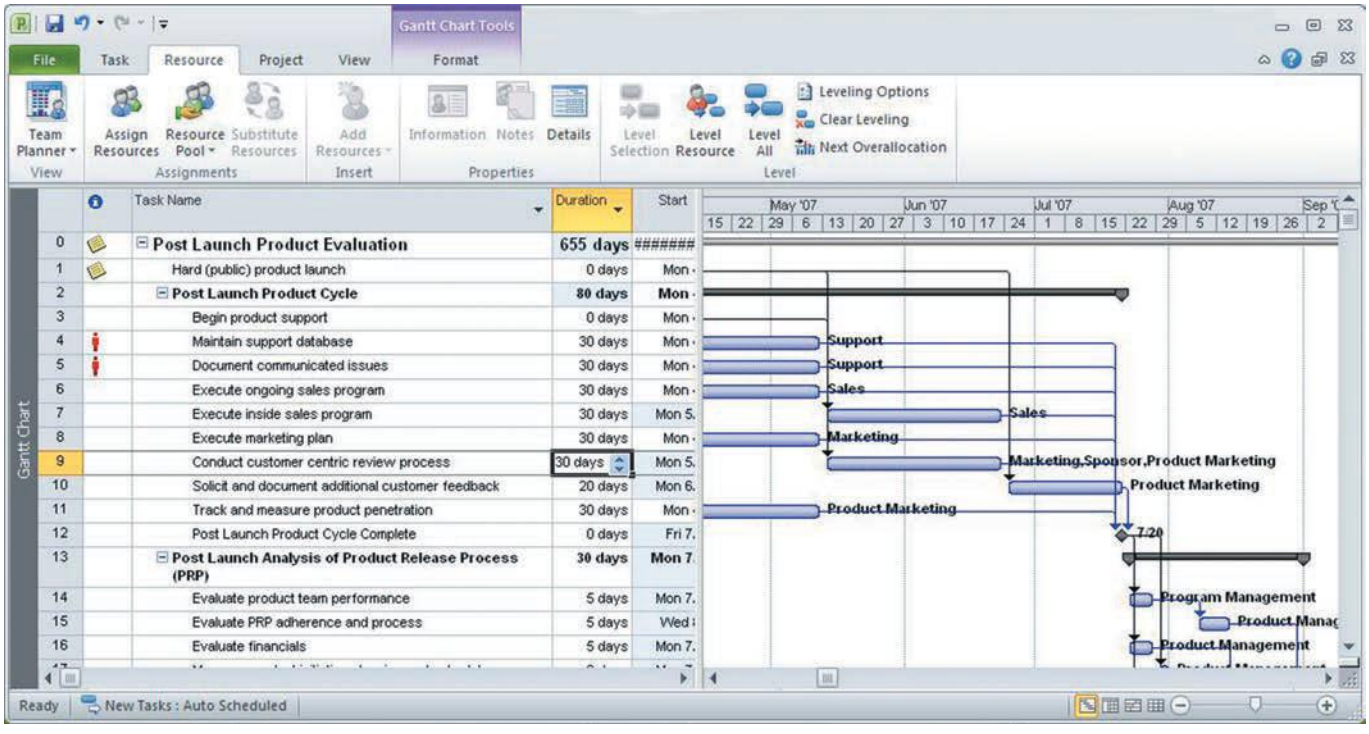


Figure 1.12 Large projects use professional project management software to organise tasks, people and deadlines.

Microsoft 2010 Preview © Microsoft Corporation

Group work

In any area of business, groups of people are brought together to work on projects so that there is a range of expertise within the team. People find themselves working with people whom they don't know very well and may have different views on a number of work issues. The challenge for any team leader is to encourage **collaboration** so that each member of the team can contribute positively to the project. Every situation can provide opportunities to develop organisational, communication and negotiation skills.

Roles and responsibilities

Organising a list of the roles and responsibilities for the team is important at an early stage in the project planning. Individuals can then plan each task so that it fits with everyone else's schedule.

Sharing time and experience is important in developing group dynamics, and each team member should be prepared to do this. At group meetings, take turns in expressing ideas and reporting problems. You can learn a lot from listening carefully to other people's problem-solving techniques. Take the opportunity to understand other people's strengths and weaknesses.

When working as a group, it is important to let everyone have the opportunity to express their opinions in a positive and comfortable atmosphere. Write down ideas and decisions so there is no misunderstanding later on by any individual. Describing a problem and its solution can help to prevent similar problems being repeated in the future. If you are using email, make sure everyone receives a copy of each message. Accept comments from your partners as positive feedback and consider how any conflict might be resolved calmly and in a friendly way.

Collaboration

Collaboration means working together to produce quality solutions. This is not always easy, as people work differently from each other.

It is essential to document ideas and decisions so that everyone in the group understands their responsibilities. Plan regular meetings so that team members will work to deadlines and can report their progress. Phone calls and emails are effective for reminders, but all members of the team need to be notified of any discussion that took place. Figure 1.13 illustrates how effective videoconferencing can be. With increasing bandwidth, and user-friendly tools such as Skype, Viber and Adobe Connect, videoconferencing can bring together people who live many kilometres apart. This has the advantage of:

- including a wider range of people with different knowledge and skills
- saving time
- saving on expensive travel and accommodation
- giving visual cues for speaking and agreeing.

Many software projects have been completed entirely online without anyone meeting physically. Online collaboration on documents has also become possible with the development of free and sophisticated documentation software. For example, blogs and wikis allow a large team to develop ongoing ideas and documentation.

Allow time at meetings for each member of the group to comment on the development of the project as a whole. Agree on strategies for assessment of individual contributions. If anyone seems to be falling behind the agreed schedule, it is important that the problem be discussed and a solution negotiated.

In the final evaluation of a project, you should reflect on the challenges that collaboration presented and the advantages you found from working as part of a group.



Getty Images/Hero Images

Figure 1.13 Videoconferences allow people to work together even though they may be many kilometres apart, bringing significant benefits to a project.

INFOBIT

Project experts suggest that the maximum number of people in a team is eight. If the team gets any larger, team members can spend too much time communicating instead of applying their skills and knowledge to their part of the task.

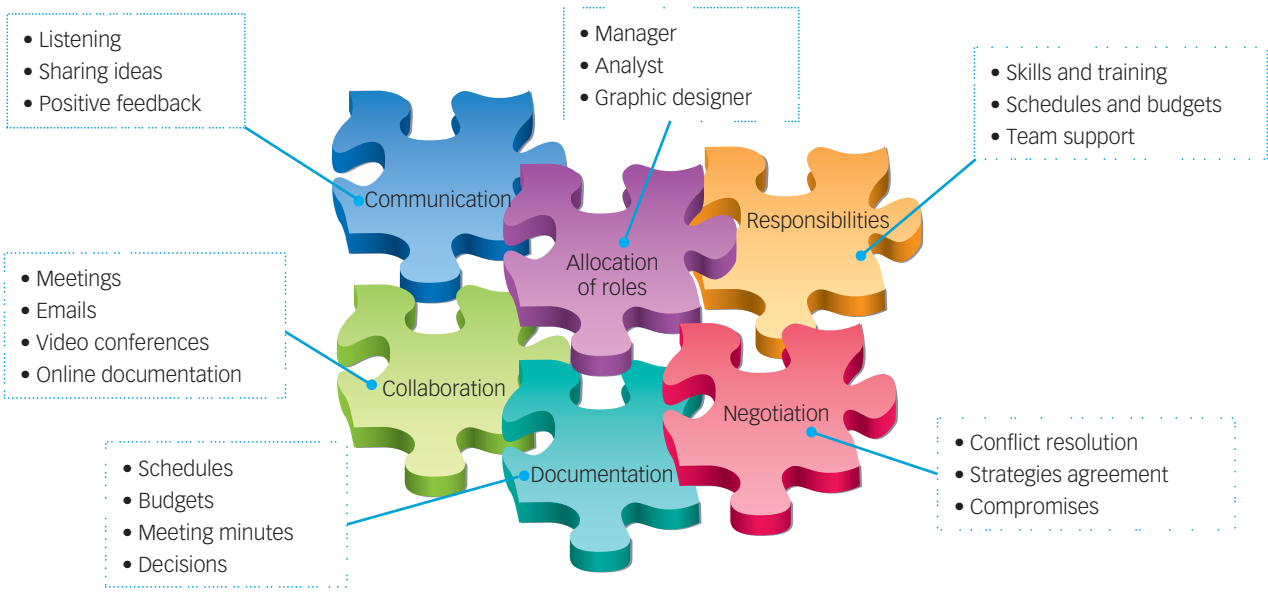


Figure 1.14 Important elements in group work

CASE STUDY

Implementing a computer system *(cont.)*

Project management

Andrew is an experienced project manager who has worked in the computer industry for many years. However, every project that he undertakes allows him the opportunity to think creatively and to apply some new ideas. He documents his ideas for Denis and Susan, and is confident he will keep within the scheduled time and cost estimates. He knows he will need to subcontract some of the work to other professionals whom he has worked with in the past. This will enhance the effectiveness of the solution and allow him to deliver the solution in the shortest possible time frame.

Denis and Susan have every confidence that Andrew will produce an effective solution to the problem in the shortest possible time. It is still important, however, for all of them to keep in touch and receive regular feedback as the project progresses. Andrew has been careful to make notes of all discussions and has kept the documents that contained their original ideas. He will continue to do this throughout the project, and to date and sign all decisions that they make together. In turn, Andrew will need to pass on specific tasks and time schedules to the members of his team.

QUESTIONS

1. What are the major advantages in employing a project manager in this scenario?
2. Summarise the main types of communication used in project management.
3. What are the specific roles and responsibilities of the people working on this project?
4. Look back at the unfolding situation presented throughout this case study. Identify each step in effective project management.

ACTIVITIES

1. Identify at least three ways to communicate information and discuss the advantages of each.
2. Consider a group project that you have completed for another subject. What strategies did you use to ensure the project was completed on time? What were the areas of most concern? How did you negotiate through difficult situations? What strengths do you think that you bring to a project team?
3. Imagine that you have been asked to create a documentary about your home suburb or local sports club. List all the tasks that will need to be done before you actually start work on shooting the footage. Create a storyboard and a time plan. Estimate the cost of the project, using a spreadsheet. Where will you get information from? Who will you include in your team to help you complete the project? Will they be available for regular meetings?

Review questions

2 CORE Hardware

Syllabus outcomes: 5.1.2, 5.3.1

Chapter outcomes

You will learn about:

- functions that hardware performs
- hardware components
- classifications of systems
- hardware solutions
- troubleshooting
- care and maintenance of hardware.

You will learn to:

- identify hardware components
- classify hardware devices
- describe the uses of microprocessors
- develop hardware solutions
- identify troubleshooting procedures
- apply basic procedures for the care and maintenance of hardware.

Key terms

Bus lines
connections between chips on the circuit boards

Control
allowing data to move through the system

Controller cards
circuit boards that hold chips performing secondary functions such as sound and video display

Display
appearance of output presented to the user

Hardware
physical parts of the computer

Input
function of a device, such as a keyboard or mouse, used to send data to a computer system

Microprocessor
general name for an integrated circuit (also called a 'chip')

Motherboard
main circuit board that holds most of the main chips

Output
function of a device, such as a monitor or printer, that communicates information from a computer system to a user

Port
point of connection between an external device and a computer

Processing
changing data from one form to another

Secondary storage
devices that can hold data after the power is turned off

Server
networked computer that performs certain tasks for other computers on the network

Storage
part of a computer system used to hold data for current and future use

Troubleshooting
systematic method for finding faults in a computer system

IN ACTION

Roll up! Roll up! Get your super-flexible screens here!

Mobile devices such as phones, computers and media players have been shrinking in size since they first appeared on the market. Reducing the size of these devices increases their portability, but there is a point where the screen becomes too small for effective image display. Technology companies are producing flexible screens that can be rolled up like a window blind. These screens are made up of a thin film of pixels that can be rolled tightly around a cylinder as small as a pencil yet are still able to display moving images. The screens are lighter and generally tougher than conventional glass-based displays, so this idea can be developed further into areas of wearable items such as wristbands, or displays on the outside of moving vehicles or even on the steering wheel.

One type of display is made up of an array of organic light-emitting diodes (OLEDs). These OLEDs are molecules that can produce light when a voltage is applied to them, and can retain the image for several months without electricity.

A rollable display might measure a few centimetres wide and about 80 micrometres thick, which is thinner than a human hair. It can produce 16 million colours, which means full-colour quality. These panels are able to produce moving images while being repeatedly rolled up and unrolled. Even after 1000 cycles of rolling and stretching, the video image does not appear to be adversely affected.

Ordinary light-emitting diodes (LEDs) have been used in electronic circuits for many years; for example, as a monitor on-off indicator light. With circuitry now being developed at a molecular level using organic materials, the technology is now referred to as 'organic'. The display devices can be created from liquids in a similar way to artists creating screen-prints. This type of production requires fewer steps and uses materials more efficiently than previous display production, with less impact on the environment.

High-resolution television screens present another important application that benefits from flexible, lightweight, low-energy-consumption screens. As screens get larger and image quality is enhanced, the demand for smarter technology increases.



Shutterstock.com/Chesky

Figure 2.1 A smartphone on a wristband



Shutterstock.com/Milles Studio

Figure 2.2 Exercising with wearable smart devices is no longer a futuristic idea.

QUESTIONS

1. In what ways are flexible screens more useful than rigid ones?
2. How thin is the screen? How tightly can it be rolled?
3. What does OLED mean?
4. Explain how these screens are more environmentally friendly than conventional screens.
5. What other devices could use the flexible screen idea?

2.1 Input, output and storage

A computer is often defined as an information processor – we supply it with data to be changed into an appropriate format, which can then be stored or displayed for a specific purpose. The components of a computer system are classified according to the type of function they perform – **input**, **output**, **storage**, **processing** and **control**. The **hardware** of a computer system has a part to play in all of these functions, as we shall see in this chapter.

Hardware includes a range of physical devices – items that you can see and touch. Figure 2.3 shows a picture of a typical computer hardware system. The hardware components work together to complete the overall task.

Input

An input device collects data from the outside world and changes it into a form that the computer can work with. The keyboard, mouse and touchpad are probably the most commonly used input devices. The keyboard will convert the press of a key into an electrical signal to be transmitted either wirelessly or along a cable to the system box. Different signals will indicate which key has been pressed. This data is stored in memory until it can be processed by the central processing unit (CPU).

Microphones, scanners, digital cameras and graphics tablets are also fairly common input devices. Some systems have sensors that collect data such as temperature, light, noise and movement, which they send to a central unit for processing into appropriate information.

Output

An output device communicates information from the computer to the user. Information may be output as a **display** on a monitor or printer, or it may be output as sounds from a speaker. The monitor converts digital electrical signals from the system into patterns of light on the screen, which can be interpreted by the human brain as text or images. Head-up displays, 3D printers and laser cutters can also function as output devices. Speakers take electrical signals output from a computer and convert them into sound waves, perhaps speech, music or sound effects.

Today's monitors are capable of displaying graphics, animation and video, so it is important to know a little bit about what determines size and quality. The screen is divided into small picture elements or 'pixels'. Typically there are about 72 pixels per inch, or 28 to the centimetre. The electronics of the monitor assign a colour to each one of these pixels, and so build up a meaningful image. This may be text or a graphical image.

Most monitors now have flat screens and use liquid crystal display (LCD) technology. Figure 2.4 shows how



Figure 2.3 Most parts of the computer system have a specific task. These tasks can be classified as input, output, storage, processing and control. Can you identify and classify each hardware item illustrated?

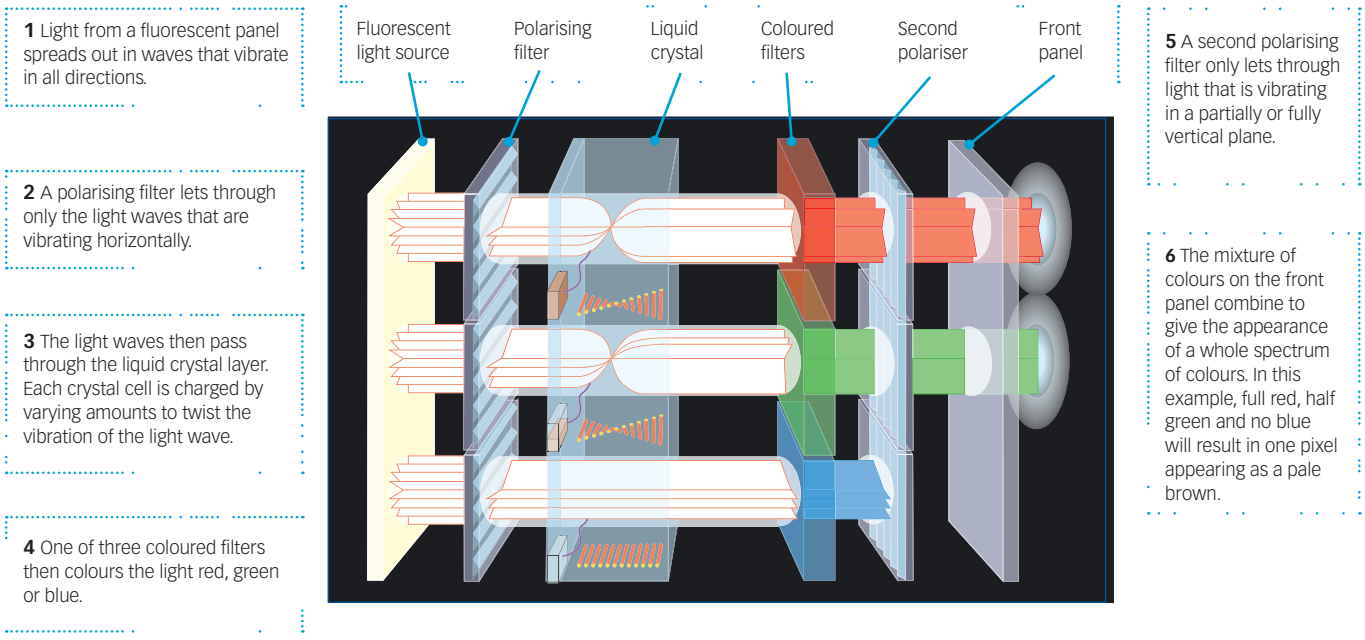


Figure 2.4 How the liquid crystal display works

the LCD monitor works. A 60-centimetre monitor will typically display 1900 pixels across and 1200 down. This is referred to as its resolution. It may have a 32-bit colour depth, which means it can display over four billion colours. Touchscreens on mobile devices such as phones and tablet computers are made up of a clear glass panel with a touch-responsive surface. This generally has a (small) electrical current going through it, which changes when touched. The processor connected to the device is able to calculate the coordinates of where the screen was touched.

Data projectors and interactive whiteboards are now commonplace in classrooms and are extremely useful for demonstrations and digital media presentations. Rear-projection laser systems are used for large concerts and presentations, sports events and for public advertising. Clusters of full-colour LED systems are used as intelligent road signs.

Sometimes you will need to produce your documents as hard copy, which means printing onto paper. This allows you easier access to your document when you are not working at your computer. Figure 2.5 on page 18 shows how a laser printer works. Colour laser printers are now fairly inexpensive and produce high-quality images. Choosing the most appropriate resolution before you print can save you time and toner. For everyday documents, 300 dots per inch (dpi) is adequate; use 600 dpi if you need a more professional look. A professional photographer would usually require 1200 dpi.

INFOBIT

As technology rapidly evolves, innovations for input and output devices offer endless possible applications. 3D printing is an exciting resource that is becoming available to many schools. However, 4D printing has now been suggested as a tag, whereby time is added as a fourth dimension. This means that the 3D structure can change with time – like transformers; for example, a water pipe valve that can open and close in response to water temperature. Other 4D printed devices may be transformed by movement or magnetism – sensors acting as input devices.

Power supply

The many components that make up the computer system all need electricity to work. The power supply is a small box inside the computer case that ensures that power is supplied to each component in an appropriate form. Some components need only a very small voltage, and so the mains supply needs to be transformed to a suitable level. Fans are usually required as computer circuits produce significant heat.

If a computer is working from a battery, it will need recharging at regular intervals. If the system is part of a network or large mainframe computer, an uninterruptible power supply (UPS) is often used to protect the system in the event of a power failure.

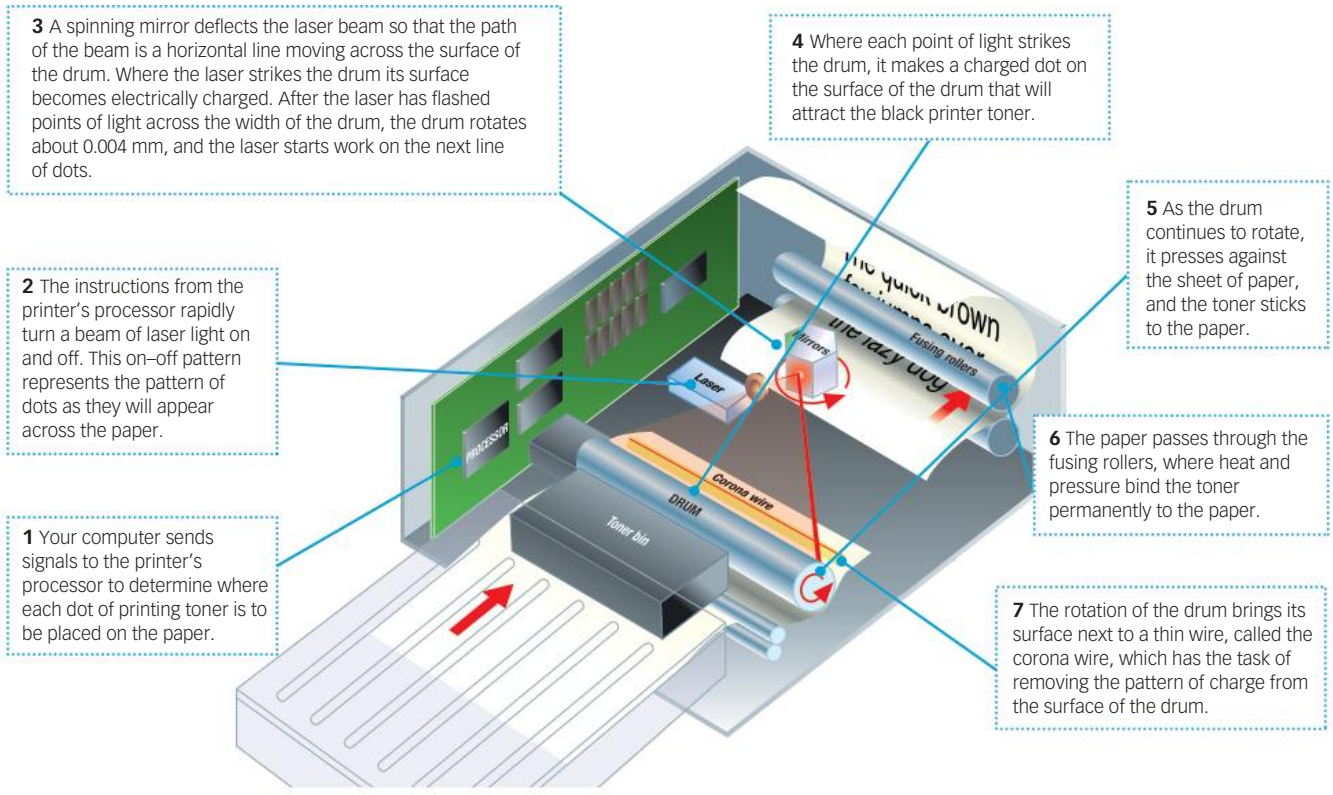


Figure 2.5 How the monochrome laser printer works

Storage

You will already understand the need to save your files to a hard disk as you are working with them. Also, before you turn your computer off, the documents you have been working with need to be stored for future use. There are several **secondary storage** devices that can do this for you. They all have different capacities, access speeds and portability factors, so you will need to make a decision about which one is most suited to your needs. Magnetic storage such as a hard disk is fast and cheap, but may not be very portable. Digital versatile discs (DVDs) are much more portable than hard disks but are slower in reading and writing the data, and have a limited storage capacity. Flash memory sticks have excellent characteristics for secondary storage, but they are easily lost or broken.

Figure 2.6 shows how data is stored on a magnetic hard disk.

Storage devices can be local or remote. Local external drives are being replaced in many cases by online storage using remote **servers**. Networked and online file servers are designed to allow secure storage of data and are often accessible across the Internet. This reduces the risks involved in physically carrying around portable devices, such as accidental loss or damage, and also offers the advantage that the data may be accessed by many people from various locations.

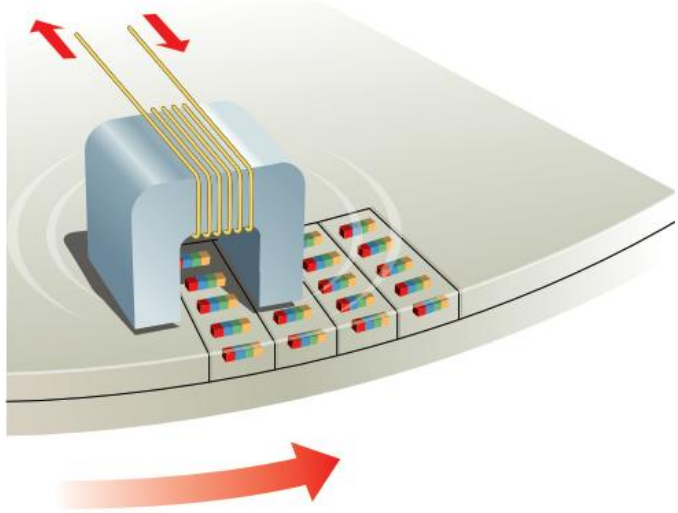


Figure 2.6 Hard disks are coated with a magnetic material. The read–write head of a disk drive magnetises a spot on the surface to record the data, which can later be read back.

Ports

External devices, such as keyboards, monitors or printers, are often attached by a cable to the system box. The **port** is the interface, or point of attachment, to the system box. There are different types of ports depending on the device to be connected. However, having standard ports and connectors greatly simplifies the process of attachment.

A universal serial bus (USB) port can input or output data to devices such as keyboards, printers, digital cameras and data gloves. For devices that do not have their own power, USB ports even provide a small amount of electricity for various low-power demand devices such as a mouse or flash memory stick, and even novelty devices.

A digital video interface (DVI) connector is used to connect to a monitor or HD TV, while a high-definition multimedia interface (HDMI) port will carry both audio and video. These can be used instead of the video graphics array (VGA) port, which provides an analog connection to a data projector or monitor.

The memory card reader slot on many new laptops allows you to upload images from a digital camera memory card. An express card slot can be used for devices such as cellular broadband cards, digital memory card adapters and network cards.

The local area network (LAN) or ethernet port is used to connect the computer to a switch or router on a local network or to a high-speed Internet service such as an asymmetric digital subscriber line (ADSL) modem. You can learn more about the terms 'LAN' and 'ADSL' in chapter 12: The Internet and website development and in chapter 13: Networking systems.

USB	The most widely used port; can be used to connect many types of devices
LAN/ethernet	Connection to a wired computer network or high-speed broadband
HDMI	Popular in entertainment equipment such as high-definition LCD or plasma TVs, and HD-DVD or Blu-ray™ players
VGA	Analog connection to a monitor, data projector or LCD TV
Memory card reader	Accepts most digital camera cards, including secure digital (SD) cards
Express card slot	Largest expansion slot, used for devices such as cellular broadband cards and network cards
DVI	Digital connection to a monitor or HD TV



Shutterstock.com/Vartanov Anatoly


Shutterstock.com/Tobias Arthelger

Figure 2.7 Left: Ports on a laptop computer – different ports for different devices. Right: A selection of common USB plugs.

ACTIVITIES

1. Identify the five functions that elements of a computer system perform.
2. Draw up a table of hardware devices that you know of. Identify each one as a device for input, output or storage.
3. How do you think a touchscreen device should be classified – input or output? Could it be both?
4. What sort of data is collected, stored or output from the devices you identified in questions 2 and 3?
5. How many display devices can you see in your home?
6. Scanners and printers can now operate in 3D (three dimensions). For example, a 3D scanner can capture the finest detail of a locomotive and a 3D printer can output that image on any (reasonable) scale. Research the availability and operation of these devices and present a report to the class. What other objects might these devices be used for?
7. USB ports support both input and output devices. What does USB stand for?
8. Draw up a table to compare the characteristics of different storage devices. Include a comparison of capacity, portability and speed, plus any other relevant comment.
9. How does flash memory work?
10. Look at the ports on your computer. Can you identify all the ports? Draw a diagram and label each one with a device that could be attached.

2.2 Processing and control

Figure 2.8 shows the flow of data as it is input into the system so that it can be processed, stored and output from the system. Let's now take a look inside the system box. This is where most of the processing occurs, changing the data we input into the computer into meaningful output.

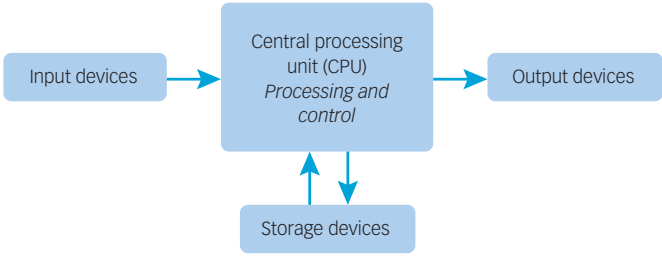


Figure 2.8 Data flow – most of the devices connected to the computer are under the control of the central processing unit. Data and information flow into, around and out of the system. Match the devices mentioned here with the items in Figure 2.3 on page 16.

The motherboard

Figure 2.10 shows the main sections inside the system box. The main item inside the system box is called the **motherboard** and this houses a variety of components, including the all-important chips. Chips are collections of complex electronic circuits mounted on a wafer, or chip, of silicon. The main chip, the CPU, is responsible for the processing and control of data. It works at high speed (typically more than a billion operations per second!) and so it needs memory chips, such as RAM (random-access memory) and ROM (read-only memory) chips, to hold data for it while it is working on current tasks.

The CPU is often referred to as the brain of the computer. It can comprise a single integrated circuit (chip) or a number of chips working in parallel. It is responsible for the processing and control of all the data flowing into, out of, and around the system.

Computer chips are made up of millions of tiny electronic components called transistors. A transistor is really just a switch. By connecting these switches in complex circuits, **microprocessors** are able to perform a variety of complex tasks. Some of these chips (for example, RAM chips) are classed as storage devices, as they store programs and data that need to be instantly accessible to the CPU. Other chips act as processors to carry out routine tasks, such as preparing audio and video data for output.

RAM is volatile, which means it loses all its data when the power is switched off. That is why you need to save your files to secondary storage devices such as your hard disk. ROM chips hold information that the CPU needs on a regular basis, such as when the computer is starting up. This data cannot be changed by the user. These ROM chips hold their content even after the power is switched off, otherwise your computer would not be able to start or perform other essential operations.

Coprocessor chips are designed to perform specific processing tasks, such as numeric calculations or video decompression. They allow an increase in the overall speed of the application, as they relieve the CPU of some of the routine tasks. Coprocessor chips can be located on the motherboard, or on other **controller cards**, such as graphics cards.

INFOBIT

Before the introduction of the Apple I in 1975, a computer was usually built in a case or mainframe with internal components connected by wires. The CPU and memory chips were housed on individual printed circuit boards rather than a common motherboard.

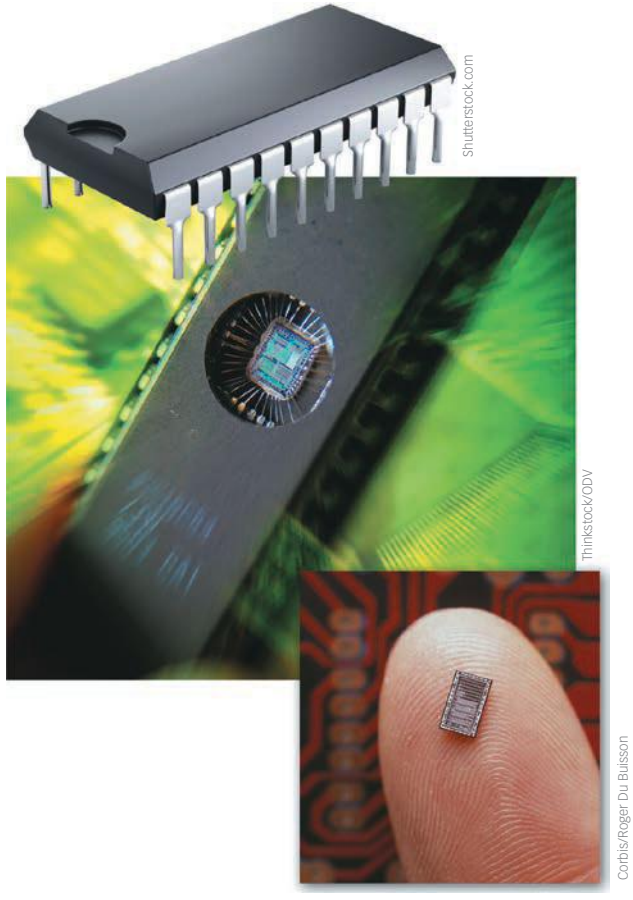


Figure 2.9 Chips are very small and so are housed in boxes for protection. Connector legs make it easier for them to be installed on circuit boards.

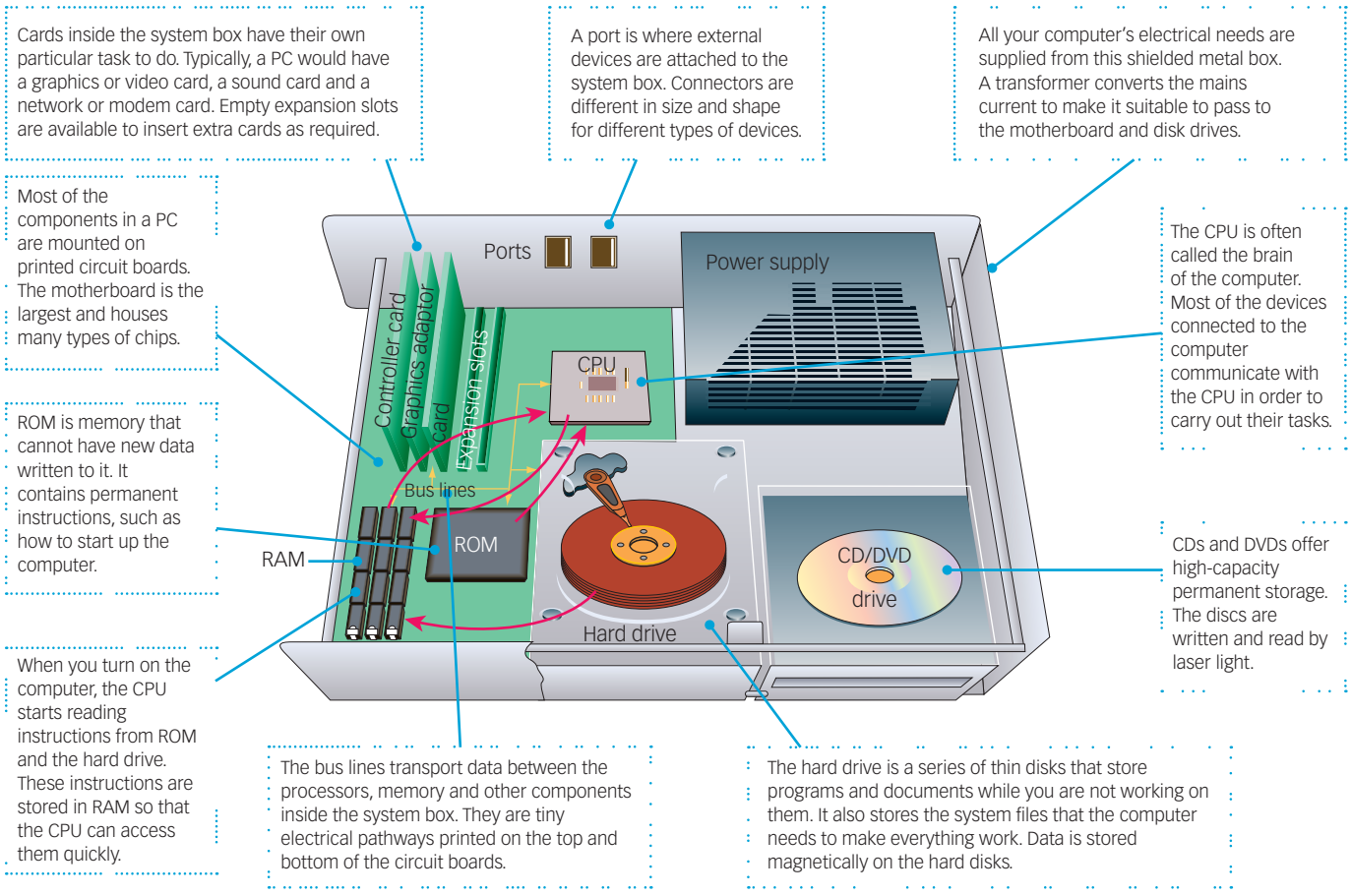


Figure 2.10 Inside the system box of a desktop computer

Controller cards

Controller cards are often expansion boards that fit into slots in the motherboard. They include video cards, sound cards, network cards and modem cards. A video card, also called a graphics adaptor card, converts computer output into a video signal that can be sent through a cable, to display an image on a screen. Video cards contain their own processing and memory chips. A sound card allows sound to be input through a microphone and output through speakers, the data being passed through processing and storage devices in between. Coprocessors on graphics and sound cards help the CPU to process some of the data so that operations run faster.

Notebook and other digital devices have special expansion slots for installing controller cards. These can add memory, sound and modem capabilities. Similarly, some computers and printers use flash memory cards.

INFOBIT

The term 'booting' comes from an old expression, 'to pull yourself up by your bootstraps'. It is used to describe a simple program activating a more complicated program, in particular the startup process.

Bus lines

In a typical desktop computer, the CPU and memory chips are attached to circuit boards, and data can pass between them along connecting channels or **bus lines**. Buses typically have 32, 64 or even more paths that the data can travel along in parallel, which allows much faster transmission and processing. Some buses connect to expansion slots inside the system box. Other buses connect to external ports or sockets on the outside of the system box.

ACTIVITIES

1. What is the motherboard? What components does it house?
2. What functions is the CPU responsible for in a computer system?
3. Compare the functions of RAM and ROM chips.
4. Describe the movement of data between RAM and secondary storage while you are working on a word processing document.
5. What are controller cards and how do they connect to the motherboard?
6. The CPU follows a 'Fetch–Execute' cycle while it processes data. Investigate how this works. How is the data accessed and processed by the CPU?

2.3 Classification of systems

Computers are often classified according to how powerful they are, and this usually determines what type of job they do. System classification is used to give people a general idea of what the hardware can do. These classifications are sometimes a little blurred because technology changes so rapidly. For example, mobile devices such as phones and tablets now have the power that only desktop PCs had a few years ago.

Microprocessors

Microprocessors are tiny electrical circuits made up of millions of transistor switches, mounted on a silicon chip, that control the flow of electrical signals. Much of what a computer does is dependent on these electronic switches routing data in different ways, according to the software instructions. The CPU inside the system box of a personal computer is often referred to as the processor, or microprocessor, as it is very small and controls the main operations of data processing.

As well as computers, microprocessors are found in many different electronic devices. Their job is to store and process data – that is, to change data into a form that is useful to humans or another device. These devices include cameras, watches and monitoring devices. Figure 2.11 shows a range of devices that use microprocessors.

Figure 2.12 shows five different types of hardware systems – personal computer, smartphone, server, mainframe and supercomputer.

Digital camera

Microprocessors enable the camera to automatically focus on a subject and take a reading of the available light. The camera sets the aperture and shutter speed for optimal exposure. A processor may then perform a preset level of compression on the data and store it in a memory device – often a flash memory card.



iStockphoto/wabeno

Digital watch

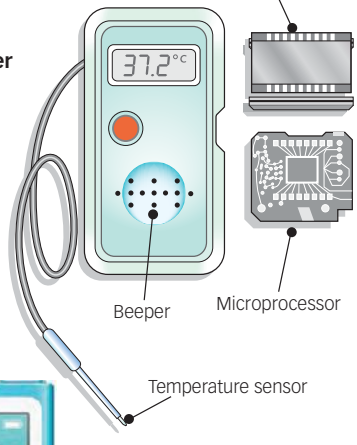
Inside a digital watch, a quartz crystal vibrates 215 times per second. The processor counts the crystal's vibrations and advances the digital display one second each time the total reaches 32 768. The chip is also able to store information input by the user, such as phone numbers and appointments. Smartwatches are complete computers in the format of a wristwatch that can connect to other mobile devices.



Getty Images/Universal Images Group

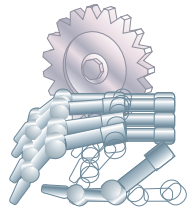
Digital thermometer

Inside a digital thermometer, the processor converts the data from the temperature sensor and advances the LCD reading. When the temperature is steady, the reading is locked in and a beeper sounds.



Sensors

Sensors for temperature, location and many other functions provide data to processors in hundreds of applications, such as climate control systems and robotics.





Getty Images/Thomas Cooper

Smart card

Smart card chips are used in applications such as banking and health care. They contain all of the information and functions needed to complete transactions and complex calculations.



Apple.com

MP3 player

The microprocessor is also the brain of the MP3 player. It monitors user input through the playback controls and displays information about the stored songs on the LCD panel. It pulls the chosen song from its memory and decompresses it to play it through the headphones.



Shutterstock.com/PILart

Mobile phone

A SIM (subscriber identity module) card used in a mobile phone contains its unique serial number security authentication information, temporary information related to the local network, a list of the services the user has access to and passwords.

Figure 2.11 Microprocessors control a large range of electronic devices.



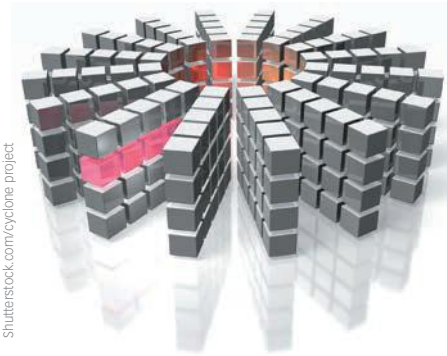
Shutterstock.com/Oleksky

A smartphone is now more like a computer than a phone.



Shutterstock.com

A personal computer might be small enough to sit on your lap, yet powerful enough to act as a server on a network.



Shutterstock.com/cyclone project

Supercomputers are used for weather forecasting and scientific research.



Shutterstock.com/dotshock

Network servers are housed in cabinets and are easily removed and replaced.



Alamy/Juice Images

Mainframe computers are used by banks to process millions of transactions per day.

Figure 2.12 Portability and power are two factors that must be considered when designing new hardware systems.

Smartphones

Smartphones have increased in popularity as they now provide many more functions than just phone services. Most of their data processing is done on the server that they connect to, although the high speed at which they transmit and receive the data tends to obscure this fact.

Personal computers

A personal computer is a computer that can perform all of its input, processing, output and storage activities by itself. It is small enough to sit on a desktop, although the system box is sometimes positioned on the floor. A workstation is a networked desktop computer that can be used in combination with a server or other computers on a network for a wide range of tasks, including complex calculations and graphics processing. A notebook or laptop computer is light and portable, yet still powerful enough to meet most needs of the individual worker.

Servers

A server can be any networked computer located anywhere that has appropriate server software installed. In larger organisations, servers are usually dedicated machines that control access to software, files and printers. They are often required to support thousands of connected users at one time. These host computers can be used on the Internet to act as web servers.

Mainframe computers

Mainframe computers cost up to several millions of dollars. They can store vast amounts of data and are accessed with terminals or personal computers. Banks and large government organisations might use mainframe computers to process data. Users communicate with these computers using terminals.

Supercomputers

A supercomputer is the fastest and most expensive of all computers. Supercomputers will contain thousands of processors that can share jobs and work in parallel. This means that they are capable of processing many trillions of instructions in one second and can be used for complex mathematical calculations such as weather forecasting or scientific research. A supercomputer might cover the area of two basketball courts. They are often used to make weather predictions, making sense of huge amounts of data.

ACTIVITIES

1. Draw up a table to compare the different categories of computer hardware systems. For each category, compare physical size, cost, storage capacity, processing speed and typical applications.
2. Investigate two other devices that have microprocessors; for example, a calculator and a car or domestic appliance.

2.4 Hardware solutions

Every day, millions of computer users around the world rely on different types of computer systems for a variety of purposes. A student working at home might require access to the Internet for research; a business person might need access to documents or a printer on a local network. A bank or large retail organisation may need to process millions of transactions every day, yet still have fast and secure access to data. A different hardware solution is needed for each of these scenarios to allow their tasks to be completed as required.

Developing solutions

Whatever the situation, it is important to develop hardware solutions with careful planning and consultation. In chapter 1, we considered the processes involved in project development – design, produce, evaluate. When considering a project in which you are required to find a hardware solution for a small business client, it is important to work through the following steps.

- Define and analyse the problem: Write down the criteria to be met in the solution. What are the most important factors? Cost? Speed? Reliability? Storage capacity? Security?
- Design possible solutions: Put together some ideas that might provide a solution. What are the essential items of hardware that will be needed? Are there any extra items that might be useful? Find out how much the system might cost, how easy it would be to install and train users, and how long it would take.
- Producing solutions: What problems might there be when the system is to be installed? Would it be better to gradually install each hardware item, or will the whole system need to be installed in one go? Training courses and user manuals will need to be ready at this stage.
- Evaluation: Each component of the hardware should be tested to ensure it performs the task it was intended for. Usually, test data has been prepared in the design stage so that all important criteria can be tested. A test report should be written to confirm that the system performs as expected. As time goes on, new technology may become available or the users' needs may change, so evaluation of the system is an ongoing process.

Troubleshooting

We all rely on computers to work correctly and efficiently, but there often comes a time when the system does not seem to be working correctly. **Troubleshooting** is a systematic, step-by-step, elimination process for finding a system fault. Quite often, there will be an easy solution if we know what to look for. According to some technicians, the most common problem is that cords are not plugged in properly! If you are sure this is not a problem, figure 2.13 might help.

It is possible that worn parts, such as disk drives, or dirty or damaged laser lenses in DVD drives, may need to be replaced. In this case, some professional advice may be needed.

Care and maintenance

Most computer equipment will last for years if treated with care. Follow these rules.

- Make sure the computer is positioned correctly on a secure surface, with plenty of air circulation. Cables should be tidied away so that they are not caught on feet or furniture. If you connect or disconnect any power cables, make sure you switch the power off first.
- Environmental factors, such as heat, humidity, static electricity and dust, can affect the correct running of a computer system. Clean your computer occasionally using a soft, damp cloth.
- Food and drink are potentially fatal to computers. Keep them well away from computer equipment.
- Take a moment to close documents and remove memory sticks correctly to avoid corruption of files. All optical discs should be handled with care – hold them by their edges and use a soft-tipped pen if you need to write a label on them. Avoid exposing them to excessive heat, and store them in their own jacket or case.
- Update software using free online manufacturer's regular upgrades for both security and functional reasons. Protect your system from viruses – many computers benefit from running security software regularly. You will learn more about this in chapter 12: The Internet and website development.
- Purging old files and applications will help to keep your system running efficiently. Back up your important files regularly.

Problem	Check
Computer does not turn on	• Check power source – use another electrical appliance to confirm this. • Check all leads are plugged in firmly and that power source is turned on. • Check power lights on computer and monitor.
Computer system acts erratically or fails to connect to network	• Check connectors for each peripheral device. • Check ethernet cable is plugged in correctly. If the connection is faulty, check the port for bent pins or other faults.
Monitor does not display correctly	• Check connections. • Check the resolution, colour settings and brightness setting. • Adjust the picture width and height settings.
Printer does not work	• Check printer is switched on and that 'on line' light is on. • Check paper is loaded correctly and door is closed firmly. • Check the correct printer has been chosen in the print dialogue box.
Poor quality print	• Check printer cartridge. • Check whether 'draft quality' has been selected in the print set-up dialogue box.
Mouse does not respond correctly	• Check the connections. • Change to different surface – less reflective • Reboot the machine.
Newly installed peripheral does not work correctly	• Ensure that the correct driver is installed. • Check the manual and manufacturer's website.

Figure 2.13 Some common computer problems and possible solutions

- When you delete files from your hard drive, it can leave many differently sized spaces empty on the disk. When you add new files, the computer will try to fit them into those empty spaces, even if this means splitting up the files into several small pieces. Eventually, this will mean the operating system takes longer to find files. Defragmenting (often called defragging) means that the file parts that have been split up on the hard disk will be reorganised so that they are stored sequentially, in one place. Many modern operating systems will perform defragging automatically. Otherwise defragment the hard disk regularly, as this can increase the speed of your system considerably.



Shutterstock.com/Scott Rothstein

Figure 2.14 Taking care of your hard drive is very important.

ACTIVITIES

1. For each of the following scenarios, develop a hardware solution by applying the four stages of project development. Suggest what hardware would be required and justify your selection.
   - **a** Students needing a new multimedia room
   - **b** A graphic designer working in an advertising agency
   - **c** An international airline implementing a new booking system
   - **d** A sales representative working across several states
2. List some of the more common problems that you have encountered with hardware. Discuss how best to avoid these problems in the future.
3. Design a poster to alert users to the importance of computer care.

Review questions

3 CORE Software

Syllabus outcomes: 5.1.1, 5.2.2

Chapter outcomes

You will learn about:

- different types of software used on computers
- interface design
- features of the user interface
- the need for operating systems
- hardware requirements of a computer.

You will learn to:

- explain the purpose of a software system
- distinguish between types of software
- compare software packages and their features
- explain the function of the user interface
- explain and evaluate the features of a GUI
- discuss how software affects hardware requirements.

Key terms

Application software
program that allows a user to create, edit or display computer-generated files

Control elements
buttons, tabs and drop-down lists that allow a user to interact with the application

GUI (graphical user interface)
interaction between a user and computer screen; the best known GUI is the WIMP (windows, icons, menu and pointer), but other types also exist

Hardware requirements
components that need to be used to run software correctly

Inclusive design
software presentation that allows people with a wide range of abilities to use it

Interactivity
communication between a user and the application

Macro
set of stored instructions labelled and used repeatedly in an application

Navigation
movement by a user between different sections of an application

Operating system
control of hardware components by application software

Utility software
program that has specific housekeeping tasks to perform

IN ACTION

Who invented the GUI?

The emergence of the GUI (graphical user interface) on personal computers in the 1980s was a significant turning point in software development. No longer was the computer the closed domain of the technical experts. Many other people were able to use the computer and soon began to develop software applications for it.

Since then, the computer's power in applications and technical specifications has expanded, pushed by ever-increasing market forces. More sophisticated programs demanded more powerful central processing units (CPUs) and monitors, greater storage space and, ultimately, the need to communicate over the Internet to transfer multimedia.

However, for years there was fierce debate and litigation to decide who originally invented the GUI. Consider this article from the website inventors.about.com.



Old-computers.net

Figure 3.1 The Macintosh computer was introduced in January 1984 and was the first to use a WIMP (windows, icons, menus and pointer) GUI.

Take a look at your computer screen. The GUI provides you with windows, pull-down menus, clickable buttons, scroll bars, icons, images and the mouse or pointer.

The first user interfaces for computers were not graphical or visual; they used only text and keyboard commands and are known as command line interfaces [see figure 3.16]. MS-DOS is an example of a text and keyboard method of computer control that you can still find on many PCs today.

The very first graphical user interface was developed by the Xerox Corporation at their Palo Alto Research Center (PARC) in the 1970s, but it was not until the 1980s that GUIs became widespread and popular. By that time the CPU power and monitors necessary for an effective GUI became cheap enough to use in home computers.

Steve Jobs, co-founder of Apple Computers, visited PARC in 1979 (after buying Xerox stock) and was impressed by the 'Alto', the first computer ever with a graphical user interface. Several PARC engineers were later hired by Apple and worked on the Apple Lisa and Macintosh. The Apple research team contributed much in the way of originality in their first GUI computers, and work had already begun on the Lisa before Jobs visited PARC. Jobs was definitely inspired and influenced from the technology he saw at PARC, however, enough for Bill Gates to later defend Microsoft against an Apple lawsuit over Windows 1.0 having too much of the 'look and feel' of an Apple Macintosh – Gates' claim being, 'hey, we both got it from Xerox'. The lawsuit ended when Gates finally agreed that Microsoft would not use Macintosh technology in Windows 1.0, but the use of that technology in future versions of Windows was left open. With that agreement, Apple lost its exclusive rights to certain key design elements.

Source: inventors.about.com



Flickr/cmnit

Figure 3.2 The Xerox Alto was the first computer to use the desktop metaphor and the mouse-driven GUI. The separate hard drive seen below the computer could hold 2.5 megabytes (MB) of data.

QUESTIONS

1. Who first invented the GUI?
2. How did people interact with computers before the GUI was invented?
3. How is the GUI on today's personal computers different from earlier ones?

3.1 Software systems

Software systems enable the hardware to do any task at all. The user is able to complete these tasks only by indicating to the software what needs to be done; for example, to create or print a document. The software is a list of instructions that enables documents and data to be processed by the hardware. This software is created in a range of programming languages, and can be written using graphical icons or English expressions.

Application software

Today's computers and digital devices have a range of uses, and each of them will need to have a particular type of software. Most people are familiar with **application software** such as word processors, graphics editors and web browsers that are able to perform a range of tasks in creating, editing, formatting and displaying documents. Increasingly, people are creating their own applications (apps) for mobile devices. These small applications can perform a single or limited task and can be created using open-source (free), user-friendly software.

Some devices, such as automatic teller machines (ATMs), routers and traffic-light controllers, perform just one or two, sometimes complex, tasks. Other hardware, such as microwave ovens, has software embedded in it so the devices are fast and reliable.

Operating system

On a personal computer, an **operating system** is needed to work with application software to control the computer's hardware. Microsoft® Windows® is one of the most widely used operating systems around the world.

The operating system is the first thing we see on the screen when we start up a computer. It provides the interface that asks us to log on or it can display the desktop and its icons immediately. Similarly, when we close down the computer, it tells us that it is logging off and it closes all the files in a systematic order before it actually powers off the hardware.

Utilities

In addition to the application software and the operating system, there is a third type of software, called **utility software**. A utility program has a specific task to perform, usually for 'housekeeping' such as file management or virus protection. Utilities are sometimes listed in the applications layer and sometimes in the operating system layer, depending on the task they do. When utilities are grouped with the operating system, they are sometimes referred to as system software.

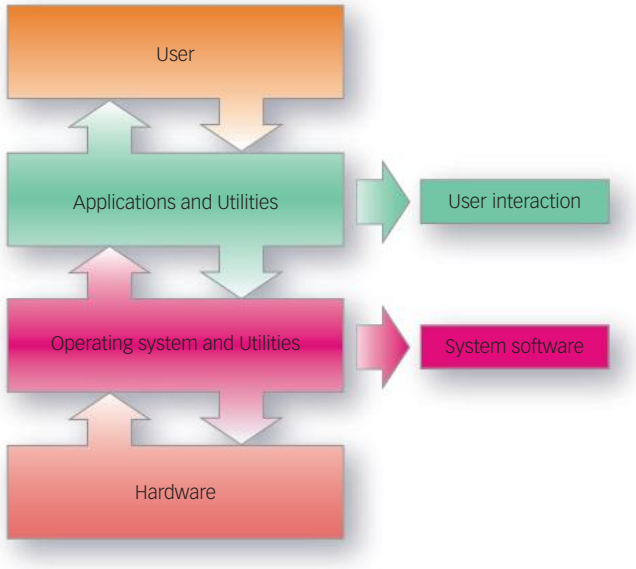


Figure 3.3 The three types of software – application, utility and operating system – are considered to be stacked, so that the application software or a utility communicates with the operating system. The operating system will then communicate directly with the hardware.

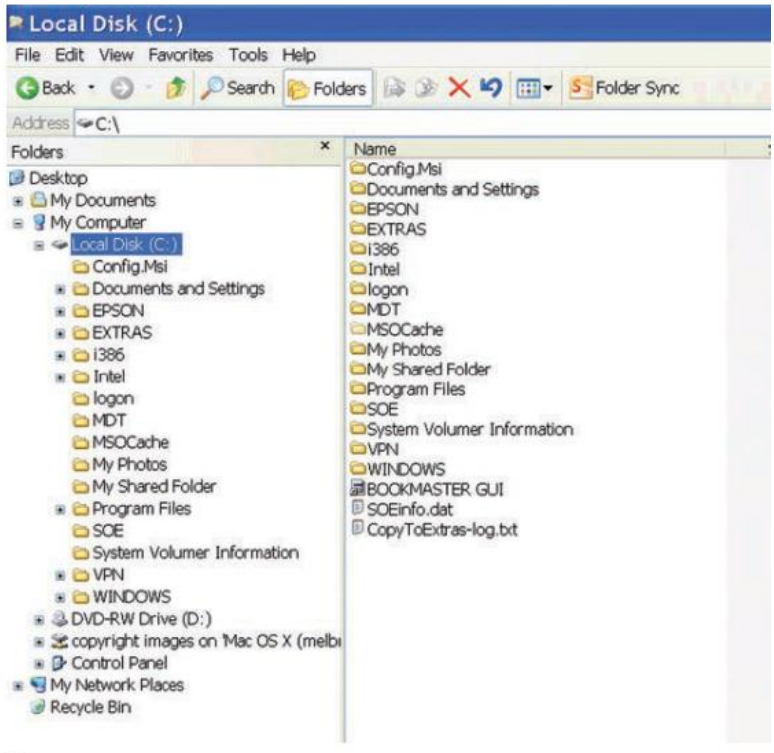


Figure 3.4 Windows Explorer is typical of operating system utilities used for file management. It provides a graphical view of the way the files are stored, as well as letting you browse files stored on other connected computers.

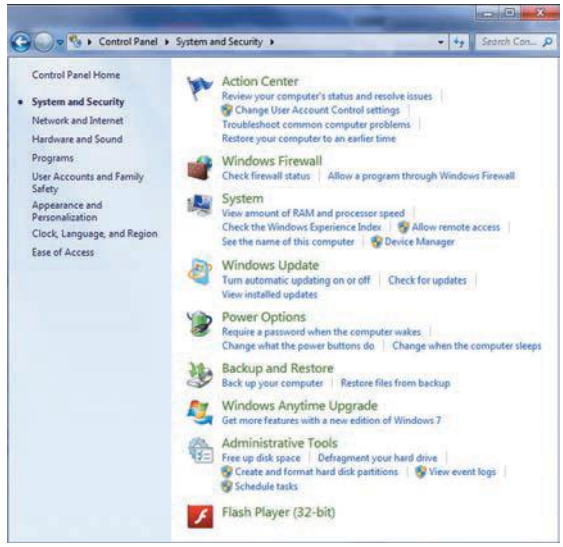
Utility software

Utilities are often already installed on your computer when you buy it. They are usually part of the system software, and work at the operating system level. They include functions such as creating directory structures, copying and deleting files, performing backups and altering system settings. Other utilities work at the application level and include virus scanners, file sharing and compression software.

System utilities focus on how the computer operates. These include a range of tools that might be used to protect or maintain a computer, or help a computer to be more versatile.

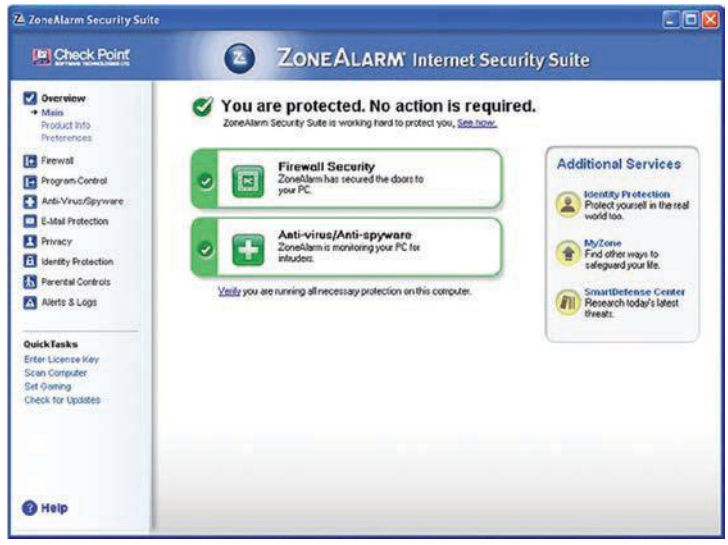
Figures 3.4–3.6 illustrate some types of utilities. Consider the following specific examples.

- File management tools such as Windows Explorer or Apple's Finder provide convenient methods of performing routine tasks such as deleting, renaming, moving, copying and merging files.
- Disk management tools are used to organise the space available on large hard disks into areas called partitions. These tools can partition, format and maintain the hard disk to suit your data storage needs. They can also be used for defragmenting, which reorganises the way computer files are stored so that they can be read into memory more quickly, and make more disk space available.
- Backup software is used by wise computer users to make sure that the work they do is regularly copied (backed up) to protect against loss of data. Backup software is a must on computer networks.
- Security software protects a computer system from computer viruses and related problems. The example seen in figure 3.6 is from ZoneAlarm®. To protect your computer effectively, all security software tools need to be kept up to date.
- System management tools are used to ensure that a computer functions properly and help prevent computer operating systems from crashing. The tools can be used to diagnose and automatically repair problems that sometimes crop up when users make changes to their computers.
- Compression tools are used to compress or 'squeeze' large files into a smaller size, usually when they need to be transferred over the Internet. A compression program is part of the Windows suite of utilities. Other compression programs include WinZip® and StuffIt®.



Windows

Figure 3.5 These system tools are utilities that are included in the Windows operating system. They include access to RAM and CPU information, automatic virus scanning and backup scheduling, and disk defragmentation.



Check Point Software Technologies Ltd. © 2003–2011

Figure 3.6 A package of security software contains protection against a range of risks, hackers and viruses, and allows blocking of specific types of web content.

INFOBIT

A dictionary may define the term 'utility' as a public service, such as telephone, electricity or water supply.

ACTIVITIES

1. Write a list of the most common things you use your computer for, at home and at school.
2. Which software applications would you use to complete the tasks in question 1?
3. Identify the three types of software that make up the software system on most desktop computers. Give an example of each.
4. What are the most common examples of utilities found on computers?
5. What are the differences between system utilities and application utilities?

3.2 Types of application software

In general, application software is designed to allow the user to process data; for example, to create and edit a file, or to display and transmit information across a network.

Application software can be classified in a variety of ways. For example, applications can be sorted into different groups according to cost, intended use, and by publishers such as Adobe and Microsoft. Consider the following categories.

Software for schools

All students in New South Wales are required to meet specific standards when using computing technology. Consequently, most schools will have a list of standard software installed on their computers for students to use. Students who choose computing as an elective will learn to use more sophisticated software and probably in a more innovative manner than their peers. In addition, school administrators use software to create and publish reports, and to store and submit data to educational authorities. Most of this work will be database-driven.

Most software applications produce files that are fairly compatible with each other. For example, a graphic created in Adobe® Photoshop® can be exported in the JPEG (Joint Photographic Experts Group) file format and imported easily into Microsoft® Office®. They also have fairly consistent interfaces; for example, File and Edit menus are usually at the top of the user's screen and perform much the same sort of functions as in other applications.



Adobe® Creative Suite®

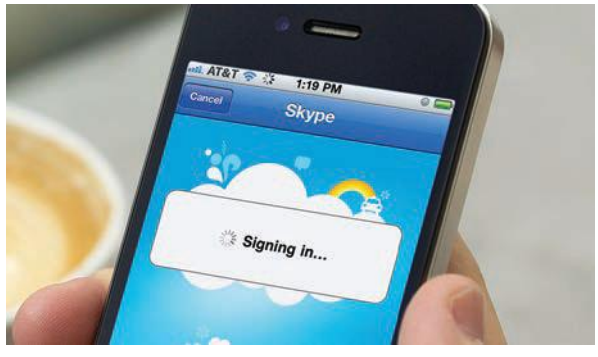
Figure 3.7 Adobe® Creative Suite® is a market-leading collection of applications.

However, some applications can do some jobs better than others. For example, a graphics program can create illustrations better than a word processing application, although even these can do each other's jobs to a limited extent.

Communication software

As broadband is now standard in most places across New South Wales, the Internet is being used for an increasing number of tasks.

- Internet browser software is used to download a wide variety of Internet and intranet documents. Browsers also enable users to interact with web applications; for example, online banking and shopping.
- Instant messaging software enables real-time communication between two or more people.
- File transfer programs allow users to upload files over the Internet; for example, to web servers and wikis.
- Remote access programs enable users to connect to and control another computer over a network or the Internet. Examples of this sort of software include Symantec® pcAnywhere®, Apple® Remote Desktop or the built-in Remote Access facility in Windows.
- Communications software, such as telephone and fax programs, allow the computer to be used to make telephone calls and transfer document images. Increasing numbers of companies are moving to 'IP telephony' or VoIP (voice over Internet protocol), which enables workers to make much cheaper phone calls. Skype™ is a popular example of this.
- Videoconferencing software enables video and audio communication between users over the Internet. These programs can provide other tools, such as chat and multi-user document editing.



Alamy/Pixellover RM 10

Figure 3.8 Communications software such as Skype allows screen sharing over the Internet so that users can discuss their documents online.

Business software

Business organisations depend on a variety of software tools to manage their workload effectively. Word processing and email software are essential elements in today's modern business. In addition, intranets or knowledge management systems enable information to be posted for reference by all or specific employees. Many schools are now using intranets for similar purposes.

Project management software is useful for scheduling tasks and resources in large team projects. Resources planning software is used to manage resources such as staff and finances. This helps to keep all branches of a business fully informed of essential business information, especially in large companies that may be developing rapidly or located in different parts of the world.

Businesses often use computer models to help them make decisions; for example, by identifying market trends. These can range from a simple spreadsheet to a powerful analytical tool custom-built by software specialists.

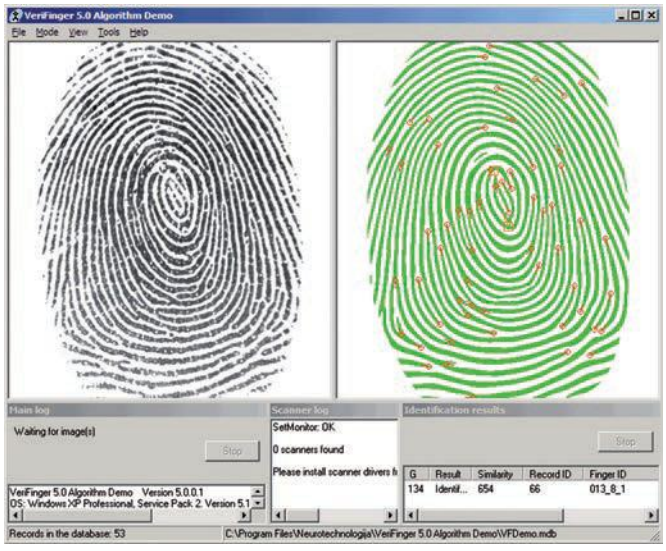
Science and research

Most areas of science and research have their own specially developed software to analyse large volumes of information and help them in their quest for new knowledge. Expert systems and artificial intelligence have also been used in this area, and have potential for further development. Current applications include fingerprint matching by forensics teams and diagnosis of cancer cell malignancies.

Applications for mobile devices

Software applications on mobile devices are commonly referred to as 'apps'. People are developing games and other apps for their smartphones and tablet computers. User-friendly software is available to help with this, so that you do not have to be a specialist programmer to develop your own apps.

Figure 3.10 shows Google Inc.'s App Inventor for Android®, which allows users to build apps for mobile devices that run on the Android operating system.



http://www.neurotechnology.com/contact.html

Figure 3.9 Software can work through large volumes of data looking for matches to a particular fingerprint.



http://appinventor.googlelabs.com/learn/tutorials/paintpot/paintpot-part1.html

Figure 3.10 The App Inventor program allows users to build their own apps for mobile devices that run on the Android operating system.

ACTIVITIES

1 What software application would you use to perform the following tasks? Justify your answers in terms of availability, cost and ease of use.
   - **a** Write a story.
   - **b** Draw a 2D plan of your classroom.
   - **c** Edit an image of a landscape.
   - **d** Create an animation.
   - **e** Edit a short film.
   - **f** Download a web page.

2 Apart from the application software you identified in question 1, what other software do you know of and what is its purpose?

3 An older relative has asked your advice on the programs they should buy when they purchase a computer. Write a list of questions you might ask them before giving your advice.

4 If you could create a new piece of software, what would be its purpose?

5 How is new application software created?

3.3 Features of application software

The features that are important to you in a software package depend on what you use the package for and your level of expertise in using the package. In this section, we look at some of the features that are common to many software packages.

Standard interfaces

Microsoft Office and the Adobe Creative Suite have consistent interfaces with menu bars and toolbars placed strategically for the user. The applications in these packages enable you to save, view, edit and format data contained in documents, databases or other files. Layers are often useful for working with separate objects in the same document.

Microsoft Word is a widely used tool for working with text documents, while Adobe applications are more relevant to graphical media. However, keyboard shortcuts and toolbar icons are quite similar in each application.

Edit and format

Editing a document implies that the content of the document is changed – words may be replaced after a spellcheck or a graphic may be cropped. Inserting and deleting material is easy to do with most software. Copy and paste commands can be used within and between documents. The clipboard is a temporary memory that the application uses to store the section of the document to be moved. This works differently when the drag-and-drop feature is used and the clipboard is not involved.

Formatting plays an important role in making a document easy to read and understand. The choice of typeface and point size, the layout of the text and images, and adding page breaks, headers and footers can all help to give a document a clear and professional look.

While the user is editing or formatting a document, several stages are retained in memory so that the undo and redo features can be used. The software usually discards these changes when the user saves the document to secondary storage.

Search facilities

Most software packages have advanced search facilities that help you to find a particular term or word. You may be searching for a phrase in a document, a document with a specific word in the title or one that was created within a certain time frame.

Protecting a document

There are often reasons why you need to provide documents to others, but you may not want them to change the document contents. Therefore, you may choose to set the document as read-only to prevent accidental change. Another method is to publish the document in the portable document format (PDF), which effectively produces a digital image of your document. Passwords can also be attached to documents so that only authorised people can open or edit them. To provide yet another layer of security, digital signatures can be attached to documents.

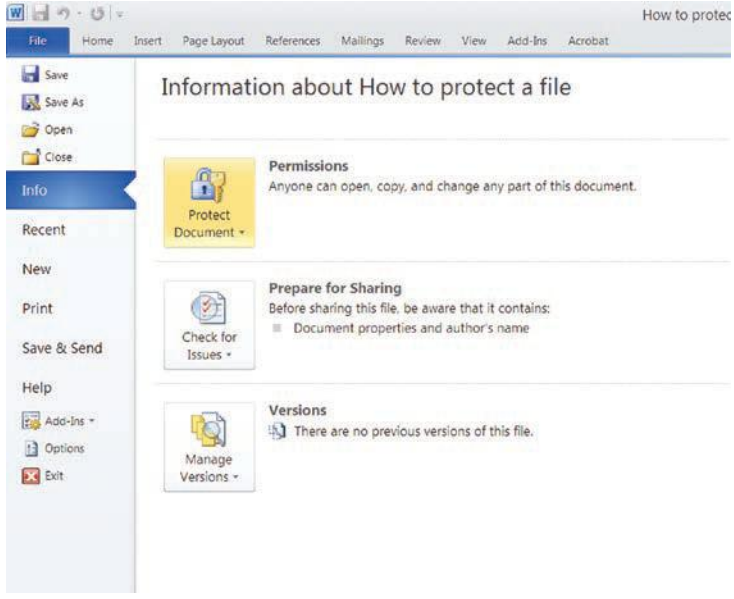


Figure 3.11 Setting a password on a Microsoft Word document means that only authorised people can open it.

Versions

When project teams are working together over a prolonged period of time, it is often useful to save sequential versions of documents. Previous and different versions can then be referred to as required. Alternatively, date and time data can be included in the footer of a document, along with file paths and the author's name. Another option is to track changes in a Word document, so that collaborators can accept or decline suggested updates to the text.

Macro capabilities

Microsoft Office programs such as Word, Excel®, Access®, PowerPoint® and Outlook® have sophisticated **macro** capabilities. A macro is like a mini-program – a set of stored instructions grouped together, which you may use many times. Macros are often used when the same task is performed repeatedly, particularly when the task involves several steps; for example, formatting a document in a particular style.

Some users create macros by using a macro-recording wizard. When activated, the macro recorder will 'watch' and record what you do – which commands you use, what you select in the document, keystrokes you use, and other events. When you have finished recording, the wizard creates a set of macro instructions to enable you to repeat the work the wizard has just recorded. The macro may be given a name and a keyboard shortcut or attached to a button, so that you can quickly execute or run the macro again when you need to.

Alternatively, you can write your own macros in Microsoft® Visual Basic® script, which is a complete programming language for expert users. A variety of macros can be found on the Internet, ready-made for standard tasks. For example, you may want to set the tabs in your Word documents at the left and right margins, or format cells in a spreadsheet with a certain fill and font.



Figure 3.12 In the View menu, you can start recording your macro and attach it to a button or keyboard shortcut.

Help files

Most applications include a help feature on their menu bars. These can provide you with an indexed list of features and often will link to online tutorials.

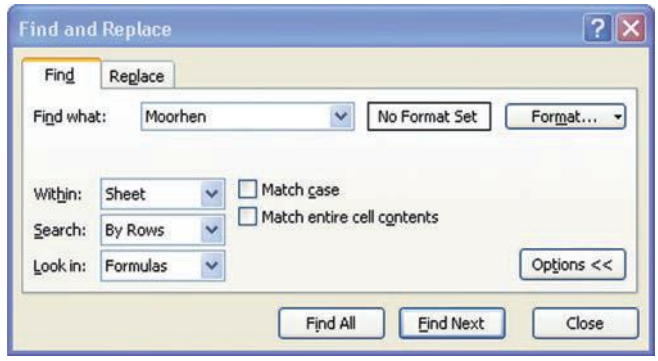
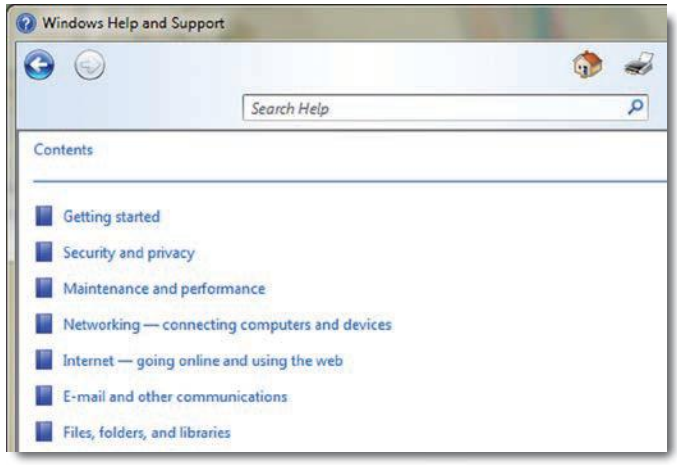


Figure 3.13 You can search for a word or phrase in many applications and replace it if necessary.



Windows

Figure 3.14 Searching the help files in any application is a good way to find out how to do tasks.

INFOBIT

The main reason the Google search engine home page is so bare is because the creators did not know hypertext markup language (HTML) and just wanted a quick interface. Originally, the 'Search' button was missing and hitting the 'Return' key was the only way to start Google searching.

ACTIVITIES

1. Explain what the following features do in most applications: save, drag and drop, undo.
2. Open two different software applications – one from Microsoft and one from Adobe. Make a table to compare and contrast their features. For example, how do the menus or toolboxes compare, and what can you do with one that you cannot do with the other?
3. Investigate how each of your chosen applications can export your documents in different formats.
4. Describe and give specific examples of how you can search your directories for phrases in documents or filenames.
5. Record a macro in Word or Excel to add a series of formatting features to any word that is highlighted in your document.

3.4 Interface design

The function of the user interface is to allow **interactivity** between the user and the system, and in particular, to facilitate communication with the operating system and the application software. To use a computer, you need to know what functionality the computer system has – what it can do for you. A well-designed user interface enables you to communicate or interact with the computer intuitively.

Interactivity with the user

Most typically the user interface is represented on a monitor screen so that the user can see the required inputs and understand the resulting outputs after processing has occurred. However, there may be other forms of interface, such as the spoken word or sensing devices.

The interaction between the computer and the user is commonly via a **GUI (graphical user interface)**. This involves some mechanical action by the user – you move the mouse, click mouse buttons, tap the keyboard or touch the screen. A graphics drawing tablet or interactive whiteboard responds to the touch and movement of a stylus or pen. Similarly, a touchscreen provides an intuitive interface for young children and adults alike.

The computer has been programmed to respond to these actions in an appropriate manner. You have a conversation with the computer system through an exchange of signals. The software responds by providing visual signals on the screen, and by performing other actions that are unseen by the user.

Applications and operating systems

As a regular computer user, you can communicate with the application software to perform the myriad tasks to complete each day. The application software communicates with the operating system to drive the hardware to process, save or transmit your data. You also have the opportunity to talk directly to the operating system; for example, changing your screen settings or installing new software. The graphical user interface provides the means for the user to do all this in an intuitive and consistent environment.

However, there are several other options that offer advantages in different situations.

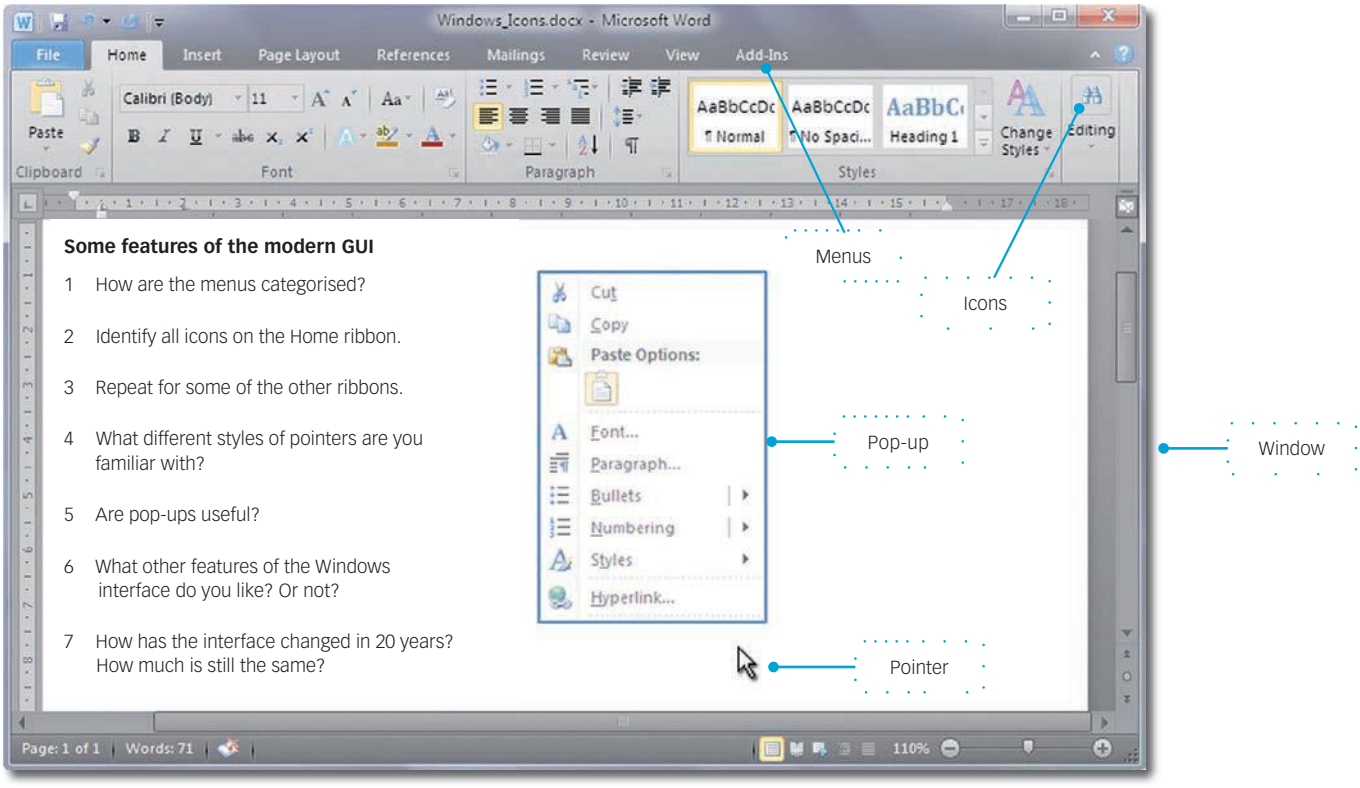


Figure 3.15 A typical graphical user interface provides windows, icons, menus and pointer (WIMP) for the user and computer to interact. Answer the questions listed in the displayed document.

Types of interfaces

The way you interact with a computer system depends on the type of interface you are using. There are three main types of interface we will consider. These are the:

- command line interface (CLI)
- graphical user interface (GUI)
- natural language interface (NLI).

Command line interface

Early user interfaces on personal computers were CLIs. They are still used today by terminals running the Open Group's Unix® operating system and by some network administrators to control busy servers. They do not require as much processing power as the GUI, and so they have the advantage of running many tasks simultaneously.

In figure 3.16 you can see several lines of information displayed on the CLI after the user has run the 'dir' command, which displays information about the folders and files on the computer.

A CLI works a little bit like a chat program, except that you 'chat' with the computer operating system. However, to use a CLI, you need to know the commands that can be used, and you need to type them in at the keyboard.

Graphical user interface

The first WIMP-based GUI for a desktop computer was released by Apple in the early 1980s. Compare the images in figure 3.1 and figure 3.22. They have a common user-friendliness yet show a remarkable difference in sophistication.

The main idea of a graphical interface was to create a visual metaphor. We consider the features of this metaphor in more detail in the next topic. The metaphor uses the screen view to represent the business desktop and small pictures called icons to represent our working documents. The window is a metaphor for a window into a document so that we can see and work on the document through the window.

The click of a mouse or the drag-and-drop functionality is a fairly easy method for a new computer user to learn. The mouse pointer becomes an electronic extension of the user's hand. The introduction of this technology is still considered by some to be the turning point for the adoption of computing methods by the world at large.

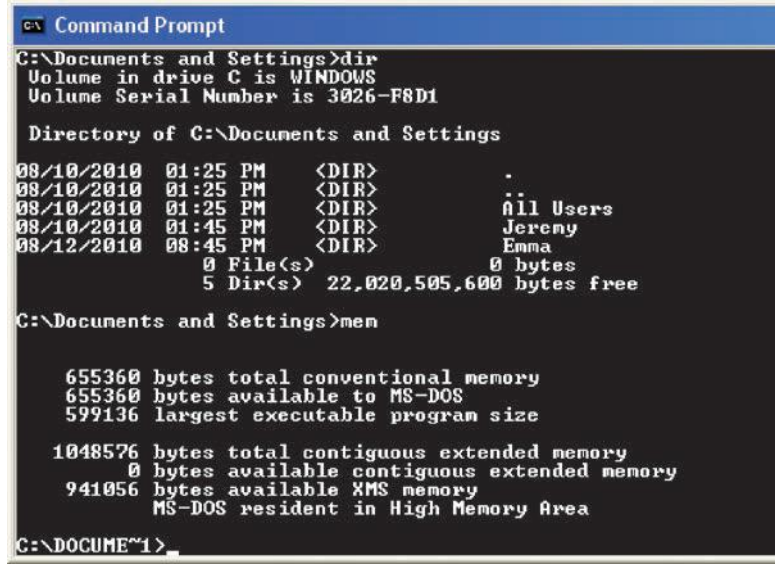


Figure 3.16 A command line interface. The 'dir' and 'mem' commands are used to display details of the directories and memory usage respectively.

Natural language interface

Natural language tools use speech recognition technologies so that you can give commands by speaking to the computer, or request a word processor to take dictation. Many such interfaces have been developed and may be included in operating systems or as a part of special packages. The NLI is useful for those who find it difficult to use a keyboard or mouse, particularly people with disabilities.



Getty Images/Tony Avelar

Figure 3.17 Voice control uses speech recognition and the iPhone contact list to match spoken names, allowing users to make a phone call by saying 'call Peter'. Users can also request a particular music track or even ask what track is playing.

INFOBIT

Gesture recognition can be used as a way for computers to understand human body language, either with the hand or facial expression. In this way, we may be able to interact with gaming consoles, robots or other machines to input commands.

ACTIVITIES

1. What is the purpose of the user interface?
2. Briefly describe the ways in which a user interface allows us to interact with the computer.
3. Compare interacting with an application with interacting with the operating system.
4. Compare the three common types of user interfaces.

3.5 Features of a graphical user interface

The design or customisation of software applications requires that graphical user interface elements are applied consistently. One of the strengths of a well-designed user interface is that once you have learnt how something works, you can use that knowledge when using a new application.

Consistency of elements

A good GUI should be consistent in the:

- colour of forms, controls and text
- layout of controls on forms and dialogue boxes
- behaviour of controls – drop-down lists, radio buttons, checkboxes and other types of controls should behave consistently across applications.

There are widely used standards to help software designers maintain consistency – this helps to make the software more intuitive.

Functionality

Menus and toolbars are used to provide access to a range of commands. Simply by pulling down the menus and exploring the dialogue boxes, we may be able to work out some of the things the software is capable of. Therefore, to make software relatively easy to use, programmers creating the software need to consider how to arrange the menu and command structures – choosing the words carefully.

Help menus usually provide a link to online tutorials and indexed searches.

Navigation

Navigation in software is the process by which you find your way to specific parts of the software's functionality. Software may have a hierarchical menu and command structure. For example, to insert a picture into a Word document, you might do the following:

- click the Insert menu on the ribbon
- choose the picture command
- choose from a submenu under the picture command
- make choices from a dialogue box.

You may choose to use the mouse or keyboard shortcuts to work your way to the same part of the software. You should always try to minimise the number of steps that have to be taken to perform an action.

Similarly, if you are designing a layout for a website, you would try to minimise the number of mouse clicks the user will need to make to find any page on the site.

Control elements

In figure 3.18 you can see some of the **control elements** used in software applications. The most commonly used include buttons, drop-down menus, palettes and text boxes.

Other controls that you may have used are:

- sliders – these provide a graphic representation of a sliding switch; for example, a volume control
- tab controls – these are used to group things together in a logical way on a dialogue box or form, and to save a lot of screen space
- spin boxes – these allow us to cycle through a list of choices.

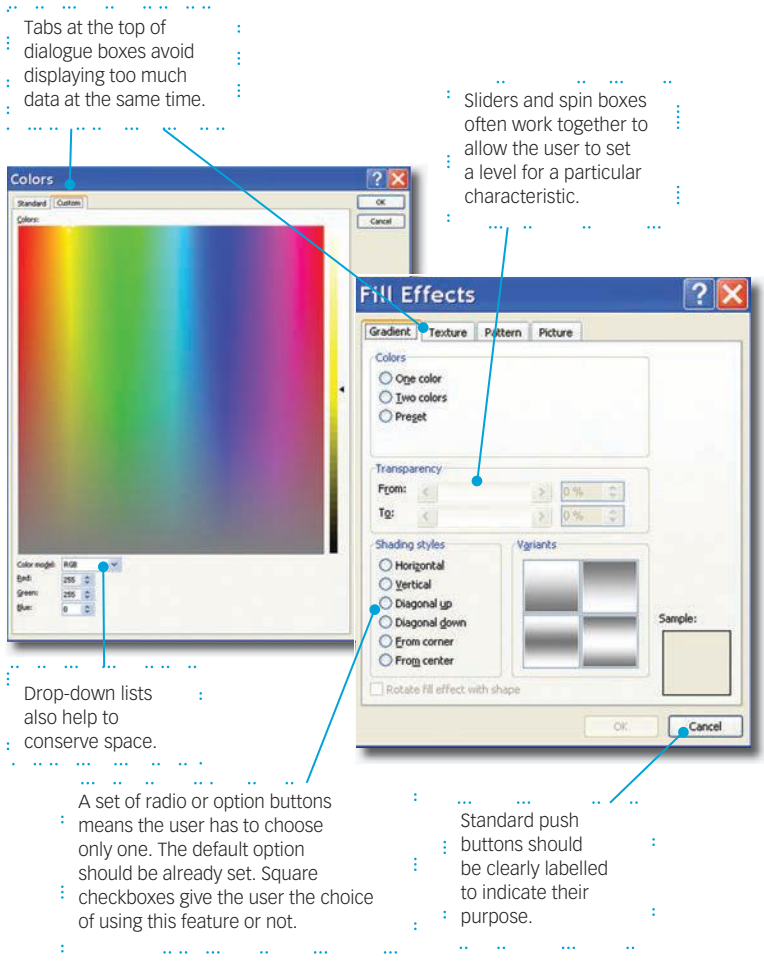


Figure 3.18 Some examples of control elements in the GUI

Borders and white space

Borders and white space need to be used carefully in designing the interface. White space is not necessarily white; it is empty space without text, graphics or objects.

It is good design to include enough white space so that the design does not look crowded. The amount of white space to include in any design is rather subjective, so the designer needs to consult with users who are testing the interface to find out how they respond.

Borders can be used to group things together, to focus on some specific controls. The use of too many borders, or borders that are too thick, can be very distracting for the user. Again, feedback from test users can guide designers in the appropriate use of borders.

Instructions to the user

Good software design includes well-thought-out instructions to help the user achieve what they are trying to do. Some actions require little explanation as they are quite intuitive.

If an online multimedia presentation contains audio or video material, the user may need to be reminded to turn on the speakers or click an icon to play the clip. Any instructions given should always be quite brief and very clear in their meaning. The last thing a software developer wants to do is confuse the user!

When a specific date needs to be entered in an online form or application, the different formats can be confusing. Having a drop-down calendar is a good solution to this problem, as shown in figure 3.20.

In some software, the user is asked for confirmation of their intentions, particularly if the action following a command is potentially damaging. Warnings such as 'This will delete all files – proceed?' give the user a last chance to change their mind.

Inclusive design factors

For a long time, software was designed to suit those in the community who were able-bodied and had good eyesight. Over recent years, however, changes have taken place in community attitudes and legislation to ensure that software potentially includes all groups in society.

The move to **inclusive design** takes into account the needs of the ageing and those with disabilities.

The first step in inclusive design is to adopt an attitude that it is important to include as many different groups with various needs as possible.

Such inclusive design principles are known as accessibility features.

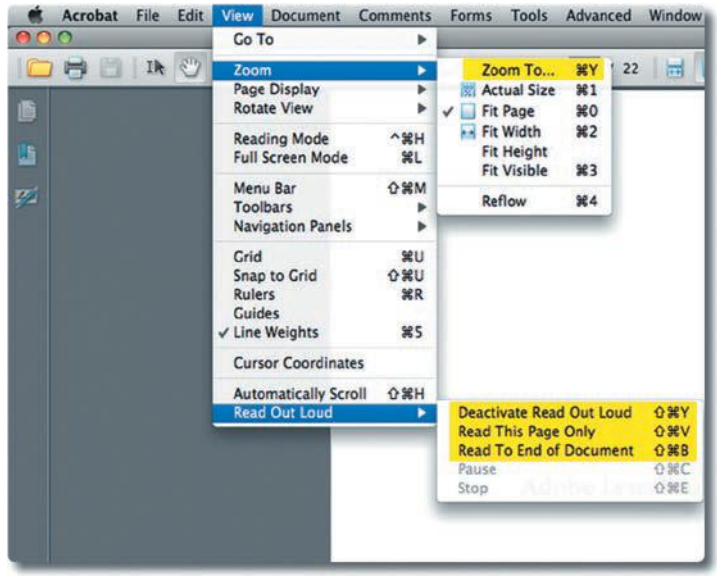
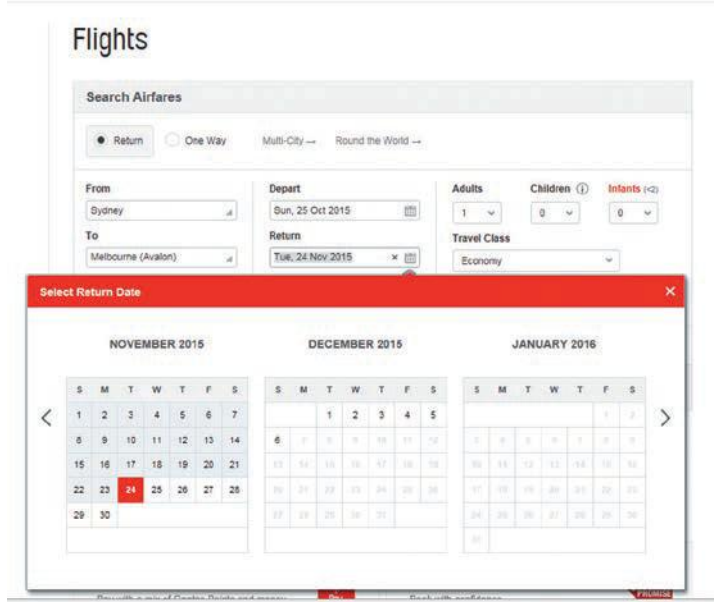


Figure 3.19 Many applications, such as Adobe® Acrobat®, allow the user to have the text magnified and read aloud.



http://www.virginaustralia.com/au/en/bookings/flights/make-a-booking/

Figure 3.20 Using a drop-down calendar to enter dates can avoid confusion about formatting.

ACTIVITIES

1. Identify all the control elements in figure 3.18. Describe their functions.
2. What is the difference between a radio button and a checkbox?
3. Create your own GUI in a Word or HTML document by including some of the control elements used on a form. Alternatively, you could use a programming language such as JavaScript.
4. Evaluate the GUI features in an application such as Photoshop. Discuss the criteria you have used with your class.

3.6 Operating system software

In the system software stack in figure 3.3, we saw that the operating system sits between the application software and the hardware. This is because it controls the ways that application software uses the hardware. This includes input and output functions and memory allocation. It also allows the user to install new applications and manage the way the interface looks.

Functions of operating systems

The functions performed by most operating systems can be split into six general categories.

User interface: What you see on the screen of a computer when it starts up is some of the output of the operating system. This is often referred to as the desktop, and it allows the user to start up applications and some utility software; for example, to manage the interface.

Application interface: When the user wants a task to be performed, such as save or print, they can click an icon on the screen, and the task is then handed to the operating system to perform.

Security management: Computer systems are often protected by requiring usernames and passwords for logging on. Other methods of authentication, such as magnetic cards or biometric data, might also be used.

Device management: When data needs to be sent to a printer or hard drive, or received from a keyboard or network card, the operating system must control how this data will be transferred. This might include the speed at which the data can be sent or, if the printer is not connected, sending a message back to the user.

Storage management: Accessing documents stored on disks is a central feature of all operating systems. The user can name, rename, move and delete documents using the operating system interface. Other attributes such as date and time of last update, file size and associated application will also be handled by the operating system. When multiple programs are running, the operating system must ensure that they are stored separately in RAM (random-access memory). It can also allow virtual memory allocation if primary memory is too low.

Processor management: The operating system ensures that each task being executed by the CPU (central processing unit) continues at the maximum rate. For example, when an application is running, the CPU has to communicate with RAM and also respond to further inputs from the user's keyboard. When multiple applications are running, organisation is even more critical, and the CPU can swap from one task to another without the user realising.

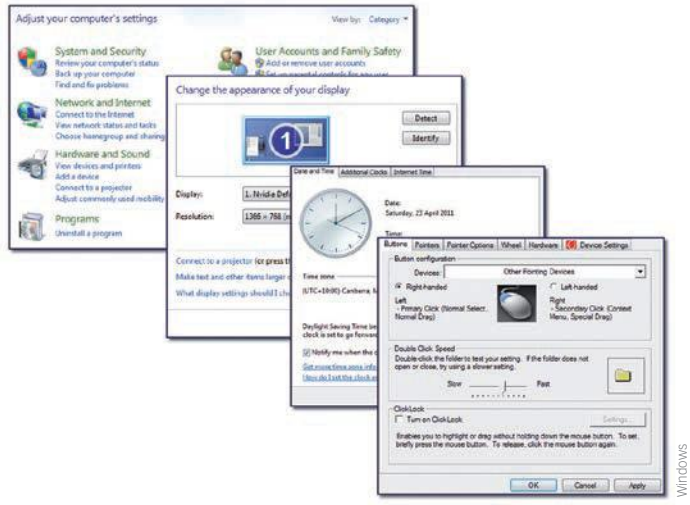


Figure 3.21 System utilities are part of the operating system – you can use them to configure how the operating system controls the hardware. These examples are from the Microsoft Windows operating system.

Starting up the operating system

The operating system is usually stored on your computer's hard disk, and is loaded into computer memory when the power is turned on. Once the main part of the operating system, the kernel, is loaded, it has control of the computer. The kernel loads the rest of the operating system and prepares it for you to use. You are then able to use and control the computer by using the operating system and the tools it provides.

Computers have a small piece of software called the basic input output system (BIOS), which is stored in a ROM (read-only memory) chip on the motherboard. An important task of the BIOS is to manage the computer 'boot' process of getting the computer started. The BIOS does the work of loading the operating system and giving it control. Once the operating system is running, the BIOS acts as a translator between the operating system and hardware devices such as the keyboard and hard drive.

INFOBIT

Virtual machines or emulators are software packages that enable you to run one operating system (OS) inside another OS. For example, if you have a Mac, you can run Windows or Linux as a 'guest operating system' inside the Mac OS. In this case, Mac OS is the 'host operating system' and Windows or Linux is the 'guest operating system'. These software packages are often available free for download from the Internet.

Types of operating systems

There are several different types of operating systems that are in widespread use on desktop computers and networks. These include Microsoft Windows, Apple® Mac OS X® and Linux®.

Apple's iOS, Android, Symbian, BlackBerry® and Cisco IOS® are all operating systems used on mobile devices such as phones and tablet computers.

Operating systems are found on almost any device that contains multiple programs, not only desktop computers but devices such as video game consoles, smartphones, web servers and supercomputers. The majority of ATMs around the world use a Microsoft operating system.

Most desktop operating systems are able to process multiple tasks for the one user, by effectively dividing their time between applications. For example, you may be running a graphics application and accessing the Internet at the same time. Some operating systems are able to deal with more than one user requiring attention at one time, such as on a web server. Again, the operating system will need to divide its time between tasks. This is known as multitasking.

Some devices, such as calculators and microwave ovens, come with embedded software. They do not need a separate operating system because they only perform one type of task and so the software can be stored directly onto the processor. It does not need the user to open and close different functions.

ACTIVITIES

1. What operating system is installed on your computer at home? Compare this to what other members of the class have.
2. List the tasks that an operating system usually performs on the desktop computer.
3. Describe the sequence of events that occurs from when a user first turns on their computer to opening up an application.
4. What are the most common types of operating systems in use today?
5. Why don't all processors need an operating system?



Windows

Windows



Android

Getty Images/Bloomberg



Ubuntu

AAP/Klaus Guertler



Mac OS X

Apple

Figure 3.22 A variety of operating systems: Windows 7, Android and Mac OS X. Each OS is appropriate for the hardware system it runs on.

3.7 Hardware requirements

When we want to install new software on our computers, we will probably be notified of the system requirements – that is, the minimum requirements in terms of hardware and operating system versions for the software to work properly. Currently, manufacturers are producing 64-bit computers, which means the CPU, operating system and the application all have to be capable of processing 8 bytes of data in one instruction or data item.

The central processing unit

If a software package defines a 3 GHz CPU and 4 GB RAM as its minimum **hardware requirements**, the package may fail to run properly on anything less than this, or it may run so slowly that you would be disappointed with the performance.

Some programs use the CPU much more than other programs. Graphics programs that manipulate photographs and computer-aided design (CAD) systems generally use the CPU far more than word processing programs, because of the very large number and complexity of the calculations required to manipulate graphics. Businesses that need to work with the latest versions of software will need to upgrade their hardware, as well as the software, regularly.

Demands on memory

Random-access memory in the computer is used up by:

- the operating system of the computer
- any programs that are currently running
- the data those programs are working with.

If a program needs a lot of memory to run, and it works with large files in memory, your computer system needs to have more than the minimum memory required by the operating system or a single program.

When programs cannot find enough memory, the operating system may have to use part of the hard disk to store some of the data in 'swap files', and this will slow your work down. This is referred to a virtual memory, where the computer looks at RAM for areas that have not been used recently and copies them onto the hard disk. This frees up space in RAM to work with the currently used applications.

Monitors

Size, resolution and speed of your monitor can impact significantly on the effectiveness of your application. Monitor size should be decided on before you buy your computer system. Resolution and colour depth can be set in the properties window of your display.

Computers that are used for graphic-intensive applications, such as CAD, simulation programs, photographic imaging and games, are usually fitted with specialised video cards that have special processors and memory to handle the video display.



Figure 3.23 Colour depth and screen resolution can affect the quality of the displayed image. The video chip needs to be powerful enough to process the data effectively.

Other devices

Secondary storage is essential as a non-volatile means of saving your documents. It also stores the software applications and the operating system, and loads a copy of them into RAM as required. However, as software applications become more powerful and sophisticated, they will become larger and so require more space on the hard drive. Similarly, so will the documents they create. Many use online storage such as that provided by Dropbox instead of purchasing their own external drives, although online storage may involve an annual fee.

Depending on your application, you may also find the need for specialised devices such as a digitising tablet that enables a designer to draw using a pen-like stylus rather than using a mouse.

Modems and network cards also require specialised software, which make extra demands on the hardware system.

CASE STUDY

The birth of computer graphics

Computer-generated imagery is found on television and at the movies, and in newspapers, textbooks and advertising. Business professionals use images for presentation and analysis of information.

Computer graphics now include 2D and 3D imagery, both still and animated. Primary and high school students use graphics packages quite intuitively while enjoying commercial productions such as *Avatar* and *Rango*.

But where did it all start?

In 1961, Ivan Sutherland created a computer drawing program called Sketchpad that could be used to draw simple shapes on the computer screen using a light pen. The images could be saved and recalled for further editing.

These early images used vector graphics, which are composed of thin lines. They were quite light on memory but they could not create realistic colour tones easily. Modern-day graphics are raster-based and use pixels to build up an image so that high-resolution software can present continuous gradients of colour.

Also in 1961, Steve Russell created the first video game, Spacewar. It ran on the PDP-1, a minicomputer with 9 kilobytes (KB) of main memory and a CPU speed of 200 kilohertz (kHz). This was an instant success and has been developed across the decades, providing ongoing entertainment in video arcades.

In 1966, Ivan Sutherland invented the first computer-controlled, head-mounted display. It displayed two separate wire-frame images, one for each eye. This allowed the viewer to see the computer scene in stereoscopic 3D. It was called the Sword of Damocles – suggesting an ever-present peril faced by those in positions of power!

It is hard to imagine the journey from those first innovations to the present. Most people you know probably own a computer a million times more powerful than these early examples and which can be used to manipulate high-end graphics and moving images at speeds that were once impossible to imagine.



Figure 3.24 The Spacewar game was the predecessor of many of today's video games.

QUESTIONS

1. Identify the ways in which you interact with computer-generated images.
2. How do the hardware components on the PDP-1 compare to today's desktop PC?
3. Research other milestones in the history of computer-generated graphics.

INFOBIT

As well as RAM and ROM, primary memory can also refer to the very fast registers in the CPU and cache memory, which is an intermediate stage between the CPU and RAM. Although RAM uses the term 'random', all memory locations must have an address so that the CPU knows where to store the data and where to find it next time it is needed.

ACTIVITIES

1. What system hardware is installed in your computer – processor and RAM? You may need to look at the 'Control Panel' in Windows' main startup menu or 'About This Mac' in the Apple menu on a Mac.
2. Why does graphics software require more processing power than other software?
3. Look on the Microsoft website to find the system requirements for the latest version of the Office suite of applications. Do all the programs contained in this package require the same hardware standards?
4. Open a graphics package such as Photoshop. Look under the Help menu for system information. It should indicate here how much RAM it is using.

Review questions

4 CORE Data handling

Syllabus outcome: 5.3.2

Chapter outcomes

You will learn about:

- data and information
- data sources
- data forms
- data coding
- data types
- data storage
- file types
- data compression
- data transmission
- data security.

You will learn to:

- compare data with information
- convert data between analog and digital
- perform calculations on data coding
- use information in an ethical manner
- manipulate data types
- investigate transmission methods
- discuss data storage
- perform data compression
- compare data security methods.

Key terms

Analog data
data that has continuously varying values

ASCII
most commonly used code for representing text data

Binary data
represented by ones and zeros

Bit
binary digit, the smallest data item that the computer can process

Byte
package of eight bits

Copyright
ownership of intellectual property by its creator

Data compression
decrease of file size by removing data or finding patterns

Data security
procedures intended to protect data from unauthorised access

Data transmission
movement of data from one place to another within a computer system or across a network

Data types
range of media that can be processed by the computer, such as text, graphics, audio

Digital data
represented by fixed values

File format
describes how the computer organises information in different types of files

Lossless compression
reduction of file size by finding patterns in the data; full file size can be restored

Lossy compression
reduction of file size by permanently removing less important data

Plagiarism
taking someone else's work or ideas and passing them off as your own

Primary storage
RAM chips on the motherboard, directly accessed by the CPU

Secondary storage
non-volatile memory that cannot be processed directly by the CPU; it must first be copied into primary storage

Volatile memory
memory that loses its contents when the power is turned off

IN ACTION

Whose data is it, anyway?

In 2008, at the age of 102, Ivy Bean of Bradford, England, joined Facebook, making her one of the oldest people ever to use Facebook. She was an inspiration to her family and friends and several fan pages were made in her honour. When she passed the maximum number of friends allowed by Facebook, Ms Bean then joined Twitter.

Social networking sites have long been used for keeping in touch with friends and family, and more recently commercial enterprises and projects have taken advantage of this access to instant information. Civil and political groups across the globe have also connected their members with current concerns.

During this social revolution, we have been constantly reminded of the ease with which our private data can be accessed and identities stolen or maligned. However, sometimes we give away our own secrets. Voicing personal opinions on Facebook has led to people losing their jobs, and several teachers and other professionals have had cause to regret their assumption that comments they post on the Internet are restricted to their own social circles. Indeed, sometimes the trouble starts when a person applies for a job – potential employers now frequently search Facebook pages to gain a more detailed picture of applicants.

Facebook does not sell any of your data, partly because it does not have to. There are many people who will gather all data that is not set to 'private' and sell it to any outside party that is interested. And not just from Facebook. Data is collected in many ways, including the use of tracking devices such as cookies that allow a company to identify a user as they travel around the web or the apps they download to their phone that find their location.

There is now an enormous multibillion-dollar industry based on the collection and sale of personal and behavioural data. Advertisers buy this data so that they can then deliver ads to a person's browser. Since targeted ads are so much more effective than non-targeted ones, websites can charge much more for them. This is why, compared with the old banners and pop-ups, online ads have become smaller and less invasive, and why websites have been able to provide better content and still be free.

But where is the balance? It is fine for Amazon to remember past orders and make further suggestions to customers, but not if they give another company that information without permission. Online phone books make it even easier than before to find out where a person lives and their phone number. Should this be considered an invasion of privacy? Should we need to pay to have this data removed from public access?

We now expect online sites to respect our privacy, although this is an issue – the security of some Facebook and phone accounts has been compromised several times. New technology is making us consider what we are sacrificing in privacy in order to gain instant access to information. While we admire individuals like Ivy Bean and encourage them to share their news online, we need to be sure that data that we intended to be private, remains just that.

In 2011, Alasdair Allan discovered a hidden file on all iPhones that records and stores the location of the iPhone at any time. Using this, it is possible to track any person's movements on a map. Although data is being stored only locally on the user's computer, it raises potential ethical issues of privacy.

QUESTIONS

1. Identify the types of people and organisations who use social networking websites.
2. For the parties identified in question 1, describe how they use these networks.
3. What dangers are there in using social media?
4. Why do third parties collect data about individuals from the web?
5. Discuss ways in which an individual's privacy is protected in our society.



AAP/AFP Photo/Jonathan Nackstrand

Figure 4.1 Facebook data is stored on a massive array of servers similar to these, and protected by a high level of security.

4.1 Data and information

We rely on computing technology to give us access to huge volumes of information that we process and present again in a variety of forms. In this section, we consider how data is entered and stored by a computer system, and the different forms it has to take to allow the user to perform a particular task.

What is information?

Information is all around us. As human beings, we process this information all the time. We listen to the news on the radio, we look at the clock to find out what time it is, we write appointments in our diaries. It is often said that we live in the information age. We have access to much information from a multitude of sources and it has become an essential part of our lives. Banks and businesses process information endlessly; pilots rely on information to be able to fly their aircraft; doctors rely on information to help us recover from sickness.

We rely on computers to process a lot of information for us – to store it, display it and to transfer it to another computer. However, the difference between us and computers is that we can make sense of what we hear and see. For any task, computers need to be told exactly what to do and how to do it.

Data versus information

People often confuse the terms 'data' and 'information'. Imagine a list of numbers written on a piece of paper. This might be called data because it has no real meaning for anyone. However, if someone told you that the numbers were telephone numbers, then they would have some meaning. The numbers are now pieces of information.

Think about a sentence typed into a computer from a keyboard. The individual letters of each word are entered by pressing the keys. The letters are items of data for the computer to process. A word processor is used to store the letters and to display them on the screen. The output will make sense to a person, but for the computer, the display is just an arrangement of coloured dots on the screen.

As you work at the keyboard, the information in your head becomes data in the computer system. As you recognise the dots on the screen as words, so the data changes back into information.

Data can be letters or numbers, a pattern of dots, or a series of electrical or light signals. Data becomes information when it is given meaning by people.

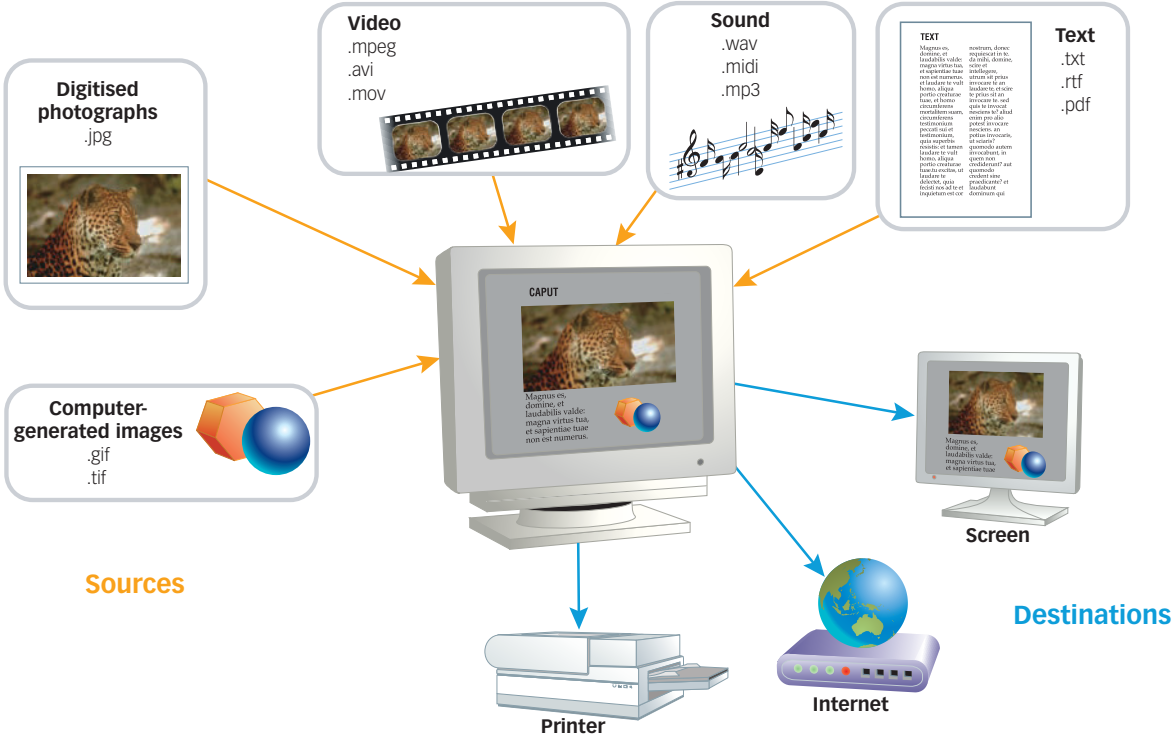


Figure 4.2 Information becomes data when we enter it into the computer for processing. It can come from a variety of sources and in many different forms. This data becomes information again when it is displayed and interpreted by people.

Data sources

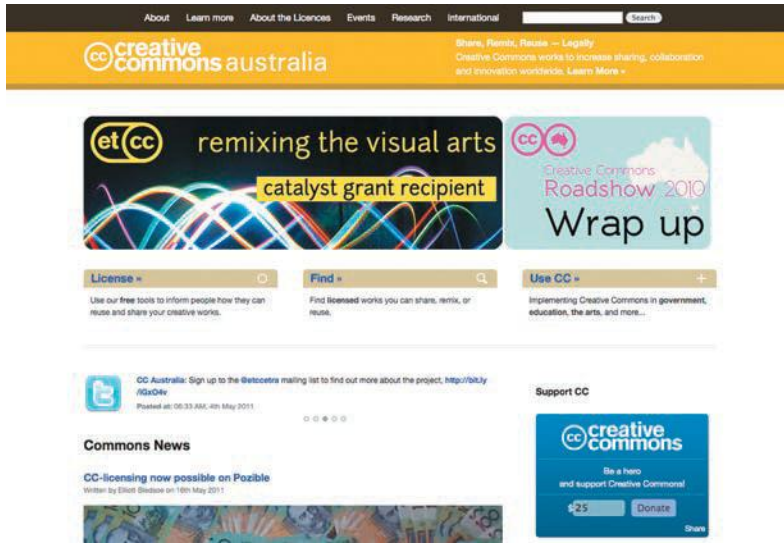
Data can be collected from many sources; for example, from interviewing people or from printed material such as books, magazines and journals. Access to the Internet allows us to find large volumes of information in digital form. It is important that any information you use is accurate and that no **copyright** laws are broken.

The source of all data should be recorded, acknowledged and checked for copyright. If you record where you found your data, it is easy to go back and check it or find similar material. If you are using other people's material, it would be **plagiarism** to imply that it was your own work. Most importantly, it is illegal to copy other people's material without permission.

Often we need to create our own material from our own ideas. It may be that we are completing a survey on market trends or we want to record an event such as a drama festival. Shooting your own video and creating graphics for credits, titles and so on can be a lot of fun. However, before you publish any information about anyone, make sure it is accurate, and that you have permission to identify people in your project.
In chapter 7: Issues, you will learn how ethical standards are applied in the field of information and software technology.

Copyright in a nutshell

- Copyright applies to all material on the World Wide Web.
- Ideas cannot be copyrighted, only the tangible expression of the idea, such as stories, songs or art.
- Work is automatically protected by copyright as soon as it is created.
- You may quote only limited portions of work – excerpts, not whole articles.
- Getting permission to use material can save you a lot of trouble.
- Ignorance of the law does not make you exempt from it.



Creative Commons

Figure 4.3 Creative Commons is a non-profit government organisation that encourages universal access to research, education and culture through the legal sharing of information.

ACTIVITIES

1 How is data different from information?
2 Write a list of data that might be entered into a teacher's spreadsheet to record student names and their marks. When does the data become information? Why is information so important to people?
3 Copy and complete the table to summarise all the ways that you can input data into a document on a computer.

Data type	Input method
Text	• Keyboard • Scan
Graphic	• Download from Internet • Create in paint program
Audio	
Video	

4 Why is it important to record all your data sources?
5 What is the difference between infringing copyright and plagiarism?
6 Visit the website of the Australian Copyright Council and find out about using graphics and music for a school project. Do teachers have to follow the same rules as students?
7 You have found a website on the Internet that allows you to download lots of popular music. You have a DVD burner on your computer. Discuss the ethics of storing this music on your hard drive, burning it to a DVD, and then copying it to give to your friends.
8 For one of the projects that you have completed in another subject, identify information that you have retrieved from three different sources. Produce a table to show how you have recorded and acknowledged your sources.

4.2 Data forms

Most of the information around us comes in variable quantities; for example, the volume of music playing or the speed of a passing car. If the values of these quantities can vary along a smooth line or curve, we refer to it as **analog data**. Some information, however, comes only in fixed quantities – counted values, for example. This is called **digital data**. The values on a digital watch do not represent time passing in a smooth and continuous way, they only display the precise number of hours and minutes that have passed since 12 o'clock.

Digital data

Modern computers are designed to work with digital data. This means that all the data that enters the system has to be digital or has to be digitised before the computer can store or process it. Most input devices, such as a keyboard or scanner, are designed to provide the system with digital data. They input data to the system in digital form. However, a microphone inputs an analog electrical signal that is digitised by the sound card inside the computer.

INFOBIT

Analog computers are still being used – often in simulation situations such as aircraft performance and nuclear power plants. They are well suited to systems where there are large numbers of continuously varying factors, such as voltages and air pressure.

Data coding

While a digital signal is allowed to take several distinct predetermined values, most computer systems work with switches or signals that can either be 'on' or 'off'. Since the computer works with just these two values, we call them binary (meaning two) digits or **bits**. This arrangement allows computers to work very quickly and accurately.

The two values are usually represented by a 0 for off and a 1 for on. We often find it quite difficult to work with binary numbers, but with a little practice it can be fun. We can use a series of binary digits, or bits, to represent bigger numbers and many patterns of data. The computer's work is performed using streams of zeros and ones.

So what does the series of bits 01100110 mean to a computer? It depends on how these bits are being used. It is very important to understand this clearly. If it is a signal coming from a keyboard, it might represent a character. If it is going to a monitor, it might be the colour of one of the pixels, or it might be part of a program instruction in the central processing unit (CPU). Remember that each bit represents a unit of data, so a series of eight bits, or a **byte**, can represent 256 or 28 patterns of data, including zero. That is enough for 256 colours on the screen or characters on the keyboard.

Counting in decimal

In the decimal system, each column value is 10 times more than the one on its right. We count up to 9, then we have to put a 1 in the tens column, and so on.

Hundreds	Tens	Ones
		0
		1
		2
		3
		4
		5
		6
		7
		8
		and so on.

Counting in binary

In binary counting, each column value is two times more than the one on its right. We count 0, then 1, then we have to put a 1 in the twos column, and so on.

Eights	Fours	Twos	Ones
			0
			1
		1	0
		1	1
	1	0	0
	1	0	1
	1	1	0
	1	1	1
1	0	0	0
			and so on.

To convert the binary number 1101 to decimal, we just read off the column values where there's a 1, and add the decimal values together.

	Eights	Fours	Twos	Ones	
Binary	1	1	0	1	
Decimal	8	+ 4	+ 0	+ 1	= 13

To convert back to binary from decimal, just share out the biggest one. For example, 43 in decimal is one lot of 32 plus one lot of 8 plus one lot of 2 plus 1.

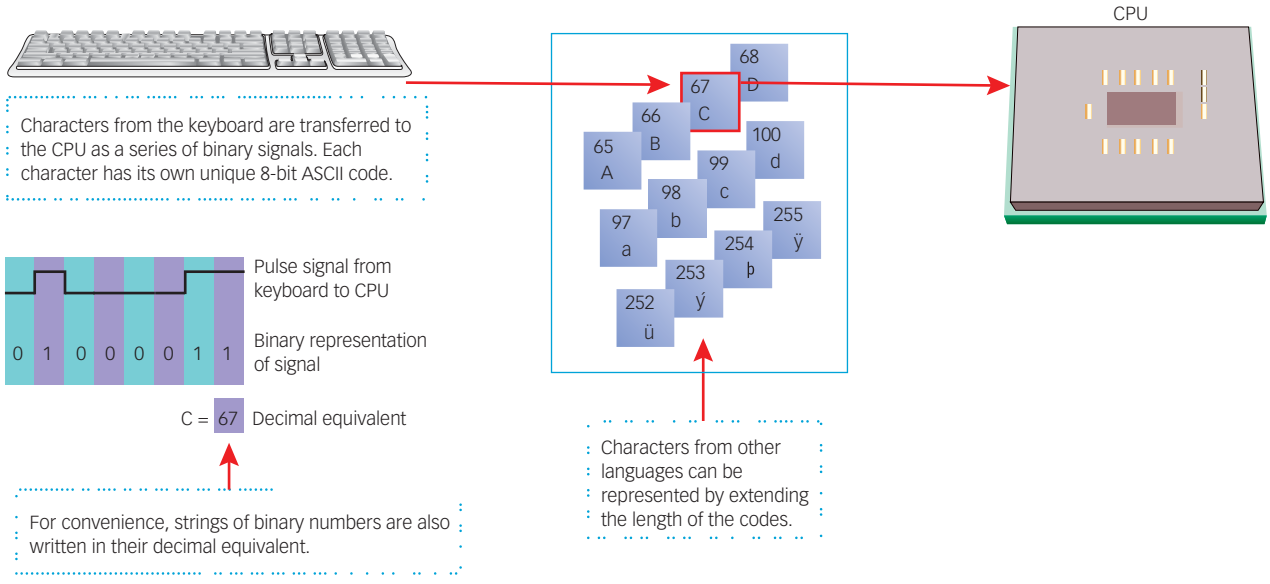
32s	16s	8s	4s	2s	1s
1	0	1	0	1	1

Figure 4.4 Counting in the decimal and binary systems

Binary code – ASCII

When we type words in at the keyboard, we think of the data as individual characters. The signals that travel from the keys to the CPU all need to have their own unique **binary data** pattern – otherwise the computer would not know which key we had pressed. Most computers use the same coding system, called **ASCII**. This is pronounced 'as-kee' and stands for American Standard Code for Information Interchange. Figure 4.5 shows how each character has its own unique binary code.

Try to imagine the words on this page written out in ASCII binary code. After the first few words, you would realise that it would be easier to write it in decimal numbers. That is why people often use the ASCII decimal code equivalents.



ASCII codes for some characters. You can work out the codes for most of the rest of the alphabet.

Character	ASCII code	
	Binary code	Decimal equivalent
A	0100 0001	65
B	0100 0010	66
C	... ...	67
I	... ...	
J	... ...	
K	... ...	
a	0110 0001	97
b	0110 0010	98
c	... ...	99

Character	ASCII code	
	Binary code	Decimal equivalent
0	0011 0000	48
1	0011 0001	49
2	0011 0010	50
3	... ...	
space	0010 0000	32
comma	0010 1100	44
full stop	0010 1110	46

Figure 4.5 A part of the ASCII character set

ACTIVITIES

1 Describe the difference between analog and digital data. Give some examples of each.

2 A light switch is used to turn a light signal on and off. Is the light signal analog or digital? Could it be considered both?

3 Why do computers work with bits rather than decimal digits?

4 Convert these binary numbers to decimal numbers:
a 0110 **b** 01100011 **c** 10101100

5 Convert the following decimal numbers to binary numbers:
a 4 **b** 64 **c** 63

6 Using three bits of data, we can make eight binary patterns: 000, 001, 010, 011, 100, 101, 110, 111. How many binary patterns could you make using:
a 4 bits? **b** 8 bits? **c** 24 bits?

7 Look at the ASCII table in figure 4.5. Complete the rows for the remainder of the letters and their binary and decimal ASCII equivalents.

8 What characters do these decimal ASCII codes represent?
a 78 **b** 32 **c** 54

4.3 Data types

Figure 4.2 illustrates some of the different **data types** and the **file formats** that are commonly used. These data types fall into five main categories – text and hypertext, graphics, audio, animation and video.

Computers are so useful for storing and manipulating this digital material that we inevitably want to convert every data type we know into a form that the computer can work with. However, it is important that you are clear about the destination for your files – print, screen or Internet – as there is an ongoing trade-off between file size and quality of the data they contain. The following provides only a brief overview of each data type. You will find more detail in section 11.3 of chapter 11: Digital media.

Text and hypertext

Text is data that consists of strings of printable characters separated by white space and other non-printing characters. Hypertext is simply text that acts as a link to another document or another place in the same document.

Graphics

A graphic is a picture or diagram used to convey information easily to the user. There are many forms of graphics that can be used by the computer and they can usually be incorporated into many types of applications. Graphics files usually fall into two main types: bitmaps or vectors. Bitmaps define the colour of each pixel on the screen, whereas vector graphics define an image using mathematical objects such as lines, squares and circles.

Audio

An audio file is digitised sound, which can be speech, music or sound effects. The amplitude and frequency of the sound are represented by a series of ones and zeros (see figure 4.6). As with graphics files, audio files can become very large, but there are several compression techniques that can be used to reduce the size. Good-quality speakers or earphones are needed to listen to long audio files.

Animation

Animation is a series of graphic images that are shown rapidly in succession so that we see it as smooth motion. These graphics are usually computer-generated or assembled and displayed using a software package. Morphing and warping images can be a lot of fun. Morphing software will change one image into another, whereas warping will create a distortion of a particular image.

Video

Video is now a common form of digital data. A video file, like animation, is also a series of graphic images. The images are usually of the real world, such as people or events. Video files usually have an audio element included in the same file. Video cameras and Internet downloads are easily accessible. Video file sizes can be a problem, but streaming can be used to speed up download and playback.

The main difference between video and animation is that video is based on continuous motion, which is then broken up into a series of frames, whereas animation takes individual pictures first and puts them together to form the illusion of continuous motion.

As you learnt earlier in this chapter, all data types are represented as a series of ones and zeros inside the computer. The software knows how to interpret these huge volumes of binary data and to process them to display as required.

Manipulating data types

There are several ways to input data into the computer and several ways we can store it, process it and display it. This means that you have many opportunities to manipulate your data into different forms. In chapter 2: Hardware, you learnt about the hardware you can use to input, process and output data and information. In many of the option topics you will need to process your data into different forms.

Later in this chapter you will learn about the different file formats associated with each data type. Most application software today will allow a range of different data types to be used in one document. For example, a sound effect can be included in an Adobe® Flash® animation or a graphic can be stored in a database.

Text can be input to the computer via the keyboard or it can be scanned in and converted to text using optical character recognition (OCR) software. Pictures can be changed and resized using a graphics package. Video clips can be digitised using a combination of hardware and software. Often a digital video camera is used to create movies. These files can then be uploaded to the computer to be edited, compressed and stored as different file formats. Data such as clip art or audio files are already digitised and you can access these from databases on the Internet. However, you may be able to edit them and save them as different formats. Useful documents are also published on the World Wide Web and you can copy a selection into a local document – but remember to acknowledge your sources.

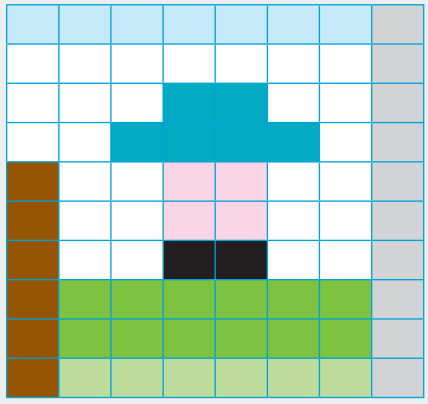
CASE STUDY

Understanding bitmapped images

The amount of colour information in a picture is usually referred to as the colour depth or the number of bits per pixel. The greater the colour depth, the more colours that can be represented. The example to the right is using four bits to represent each colour, so it has a colour depth of four bits per pixel. Pixel refers to a picture element or one dot in the image.

For a given picture size, more colours means larger file size.

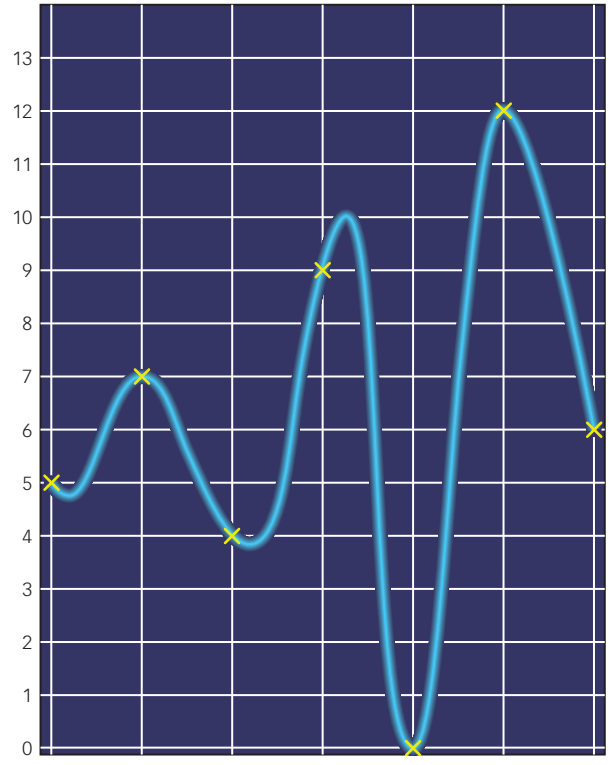
- four bits per pixel (16 colours) appears as cartoon art
- eight bits per pixel (256 colours) is used in clip art and low-resolution pictures
- 24 bits per pixel (millions of colours) gives continuous tone such as you see in a photograph.



Colour codes	
	1001
	0010
	1111
	1100
	0011
	1011
	0000
	1110
	0110

QUESTIONS

1. How many pixels are there in the above graphic?
2. If it takes four bits to record the colour of a pixel, how many bits are needed to record the whole picture? What would be the file size for this graphic?
3. Write out the string of colour codes for each pixel across each of the 10 rows.
4. How many bits would be needed for colour depth of 24 bits per pixel?
5. What would be the file size if the resolution were increased to 100 pixels square at four bits per pixel? And at 24 bits per pixel?



Measuring the height of the wave at regular intervals, we get a series of values:

5, 7, 4, 9, 0, 12, 6.

These are then converted to binary:

0101, 0111, 0100, 1001, 0000, 1100, 0110.

This is now our digitised audio file.

Figure 4.6 Converting analog sound to digital

ACTIVITIES

1. Identify the five main categories of data types and think of another word for each of them; for example, 'text' might become 'words'.
2. Why should you think about the destination of your data when deciding on file format?
3. Define the following data types: hypertext, bitmapped graphics, vector graphics, audio, animation, video.
4. Draw up a table to identify the ways in which you can manipulate each data type.
5. Why is it necessary to compress some data types and not others?
6. Look at figure 4.6. This is part of an analog sound signal that has been converted to digital values. Repeat the exercise for the intermediate values to make the representation more accurate.

INFOBIT

In 1981, Shigeru Miyamoto drew the famous video game character Mario. Mario wears a cap so his hair does not need to be animated. The moustache avoided the need to draw a mouth and facial expressions on the small on-screen character.

4.4 Data storage

When users refer to **primary storage** in a computer, they usually mean random-access memory (RAM) and read-only memory (ROM). **Secondary storage** holds data files and software that is loaded into memory when it is needed.

Primary storage

RAM consists of memory chips that can be read from and written to by the processor and other devices. When the computer is switched on, operating system files are loaded from the hard disk into RAM. When additional programs and data are needed, they are also loaded into RAM. Most RAM is **volatile memory**, meaning that when the computer is switched off, its contents are lost. For this reason, you must save any data files you have been working on. Saving is the process of copying items from RAM to a secondary storage device such as a hard disk.

Memory chips are located inside the system box and usually on the motherboard. They have fast read and write access times, so they can supply the CPU quickly with the data that needs to be processed.

ROM refers to memory chips that store data that cannot be changed by the user. It is non-volatile, which means that its contents are not lost when the computer is switched off. Examples of ROM are the BIOS (basic input output system) chip that helps to boot your computer, or a chip in a printer that stores data about a variety of fonts.

The biggest problem with memory is that the chips do not hold as much data as secondary storage devices. That is one of the reasons why we use chips for the immediate needs of the CPU, and secondary storage for other data that will be needed in the future.

Secondary storage

There are many types of storage media that meet different requirements. Capacity, cost and portability are all factors that need to be considered when choosing which one to use.

Hard disks store data using magnetic particles to represent the data bits. Compact discs (CDs) and digital versatile discs (DVDs) use small surface indentations and optical technology, which means that laser light is used to read and write data to the disc.

Tape cartridges are sometimes used to back up hard disks and file servers. The tape is similar to audio tape and data has to be found by sequential access. This means that you must forward or rewind the tape to find the data you need. Magnetic disks and optical discs all use random or direct access methods, so the location of the data is known without having to search through other data. This makes it much faster to find a particular data item or file than using sequential access.



Figure 4.7 Different storage devices are used for different purposes.

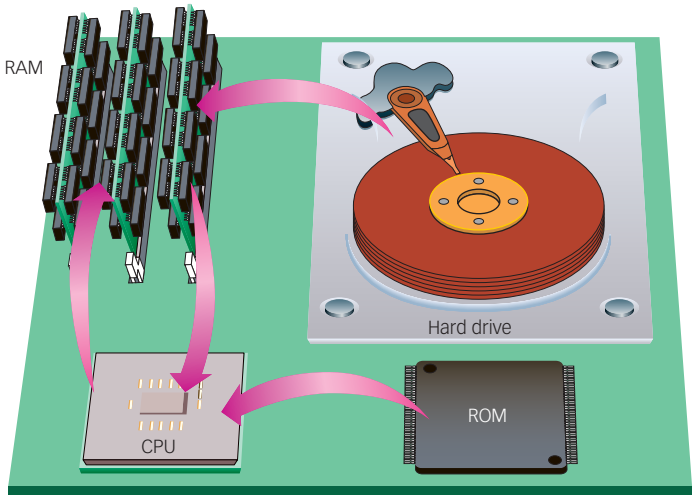


Figure 4.8 When data moves from a chip, such as RAM, ROM or the CPU, to the hard disk, it needs to be changed from a pattern of high and low voltages to a pattern of magnetic regions. Changes in the direction of magnetisation are used to represent the binary data bits.

Units of data storage

You have already learnt that the bit, or binary digit, is the smallest unit of data that the computer can work with. People think about this bit as being a 'one' or a 'zero'. The reason for this is that computer chips are made up of millions of transistors that are like tiny switches. These switches can be on or off. A series of switches can therefore represent a series of ones and zeros, which in turn represent a letter, colour or a musical note.

When this data is saved onto a hard disk, these bits – or series of ones and zeros – are recorded as tiny magnetic spots. The direction of the north–south poles of the magnetic spot will represent the bit as being a one or a zero.

Similarly, binary data is stored on an optical disc as a series of tiny pits and lands. A pit is an indentation made on the lower surface of the disc and a land indicates the absence of a pit. A laser beam scans this series of pits and is scattered every time it finds a pit edge. This is then interpreted as a binary 'one'. Figure 4.9 illustrates some of the data forms in common use.

By convention, we count bits in groups of eight and call them a byte. The number of units of data stored in a word processing document or graphic is often measured in kilobytes (KB) or megabytes (MB). The prefixes used are approximately equivalent to conventional usage – kilo equals 1000 and mega equals one million. The capacity of storage devices is increasing day by day. Gigabytes (about 1000 MB) are now used to measure the capacity of hard drives and DVDs, and terabytes (about one million MB) apply to devices such as network servers and, now, even portable USB drives. Figure 4.10 compares these units.

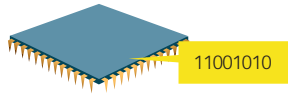
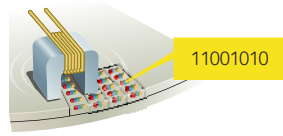
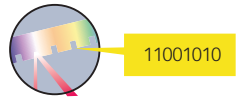
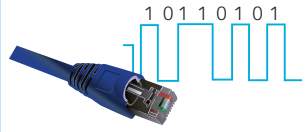
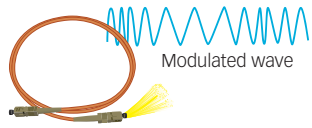
Data storage or transmission type	Bit represented as:	
RAM chip	Voltage high or low in a register	
Magnetic hard disk	Direction of magnetised particle	
Optical disc	Detection of edges of pits	
Network cable	Voltage high or low	
Fibre-optic cable	Change in phase or intensity of light	

Figure 4.9 Some of the data forms in common use

Prefix	Abbreviation	Size
kilo	k	2^{10}
mega	M	2^{20}
giga	G	2^{30}
tera	T	2^{40}
peta	P	2^{50}

Figure 4.10 Common prefixes and what they mean

ACTIVITIES

1. Draw up a table to compare RAM and ROM. List their similarities and differences.
2. Why do computers have both primary and secondary storage?
3. Find out how much RAM you have in your computer. If you are working in a Windows environment, you can look at this through the system properties in the control panel. For Apple® Macintosh® computers, you can find this in the Apple menu at top-left under 'About This Mac'.
4. Draw up a table to compare and contrast a range of primary and secondary storage media. You might include some of these headings: Examples, Location, Capacity, Speed.
5. Draw a table to compare the cost per MB of different storage media.
6. How is data stored on the following media?
   - **a** Hard disk
   - **b** DVD
   - **c** Flash memory
7. How many bits are there in a byte?
8. How many megabytes (MB) are there in:
   - **a** 20 gigabytes?
   - **b** 2 terabytes?
   - **c** 100 kilobytes?

4.5 File types and data compression

You will have noticed that when you create and save a new data file in a word processor or spreadsheet, your computer will automatically assign a file type to it. For example, a Microsoft Word document will have the file extension .docx and it will be associated with an icon featuring a large 'W'.

File types

Figure 4.11 shows some of the most common file types and their icons. Look at the icons and extensions associated with each. The icon in front of each file serves as a reminder of which application your computer will use to open each one. The extension at the end of the filename will indicate what type of file it is.

Name	Size	Type	Date modified
Birds.pptx	328 KB	Microsoft PowerPoint Presentation	28/08/2010
Cat.png	276 KB	Adobe Fireworks PNG File	24/11/2008
Class.gif	6,328 KB	GIF image	3/12/2008
Exam.pdf	344 KB	Adobe Acrobat Document	30/08/2010
ICT.mp4	79,689 KB	MP4 Video	9/06/2010
LaunchU3.exe	1,070 KB	Application	8/12/2006
Library.accdb	1,224 KB	Microsoft Access Database	24/10/2010
May.docx	442 KB	Microsoft Word Document	29/04/2011
May.rtf	14,089 KB	Rich Text Format	29/04/2011
May.txt	33 KB	Text Document	29/04/2011
Newt.pub	59 KB	Microsoft Publisher Document	29/04/2011
photo.bmp	30 KB	BMP File	18/05/2010
photo.jpg	36 KB	JPG File	7/08/2010
Survey.xlsx	41 KB	Microsoft Excel Worksheet	29/04/2011
Tree.swf	23 KB	SWF Movie	27/02/2008
Word Files.zip	566 KB	Compressed (zipped) Folder	15/02/2010

Figure 4.11 File icons and extensions. Why are there so many file formats in use?

By default, your computer will open a particular type of file with a particular application. For example, files with the extension .xlsx will be opened in Microsoft Excel, while those with the file extension .mov can be opened in Windows Media Player or Apple QuickTime® Player.

When we save a file, the Save as … dialog box will already display a file type and its extension. We can, however, choose differently. For example, we might be creating a graphics file in Adobe Photoshop, but choose to save it in .jpg format rather than the default .psd (Photoshop document). This has the advantage of the file being able to be read by other graphics software applications.

Many applications can accommodate a variety of different file formats. For example, a word processor can display both a spreadsheet and a graphic created in other applications.

Data compression

As you learnt earlier in this chapter, data files are a series of ones and zeros with which a computer can work. A graphics file will have a string of this binary data for each pixel to be displayed on the screen. An audio file will contain a string of binary data to represent each note of sound to be produced. The better the quality, the longer each string of binary data will be. As a result, graphics, audio and video files tend to be very large, which can be a problem for storage devices and transmission times.

We can, however, choose to compress the data files so that they take up less room in storage, but sometimes this means a loss of quality and we need to be careful about how much quality we can afford to lose. We will now look at some of these options for **data compression**. You will find more detail on these in section 11.4 of chapter 11: Digital media.

Lossy techniques

The JPEG (Joint Photographic Experts Group) format is a common file format, especially for graphics on the Internet. The original file of binary data has been reduced by averaging areas of colours. This type of compression works best for photographs or pictures containing gradient colours. It results in the loss of some of the original colour information, which cannot be restored. For this reason, it is called **lossy compression**. However, the amount of reduction in picture quality is often able to be set by the user.

Similarly, the MPEG (Moving Picture Experts Group) and MP3 (MPEG Audio Layer III) formats are compressed file formats for video and audio respectively.

Again, these are lossy techniques, designed to significantly reduce file size by eliminating sections of information that humans cannot see or hear very well.

Lossless techniques

The GIF (graphics interchange format) and PNG (portable network graphics) graphic file formats are both lossless methods of data compression. This means that original quality is maintained in the displayed images. They work best for graphic images with only a few distinct colours, such as line drawings and simple cartoons. GIFs will only support 256 colours, but PNGs will support 24-bit colour. In both cases, the file size is reduced by looking for repeated patterns of colour in a line of pixels. Figure 4.12 shows how this works.

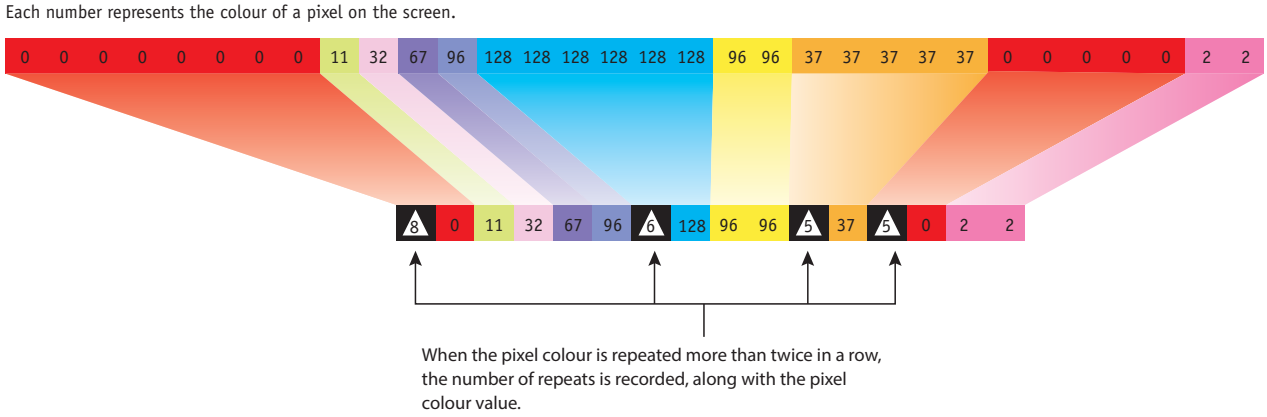
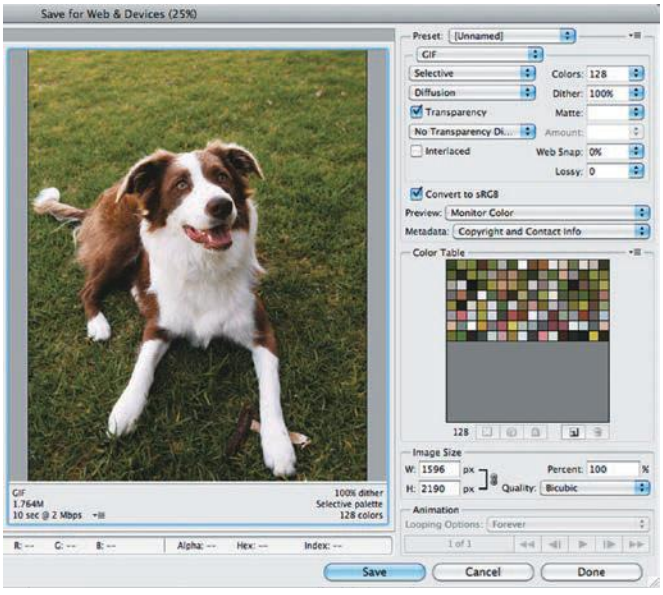


Figure 4.12 Lossless compression in a GIF graphics file. How will the decompressed file differ from the original file?

Compressing text data files needs to be done using a **lossless compression** method. All the data needs to be retrieved when the data is decompressed, so that the ASCII codes will actually make sense to the computer. Again, repeated patterns of data are replaced with a simple symbol. For example, when we write summary notes, a repeated phrase such as 'information and software technology', can be replaced with the abbreviation IST. Text files such as word-processed documents and databases can be compressed in this way by saving them using a zip application.



Thinkstock/Kane Skennar

Figure 4.13 The quality of an image can be reduced in Adobe Photoshop. This reduces the file size. However, before sacrificing quality, consider the size of the image. How many pixels wide and high does it need to be?

ACTIVITIES

1. Identify the file extensions on some of the documents on your computer. Investigate some other file extensions such as .pdf, .exe, .mp3. What sorts of files or applications do these represent? Are there any other common file types that you use?
2. Open one of your existing word processing documents and save it as a text file. What difference has this made to the file size? Open the text file. Which application has opened it? How is the appearance of the contents different from the original file?
3. Save several different types of files into a compressed format; for example, a bitmap as a JPEG file, a Word file in a zip folder. Examine and compare the compression ratio of each. Which types of files does this work best for?
4. Describe the difference between lossy and lossless compression. Why is there a need for both?
5. Why is it important for text files not to lose data, but it is acceptable for graphics, audio and video to lose data?
6. How big is one of your typical word processing files? How many words does it contain? Using the approximation that each ASCII character takes one byte of memory, estimate the theoretical size of your file. Are the two values roughly equal?
7. Use a scanner to copy one of the graphics in this book. Scan it several times at different resolutions. What effect does the resolution have on the file size? What difference does it make to the quality when it is displayed on the screen?
8. Using the graphic from the previous question, open the largest file by using a graphics package such as Adobe Photoshop. Save the graphic in different file formats and examine the file size of each. Discuss which is more important – file size or image quality.

4.6 Data transmission and security

Data is repeatedly moved around different parts of your computer system, and across networks and the Internet. While speed is important, so too is the security of this data. Systems constantly check that data has arrived safely at its destination. However, sometimes the human factor can affect even the most robust of security measures.

Data transmission

On starting up your computer, data moves from the ROM chips to the CPU, and the operating system and applications are transferred from the hard disk to RAM.

As you input data from the keyboard, the computer stores your data in RAM and transfers it to the CPU for processing. The output may also be sent to the screen, a printer, over a local network to a file server or across the Internet to the other side of the world. The data will be sent by different methods, depending on how far it has to go.

Inside the computer, the data travels along multi-lane tracks called buses or bus lines, so that 32 or 64 bits of data can travel at the same instant. This is parallel transmission. Your processor works at thousands of millions of instructions per second, so it is important to move the data quickly between the CPU and RAM.

Unfortunately, if the data has to go any further than about half a metre using parallel transmission, it tends to get out of phase, so serial transmission is used instead.

In serial transmission, the data bits travel one after the other along the same wire. It is used to send data from the mouse and keyboard to the computer and also to modems and over networks.

In fact, as new technologies are developed, serial transmission within the system box is becoming more common. Retrieving data bits from a magnetic hard disk is a serial process, so by the time a group of bits is lined up ready to be sent in parallel mode over the multi-lane channel to RAM, it may be quicker to just send each bit as it is retrieved, in serial mode. Add to this the fact that parallel transfer is more prone to data corruption, and the case for serial transfer becomes stronger.

The rate of data transfer becomes an issue for us only when things start to slow down. This is usually when we are accessing the Internet or saving a large file to a DVD or flash memory stick. Rates of data transfer from the Internet to your computer will be determined by what type of connection you have – fibre-optic, asymmetric digital subscriber line (ADSL) or wireless. The term 'bandwidth' is used to measure how many channels are available for the data to travel over a network. This has a direct effect on the time it takes to transfer a data file.

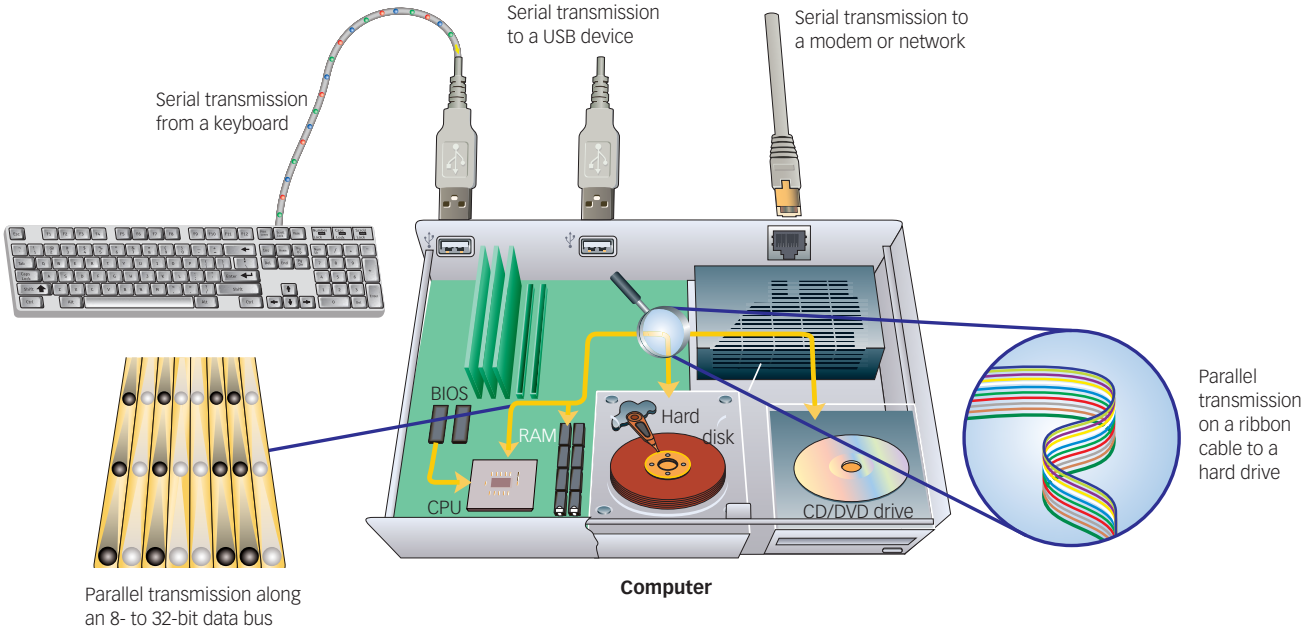


Figure 4.14 Serial and parallel data transmission. Data bits travel in series or parallel, depending on their source and destination.

Data security

It is important to put safeguards in place to keep data secure. This has two major implications. First, data needs to be protected from deliberate or accidental damage. This might be caused by a virus or an inexperienced computer user. Second, the law entitles people to have their personal details kept private. Releasing medical or financial details about someone is illegal and can be insensitive.

Protecting data

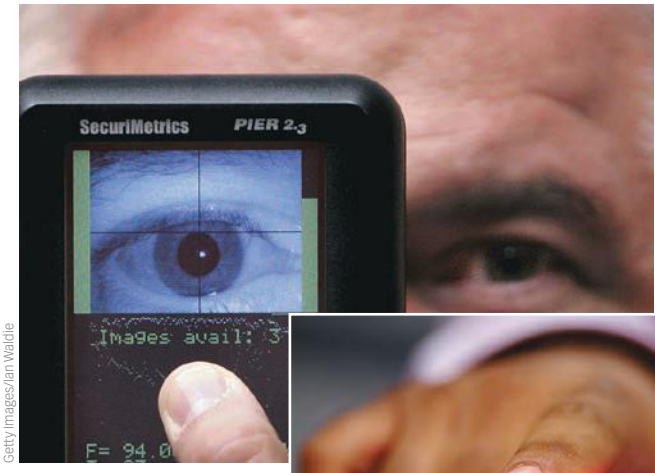
One way to keep data secure is to make sure that only authorised people have access to computer systems. Organisations use ID tags and biometric devices to prevent unauthorised people from entering rooms and buildings where data is processed. Logins and passwords are most commonly used to restrict access to computer systems, for both networks and workstations. Passwords can protect files and directories too.

Many organisations use firewalls or a software or hardware barrier to guard their internal networks from unauthorised access via the Internet. Hackers and viruses can cause an enormous amount of damage to data stored on any system. To protect sensitive or confidential information as it is being transmitted across the Internet, files may be encrypted (encoded), which means that the information cannot be read until it has been decrypted by a person with the correct key.

In the event that disaster does strike a computer system, network administrators or managers put procedures into place for regular backups of the system. Many large systems are backed up automatically at least once a day, so that data can be recovered quite quickly. It makes sense also for individuals to keep copies of important files and documents on separate systems or storage devices, in case of technology failure.

Protecting people

Most people in Australia don't think very often about how much data about them is stored in the many databases around the country. For example, some software programs that are now commonplace on desktop computers and mobile devices can recognise faces, voices and fingerprints. However, the *Privacy Act 1988* (Cwlth) legislates for the collection, use and disclosure of personal information. It gives you rights to access and correct personal information about you held by any institution. You also have the right to make a complaint if you think your personal information has been mishandled.



Getty Images/Ian Waldie

Scanning a retina


Alamy/Glyn Allan

Scanning a fingerprint



Wikipedia

A biometric passport



iStockphoto/Kokkai Ng

Figure 4.15 Biometric devices offer a high degree of security but may also challenge our right to privacy.

ACTIVITIES

1. What is the difference between serial and parallel transmission?
2. What is the advantage of transmitting data bits in parallel? Why is this method not always used for data transmission?
3. Compare the data transfer rates for downloading a file from the Internet to opening it from your hard drive. Why is there such a difference?
4. Compare the different ways in which data is protected. Which of these provides the highest level of security?
5. What is the purpose of the Privacy Act?

Review questions

CORE

5 Past, current and emerging technologies

Syllabus outcomes: 5.3.1, 5.4.1

Chapter outcomes

You will learn about:

- the impact of past, current and emerging information technologies on the individual and society, including different cultural groups
- environmental considerations.

You will learn to:

- explore and discuss relevant current information technologies
- identify past, current and emerging information technologies
- evaluate the appropriateness of current and emerging technologies for specific purposes
- assess the effects of past, current and emerging information technologies on the individual and society
- describe the impact of information technologies on the environment.

Key terms

Augmented reality
integration of real-world video with computer-generated images to deliver an interactive 3D environment

Convergence
trend of combining previously separate technologies into single items of equipment

Expert system
computer program that contains stored knowledge and solves problems in a specific field

Fuzzy logic
assigns a probability to events and predicts the most likely conclusion from a range of possibilities

Generations of computers
groupings of computer hardware advances over time, each group presenting a significant advance in technology

Metcalfe's law
states that the value of a computer network increases in proportion to the square of the number of people connected to it

Moore's law
Gordon Moore's prediction that the circuit densities of processing chips will double roughly every one and a half to two years

Natural language
ability of a computer to be controlled entirely by human speech

Neural networks
branch of artificial intelligence modelled on the processes used by the human brain, where a database's accuracy improves through repeated trials

Pattern matching
process of checking digital sequences to identify exact matching patterns in a database

IN ACTION

Augmented reality

A mechanic wearing special display glasses leans over the engine of a BMW car and sees, in 3D and colour, the engine part he needs to replace, along with animations of the bolts to be removed; a fighter jet pilot sees navigational data and instrumentation for his flight displayed on the windscreen; furniture from an IKEA catalogue is seen in position in your lounge room; constellations are named and the International Space Station is seen on your tablet when held up to the night sky; a Sydney band releases a video clip where each member performs as a hologram standing on a printed logo held to the computer's webcam; a mobile phone user looks at a virtual soccer ball above their feet and juggles it from foot to foot as long as possible to gain maximum points … all these are applications of an emerging technology called augmented reality (AR).



General Electric

Figure 5.1 General Electric advertised renewable energy using augmented reality online. The real-world object in this picture is the marker held by the user acting as the trigger for objects generated in 3D by the computer. The sun rises and sets and wind turbines speed up when you blow into the microphone.



GE Finance

Figure 5.2 When this marker page is held up to your computer's video camera, the animated 3D image shown in figure 5.1 'pops out'.

AR can add computer-generated imagery (CGI) to live video. It locks this 3D CGI onto an image in real time and so expands the real-world view. It blends these real and virtual live images and adds virtual features to the real world.

The national flags that appear in the lanes of Olympic swimming events at the finish line and the colourful advertisements displayed on football fields on television broadcasts are examples of AR. These images are 'locked' into the real-world scene and are made to look part of them.

Macquarie University's Museum of Ancient Cultures contains rare items that are more than 3000 years old and cannot be handled or are too large to view easily. These come to life in AR when triggered by a 2D image. The high-resolution 3D models can be rotated and enlarged and studied by students of ancient history without touching the originals.



Apple.com

Figure 5.3 A mobile phone user juggles an imaginary soccer ball using ARSoccer, an augmented reality application.

The increasing popularity of AR is due to the development of tools that allow computer users to create their own AR experiences.

Explore the AR apps on your smartphone or tablet. Ask your teacher to recommend some for you to try.

QUESTIONS

1. Use the web or download mobile apps to explore the emerging technology of AR by finding five online working examples of AR. YouTube displays many video examples of AR. Your computer or mobile device must have a camera to use AR. Take screenshots to illustrate these and write a paragraph describing what each example does.
2. Using your imagination, invent a future use for AR technology.

5.1 Past information and software technologies

The technology we use today only exists because of the hard work and vision of others. Many discoveries and inventions have led to the development of today's powerful personal computers and to important communication technologies such as the Internet.

The timeline that runs throughout this chapter (figure 5.4) highlights major milestones in the history of information and software technology. Most of the inventions described in the following section are illustrated on this timeline.

Important inventions

Prehistoric herders of sheep kept count using notches on a stick.

The abacus, with its sliding beads, was invented thousands of years ago as a very fast calculating device.

In the 1600s, Blaise Pascal and Gottfried Leibniz created mechanical calculating devices that used the same basic methods that modern computers use today. However, calculating devices are not computers. What makes a computer different is that it can be programmed to perform many different functions.

IBM's invention of punched cards to input data for computers was based on Joseph Jacquard's earlier punched cards, which controlled his cloth weaving machines. Howard Aiken and Grace Hopper's Mark I computer in 1944 was modelled on Charles Babbage's calculator from the 1800s – the Analytical Engine. Babbage's colleague Ada Lovelace said 'it weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves in cloth'. Babbage died before his machine was built, but in 1991, after 17 years' work, a successful working model was finished by the British Science Museum using Babbage's original drawings, thus proving his design.

The modern computer's logic gates are an application of English mathematician George Boole's writings in the 1840s.

In the early years, mathematicians wished to automate the huge numbers of calculations needed for creating trigonometric and logarithmic tables for astronomers and engineers. Boole's ideas were also the motivation for the early inventors of mechanical calculators, such as Charles Babbage.

Most inventors begin work by studying what has been created before, avoiding repetitions and dead-ends, and picking up the challenge where others left off, yet most computing courses pay little attention to history. Apart from the fact that studying history is fascinating, if we do not study it, we produce fewer and poorer inventors.

Invention, war and profit

It is a sad truth that many major developments in computing have been funded and motivated by war. The developers of early electronic computers wanted to develop machines that could calculate rocket and missile trajectories more accurately and quickly than the enemy could, and to code and decode secret messages – to kill the enemy before being killed.

Alan Turing is famous for his early work in computers, but this happened only because of his involvement in unravelling the secret code used for communication between German officers in the Second World War. The successful cracking of this famous Enigma code was an important achievement in information technology during the war.

Figure 5.4 Some important milestones in the history of information and software technology

Earliest times

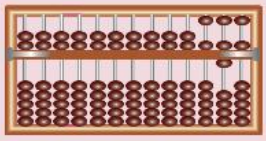
Fingers used for calculation



Shutterstock.com/Ambrophoto

2600 BCE

The abacus, world's first mechanical calculating device



1617

John Napier (Scottish theologian, mathematician and weapons designer) invents Napier's Bones



Alamy/Mary Evans Picture Library

1621

Slide rule invented, using Napier's ideas on logarithms

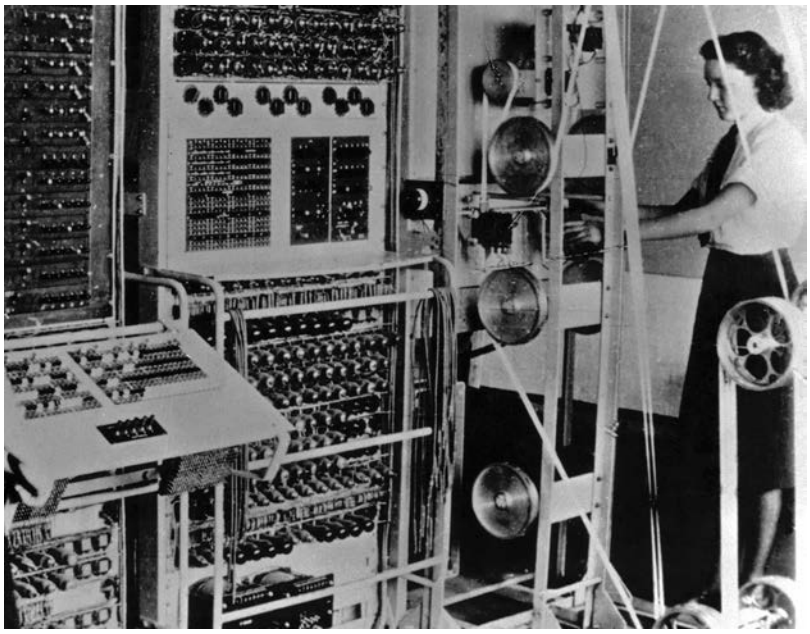


Thinkstock/Hemera Technologies

1642

Blaise Pascal (French theologian and mathematician) invents a calculator he calls the Pascaline, first automatic calculating device





Alamy/Pictorial Press Ltd

Figure 5.5 This computer, named Colossus, was used to decode encrypted German teleprinter messages during the Second World War. It compared two data streams. If a suitable match was recognised, this would be sent as output to an electric typewriter.

One development that did not involve war was the technology used to tabulate the United States census of 1890. As Herman Hollerith observed, the 1880 census was still being counted eight years after it had been completed! His solution led to the formation of the business computing company IBM (International Business Machines).

It is often wrongly stated that the world's first working electronic, programmable computer was the US Army's ENIAC (Electronic Numerical Integrator and Computer). But in fact, this honour goes to Colossus, which until quite recently remained a wartime British Government secret. It was completed in 1943, two years before ENIAC, and was built at Bletchley Park near Oxford in England to help decode Germany's secret messages during the Second World War.

The technological advances of the 1960s were driven by the launch of the *Sputnik* satellite and US fears that the Russians might beat them to the first space flight and moon landing.

Fearing too that America's educational system was falling behind, educators and policy-makers put more emphasis on physics, mathematics and other sciences – leading to huge technological growth among Western nations.

Today, one big motivation for innovation is the profit to be made from the high demand by consumers for mobile computer-based devices. Large companies work hard to produce ever more sophisticated products in information and software technologies.

Generations of computers

Since Colossus and ENIAC were invented, many advances in computer hardware have been made, but some are so important that they create an entirely new **generation of computers**.

- Colossus and ENIAC were in the first generation of computers and used vacuum tubes for switches.
- The second generation used transistors, which were far more reliable.
- The third generation used integrated circuits, combining many transistors on a single 'chip' of silicon.
- The fourth generation, in early 1970, placed the whole central processing unit (CPU) on a single chip, known as a microprocessor.
- The fifth generation of computers uses many CPUs working together as multiprocessors.

What will sixth-generation computers be like? Will they use light rather than electricity?

ACTIVITIES

1 Ada Lovelace played an important part in the work of Charles Babbage. Using the Internet, find out who she was and what her contributions were.

2 Use the Internet to list some important achievements of Bletchley Park during the Second World War.

1678

Grillet de Roven (clockmaker to King Louis XIV of France) turns the Pascaline into a pocket-sized device

1679

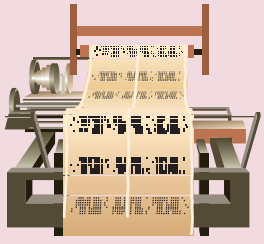
Leibniz invents binary system of counting



Alamy/Interfoto

1805

Jacquard controls loom by using punched cards



1822

Charles Babbage, known as father of modern computing, designs Difference Engine for calculating – first digital computer – assisted by Ada Lovelace

5.2 Current and emerging technologies

Many current and emerging technologies span more than one option of this course. For example, the current trend of combining technologies into single pieces of equipment, known as **convergence**, is relevant to almost all fields of computing technology.

We can trace trends in information and software technology by looking at the journey they have made to the present and then predict the future by looking ahead. It is a very brave (or foolish) person who tries to predict the future, but we'll give it a try!

The problem of predicting the future

Many science-fiction movies have tried to predict the future, with some very humorous attempts. In 1950, some people expected that in today's society, robots would clean our homes and we would all travel in hovercrafts to work.

In 1876, an executive with the Western Union Telegraph Company predicted that the telephone had too many problems to be seriously considered as a means of communication. The chairman of IBM predicted in 1950 that the world would only ever need four or perhaps five computers!

One future prediction was extremely accurate. In 1987, Apple commissioned a special effects film-maker to visualise its own view of the future. This involved a personal digital assistant that acted as a secretary. An animated image appeared on screen and conducted a normal conversation. It announced diary entries, asked what food you wanted delivered, and automatically phoned, responding to your spoken instructions.

Some large companies and governments employ scientists whose job is predicting the future. This profession, known as future studies, uses many techniques, such as trend analysis. In chapter 8: Artificial intelligence, simulation and modelling, you will use an ordinary spreadsheet to try this approach yourself.

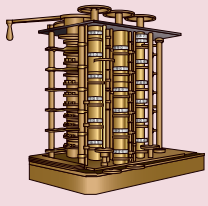
Social trends

Although we cannot be certain about what the future will be like, we can pick out some social trends, influenced by technological changes, that raise important social and ethical issues.

- The way computing is extending more into our existing physical world. We will not merely view atoms and DNA, but build with them. We need to ask if we are ready for the world we will make. How much of the natural world that sustains us should best be left untouched? The term 'the Internet of things' has been coined to describe the trend for technology to be embedded into items we use daily, such as lighting in our home, monitoring the oven or fridge or controlling a car.
- The way in which fields of human knowledge will converge in the same way as technologies. Advances in biology and agriculture will affect those in electronics and vice versa.
- The increasing influence of networked individuals as a result of the power of the Internet. Regular users of the Internet now have tools that can be used to compete with larger organisations and governments over such issues as the environment, human rights and politics.
- The increasing customisation of advertising to our purchasing patterns. As advertisers track our online purchasing, they predict what products and services might interest us. Retailers can use our mobile phone

1834

Babbage's Analytical Engine designed but never built, with similar ideas to the modern computer: sections for input, processing and output



1847

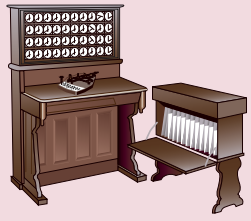
George Boole (English mathematician) publishes his ideas on logic



Thinkstock/Photos.com

1890

Hollerith tabulator, first commercially successful computer, adds up the 1890 US census



1913

Invention of vacuum tube



Alamy/Sciencephotos

1936

Konrad Zuse in Berlin builds first working digital computer in his kitchen, using relays



Getty Images/ullstein bild

data to highlight personalised offers when we are close to their store. It is likely this trend will accelerate.

INFOBIT

Thanks to social networking sites, the next generation of teenagers will find themselves with friends all over the world. By 2020, almost every electronic device will be capable of universal language translation.

Storage capacity and Moore's law

Writer Robert X Cringely once joked that if the automobile had followed the same development history as the computer, a Rolls-Royce would today cost $100, travel one million miles to the gallon, and explode once a year, killing everyone inside. Indeed, the speed of technological development in computing has been astonishing.

Gordon Moore, at one time chairman of the Intel Corporation, predicted that the circuit densities of processing chips will double roughly every one and a half to two years, a trend known as **Moore's law**. Figure 5.6 shows how true this has been.

We can see this same pattern in storage devices. The gigabit chip can store four hours of digital music, 25 uncompressed high-quality pictures or 10 minutes of compressed video.

The only limit to Moore's law seems to be a physical one. When the components of the chip are similar to the size of a single atom, further storage increases will require new technologies.

Because data is merely zeros or ones (off or on signals), there are many possibilities for storage. The difficulty is in addressing and accessing the data. A lot of research at present is concentrating on biological molecules, a field of study known as bioinformatics, where protein molecules are used to store data. Another emerging storage technique is 3D optical data storage or holographic data storage.

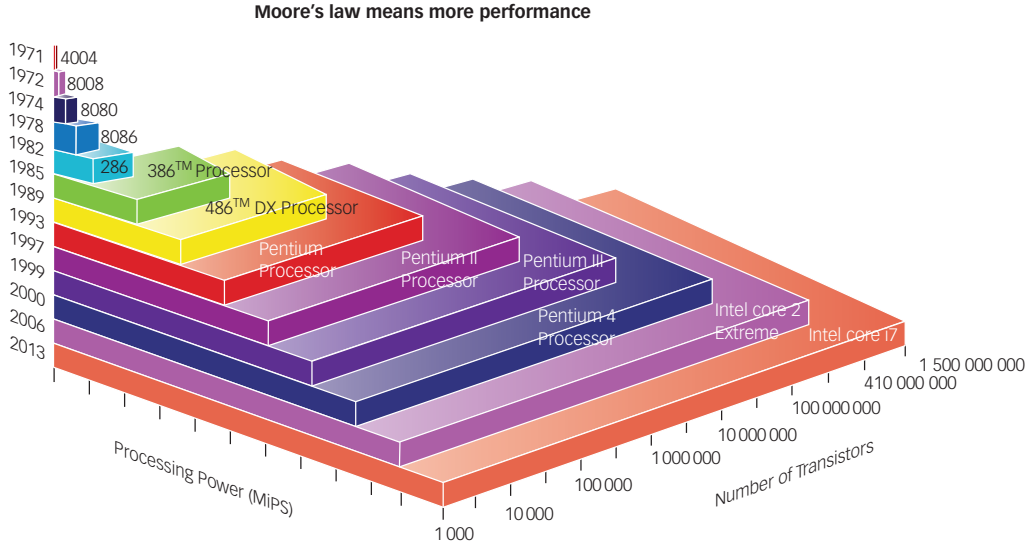


Figure 5.6 Gordon Moore predicted that the number of transistors (and so memory capacity) on a chip doubles approximately every two years.

1937

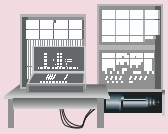
John Atanasoff in Iowa builds first electronic computer



Corbis/Bettmann

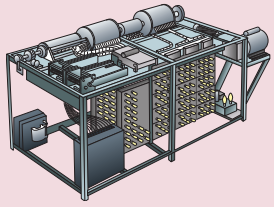
1941

Zuse Z3 built, first working programmed computer



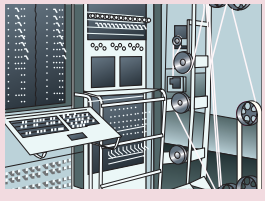
1942

ABC (Atanasoff–Berry computer), first modern computer



1943

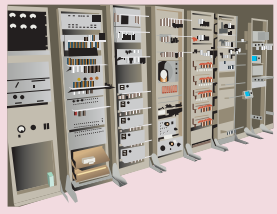
Turing and Bletchley Park develop Colossus, first electronic special-purpose computer



Alamy/Pictorial Press Ltd

1944

Mark I, first electronic general-purpose computer, based on Babbage's ideas



Computer size and cost

Computers are becoming smaller and cheaper. To gain the processing power of a modern laptop in 1960, you had to pay more than a million dollars and set aside the whole floor of an airconditioned building (usually at a university).

Now the science-fiction vision in the popular 1940s Dick Tracy cartoons has become a reality. This early cartoon character used a computer the size of a watch strapped around his wrist that sent his voice, along with his moving image, to anywhere in the world. Readers at the time thought this was a wonderful but unachievable dream. It is now reality!



2015 Dick Tracy ©Tribune Content Agency, LLC

Getty Images/Bloomberg

Figure 5.7 Dick Tracy's famous watch, seen in this 1940s cartoon, took 75 years to become reality. What will replace it in another 75 years?

Convergence of technologies

When technologies become smaller, cheaper and more powerful, it is possible to combine them easily into a single piece of portable equipment. This process is known as convergence.

The biggest challenge is finding a way to connect technology and devices that have different standards.

The changes we see in the mobile phone are an excellent example of convergence. Smartphones transmit video, audio and SMS (short messaging service) text messaging. They have touchscreens, accelerometers, compasses and allow wireless services to run countless specialised applications – as well as being able to make phone calls. Your mobile phone, computer, radio, music player, web browser, email program, personal organiser and TV have become integrated into a single device. In the first edition of this textbook the last sentence was written as a prediction about the future – but it has now become reality!

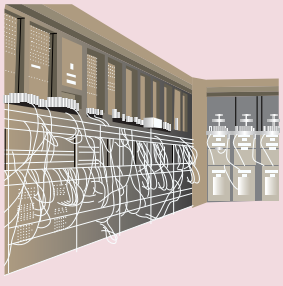
At present, five huge digital industries are rapidly becoming one. These five industries are personal computing, consumer electronics, communications (including the Internet), publishing and entertainment.



Figure 5.8 One member of a famous early family – the IBM 360 series of mainframe computers appeared in the 1960s.

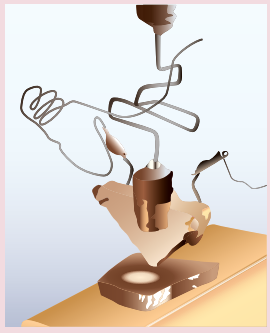
1945

ENIAC, first general-purpose stored-program electronic computer



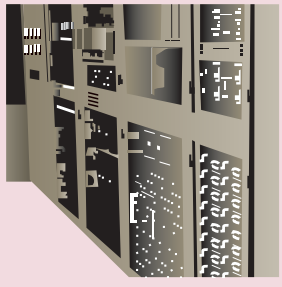
1947

Invention of transistor



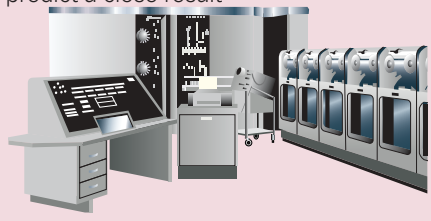
1949

CSIRAC, first Australian electronic computer and only fifth in the world



1951

UNIVAC, first commercial computer sold, correctly predicts outcome of US presidential election, but then reprogrammed to incorrectly predict a close result



The nature of work and study

The Internet can be a fascinating world. The increased use of online games and the growth in social networking has meant that many users can inhabit a virtual world for many hours without noticing time passing. It can become a form of addiction.

Many people feel the need to respond to emails, check in on their Facebook account or tweet constantly. Life at home can mean working more and more at a computer. The popularity of social networking may mean we become conditioned to redefine friendships in a less meaningful way. What effect may this have on families and genuine social relationships?

Some social commentators suggest that these changes in lifestyle habits result in increases in psychological problems, such as depression and loneliness.

It is now possible for employees to work from home. This is known as telecommuting, the virtual office or SOHO (small office, home office). Interactive videoconferencing, online databases and email allow work to be completed from home.

One successful computer game was created in this way in different parts of the world by people who have never met.

Such changes in work patterns mean changes for society. They may lessen road congestion at peak hours, but may also place pressures on family life as workers remain around the home all day. It may be difficult for them to feel that home is a true break from work.

Students increasingly do homework and research online. Already universities are reducing face-to-face tutorials and eliminating some larger lectures by introducing online substitutes. Some institutions are eliminating large lecture rooms in their new buildings.

One important but negative consequence is that social interaction between students and between teachers and students, which is a vital part of education, is reduced.

A paperless world?

Some years ago, the prediction was a bright future of paperless offices and a completely digital future.

The resolution, ease of display, random access of its parts (you can easily flick to any page of a book quickly), accessibility, low cost, presence and effectiveness of paper is superior to most other media. What print lacks is dynamism – characteristics such as change and movement. It cannot display video or audio data. Even this limitation can be overcome using **augmented reality** (see 'In action' at the start of this chapter).

However, with the advent of devices such as the iPad, the predictions of an entirely digital office are closer as display technologies, touchscreen interfaces and ease of transmission, storage, retrieval and portability are improved.

Newspaper companies are struggling to maintain printed versions, but attracting readers to paid online versions has also proven to be a challenge.

ACTIVITIES

1. Watch the video of Apple's Knowledge Navigator online.
2. Predict two information and software technology changes that you expect to see in your lifetime.
3. Describe Moore's law. Can it continue indefinitely?
4. Outline three equity issues in information and software technology.
5. What is convergence? Identify a product that displays convergence.
6. Identify one way in which the nature of work has changed for one member of your family since you were born.
7. Exercise your imagination and draw a picture of a typical high school classroom 25 years from now. Label the drawing with descriptions of its features.

1954

IBM markets the 650, first mass-produced computer



1956

IBM develops Fortran (Formula Translator) programming language for mathematics

1959

Grace Hopper invents COBOL (Common Business Oriented Language) programming language for business

First integrated circuit built



US Navy

1964

BASIC (Beginner's All-purpose Symbolic Instruction Code) becomes first widely used general programming language

IBM launches 360 series, first 'family' of mainframe computer models



5.3 Exploring current and emerging technologies for each option

Although each option chapter will feature its own examples of past, current and emerging technologies relevant to that option, this core chapter provides you with an overview.

Artificial intelligence, simulation and modelling

The great quest of artificial intelligence (AI) has always been to imitate human intelligence. Over the past 50 years, we have discovered that human intelligence is far more complicated than first thought.

No one has yet been able to define intelligence. It involves at least these abilities:

- to learn and remember
- to reason
- to adapt and plan
- to communicate
- to recognise patterns.

In the 1950s, British computer scientist Alan Turing devised a way to decide if we had built a truly intelligent computer (see page 89). He said that if a person asking a computer any question was unable to tell from the answers if they were talking to a computer or a human, then a computer could be called intelligent. For the first time in 2014 a computer passed this Turing test, but is this a valid test – should we call such computers intelligent?

Speed, not intelligence: Deep Blue

Many people are convinced that computers are intelligent, but they confuse intelligence with speed. In fact, compared to humans, computers are unintelligent but are amazingly fast.

Scientists use the calculation ability of the computer to simulate human intelligence. On 11 May 1997, for the first time in history, a computer, IBM's chess-playing Deep Blue, beat an international chess champion, Garry Kasparov. Deep Blue was able to analyse 200 million moves per second.

Data, not thinking: Watson

In 2011, IBM's next AI computer, called Watson, played and won against two human opponents in the TV quiz game Jeopardy! Philosopher John Searle pointed out that Watson was not thinking but only manipulating symbols (letters and words) and had no understanding of what those symbols meant.

Pattern matching

Pattern matching is the process of checking digital sequences to identify matching patterns in a database. Computers have used pattern-matching techniques for some years now. Optical character recognition (OCR) and handwriting recognition are both examples of pattern matching and are treated in more detail in chapter 11: Digital media.

Computers can be used to match faces in a crowd to a known database using the proportions and features of the face. Faces can be identified from matches of digital images taken of arrivals at an airport.

One clever application uses pattern matching as a keyboard input technique. The user traces the letters of a word on the touchscreen keyboard of a smartphone and the resulting shape is interpreted to predict the word being spelt.

1965

PDP-8, first mini-computer

1967

256-bit RAM chip

Keyboards used for input

1969

ARPANET created, basis of the Internet

UNIX operating system developed

1970

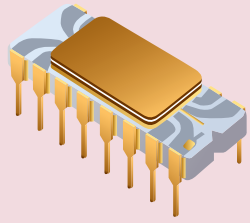
Niklaus Wirth creates Pascal programming language



Wikipedia (public domain)

1971

Intel® 4004 created, first microprocessor (chip)





Getty Images/Tom Mihalek

Figure 5.9 Perhaps history's most famous chess match – IBM's Deep Blue plays Garry Kasparov in 1997.

Translating language

Try this: within seconds it is possible to have today's *Sydney Morning Herald* (or any other web page) translated into another language. Visit translate.google.com and enter any website address you wish to translate. Of course, the process is not yet perfect, but it is enough for us to understand what is written and it is the beginning of true **natural language** translation.

Next use a smartphone to ask the AI assistant (such as Siri, Apple's iPhone assistant) to tell you a bedtime story, ask 'Who is near me?' or 'How high is Mount Everest?' or 'Remind me to call Mum'.

As the ability to recognise idiom and slang increases, true language translation from speech will become possible, potentially breaking down one of the barriers between nations.

Towards natural language input

The keyboard is a very primitive input device, but for many years it was the only choice. When the mouse appeared in 1984, it was possible for the first time to manipulate objects on the screen directly. This was a major breakthrough and has stood the test of time, and has evolved into touchpads and mobile touchscreen keypads.

Many expected that by now direct voice input would be commonplace and keyboards would no longer be used, but it has proved a more difficult technology than expected to get working smoothly and conveniently.

Help desks use speech recognition to answer calls. Telstra's Directory Assistance uses this facility. Booking services for movies, airlines and taxis use speech recognition to cut costs.

The ultimate goal is a natural language interface for a computer, whereby any human speech can be recognised by the computer, and the computer can be operated entirely by conversation.

1972

Frames (windows) used for first time

The 8" floppy disk

First pocket calculator, made by Texas Instruments



Flickr/Daniel Sancho

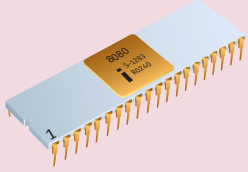
1973

RAM chips reach 4 KB, then 16 KB in same year

Hard drives sold by IBM

1974

Intel 8080, first commercial microprocessor

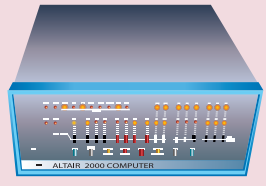


1975

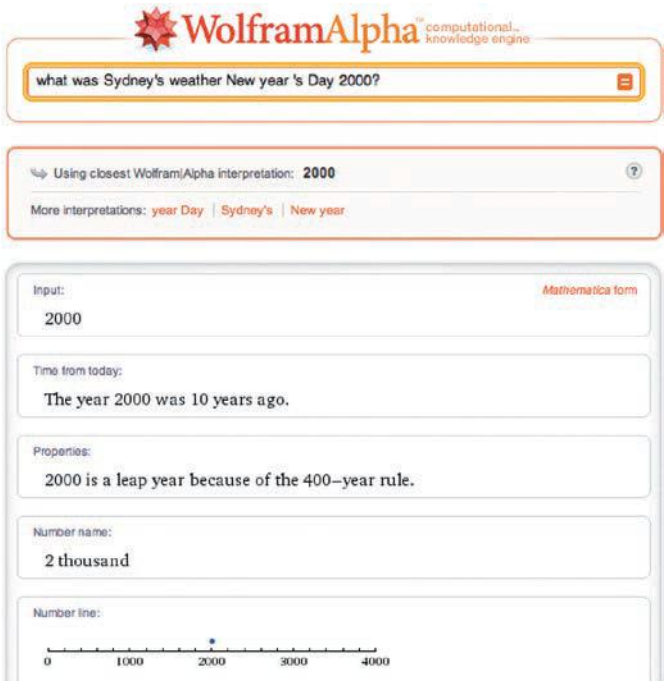
Bill Gates creates DOS system language for Altair PC

Laser printers

Altair 8800, first personal computer in kit form



Altair PC



permissions@wolfram.com

Figure 5.10 WolframAlpha's intelligent search engine, an AI-based web application and also used by Siri, Apple's iPhone AI assistant

Expert systems

The knowledge and diagnostic abilities of medical experts and others can be programmed into computers. **Expert systems** have not yet replaced human experts, but the trend will continue. At present, every time a skilled specialist retires, their lifetime of personal experience and specialist knowledge is lost to future generations.

In the future, many visits to doctors will become unnecessary because patients will be able to use 'virtual doctors' over the Internet, in the form of expert systems. Even now, it is possible for us to self-diagnose using the web. Naturally, there are risks involved: you may wrongly decide that you are not in medical danger and therefore not visit a real doctor. IBM is marketing their AI computer Watson to advise nurses on cancer treatments.

Fuzzy logic assigns a probability to events and predicts the most likely conclusion from a range of possibilities. Applications of fuzzy logic will also become more widely used.

Fuzzy logic is currently used to adjust the picture in hand-held video cameras to reduce shaking. The camera's hardware has to decide which movements in the image are meant to be part of the actual scene and which are not.

Figure 5.10 shows a popular expert system search engine.

We study expert systems in detail in chapter 8: Artificial intelligence, simulation and modelling.

Neural networks

Neural networks are trained to guess by trial and error. Every time they are incorrect, the link they are using is made weaker. If they are correct, they are strengthened. This is similar to the operation of the human brain.

At present, neural networks are used to recognise signatures, identify heart-attack risks by examining the heartbeat patterns of patients, and predict share-market trends. Applications using this type of network will increase in the future.

Authoring and multimedia

Future delivery in the cloud

In the same way as you now edit home movies on your computer, the ability to create full multimedia productions will become more common in the future. At present, considerable skill and training is needed to use complex authoring software, as you will discover in chapter 9: Authoring and multimedia, but this is becoming easier to use as interfaces and software improve.

Desktop applications such as word processors, image and movie editors are available online and on demand. This trend is sometimes known as 'cloud computing'.

Movies on demand, selecting a movie ending, ordering over the Internet and choosing your own camera angles in sporting matches are all possible.

1977

Apple II, TRS-80 and PET, first popular commercial personal computers



Apple II

1978

First 5" floppy-disk drives

1979

First popular spreadsheet application, VisiCalc

First popular word processor application, Wordstar

1980

RAM reaches 64 KB

1981

First popular database application, dBase II

First IBM PC



Getty Images/Science & Society Picture Library

1982

Internet begins when rules are agreed

Future storage

The web has largely replaced disk-based multimedia. A full-length movie fits on one digital versatile disc (DVD), but the Internet has become the common movie delivery platform.

Remote storage tools such as Dropbox remove the need for users to retain large quantities of data on purchased hard drives, but raise privacy issues.

Portable flash memory is widely used and will continue to increase in capacity and usefulness.

Spinning hard disk mechanical drives are replaced completely by flash storage solid state drives (SSDs).

Augmented reality

Augmented reality technology integrates real-world, real-time video with computer-generated images to deliver a convincing interactive 3D environment. Users usually hold a printed page, containing an image, up to the camera and the computer superimposes a CGI image over it. Advertisers have been aware of its potential and applications using it have been developed for mobile phones. See the 'In action' section on page 57.

Database design

Pattern matching

Pattern matching, referred to earlier, is used in databases to analyse huge volumes of data collected and discover trends. This is an important application in the commercial world. Analysis of shoppers' purchasing patterns can uncover emerging trends. Manufacturers want to know what will be popular in three to five years so that they can set up designs and machinery to manufacture sufficient quantities to meet demand and maximise profit.

Privacy

Our personal details are collected every time we do business, attend school or university, buy a movie ticket online, pay a fine, apply for a licence, pay tax, or undertake hundreds of other daily tasks.

If these databases are linked – and networks today allow this to happen easily – information may be available about us that we never intended to reveal. When our income is matched with our educational background, our driving history, our medical records or even our DNA, a new set of information is created and may constitute an invasion of our privacy.

These trends are likely to lead to difficult decisions for future law-makers.

Digital media

Cyber actors

Three-dimensional animation is already extremely realistic. It will not be long before cyber actors (either recreated from actual actors of the past or newly imagined ones) starring in their own movies become common, and it will be difficult to distinguish these from real people.

Are there ethical issues involved here of copyright in a person's likeness? We treat this issue more fully in chapter 11: Digital media.

The home of the future

We can glimpse our domestic futures by looking at our own homes now.

It is likely that the trend towards automation that we see now in individual appliances will spread to the whole house. The airconditioner, the TV, lighting, the coffee maker and the stove are controlled individually at present. These are likely to become interconnected to a central household console or desktop device such as a computer.

Appliances are now able to 'phone' for service when they are not operating correctly, and individual appliances are programmed to work together, such as the alarm waking you to the morning news, the coffee maker being turned on, and the toaster popping up once the coffee has finished brewing.

Cheap 3D printers will be used at home to download files to print replacement parts for appliances rather than have them stored and mailed by manufacturers.

1983

First graphical user interface personal computer with mouse, Apple's Lisa

RAM at 256 KB



Apple Lisa

1984

Macintosh computer, first successful GUI computer



Apple Macintosh

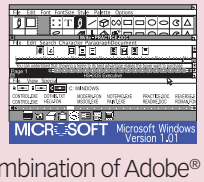
Apple launches 3.5" floppy disk

RAM over 1 MB

Over 1000 Internet hosts

1985

Microsoft launches Windows



Microsoft Windows

Combination of Adobe® PageMaker®, Macintosh and laser printer begins desktop publishing revolution using personal computers

1992

Apple® Newton™ personal digital assistant (PDA) launched by Apple. First with handwriting recognition



Apple Newton

Bill Gates becomes richest person in United States

First web browser, NCSA Mosaic™ (later to become Netscape Navigator), allows the World Wide Web to become popular

Networking systems

Networking has changed information technology forever.

Metcalfe's law states that the value of a computer network increases in proportion to the square of the number of people connected to it.

Already, genetics projects requiring huge amounts of processing power have been made possible by having thousands of computers around the world connected by the Internet, all working at once to do the calculations that would otherwise require hundreds of years for one supercomputer.

By linking computers together, the Internet's vast resources have been made available to every person. We can expect that governments will try to become more involved in control of and access to content.

Businesses networking results in efficient sharing of resources among employees, and collaboration is made possible on team projects.

The social networking phenomenon continues to change the way we interact with one another and the interest groups to which we belong.

Operating systems

Major manufacturers of computers and software are constantly updating their systems to make them more user-friendly and powerful.

We see already a trend to integrate applications and operating systems of computers with the Internet and turn every computing session into an online experience. Adobe Creative Cloud is an example of this trend.

Apple promotes its synchronisation of applications between all of a user's devices, calling it iCloud®.

Microsoft Windows 8 operating system attempts to satisfy the needs of both mobile touch devices and desktop computers.



Apple.com



Microsoft

Figure 5.11 Two modern operating systems: Mac OS X and Windows 8

1996

Hotmail launched

1997

IBM's Deep Blue becomes first computer to beat a reigning chess champion, Garry Kasparov

1998

Apple Computer launches successful all-in-one iMac, first home computer without a floppy drive



Getty Images/Hulton Archive

2000

Microsoft launches Windows 2000

Sony releases PlayStation 2



Getty Images/Philippe Petit

2001

Apple launches the first iPod and releases Mac OS X



Getty Images/Handout

Microsoft releases Windows XP

Robotics and automated systems

One reliable method of predicting future trends is to look at toys and popular entertainment. Robot dogs that can play soccer competitions exist, but these may be forecasting the kind of personal robot we have all dreamt about that will clean the house, mow the lawn and cook!

Movies have always attempted to imagine what robots will be like in the future. The movie *Bicentennial Man*, based on an Isaac Asimov short story, imagines a robot, Andrew, who wants to become human and gains human-like emotions. Andrew shows clear signs of thinking, rather than just behaving as its 'personality programming' might tell it to behave. Steven Spielberg's movie *AI* is a modern Pinocchio story. It makes an attempt to imagine the reverse situation – could humans form strong emotional links with robots? Both films imagine robots with artificial intelligence. Such a world may be a while off yet, but there are real robots among us now.

Robots are increasingly used in dangerous situations in space and for repetitive programmable tasks, such as motor vehicle assembly, including spray-painting, welding and assembly of parts, or in bomb disposal.

Another common application is inventory warehousing, where robots retrieve precise quantities of stored goods from huge aisles of goods using the exact location and sensing a bar-coded destination. Stocks can be reordered automatically and orders made up and packaged without human intervention.

Robots are not always mobile. The majority of cars are now manufactured using stationary automated welding and assembly robots.

In the 1990s, annual sales of industrial robots exceeded US$2 billion for the first time, with more than a million robots in daily use.

Software development and programming

Software has become more user-friendly too. The home user can now perform many tasks that needed dedicated specialists in the past, such as magazine and book publishing, movie editing and music composition. Software programs operate everything from bread-making machines to mobile phones.

Amateur programmers using object-oriented programming environments can write their own software. Multimedia authoring has become possible for primary age students. Everyone can now be a programmer.



Dorling Kindersley

Figure 5.12 In the first edition of this book, we included this image using the caption: 'A future not far away – Uncle Oscar's interactive computer pad is linked to the house's controlling computer by radio link. Here Oscar is reading his newspaper and has asked the intelligent assistance to look for football and traffic news. Each family member logs in to a separate customised screen on the pad.' How close has Apple's iPad come to our early vision of the future!

2003

Apple launches Apple® iTunes® online store



Apple.com

2005

Microsoft® Xbox 360® and Nintendo® Wii™



iStockphoto/Marius FM77

2007

Microsoft releases Vista

Apple releases the Apple® iPhone®



Getty Images/Gabriel Bouys

2009

Microsoft releases Windows 7



iStockphoto/Theasis

2010

Apple releases the Apple® iPad™



AP Via AAP/Marcio Jose Sanchez

2015

Apple releases Apple Watch



Apple.com

5.4 The impact of technology on the environment

The process of building computers affects our environment. Energy is used and greenhouse gases are produced. Each year, millions of empty laser cartridges and discarded computers are dumped in tips as landfill.

Disposal and recycling

At the present rate of chip development, and hardware and operating system improvements, a computer reaches its use-by date within four years. This is a lot of old hardware to dispose of.

Electronic computer equipment is a complicated assembly of more than 1000 items, many of which are highly toxic. The list includes chlorinated and brominated substances, toxic gases, toxic metals, photoactive and biologically active materials, acids, plastics and plastic additives, as well as lead and cadmium in computer circuit boards, lead oxide and barium in the monitors' cathode ray tubes, mercury in switches and flat screens, and brominated flame retardants on printed circuit boards, cables and plastic casings.

Of course, IT is used to find solutions to countless environmental problems. We would not know about the problem of the ozone layer and greenhouse gases if information technology had not been used to design, populate and query the databases and draw the charts from which we discovered there was a problem.

There is no reason why we cannot dispose of old equipment responsibly, recycle safely and manufacture new equipment with sensitivity to these environmental issues.

There are organisations that provide old equipment to developing countries. Some groups recycle old equipment as art. Responsible recyclers dismantle components and reclaim or recycle parts.

The design of the laser printer relies on the concept of a throwaway mechanism – the rollers, imaging drum and gears are replaced each time the toner runs out. Millions of spent cartridges end up in landfills each year. Yet most of these cartridges would continue to work well for four or five refills. Many companies exist that refurbish and refill old laser toner cartridges. Is the throwaway cartridge a good idea in environmental terms? It is certainly an easier approach than inviting a person to do on-site repairs, as we do for photocopiers.

Sadly, it is usually only at the end of technology life cycles that we admit for the first time that we should have acted sooner to reduce the impact on our environment. In some cases, we can never repair the damage we have done, as in the case of some nuclear waste products.



Figure 5.13 What does Leunig's cartoon suggest is a danger in our use of technology?

CASE STUDY

Where do computers go when they die?

Old computers never die – they just pollute our environment for a long time. Computer equipment becomes old very quickly. The life expectancy of a computer purchased today is only about three years.

How many old computers, monitors and printers are lying around your home? If the whole class was asked and the number of unused pieces of equipment totalled, what do you think the total would come to?

Every year, millions of old computers are buried in landfill and start immediately to pollute our soil as they contain hazardous wastes such as lead and other metals. Some companies offer recycling services. After the leaded glass is removed from monitors and melted down, the rest of the equipment is often sent overseas so that parts with value can be stripped.

However, although we may feel positive after recycling our equipment, often we have just shifted the pollution to another place on the globe.

In one Chinese town not far from Hong Kong, mountains of hardware arrive by truck, tractor and even bicycle. Because labour is cheap, the work of removing the wiring and separating the plastic from the metal components is done by hand.

The wiring removed during the day forms huge piles from which the insulation is removed simply by burning it through the night. This action produces ash loaded with dioxins and releases toxic compounds into the air, which become part of the air we breathe. Valueless parts are often dumped thoughtlessly. Old glass and plastic fill irrigation ditches and chemicals leach into rivers.

Microchips have metal pins with small amounts of gold plating and, in a process similar to the worst days of early gold mining, they are left to dissolve in vats of acid to collect tiny amounts of gold. Fumes fill the air and the residue is tipped as slurry onto the ground and pollutes groundwater.

Perhaps it would be preferable for us to fill our garages with old equipment rather than recycle it until better methods emerge. Maybe the real solution is for manufacturers to be given responsibility by governments for the proper disposal of their equipment after it becomes obsolete. Better still, they could be encouraged to build equipment with fewer hazardous materials.



Alamy/SCPhotos

Figure 5.14 Disposal of old computers and peripheral equipment involves solving the challenging issues of recycling and disposal of toxic wastes.

QUESTION

Select an IT device and describe ways in which a company manufacturing this item could take responsibility for what happens to such devices after they become obsolete.

ACTIVITIES

1. Identify the problems associated with the disposal of old computers.
2. Find companies on the Internet that are offering recycling of old toner cartridges. How many times can an average cartridge be recycled?
3. Identify an environmental issue from the past where disposal was a difficulty but was solved. Describe how it was solved.

Review questions

6 CORE People

Syllabus outcomes: 5.5.1, 5.5.3

Chapter outcomes

You will learn about:

- roles and responsibilities of people working in the information and software technology field
- careers in information and software technology.

You will learn to:

- examine the contributions of people working in the field of information and software technology
- explore career opportunities and pathways within the field of information and software technology.

Key terms

Computer forensics analyst
recovers data from computers and other digital devices in order to provide evidence of illegal or inappropriate activities

Computer scientist
designs and develops new hardware and software technology

Cyber security expert
develops ways of protecting data and computer systems connected to the Internet

E-learning designer
creates digital teaching and learning resources

Multimedia specialist
produces computer displays using text, graphics, video, animation and audio

Programmer
writes code used to create, update and maintain software packages

Project manager
manages a project in order to keep it on schedule and within budget

Software engineer
designs and develops software for operating systems and application programs

Support staff
provide assistance for people who have problems with their computer system

Systems analyst
designs and manages information systems in order to solve problems related to computer technology

Technician
installs, repairs and maintains computers, servers and other hardware devices

Training specialist
plans, coordinates and teaches a range of activities related to information and software technology

Website designer
designs, creates and maintains websites

IN ACTION

Computer forensics analysts

Information and software technology has brought many benefits to our lives but has also enabled people to devise new and more ingenious ways of committing crimes. Computer crime is one of the fastest growing areas of criminal activity throughout the world and this has created a demand for **computer forensics analysts** (CFAs). Computer criminals generally leave digital tracks, and it is the responsibility of a CFA to uncover and analyse them. However, this is not always a simple task. Anti-forensics applications are regularly used to hide or delete a data trail, and computer crimes often traverse many borders, requiring investigations that leap from server to server.

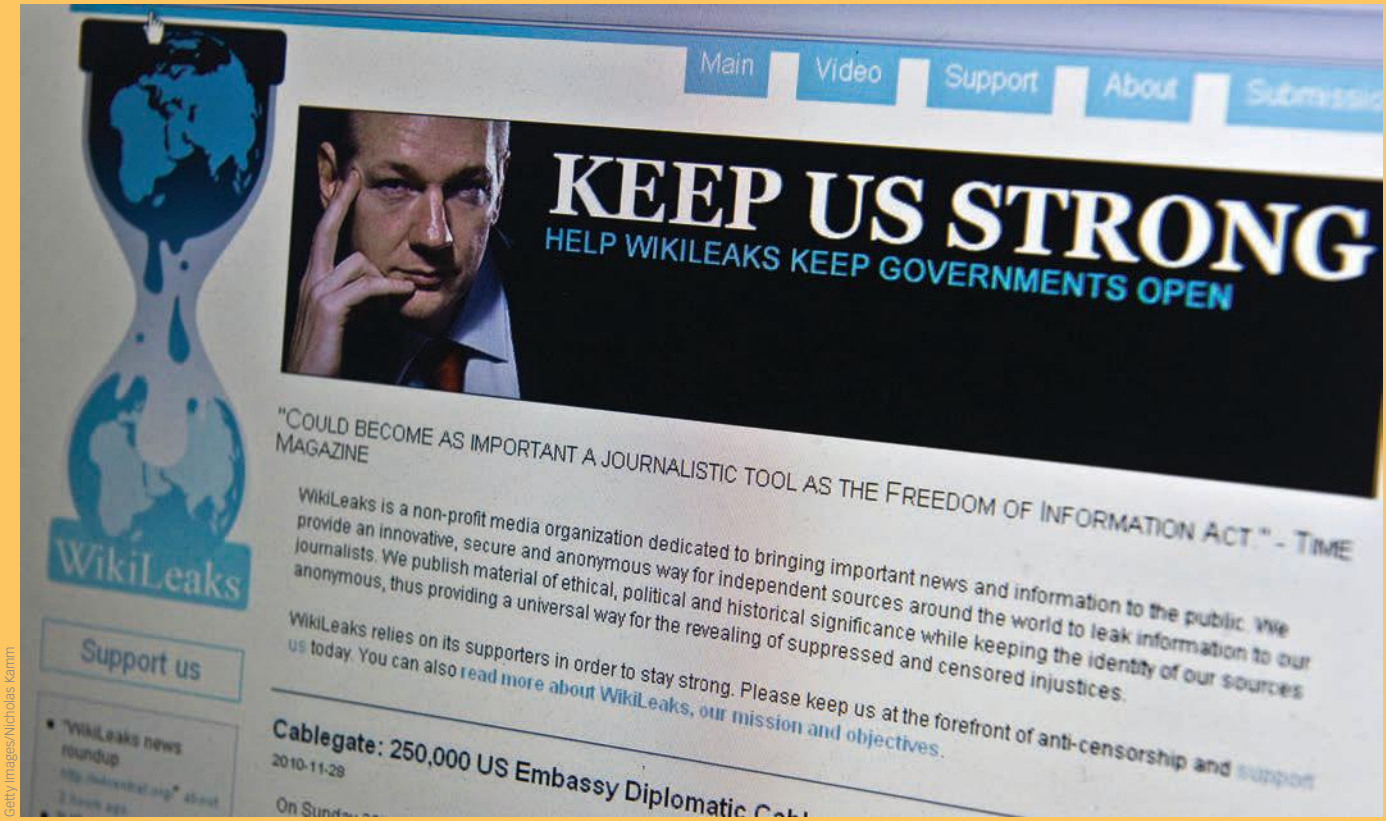
The highly complex world of computer forensics analysis requires deep technical expertise and knowledge in order to retrieve data from a range of electronic devices. Digital retrieval may involve a variety of sources, including social network postings, text messages, voice mail, illegally downloaded files and closed-circuit television (CCTV) footage. CFAs may be required to uncover evidence related to a range of digital crimes, including Internet piracy, identity theft, money laundering, sexual harassment and electronic stalking. They are also involved with 'traditional crimes'. A murder investigation, for example, may require an examination of a suspect's computer and mobile phone. Data will often need to be recovered from a device even if the user has deleted information or reformatted the hard disk. Other roles and responsibilities of a CFA may include:

- recovering data in the event of a hardware or software failure
- gathering evidence against an employee suspected of inappropriate use of technology facilities
- recovering passwords
- attending court to provide factual and expert evidence.

Remember, however, that computer forensics analysis is not always accurately portrayed in movies and television shows such as *CSI: Crime Scene Investigation*. Computer forensics analysis often requires painstaking patience, as it may take days, weeks or even months to perform a comprehensive analysis of a digital device.

QUESTIONS

1. Identify the reasons why digital tracks may be difficult to uncover.
2. List the computer crimes that may require the investigative services of a computer forensics analyst.
3. Research the meaning of cyber espionage and summarise a recent case of this type of computer crime.



Getty Images/Nicholas Kamm

Figure 6.1 WikiLeaks is an international non-profit organisation that publishes submissions of private, secret and classified media from anonymous news sources and news leaks. During a recent high-profile court case in the United States, government computer forensics analysts linked accused US Army leaker Chelsea Manning (born Bradley Manning) to documents published by WikiLeaks.

6.1 Roles and responsibilities

A career in information and software technology is obviously not for everyone, but for those interested in working in this area, there are many possibilities from which to choose. This core chapter provides an overview of the various roles and responsibilities of people who work in information and software technology.

Computer scientists and software engineers

Computer scientists design and develop hardware and software technologies. Specific tasks may include providing new approaches to security or devising improved methods for using computers in areas such as robotics, computer vision, medical research or digital forensics. Computer scientists generally require in-depth knowledge of the theoretical foundations of computer systems and the ability to construct and comprehend complex algorithms. These professionals have usually studied tertiary-level computer engineering, software engineering or computer science courses.

Computer programmers

A **programmer** writes the code used to create, update and maintain software packages. A programmer also assists systems analysts and project managers to determine the type of software a user or client needs. The programmer translates the solution into a programming language and must also test and debug the code to ensure it is error-free. These professionals have usually studied tertiary-level computer science.

Software engineers

Software engineers are involved in the design and development of software for operating systems and application programs. They use different programming languages, depending on the purpose of the program, and solve technical problems in existing software. A software engineer must be a licensed professional and will have usually studied tertiary-level software engineering courses.

Systems analysts

Systems analysts (also referred to as business analysts) play a critical role in the development and upgrading of information systems. The systems analyst's task is primarily to solve problems related to computer technology by designing and managing the development of information systems. Most analysts specialise in specific types of systems, such as accounting systems, financial systems or engineering systems. A systems analyst has usually studied tertiary-level business IT courses in information systems.

Bioinformatics

Massive amounts of information are being generated by discoveries in genetics and other biological technologies. The need for storing, extracting, organising, analysing, interpreting and using this data has led to growth in this professional field. These professionals have usually studied tertiary-level bioinformatics.

Cyber security experts

Understanding how systems may be penetrated and misused is a highly specialised skill possessed by only a small percentage of information technology professionals. A capacity to think 'outside the box' in terms of how a system's defences may be unravelled is a valuable asset for a **cyber security expert**, as is the ability to implement action when a security breach is uncovered.

Website designers

Designing and creating a website that stands out in a saturated digital environment requires an imaginative combination of graphic design skills and technical knowledge. Web servers, common coding languages, search engine optimisation and colour psychology are just some of the areas with which **website designers** should be familiar. In addition to building websites, designers may be required to liaise with clients and are often expected to maintain and ensure the continued functionality of websites. As the Internet evolves into a true 3D experience, users will increasingly interact with a web environment similar to today's video games. This is likely to result in an increasing demand for website designers who have both graphic design and programming skills.

E-learning and games designers

E-learning (electronic learning) designers use information and software technology to deliver education and training or entertainment products. There is still debate about how computers should be used effectively in an educational environment, but the demand for skilful and imaginative **e-learning designers** who can create engaging digital teaching and learning resources is likely to remain. These experts may have studied specialised tertiary courses in these fields.

Multimedia specialists

Multimedia specialists use text, graphics, video, animation and audio to produce engaging computer displays. They are often found working in the entertainment, marketing, education and communication industries. These experts may have studied interactive design or graphics design courses.

Project managers

The principles of good project management apply across every industry and can be applied to many tasks, from making a dress to constructing an aeroplane. The field of information and software technology includes projects such as the creation of websites, video games, hardware devices, computer networks and operating systems. A **project manager** is required to keep the process on schedule and within budget by providing clear communication about goals, responsibilities, performance and expectations.

IT support staff

Support staff provide assistance for people who are having problems with their computer system. Most large organisations have support staff or help desks. A help desk is a department within an organisation that responds to users' technical questions. Support staff should be able to recognise and interpret the meaning of common error codes. They also need to be able to fix general problems associated with the daily use of hardware. More specialised hardware tasks, such as the installation, repair and maintenance of computers, servers and other devices, are usually the responsibility of **technicians**.

Training specialists

The rapid spread of computers has placed more and more demands on people in terms of the technology skills they need to work, live and learn. **Training specialists** are educators who plan, coordinate and teach a range of activities related to information and software technology.



Alamy/Photos 12

Figure 6.2 Multimedia specialists may be involved in the creation of a range of products, including animated films, video games, satellite navigation systems, video clips, websites and mobile phone applications.

ACTIVITIES

1. Name four projects a project manager in the field of information and software technology may undertake.
2. Explain why the capacity to think 'outside the box' is a valuable asset for a security expert.
3. Contrast the roles and responsibilities of software engineers and programmers.
4. Describe the skills required by a website designer.
5. Use the Internet to research and describe an emerging technology career. You may wish to examine the following areas: 3D printing, cloud services and virtualisation, social media strategists, advanced robotics and automation, and intelligent e-personal assistants.



Shutterstock.com/Lauren Orr



Thinkstock/Volker Kreinacke

Figure 6.3 Project management has been around for a long time. The Egyptian pyramids and the Sydney Harbour Bridge could not have been completed without effective project management.

6.2 Careers in information and software technology

From the animations in popular films such as *The LEGO Movie* to advances in medical treatment and research, technology is embedded in almost every facet of the modern world. As our reliance on information and software technology increases, so does the demand for skilled information technology workers.

Career paths

As a result of the wide variety of career opportunities associated with information and software technology, it is difficult to make anything other than broad general statements about the qualifications and skills necessary for a career in the industry. Written and oral communication skills are very important, as is a solid all-round education. While technical abilities are obviously essential, interpersonal skills are often just as important.

During high school, work experience and vocational courses may prove valuable in determining whether or not you are suited to a career in information technology. Once you have finished high school, there are a number of education and training paths from which to choose, including technical colleges, universities and private institutions. Most courses are around five years in length. Keep in mind that some universities offer information technology scholarships. Internships and apprenticeships are also a worthwhile starting point for a career in information and software technology. They are often sourced via government departments or by contacting employers directly. Social networking websites may also provide valuable contacts in the IT job market. Often websites will have a 'career opportunities' section – and talking to someone already in the industry is a good idea too. Be prepared to adapt to new ideas and emerging trends.

It is very important to realise that many institutions offer personal applications and interviews, but do not always advertise these widely. If you develop a worthwhile portfolio of your secondary school work, it is possible to seek out an interview and not rely only on your aggregate in your final exams. Ask a number of institutions for their prospectuses.

INFOBIT

The information technology sector is one of the fastest growing areas in terms of self-employment opportunities. Self-employment allows people to have greater control of their own career. But it is probably not the right option for people who are not 'self-starters', want stability or who do not like regular change. Rapid technological advances and the dynamic nature of today's businesses mean that all information technology professionals will have to constantly update their skills.

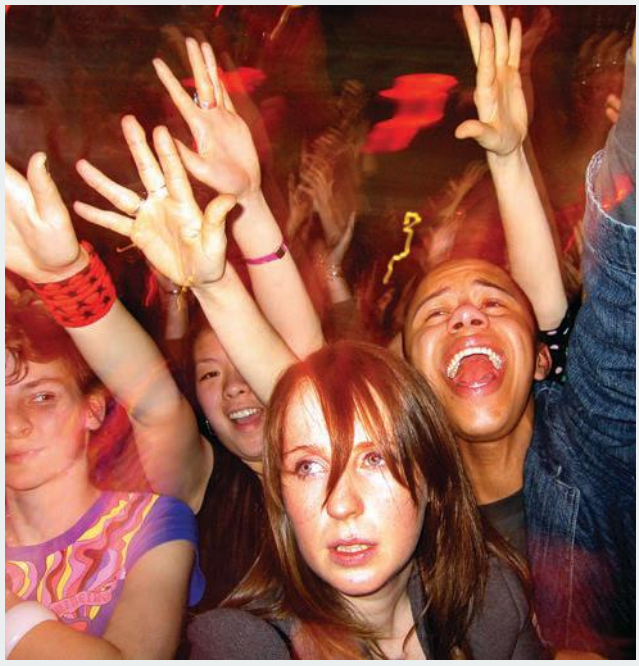


AAP/Paramount Pictures/Industrial Light & Magic

Figure 6.4 The computer-generated imagery animation in *Rango* was created by Industrial Light and Magic, the same visual effects company that created the visual effects for *Star Wars*.

CASE STUDY

Talent-spotting tweeters



Alamy/Caroline Contizo

Figure 6.5 A job in the A&R department of a record label is a highly sought after position. A&R scouts regularly attend live performances and are increasingly using technology in their quest for new talent.

In the music industry, A&R stands for 'artist and repertoire'. Recording companies generally have an A&R department that is responsible for finding new artists and signing them to their label. If you work in an A&R department, your job description includes listening to new music, visiting recording studios and attending live shows.

Technology is increasingly playing a part in this area of the music industry and the latest generation of A&R recruits has been creatively building a career with the help of social media. Tech-savvy A&R people attend gigs and blog about them. They also engage with music fans via social media such as Twitter, Instagram and Facebook, and promote new tunes on sites such as SoundCloud, Bandcamp, YouTube and Myspace.

Engaging on consumers' terms is a key focus for those seeking to uncover new talent in the music industry, and Internet-based applications such as Twitter are used to ask people for requests or their opinions about particular artists. A&R recruits can also Twitpic from gigs and engage with music lovers in real time instead of just publishing press releases. Rather than reading static content, fans can connect with the blogosphere to discover and support new music. Blogs are one of the most useful tools for an A&R department as they represent an up-to-date and primary source of information.

Specific qualifications are not required to work in the industry, so there is no reason why you can't make your mark in A&R without formal credentials. As with most areas in the music trade, establishing contacts with others in the industry is the best way to find a paid job. Social networks are one method of achieving this. A&R positions are rarely advertised, so you may be able to start by finding unpaid work as a talent spotter and moving into a paid position if a vacancy arises. Above all, you should have a passion for music and understand the current tastes of the market.

QUESTIONS

1. Summarise the job description of an A&R talent spotter.
2. Explain how A&R workers use technology as part of their job.
3. Research and describe the meaning of the term 'blogosphere'.
4. Discuss the advantages of blogs and social media services as a means of promoting and supporting new music.
5. A&R scouts are not usually considered part of the IT sector. Make a list of occupations that have not traditionally used computers but are becoming increasingly reliant on information technology.

ACTIVITIES

1. Citing examples, explain how society has become more reliant on information and software technology.
2. Apart from technical ability, identify the skills information technology employers may seek in a potential employee.
3. Research 10 information technology jobs advertised online; for example, on seek.com.au. Draw up a table, group these jobs into appropriate categories (for example, multimedia) and list their educational requirements and salaries.
4. Discuss the potential of social networking services to assist people pursuing a career in information technology.
5. Discuss the advantages and disadvantages of being a self-employed information and software technology worker.

Review questions

7 CORE Issues

Syllabus outcomes: 5.3.1, 5.3.2

Chapter outcomes

You will learn about:

- legal issues, such as copyright and piracy
- ethical issues, such as privacy and hacking
- social issues, such as the changing nature of work and enterprise
- industrial issues, such as ergonomic principles and industry standards.

You will learn to:

- examine legal issues as they apply to the development of information and software technology solutions
- identify the ethical responsibilities of software users and discuss issues of equity and inclusiveness
- identify rights and responsibilities of users of information and software technologies.

Key terms

Cloud computing
technology offering a range of applications via the Internet to perform tasks traditionally executed with software installed on an individual computer

Code of conduct
rules that set out standards of behaviour

Control
power to make decisions about who does and does not gain access to information and software technology

Copyright
ownership of intellectual property by its creator

Data accuracy
extent to which data is free of errors

Data bias
manipulation of data in order to present a one-sided view

Data security
protection of data from loss, wrongful access or modification

Equity and access
principle that all people should have equal access to the benefits that information and software technologies offer

Ergonomics
study of the relationship between machines and the people who use them

Hackers
people who deliberately intrude into computer systems without permission

Intellectual property
use of the mind to develop something new or original

Phishing
transmission of a seemingly legitimate email in an attempt to gather personal and financial information

Piracy
unauthorised copying of software

Privacy
right of an individual or group to keep their lives and personal affairs out of public view, or to exercise control over personal information

Telecommuting
working from home using modern technology to keep in touch with a place of employment

Webconferencing or videoconferencing
using Internet technologies to enable people in different locations to communicate via audio, video and text messages

Work health and safety (WHS) legislation
enacted workplace law that aims to protect the health, safety and welfare of people at work; previously known as occupational health and safety (OHS) legislation

IN ACTION

Social networking

Social networking has redefined the way we communicate with each other. Websites such as Facebook, Instagram, Snapchat and Twitter have changed society, simply because so many of us are living our lives online. Social networking services allow us to connect with others and share information such as photographs, videos and personal messages. Many sites allow users to create pages for a range of shared interests and, on the whole, social networking is regarded as a creative and enjoyable experience.

The increasing popularity of social media, however, has resulted in a more relaxed attitude towards privacy and many people seem willing to reveal intimate information online. Studies suggest that the majority of high school students say or do things online they would not want their parents or other adults to see. Provocative photographs, for example, as well as pictures showing drug and alcohol use, are casually published for the world to view. Although it may be fun to post a picture from a music festival or party, the consequences of such an everyday and seemingly harmless activity may be far-reaching. Some users have had job offers withdrawn after a potential employer viewed their Facebook page. Once something is uploaded, the task of removing it is more problematic than many people realise. Although the original post may be deleted, a copy of the image, video, audio or text may be stored on another computer or server. It may also have been printed or forwarded to others.

Given the prevalence of social networks, it is not surprising that there have been several high-profile breaches of security on sites such as Facebook. This has resulted in growing unease about a range of issues, including identity theft, cyber bullying, trolling and online stalking. These concerns may intensify with the increasing popularity of location-based services that allow users to broadcast their current geographical position.

QUESTIONS

1. Name the types of information social networks allow us to share.
2. Identify the advantages and disadvantages of social networking.
3. Why is the task of removing an online post more problematic than many people realise?
4. Investigate why so many smartphone apps request access to your location – even those that have nothing to do with maps or navigation.
5. Businesses and advertisers can already access enormous amounts of personal data on social media websites – from where you live to your interests and shopping habits. Sentiment analysis is now being used to mine online conversations for words and thoughts to be sold to advertisers. Discuss whether or not you consider this to be an ethical practice.



Shutterstock.com/Iwin Design

Figure 7.1 Generational change and the power of social media have dramatically altered notions of privacy. As personal data files expand, our lives are increasingly becoming public.

7.1 Legal issues

Those who develop software, like those who write poetry, compose music or paint pictures, have a right to control the production and reproduction of their work and to receive the benefits from their work. This right is called **copyright**.

Computer application copyright

All computer applications have copyright protection, but some software developers allow others to use their programs freely or within certain limitations. However, for commercial software programs, it might surprise you to learn that when you pay for the software you do not actually own it. What you have purchased is a licence to install it and use it on one or more devices.

In the field of information technology, copyright laws are used to legally license a range of software programs and, in doing so, protect the **intellectual property** of the people who have created them. Under Australian law, copyright generally lasts for 70 years after the death of the creator.

Piracy

The unauthorised copying of software is referred to as **piracy**. Most retail programs are licensed for one device or for one user at any time. Purchasing the software entitles the buyer to become a licensed user.

A licensed user is allowed to make copies of the program for backup purposes, but it is against the law to give copies to friends and colleagues. People who sell software that they have copied without authorisation are considered to be selling stolen goods.

Intellectual property

Most people agree that it is wrong to steal, and most agree that laws in our society that discourage theft of property are important. Yet many of the same people have difficulty applying those same principles to intellectual property – to the creative and innovative ideas that a person has worked on, perhaps for years of their life, and on which their income may depend. Intellectual property is a product of the mind that has commercial value.

Data security

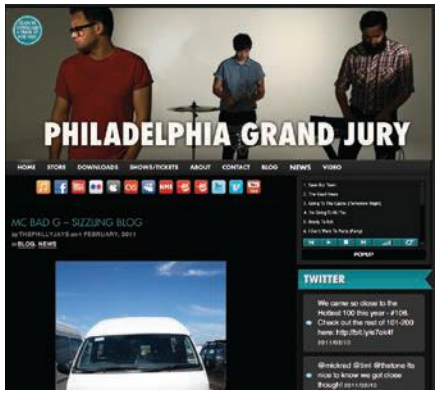
Data security refers to the protection of data from loss or modification. The loss of data can occur accidentally; for example, if a hard drive malfunctions, a file is mistakenly deleted or a laptop computer is misplaced. Other breaches of security may occur if you reveal a password to someone or leave a computer unattended while you are logged in to a password-protected account. People who deliberately intrude into computer systems without permission are referred to as **hackers**. Hackers are continually developing new attack tools and strategies to gain unauthorised access to systems, making it difficult for organisations to develop and implement effective data security procedures.

Security and protection

There are also laws designed to protect information systems and to prosecute people who commit computer crime. Examples of computer crime include identity theft, virus attacks, credit card fraud, phishing, spamming, denial-of-service attacks, and shopping and auction site fraud.



Philadelphia Grand Jury



Philly Jays website, Philadelphia Grand Jury, Anthony Tran



Philly Jays website, Philadelphia Grand Jury, Anthony Tran

Figure 7.2 Sharing music over the Internet violates the laws of many countries and, in some cases, persistent downloaders are prosecuted or have their Internet connections suspended. Many artists, including Australian band Philadelphia Grand Jury (pictured here), allow fans to legitimately download a selection of their music from the Internet.

Phishing is a major security issue involving the transmission of seemingly legitimate email in an attempt to gather personal and financial information from recipients. Typically, phishing involves sending emails asking Internet banking customers to follow a link to a fake website and enter their personal banking details. The number of reported cases of credit card and auction site fraud has increased dramatically in recent times, largely due to criminals embracing the Internet and transforming it into another area of criminality.

Legislation

We live in an environment that increasingly requires us to rely on computers. However, there are still many people who, due to lack of opportunity or sometimes as a result of unlawful discrimination or harassment, have limited opportunities for education and training in the field of information and software technology. The introduction of equal employment opportunity (EEO) legislation has gone some way to ensuring, for example, that women, Indigenous Australians and people with a disability are given the chance to gain employment and advance their careers. This means having workplace rules, policies, practices and behaviours that are fair and do not disadvantage people because they belong to particular groups.

Work health and safety (WHS) legislation is another legal safeguard for workers. WHS legislation aims to protect the health, safety and welfare of people at work by laying down general requirements that must be met at every workplace. In terms of information and software technology, this can include basic considerations such as ensuring employees are provided with the necessary training, instructions and supervision needed to work safely with computer equipment.

INFOBIT

Spear phishing targets specific individuals or small groups of employees in order to steal intellectual property or other sensitive data. The apparent source of the email is likely to be a trusted source, such as a company manager or a colleague.

ACTIVITIES

1. List four legal issues associated with developments in information and software technology.
2. Outline the licensing arrangements that apply to most software programs.
3. Identify five computer crimes related to security and protection of data.
4. Discuss the importance of equal employment opportunity legislation.
5. Investigate the landmark 2015 piracy case involving several Australian Internet service providers, including iiNet, and Dallas Buyers Club LLC. What was the outcome of this case and why was it so significant in terms of illegally downloaded videos?



Getty Images/Miguel S Salmeron

Figure 7.3 As a rule of thumb, if you receive an email message or phone call from any organisation asking for personal information, such as your bank account number and password, you should view it as a potential fraud attempt.



Figure 7.4 Anti-discrimination legislation is applicable in the workplace and aims to create an environment in which people are judged according to their abilities and not treated unfairly because of factors such as their age, marital status, race or disability.

7.2 Ethical issues

Ethics are the set of standards or moral principles that determine the behaviour of a person or a group of people. In the following section, some of the ethical issues associated with information and software technology are examined.

Codes of practice and conduct

Codes of practice and conduct are developed by business and industry groups in order to promote honesty and fairness in their dealings with the public and clients. A **code of conduct** is basically a set of rules that sets out standards of service to be provided and what can be done if these standards are not met. Such codes are not necessarily legally enforceable, but they are often used by an industry as a means of self-regulation. Codes of conduct apply to many areas, including banking, animal welfare, advertising and journalism. Most information and software technology industries have adopted codes of practice and conduct. The Internet Industry Association, for example, has a code that requires Internet service providers to take reasonable steps to ensure Internet access accounts are not provided to persons under the age of 18 years without the consent of a parent, teacher or other responsible adult.

Privacy and security

The terms **privacy** and 'security' are sometimes used to describe the same problem, but they are separate issues. Privacy may be described as the right of an individual or group to keep their lives and personal affairs out of public view, or to exercise control over personal information. In the past, discussions about privacy tended to focus on the protection of home and family life, but attitudes have changed with the ongoing development of information and software technology. Many people are now concerned about the ways in which governments or organisations use personal details such as their age, address, phone numbers and spending habits.

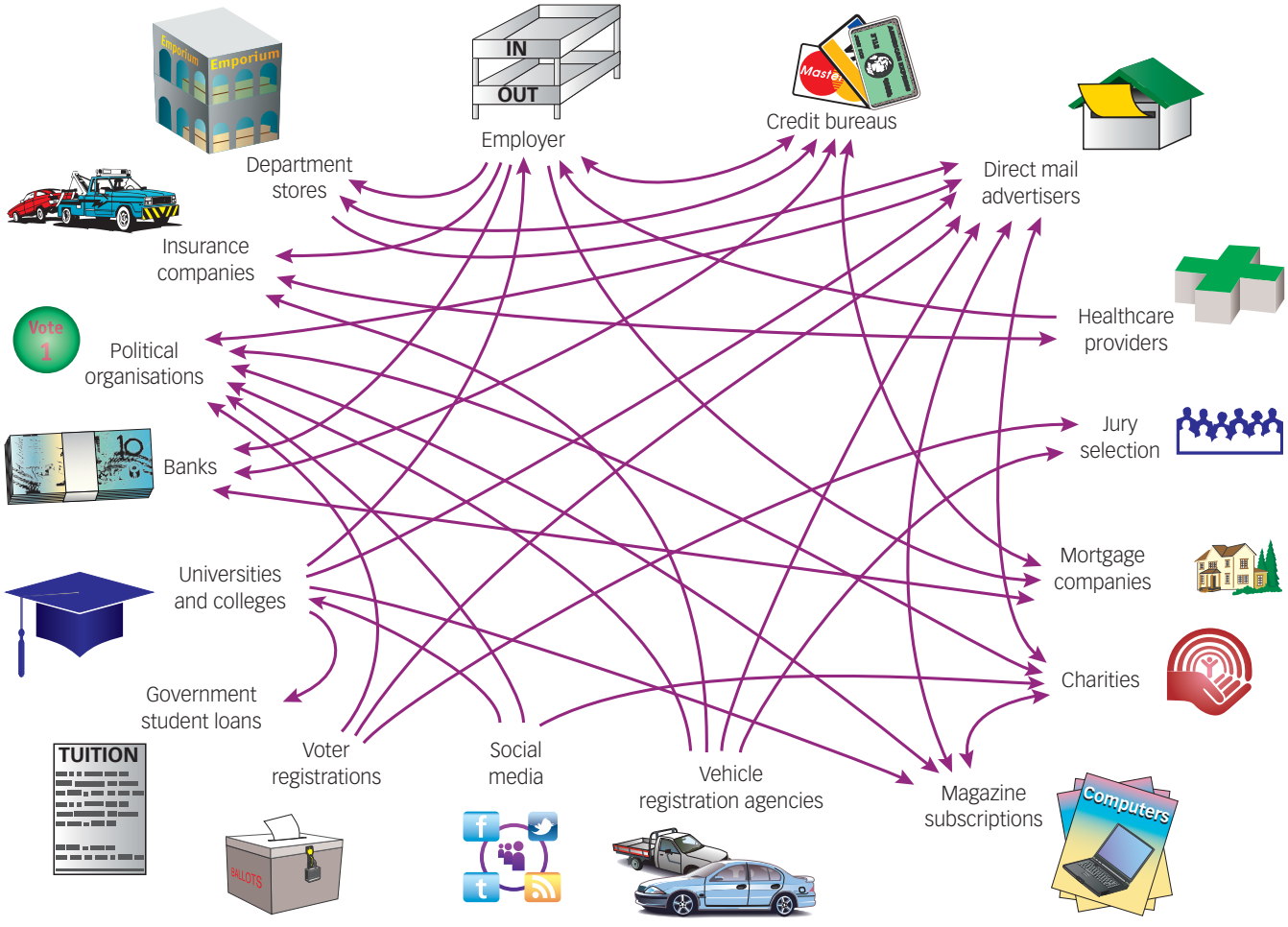


Figure 7.5 When an organisation acquires data about you, it is sometimes shared with, or sold to, other organisations.

Inappropriate usage

It is impossible to ensure that all users of information and software technology act responsibly. Personal integrity is an important part of your life as a student, and it will continue to play a major role in many of the personal and professional decisions you make outside school. Largely as a result of the Internet, there continues to be widespread concern about the inappropriate use of information and software technology. Examples of inappropriate software use include using email or a social networking site to bully a classmate or circulate offensive material.



Figure 7.6 According to recent research, more than half of Australian workers spend approximately 30 minutes per day using information technology in a manner that could be considered inappropriate.

Accuracy, validity and bias of data

Other ethical issues that need to be considered in relation to information and software technology include the accuracy, validity and bias of data. **Data accuracy** simply refers to the extent to which data is free of errors. Inaccurate data is usually a mistake, but sometimes the mistake is deliberately made. It is not always possible to know whether or not data is accurate. Digital photographs, for example, can easily be altered, leaving little or no evidence of their unreliability.

Most problems with accuracy arise from incorrect data entry using a keyboard. There are many ways to improve the accuracy of data entry. Software programs can check for spelling mistakes or reject an entry that has the wrong number of characters. See chapter 10: Database design for more information on data accuracy.

Data can also be manipulated in order to present a one-sided view of a particular situation. Sometimes poor collection techniques can result in skewed results. This is known as **data bias**. The chart and graph facilities of spreadsheet programs, for example, can easily present trends and relationships that, on closer examination, favour one point of view at the expense of another. Consider a situation where a company displays a graph showing increased revenue, but deliberately avoids showing a graph of increased expenses.

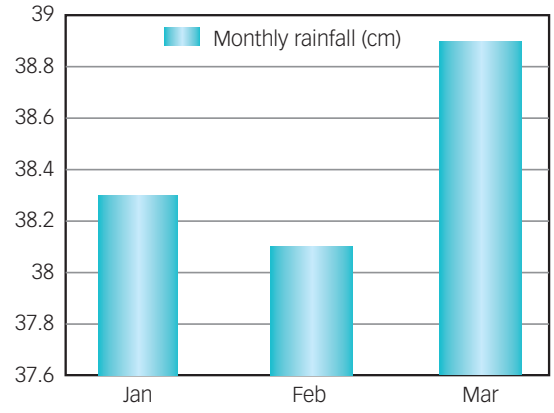


Figure 7.7 The graph above could be considered biased as it exaggerates the difference between March and the other two months. It appears as though March had drastically more rainfall compared with January and February. However, March's rainfall is less than one centimetre more than the other two months. The vertical axis does not begin at zero.

INFOBIT

Statistical data is most valid when it is collected from a large, representative population. The larger the sample size, the better. Bias in polling can happen when survey respondents do not represent the entire population. Researchers may reach a conclusion in advance and then create the sample audience that provides the preferred results.

ACTIVITIES

1. Discuss the importance of industry codes of conduct.
2. Explain the difference between data security and privacy.
3. Describe three ways in which data may be lost.
4. Identify two examples of inappropriate use of software.
5. Define cyber bullying and suggest a strategy that could make it less of a common or harmful occurrence among teenagers.
6. Create a digital presentation that addresses a legal or ethical issue related to information and software technology. (You do not have to limit yourself to those mentioned above.) Keep in mind the following considerations when creating your presentation:
   - Who is your target audience?
   - Why is this issue worth researching?
   - Are there any recent news items that you can refer to in the presentation?
   - Have you or anyone you know been directly impacted by the issue?
7. Using an online quiz tool such as Kahoots.it, create an issues quiz for your classmates.

7.3 Social issues

Information and software technology has altered the nature of work and enterprise to the extent that most jobs in the developed world now involve computers. What will society be like as we rely more and more on computers and automated systems rather than interacting with people?

Many new jobs have been created because of the development of information and software technology; for example, database administrators, social media managers and web designers. However, some jobs have been made redundant as a result of new technology. Travel agents, for example, have been significantly affected by technology. Many people now prefer to research and book their own travel plans online without the assistance of a travel agent.

Employment trends

Employment trends, such as **telecommuting**, **webconferencing or videoconferencing** and the introduction of the virtual office have changed the nature of work and enterprise. Telecommuting involves working from home, using modern technology to keep in touch with your place of employment. Jobs can be relocated to places where it is more comfortable, more convenient or less expensive to live. Many people are able to work, learn and study whenever and wherever they want, and the emergence of a range of new tools – particularly cloud-based services – has eased many of the logistical challenges posed by telecommuting and online collaboration.

Cloud computing

Cloud computing allows users to access a range of applications via the Internet to perform tasks traditionally carried out with software installed on an individual computer. See figure 7.8.

Telecommuting

Some of the benefits of telecommuting for employers include the reduction of office running costs and the removal of travel-related problems that may lead to the late arrival of employees. Employee benefits include the flexibility to work around family and personal needs, as well as the elimination of the time, costs and stress associated with travelling to and from work.

It is important to consider the potential negative impacts of telecommuting. There is less opportunity, for example, to meet people and share ideas. Webconferencing also raises the issue of loss of personal contact. Webconferencing uses Internet technologies to enable people in different locations to communicate via audio, video and text messages. It is considered relatively inexpensive to set up – particularly when compared to the travel expenses associated with face-to-face meetings.



Figure 7.8 Rather than using local servers or personal devices to handle applications such as word processors and spreadsheets, cloud computing delivers applications through a browser that can be accessed anywhere in the world.

Virtual offices

Another development in the workplace with cost-saving potential is the virtual office. Technology allows workers in many



REXwireless, http://www.blackberryinsight.com/2009/04/09/rex-connect-for-blackberry/

Figure 7.9 There is a range of software applications that allow virtual office workers to communicate with each other and organise their working day.

industries to perform their duties from almost anywhere. The available choices for communicating while on the go include smartphones, tablets, laptops and a range of other devices and services allowing remote access. Wireless networks are also increasingly available wherever people congregate.

Rights of access

Equity and access refers to the principle that all people should have equal rights and access to the benefits that information and software technologies offer. **Control** refers to the power to make decisions about who does and does not gain access to information and software technology. Unfortunately, not all people benefit from information and software technology. Quite often, those on lower incomes are unable to purchase technology or learn how to use it. Others have difficulty gaining access due to a disability or because they live in an isolated community. Access and participation can be difficult for some groups who, for one reason or another, are excluded from the information society, or perceive that they are left out. For example, the elderly are sometimes reluctant to become involved in information and software technology due to lack of confidence.

The nature of our society

Computers benefit society in many ways, including creating technology jobs, enhancing vehicle safety, predicting climate change and improving medical research. We can now more easily connect with people thanks to online collaborative workspaces, social networking applications, mobile devices and Internet telephone services. However, it is feared the ease of electronic communication may lead to weaker social ties because people are less inclined to leave their homes and actually interact face to face with others. Constant computer use may cause us to place more emotional value on events taking place online as opposed to what is actually happening in our real lives. Some features of information and software technology, such as round-the-clock Internet access and the isolated nature of its use, may affect modern society in ways that may not be fully understood for quite some time.

Industrial issues

Industrial issues often focus on the importance of safe and healthy workplaces. Most organisations use information technology and they are required to provide safe computing facilities for staff, customers and others who interact with their equipment. Personnel using information technology also have a duty of care to ensure that they work in a manner that is not harmful to their own health and safety and the health and safety of others.

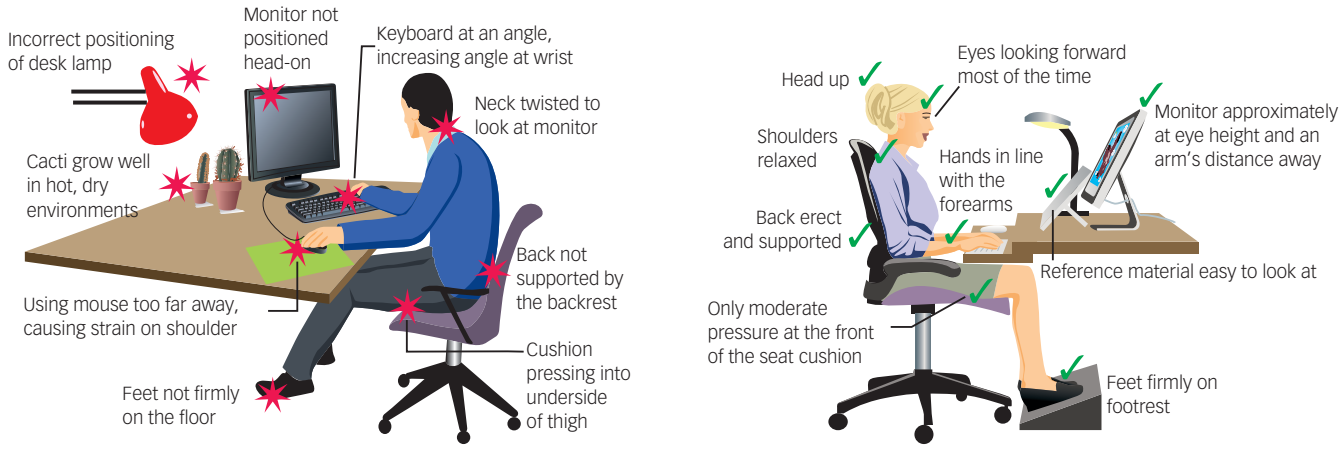


Figure 7.10 Ergonomics is the study of the relationship between machines and the people who use them. In the workplace, this includes the design of furniture and computer components such as the keyboard and mouse.

ACTIVITIES

1. Summarise the changes to the nature of work that have occurred due to advances in technology.
2. Information and software technology is more likely to have changed someone's work rather than eliminating it completely. List three occupations that have been affected by technology.
3. 'Those who have regular access to information and software technology are more likely to advance, while those who do not may find themselves marginalised.' Do you agree with this statement?
4. 'Constant computer use may cause us to place more emotional value on events taking place online as opposed to what is actually happening in our real lives.' Discuss whether or not you agree with this statement.
5. Present a report on the industrial issues related to the information and software technology sector. Pay particular attention to ergonomics and the rights and responsibilities of people who regularly use information technology.

Review questions

OPTION 8 Artificial intelligence, simulation and modelling

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- the meaning of artificial intelligence, simulation and modelling
- the application of artificial intelligence, simulation and modelling
- the hardware and software required for artificial intelligence, simulation and modelling
- the advantages and limitations of simulation and modelling programs
- the use of simulation and modelling programs.

You will learn to:

- define and describe artificial intelligence, simulation and modelling
- investigate the work of artificial intelligence pioneers
- identify and examine a range of intelligent systems and simulations
- design, create and evaluate a simple simulation
- use spreadsheets to make predictions
- propose advantages and limitations of simulation and modelling programs.

Key terms

Artificial intelligence
ability of computers to imitate human behaviour and thought processes

Artificial intelligence system
computer system that receives data through an input device to produce an intelligent response

Biometrics
study of measurable biological characteristics

Computer model
electronic representation of an object or idea

Expert
possesses specialised skill, experience and knowledge and the ability to apply this knowledge to resolve problems efficiently

Expert system
computer program that contains stored knowledge and solves problems in a specific field

Gesture recognition
emerging technology that enables computers to understand human body language

Goal seek
function of spreadsheets that is used when the desired output of a calculation is known, but the input value is not

Knowledge base
centralised repository for information

Model
simpler version of a real-world object or idea

Neural networks
branch of artificial intelligence modelled on the processes used by the human brain, where a database's accuracy improves through trial and error

Simulation
imitation of real-life occurrences in order to test a model

Simulator
hardware device that artificially imitates the conditions likely to be encountered in a particular activity

Spreadsheet
program that uses rows and columns to organise and store data requiring calculation

IN ACTION

Intelligent cars

Modern societies rely heavily on mobility. Yet transport entails a range of problems, including traffic accidents and congestion of road networks and urban areas as well as harmful effects on the environment. Imagine a world where vehicles rarely crash, where congestion is drastically reduced and where your car is energy-efficient and pollutes less.

The car manufacturing industry is using artificial intelligence in an attempt to bring this vision to fruition. Australian car maker Holden, for example, has helped style the future of intelligent motoring by designing an innovative two-wheel, pod-like vehicle that can drive itself. The Xiao (see figure 8.1) is a concept car constructed from carbon fibre and powered by electric motors in each wheel. These cars can be recharged using a conventional household power outlet and can search the electricity grid to find out the most suitable off-peak time to recharge. The Xiao can carry two passengers with a range of at least 40 kilometres on each electric charge. Using drive-by-wire technology, the electric motors not only power the car but act as brakes.

Car manufacturers are gradually moving away from traditional elements of motor vehicle design to develop new themes and intelligent technologies. As the intelligent features in cars improve, they will reduce the number of motor vehicle accidents and hopefully help meet the many transport challenges associated with growing populations around the world.

Technologies that will soon be available to motorists include vehicle-to-vehicle communications and distance-sensing systems that will allow cars to be driven by the occupant or by an on-board computer system. Traffic sign recognition is currently in development and will eventually enable vehicles to identify and respond to traffic signs such as 'dangerous bend' or 'school zone'.

Many 'smart' devices can already be found in cars and other vehicles. Navigation systems help reduce road congestion by automatically selecting the fastest route based on real-time traffic information. Sensors and camera systems have improved pedestrian safety, particularly when vehicles are reversing. Other safety features include lateral support systems that provide lane departure alerts and warning systems for sleepy drivers. The Intelligent Parking Assist System (IPAS) allows a car to guide itself into a parking space with little input from the driver.

It is important to remember, however, that intelligent cars are intended to assist drivers – not replace them!

QUESTIONS

1. How may intelligent cars such as the Xiao help to reduce modern transport problems?
2. Identify the technologies that will soon be available to motorists.
3. Identify the intelligent vehicle features that are already available to motorists.
4. Investigate Google's self-driving car and explain how it operates without a steering wheel, accelerator or brake pedal.
5. Consider a situation where an intelligent parking system malfunctions and, as a result, you reverse into another parked car. Who should be responsible, you or the car manufacturer?



AAP/PR Handout Image

Figure 8.1 The embedded artificial intelligence in this smart car allows drivers to communicate with other vehicles and automatically avoid traffic jams and crashes.

8.1 Artificial intelligence

In the 1960s, some people in the computer industry were predicting that machines would be smarter than humans by the 1980s. They theorised that artificially intelligent computers would be building cities on Mars, driving buses, answering complex philosophical questions and solving diplomatic crises.

What is intelligence?

There is no strict definition of intelligence because there is no straightforward way to measure it. Intelligence can include the ability to:

- reason
- acquire and use knowledge
- perceive ideas
- manipulate objects.

In general terms, intelligence can be described as a person's capacity for understanding.

What is artificial intelligence?

Artificial intelligence (AI) refers to the ability of computers to imitate human behaviour and thought processes. However, this is not a strict definition. Our measure of artificial intelligence is based on perception and this makes it a difficult term to define. For example, if a computer can match or even beat the best chess player in the world, does that mean it is intelligent? Or does it just appear to be intelligent?

Weak and strong artificial intelligence

Artificial intelligence is often divided into two classes: weak artificial intelligence and strong artificial intelligence. Weak artificial intelligence makes the simple claim that some 'thinking-like' features can be added to computers to make them more useful tools. Weak artificial intelligence is based on the notion that if a machine appears intelligent, then it is intelligent. Strong artificial intelligence makes the bolder claim that computers can be made to think on a level at least equal to humans. It asserts that a computer should be able to compete intellectually with human beings on every level, and possibly even surpass us in mental dexterity. This is the kind of artificial intelligence portrayed in movies such as *Transcendence* and *The Matrix*.

There are some who believe that computers will eventually be aware of their own existence and understand that they are machines. Today's computer technology is nowhere near this level of artificial intelligence. In fact, after over half a century of development, **artificial intelligence systems** have left us with more questions than answers. The problems encountered so far have driven home to scientists just how complex humans are and how difficult it is to simulate even our most basic reasoning and thought processes. Most researchers now concede that it could be many years before the development of artificially intelligent machines that think or reason in the complete human sense of the word. Nevertheless, researchers keep making advances in these areas.

INFOBIT

In the 1968 film *2001: A Space Odyssey*, a machine called HAL proves its innate intelligence by fooling a human into thinking that he is speaking to one of his own kind. The movie, and the book it was based on, anticipated the development of artificial intelligence.

Historical perspectives

CORE ALERT Past, current and emerging technologies

The history of artificial intelligence has had cycles of success and misplaced optimism. As the designer of the first programmable mechanical computing machines, Charles Babbage was arguably the earliest worker in the area of artificial intelligence. Babbage was a nineteenth-century English mathematician whose Difference Engine was a special-purpose machine for computing numbers and was the forerunner of his Analytical Engine.

The Analytical Engine, designed but not successfully constructed during his lifetime (due to lack of funding), was a general-purpose programmable computing machine built on principles that anticipated modern electronic computers. Perhaps the most striking feature of Babbage's work was his treatment of the pattern of an intellectual activity as something that could be studied and then represented mechanically.

It is generally acknowledged that the first significant female figure in the field of computing was Ada King (nee Byron), Countess of Lovelace (1815–52), who overcame Charles Babbage's inability to communicate his ideas by

translating an Italian account of his Analytical Engine into English. She then added her own notes based on her knowledge of Babbage's work and created a program for the Analytical Engine, thus making her the first computer programmer and technical writer.

INFOBIT

The Greek philosopher Aristotle (384–322 BCE) believed that certain propositions can be said to be true because they are related to other things that are known to be true. This logical argument forms the basis of artificial intelligence.

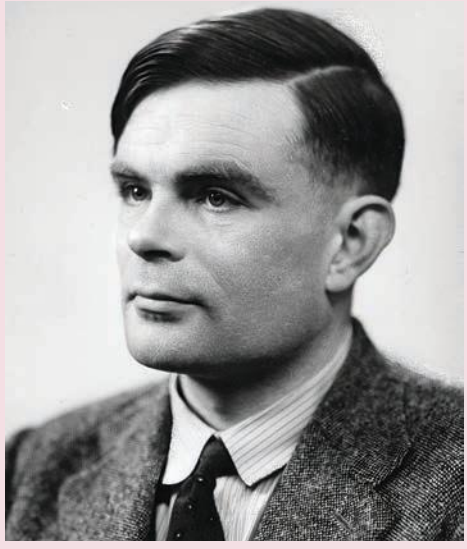
PEOPLE

CORE ALERT People

Alan Turing

In 1956, a computer scientist called John McCarthy coined the term 'artificial intelligence'. Alan Turing (1912–54), however, is considered by many to be the founder of computer science and the person who launched the field of artificial intelligence. Turing was a British mathematician who is widely regarded as one of the most important thinkers in the history of computing.

During the Second World War, he worked at Bletchley Park, the United Kingdom's code-breaking centre. There he played a vital role in deciphering the messages encrypted by the German Enigma machine, which helped to turn the tide of the war. After the war he worked at a number of institutions, including the University of Manchester, where he was a member of the team that developed the Manchester Mark 1, one of the first recognisable modern computers.



Science Photo Library

Figure 8.2 Alan Turing is credited with laying the foundations for computer science and artificial intelligence.

In 1950, Turing proposed the idea of a test in which a person uses a keyboard to ask questions of two subjects – a person and a machine – who are concealed from the questioner. Turing felt that if the questioner could not determine which of the two subjects was a machine, then the machine could be considered intelligent. Turing's contributions to computer science and early artificial intelligence extend well beyond the Turing test, but his proposal was crucial in that it suggested the possibility of imitating human thought by using computation.

QUESTIONS

1. Who coined the term 'artificial intelligence'?
2. Outline why Alan Turing is considered to be one of the most important thinkers in computing history.
3. Describe the Turing test and explain its significance.
4. Alan Turing is perhaps best known for a machine he invented during the Second World War. Find out the name of this machine and explain its significance.
5. In 2010, after thousands of people came together to demand justice for Alan Turing, British Prime Minister Gordon Brown made a posthumous apology to the computer pioneer for the 'appalling' and 'utterly unfair' treatment he received. Research and explain the reason for this apology. You might like to watch *The Imitation Game*, a film about Alan Turing, released in 2014.

ACTIVITIES

Identify

1. Define and describe artificial intelligence.
2. Why is intelligence difficult to define?
3. List three abilities that could be used to describe intelligence.
4. Who is considered to be the first significant female figure in the field of computing?
5. Identify the contributions Charles Babbage made to computing and artificial intelligence.

Analyse

6. Explain the difference between weak and strong artificial intelligence.
7. Discuss the likelihood of computers reaching a 'state of consciousness'.

Investigate

8. Evaluate the contributions of some of the other people who played a significant role in the development of artificial intelligence.

8.2 Areas of artificial intelligence

An intelligent system can be defined as a computer system that receives data through an input device such as a keyboard, microphone, camera, touchscreen or other sensing device to produce an intelligent response. One of the aims for artificial intelligence is to make computers more useful. Despite their limitations, artificial intelligence systems are considered one of the most exciting fields of computer development. If you have used telephone directory assistance, for example, you have been a user of an artificial intelligence system.

Games

After an explosion of research and development funded largely by software giants, computer games became one of the most widely available examples of intelligent systems. Many companies are designing artificial intelligence games that can match players' abilities by altering tactics and strategies. If you have played a video game released in the past year or so, you have probably encountered artificial intelligence and sensed interaction with a semi-intelligent creature on the other side of the screen. These games are delivered using sophisticated artificial intelligence programs that guide the decisions of the characters and simulate their responses. The creators of artificial intelligence games say that even they can't predict exactly how their characters will react in a given situation.

INFOBIT

It is not just televisions and video cameras that are going 3D – AI games are joining the trend too.



Alamy/Gallo Images

Figure 8.3 A contest at the University of Copenhagen in Denmark encourages students to design artificial intelligence to help make Nintendo's classic Super Mario Bros. game less predictable and more engaging.

Knowledge bases

A **knowledge base** is a centralised repository for information that may contain technical information and solutions relating to a particular product or system. Creating a knowledge base in a computer is not unlike creating knowledge for an individual. We all learn from personal experience and from the knowledge of others. For example, most people know that if you touch a hotplate when it is on, you may get burnt. We know that fish live in water. This type of knowledge is a part of our knowledge base.

An online knowledge base can save an organisation money by reducing the amount of employee time spent trying to locate work-related information.

Some other advantages of online knowledge bases are:

- cheaper distribution and easier maintenance of information
- availability of up-to-date information, any time, from anywhere in the world
- searchable information, making access faster than referring to a manual.



Word Help

Figure 8.4 The help files in most computer application programs can be described as knowledge bases. If you want to find out how to format a table in a word processing document, for example, you can use the Help menu to display a list of instructions from its knowledge base.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

Gesture-based games

Gesture recognition is an emerging technology that enables computers to understand human body language. The current generation of games allows users to intuitively play the game without the use of hand-held controllers. Gesture-based video games use motion-sensing technology designed to read facial expressions or analyse posture and body movements.

The underlying concept is that people should be able to use natural body actions and hand gestures, rather than clicking buttons or dragging mouse pointers across screens. So you might play soccer, for example, by kicking your leg rather than clicking a button on a handset or swinging a controller. Or you could drive in a racing game by holding out your hands as if you were gripping a steering wheel. You may also be able to turn up the volume in a game by making a thumbs-up sign or interact with it via spoken commands.

Nintendo popularised the idea of gesture-based gaming with the Wii console, which allows people to swing remote controls and balance on boards to control their digital avatars. With the latest gesture-recognition consoles, including Xbox One with Kinect, it is not completely beyond the realms of possibility that if the game senses you lounging about on the couch for too long it might just decide to ramp up the difficulty level from casual to hardcore!



Getty Images/Craig Barritt

Figure 8.5 Gesture recognition technology allows users to play games without a controller or joystick.

QUESTIONS

1. Define 'gesture recognition' as it applies to gaming.
2. Identify the underlying concept of gesture-based gaming.
3. Identify how the current generation of games allows users to play intuitively.
4. List three examples of how a person may interact with a gesture-based gaming system.
5. Research the term 'motion-sensing technology'. List some of the other areas where this technology can be found.

Daemons

Daemons (or demons) are intelligent processes that run in the background of computer programs and attend to various tasks without human intervention. The term comes from Greek mythology, where daemons were guardian spirits.

Typical computer daemons include print spoolers and email handlers. You have possibly noticed the words 'mailer daemon' in the header of an email message. If an email is incorrectly addressed, a mailer daemon can generate an automated message to the sender stating that the message was undeliverable. The daemon performs this task without the user having to start the program.

Agents

Agents are similar to daemons but tend to perform tasks on behalf of a particular user, as opposed to initiating processes that operate system-wide. There are agents used by online shopping sites that retrieve information about a buyer's spending habits. Also known as shopping bots, they display products or services based on previous transactions. An online bookstore, for example, may display a list of books by a particular author to a customer who has previously purchased other titles by the same author.



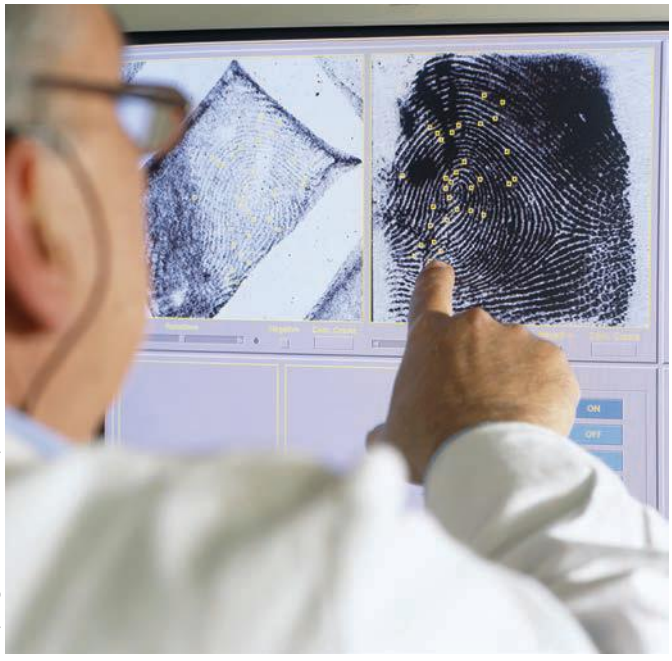
Author-created screenshot

Figure 8.6 Web crawler software can be classified in the same area of artificial intelligence as agents and daemons. Developers of search engines such as Google are constantly trying to find more efficient ways of using web crawlers to locate relevant information on the World Wide Web.

Expert systems

An **expert** is a person who possesses specialised skill, experience and knowledge, along with the ability to apply this knowledge, using tricks, shortcuts and rules of thumb to resolve problems efficiently. Experts are not always available at the right place at the right time, and some jobs are so specialised there are a limited number of people who can perform them. For example, if an organisation has employees with specialised skills, problems may arise if they become ill or take a holiday.

There are artificial intelligence systems that can provide expert information to decision makers when a human expert is not available. These systems are known as **expert systems**. An expert system is a computer program that contains stored knowledge and solves problems in a specific field, such as medical diagnosis, financial investment or agriculture. An expert system could, for example, be one of the most useful tools for providing farmers with the day-to-day specialist soil and weather information needed to grow their crops in the most efficient way. See page 172 for further explanation of expert systems.



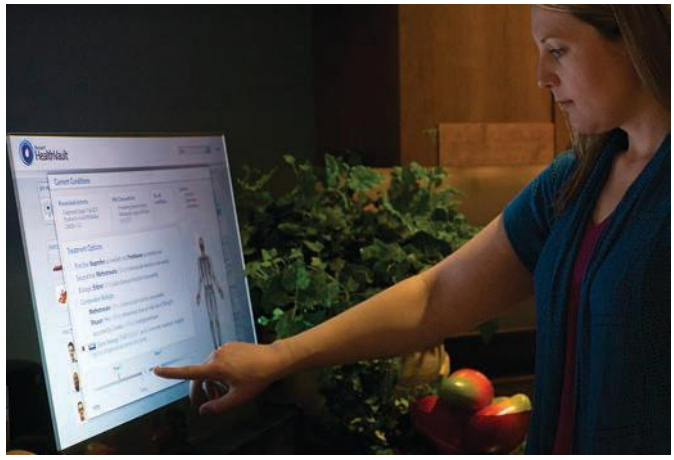
Getty Images/Science Photo Library

Figure 8.7 Fingerprint expert systems are able to quickly compare millions of fingerprints. By using such systems, police can make important decisions about matches without having to consult a fingerprint expert.

Medical expert systems

Medical expert systems are perhaps the most impressive and valuable expert systems. Some of the specific tasks they perform include:

- detecting blood infections
- identifying tumours
- diagnosing heart disease.



Microsoft Corporation

Figure 8.8 Artificial intelligence software is now used to assist doctors in diagnosis of conditions and selection of treatments.

Traffic navigation expert systems

Expert systems and the Internet are now being used in some cities to help people cope with the complex and frustrating problem of traffic congestion. Personalised routing services can advise drivers on the best way to get to their destination and how long the journey is likely to take. The system accesses traffic information from roadway sensors, and bases its recommendations on real-time data. Real-time data is immediate, up to the second, because the data is recorded at the same time the events are occurring.

The system also uses historical data to predict how traffic conditions will change by the time the driver is expected to arrive.



Shutterstock.com/Maxx Studio

Figure 8.9 Satellite navigation (satnav) devices are geographical expert systems. In a traffic navigation expert system, a user simply enters a starting point and destination. The expert system then sorts through vast amounts of traffic data and possible routes to provide efficient and clear directions. The latest navigation devices include traffic and accident updates.

Neural networks

Neural networks, also called artificial neural networks (ANN), are designed to solve problems in a manner similar to the way the human brain works. One of the purposes of neural networks is to learn to recognise patterns in data. Once a neural network has been trained on samples of data, it can make predictions by detecting similar patterns in future data. Credit card fraud and speech recognition are two common areas where neural network technologies are applied.



Figure 8.10 Google Flu Trends uses neural network technology to estimate occurrences of influenza around the world. There appears to be a close relationship between how many people search the Internet for flu-related topics and how many people actually have flu symptoms. Of course, not every person who searches for 'flu' is actually sick, but pattern recognition allows health experts to quickly detect an influenza outbreak and initiate measures that may reduce the number of people affected.

INFOBIT

With the aid of neural networks, scientists are developing intelligent machines that are in tune with humans. The most advanced robots can now respond to the finest of human gestures, like a blink of an eye or a small smile, and respond accordingly.

Credit card fraud

Artificial neural networks are more adept than humans at determining complex patterns. Credit card providers, telephone companies, banks and government departments all employ artificial intelligence systems to detect fraud and to process financial transactions more quickly. Neural networks are used to detect unusual patterns that suggest credit fraud, and take the appropriate action – such as disabling a credit card. By studying the habits of credit card users, their pattern recognition systems develop a keen eye for unusual or illegal behaviour.

Speech recognition systems

Speech or voice recognition is the field of artificial intelligence concerned with computer systems that can recognise spoken words. Recent advances in neural networks and speech technology have led to a whole new range of systems that are considered to be very reliable. Speech recognition systems can authenticate voice characteristics, enabling vehicle drivers to play music without removing their hands from the steering wheel. Many satellite navigation systems are also fitted with voice recognition software. You can simply talk to your navigator and it can plot a route for you. A spin-off application of speech recognition is voice-to-text (VTT) software, where the spoken word is immediately translated into text on a screen. VTT offers a whole new level of support for education. This technology can be particularly helpful for students with disabilities who may not possess the physical skills for handwriting or typing. There are many smartphone and tablet apps that can recognise speech and convert the spoken word into text.

INFOBIT

Early speech recognition software could not understand female voices because the underlying technology was based on recognising the lower tonal range of the male voice.

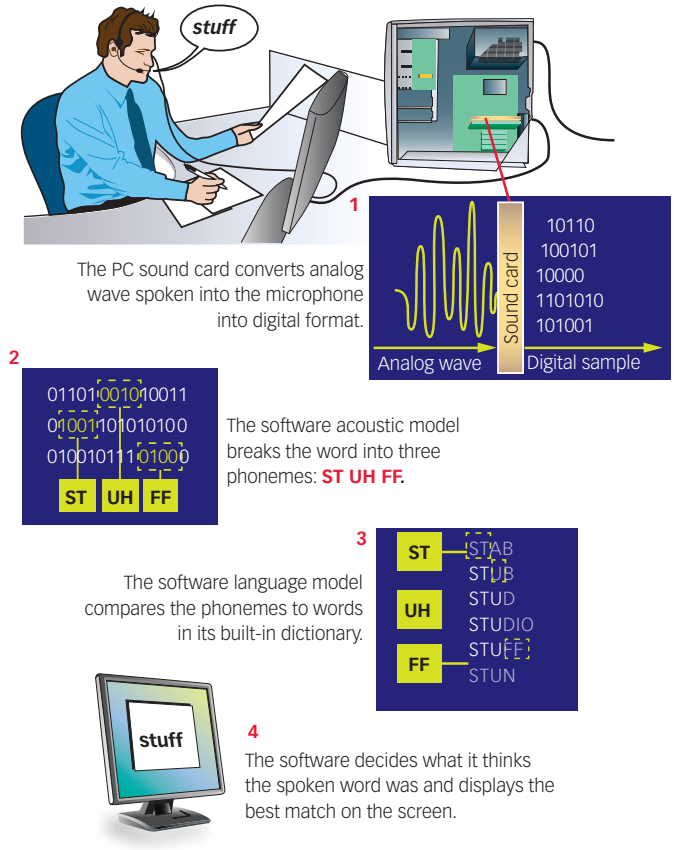


Figure 8.11 To convert speech to on-screen text or a computer command, a computer has to go through several complex steps.

CORE ALERT Issues

Facial recognition

The study of measurable biological characteristics is known as **biometrics**. In computing terms, biometrics refers to the identification of people using their biological attributes. Apart from speech recognition, biometric techniques include fingerprint and retina scanning, iris pattern matching and facial recognition.

In Australia, the New South Wales Government has compiled a biometric map of almost every adult's face, sharing information that allows law enforcement to track people by closed-circuit television (CCTV). The facial recognition system is designed to prevent people who have had their licence suspended or cancelled from obtaining a replacement. People applying for a driver's licence or photo card have their photo matched against the entire Roads and Traffic Authority (RTA) database.

Privacy experts believe that few people realise their facial features are being recorded in the RTA database. The federal body CrimTrac has asked the New South Wales Government for its database so it can be mined nationally by police using the facial recognition information it contains.

University experts in facial recognition believe the accuracy rate for facial recognition systems to be as low as 90 per cent, meaning the names of people with faces sharing a similar structure to criminals could be incorrectly returned in searches. Some privacy experts believe police want to eventually use facial recognition in smart CCTV cameras, allowing people to be tracked anywhere there is a camera.

Many airports now use facial recognition technology to give eligible travellers the option to self-process through passport control.

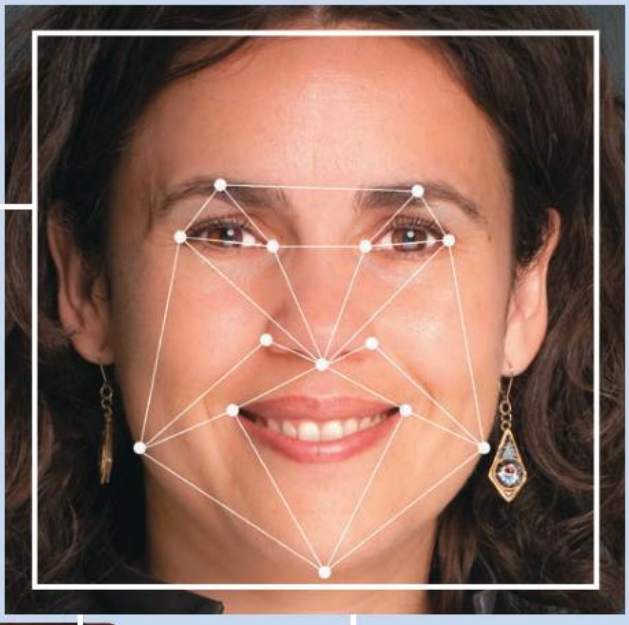
Facial recognition uses an algorithm – a mathematical process – to produce a 'matrix of numbers' that can be matched against a database.

Different algorithms use various measurement points; for example, the distance between various facial features, such as the eyes and cheeks.

Experts say the matching is 90–100 per cent accurate if pictures being compared are clear and lighting and other variables are the same.

A computer picks out facial features, skin tone, moles and other marks and assigns them a number based on where they are on a person's face.

The pupils are used to centre the image. The process is similar to plotting a map and calculating the various measurements.



Shutterstock.com/Franck Boston; AAP/Lefteris Pitarakis; Shutterstock.com/Mindscape studio



The federal government body CrimTrac wants a database of drivers' licence photos and passport photos to use for facial recognition to track criminals.

The Road Traffic Authority already has 15 million people in its system and began facial recognition in December [2009].

Images are also being provided to the police. The United States is also using the technology to track known criminals via CCTV and is looking at possible uses at border crossings. In the United Kingdom, where CCTV cameras are legion, there have been attempts to use facial recognition technology to scan crowds.



QUESTIONS

1. Define the term 'biometrics'.
2. Identify three biometric techniques that are mentioned in the case study.
3. Explain the purpose of the facial recognition system described in the case study.
4. Outline the advantages and disadvantages associated with the New South Wales facial recognition database.
5. 'The needs of society as a whole are more important than individual concerns about privacy.' Discuss this statement in relation to the New South Wales facial recognition database.

Figure 8.12 Facial recognition technology measures the distance between a person's eyes, nose and mouth and then matches that data against other images.

Computer vision

Computer vision refers to the science and technology of machines that have the ability to extract information from an image in order to perform a particular task. Biometrics is not the only application of computer vision. As mentioned at the beginning of the chapter, computer vision also allows vehicles to steer themselves. Computer vision is a relatively new field of study but it has already been applied to a diverse range of areas, including:

- gesture-based gaming
- image restoration
- 3D modelling
- missile guidance
- surgical navigation
- character recognition
- motion analysis
- augmented reality.

Artificial intelligence technologies have played a significant role in many of these computer vision developments. Researchers believe computer vision will become more and more prevalent in modern society. Some supermarkets in the United States, for example, are already using vision technologies to assess customers' responses to a particular product or object.

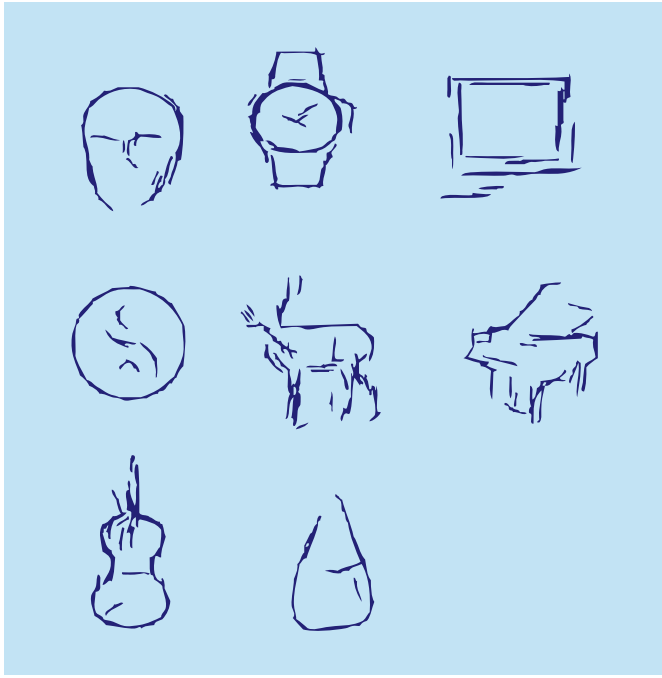


Figure 8.13 A computer vision program developed by the Massachusetts Institute of Technology uses a process of elimination to identify objects. Unlike other object-recognition programs, it does not need to be trained to look for specific features such as a nose or a mouth. It trains itself and, piece by piece, identifies everyday objects, resulting in line drawings that resemble an artist's sketch.

ACTIVITIES

Identify

1. Provide a definition of an intelligent system.
2. Outline the reasons why automated telephone directory assistance may be categorised as an intelligent system.
3. Identify one of the early aims of artificial intelligence developers.
4. Summarise the tasks involved in the development of an expert system.
5. Outline some of the services carried out by expert systems.
6. Name an educational benefit of using voice-to-text software.
7. Identify one of the early problems with speech recognition software.
8. List three applications of computer vision.

Analyse

9. Describe the characteristics of artificial intelligence games.
10. Discuss the advantages of online knowledge bases.
11. Discuss the similarities between daemons and agents.
12. Discuss the purpose of traffic navigation systems and explain the way they operate.
13. How are neural networks used to monitor financial transactions? Discuss the reasons why financial monitoring systems came into existence.
14. Why does a real-time traffic navigation system rely on the Internet?

Investigate

15. Wolfgang von Kempelen, a Hungarian engineer, built the first mechanical chess player in 1760. This amazing 'intelligent system' defeated internationally renowned players and earned Kempelen almost legendary fame. Investigate the secret behind the machine's success and how it managed to win 200 out of 300 games.
16. Use the Internet to locate five different types of expert systems. Explain their purpose and identify the type of expert needed to provide the knowledge for each system.
17. Expert systems have no 'common sense'. They can make absurd errors, such as prescribing an obviously incorrect dosage of a drug for a patient whose weight and age are entered into the system incorrectly. Outline some of the limitations of the expert systems you examined in the previous question.
18. Present a short report on how computer vision technologies are used to create effects for the film and television industries. You may wish to search for the terms 'camera tracking' or 'matchmoving'.

8.3 Requirements of artificial intelligence

Artificial intelligence systems require software that will enable them to make logical decisions and deliver intelligent responses to the inputs they receive. Computer systems often solve problems with the use of standard algorithms that manipulate data such as numbers. Artificial intelligence software is often less conventional and may be designed to execute tasks in a manner that more closely resembles human logic and intuition.



New Scientist – I, Phone © Andy Potts

Figure 8.14 App, an abbreviation of 'application', is just another word for a computer program, but the term has come to be associated with software that can be downloaded to smartphones to augment their abilities in new and artificially intelligent ways.

Games

There is a range of programming applications and languages that are used to make computer games more complex, engaging and intelligent. The real goal of software in AI games is to simulate intelligent behaviour, providing realistic, unpredictable challenges that players can overcome. Earlier generations of computer games use relatively simple programming that makes them predictable and allows many players to adopt a winning routine. Pac-Man, for example, deploys four ghosts that seemingly chase the player. Each ghost is programmed using a simple set of rules. One ghost always turns left, another always turns right, one turns in a random direction, and the last turns towards the player. As a group, the pattern of their movement appears to be complex. Individually, however, the movements of the ghosts are easily predicted, and savvy players are able to avoid them.

The latest generation of computer games uses adaptive artificial intelligence in order to display seemingly unscripted behaviour. Characters in the games exhibit new ways of responding to their world, and display strategies and behaviours not necessarily planned by the designers.

Expert systems

Expert systems contain knowledge bases that allow users to generate fast and consistent advice relating to a variety of problems. This knowledge is stored in an expert system 'shell'. Expert systems are shells in the same way that **spreadsheets** and word processors are shells. They provide the means to carry out a certain task but do not have any information or data of their own.

The most popular way of representing the knowledge in an expert system is by using rules, usually referred to as if–then rules. If–then rules are intended to reflect the 'rules of thumb' that experts use in their day-to-day work and help determine the action to take in an expert system. A working expert system can potentially contain tens of thousands of such rules. A knowledge engineer creates the if–then rules and is the person who is largely responsible for building an expert system.

To clarify these rules, imagine we have set out to build an expert system to help us with household repairs. Here are two if–then rules that have been designed after consulting a plumbing expert.

Rule 1:

- IF tap is leaky AND
- IF leak is in the handle
- THEN tighten washer nut. (Conclusion)

Rule 2:

- IF washer nut is tight AND
- IF leak persists
- THEN replace washer. (Conclusion)

The conclusions, to tighten the washer nut or to replace the washer, are made by the expert system's inference engine. The main function of an inference engine is to make a recommendation for the user.

TASK 1

Create an expert system

Step 1: Download an expert system shell, such as ES-Builder.

Step 2: Use the if–then rules in the table below to create a system that will help identify different types of birds.

Rule 1	Rule 2	Rule 3	Rule 4
IF animal is bird AND IF animal not flies AND IF animal swims AND IF animal is black and white THEN animal is penguin	IF animal is bird AND IF animal not flies AND IF animal has long neck THEN animal is emu	IF animal is bird AND IF animal flies AND IF animal flies long distances AND IF animal has webbed feet AND IF animal has hooked beak THEN animal is albatross	IF animal is bird AND IF animal flies AND IF animal quacks AND IF animal has webbed feet AND IF animal has flat beak THEN animal is duck

Neural networks

Artificial neural network software is intended to simulate the way the brain works. As information comes into a neural network, the software is able to recognise patterns and, for example, identify unusual financial transactions. Consider a scenario where a credit card holder's spending habits are analysed. A person may spend an average of $300 on a credit card during any given week. If the same person suddenly spends over $10 000 in two days, the algorithms within the neural network are designed to identify this apparent anomaly in the pattern and indicate potential fraudulent activity. It would then be up to the user of the neural network (maybe an employee from a bank or a credit card company) to make a decision on whether or not to investigate the pattern deviation.



Copyright 1996–2015 Ziff Davis, LLC

Figure 8.15 Most computer gamers are familiar with constantly escalating hardware demands of the latest games. Graphics cards are important for the performance and look of a computer game, as they determine the number of frames per second (frame rate) your system can display.

Hardware

CORE ALERT Hardware

Artificial intelligence systems generally require powerful processors to quickly execute complex tasks. Voice recognition systems require large hard disks for data storage. Modern computers have multiple processing cores (or computing brains), allowing games to respond to your actions almost instantaneously. High-resolution monitors heighten the effect of the graphics and animations in computer games. Other hardware required for computer games includes consoles and controllers.

ACTIVITIES

Identify

1. How many if–then rules might an expert system typically contain?
2. Identify the main function of an inference engine in an expert system.
3. Identify the person who is largely responsible for building an expert system.
4. Identify the part of the human body that neural networks are designed to simulate.

Analyse

5. Provide an explanation of the term 'rules of thumb'.
6. Explain the importance of pattern recognition in detecting financial fraud.
7. Why do voice recognition systems require large hard disks?
8. Why are high-resolution monitors important for artificial intelligence games?

Investigate

9. Investigate the use of image recognition and neural network technology to recommend holiday destinations.
10. A chat bot is a computer program designed to interact conversationally with humans. Use an Internet search engine to locate an example of a chat bot. Conduct an online conversation and discuss whether or not you think you are interacting with intelligent software.

8.4 Modelling and simulations

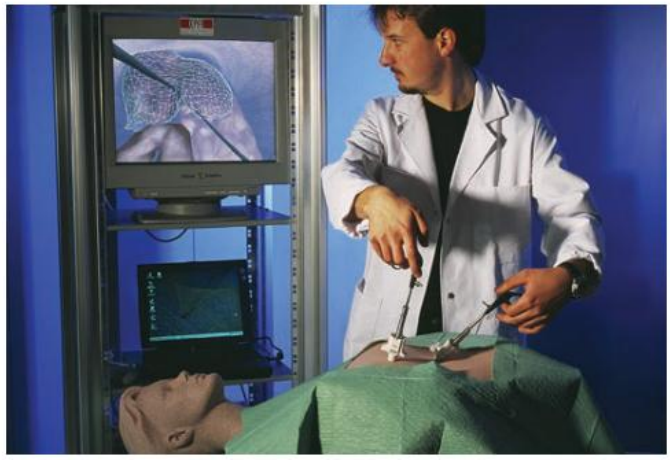
Computer models and **simulations** are used in diverse areas to help us gain a better understanding of the world in which we live. Will climate change increase the number and severity of cyclones in northern Australia? Is there likely to be another global financial crisis? Computer simulations and models help us make predictions and gain insights into natural, human and technological systems that would not be possible using traditional non-computerised methods.

What is a model?

A **model** is a simpler version of a real-world object or idea. A model can be relatively simple, like a model aeroplane, or something more complicated, like a model of the Earth's climate. Modelling (creating a model) is a basic and common human activity, and from an early age many people learn to represent objects as a model. As well as being a fun and enjoyable pursuit, building a model enables you to gain a better understanding of the object in question.

What is a computer model?

A computer model can generally be described as an electronic imitation or copy of an object or idea. Computers can be used to create models of all sorts of things, including cars, buildings, aeroplanes, hair dryers, personal budgets, bowling balls and kitchens. They have become an important tool in areas such as business, science, entertainment and education.



Science Photo Library/Pascal Goetgheluck

Figure 8.17 Simulation devices are used to train surgeons and other medical professionals.



Designing and engineering: Computer models are used to design, build and test a range of structures, including bridges.



Weather forecasting: The enormous improvements in weather forecasting over the past 30 years are due to sophisticated models and simulations as well as the expertise of meteorologists. The Australian Bureau of Meteorology uses models and simulations to produce regular weather reports and to predict unusual events such as cyclones.



Training and education: Medical simulations are used for virtual exploration of the human body and real-time interactive training programs for medical devices and surgical procedures.



Entertainment: Simulation games are often used for entertainment, but are also created for the purposes of decision making, exploration or education.

Figure 8.16 Models and simulations are used in a range of areas.

What is simulation?

Simulation is the process of imitating real-life occurrences in order to test a model. A computer simulation, therefore, generally tests a computer model.

Testing the computer model of a house to see what would happen to it in an earthquake is an example of a computer simulation. Testing the structure of a computer-generated model of a bridge by running a computer-generated train over it is another example.

Purposes of models and simulations

The main purpose of a model is to allow us to establish an understanding of an object or an idea. The main purpose of a simulation is to test a model in order to predict how the real object or idea will react under different conditions.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

A model of the brain

Our increasing knowledge about the brain's building blocks is bringing us closer to the ultimate neurology experiment: building one. The Blue Brain Project is one effort to create an in situ brain, using software instead of proteins in a supercomputer called Blue Gene to model the brain of a two-week-old rat. It does so by creating a 3D computer model of neurons in the neocortex (the 'intelligent' sector of the brain) where scientists can simulate the sizes, shapes, densities and receptiveness of different neurons and watch their behaviour under certain conditions.

The goal of the Blue Brain Project is to model the brain's response behaviour down to the nanolevel. If we've programmed the way each neuron operates, we can impose specific conditions such as injuries or diseases that will tell us how a biological brain will behave without risk to a living patient.

This interconnectedness is also the secret to that elusive quality we call intelligence. Older scientific understanding might have convinced us to try to replicate the brain by creating a super-driver, but a better approach could be found via the linking of a huge number of simple, low-powered processors. According to author Jeff Stibel, 'a brain is really a massive composition of mini-brains or hives. There's no such thing as a central decision-maker in the brain; intelligence emerges from complex parallel processing of information'.

If we can perfect the mechanism to generate the required hundreds of millions of computations in a simulated brain, the mental commands we know as decisions, emotions or thoughts might arise as spontaneously and magically in it as they do in us.

The applications of brain modelling could transform neuroscience. We can already model chemicals – most of you did so in Year 7 science. If we have a virtual mock-up of how they interact at the synaptic level, it would let us design better treatment for a huge range of conditions, from depression to stroke.



Shutterstock.com/Jeff Cameron Colling

Figure 8.18 The applications of brain modelling could have far-reaching health benefits.

QUESTIONS

1. According to the case study, what is the ultimate neurology experiment?
2. Identify the neuron characteristics that scientists can simulate using Blue Gene's 3D model.
3. Identify the goal of the Blue Brain Project.
4. 'There's no such thing as a central decision-maker in the brain.' Explain this statement.
5. Discuss the benefits that may be derived from the Blue Brain Project if it is successful.

Sydney Morning Herald/Drew Turney, 9 June 2010. This work has been licensed by Copyright Agency Limited (CAL). Except as permitted by the Copyright Act, you must not re-use this work without the permission of the copyright owner or CAL.

ACTIVITIES

Identify

1. Identify the benefits of creating a model.
2. Identify the main purpose of a model.
3. Provide a definition of simulation.

Analyse

4. Explain how simulation is used in the design of structures such as houses and bridges.
5. Explain the relationship between a model and a simulation.

Investigate

6. Investigate the purpose of models and simulations in one of the following areas: pollution, coastal erosion, population growth, vehicle safety.
7. Research and provide a definition of emulation.

8.5 Requirements of models and simulations

Computer modelling is similar to building a model out of scrap materials. The main differences are the materials – using software and hardware rather than detergent bottles, toilet-roll tubes and cereal packets.

Hardware

CORE ALERT Hardware

Generating and processing graphics for modelling and simulation systems involves considerable processing time. Modelling and simulation systems therefore require hardware that is capable of very fast processing. Modelling and simulation programs are most suited to computers that have many processors that can work parallel to each other.

Parallel processing involves the linking of two or more processing units within the one computer. If we consider a processor to be comparable to the human brain, then parallel processing simply provides a computer with more 'thinking power'. Of course, there are many modelling and simulation programs that will operate on a standard desktop computer with just one central processing unit, but the more complex programs, particularly those that have a large graphical component, will require significantly more processing power. A large amount of memory space is also important in order to store the demanding data types – such as graphics, audio and video – required for realistic computer models and simulations.

Simulators

A **simulator** is a hardware device that artificially imitates the conditions likely to be encountered in a particular activity. Our lives are full of primitive simulators. Rocking horses, for example, simulate the feeling of riding a horse for young children.

Simulations are often applied to dangerous, historical or time-consuming activities. In theory, any situation that can be reduced to mathematical data can be simulated on a computer. In practice, however, simulations can be extremely difficult to program. A tsunami, for example, involves so many natural and unpredictable elements that it is difficult to precisely define and simulate its interrelationships.

INFOBIT

Computer simulation training is widely used to prepare people for disasters such as bushfires, earthquakes, chemical spills and terrorist attacks. The simulations allow users to practise their emergency skills in a safe, controlled environment.



Alamy/Tom Wood

Figure 8.19 Vehicle simulators allow researchers to study behaviour under conditions in which it may be illegal, dangerous or unethical to place drivers. Studying a driver who is over the legal alcohol limit, for example, would be much more complicated and hazardous without simulators.

Flight simulation demands a great deal from computer hardware. A flight simulator generally consists of four hardware components:

- a working replica of the interior of the cockpit of an aircraft
- computers
- projectors
- screens.

The replica has all the usual instruments and is mounted in such a way that it can be moved to simulate the rolling, pitching and other motions of an aircraft. The instrument readings, the position of the simulator, information about the characteristics of the aircraft being simulated, weather conditions and details about the terrain over which it is supposed to be flying are coordinated by a powerful computer so that the student experiences everything except the acceleration of actual flight.



Getty Images/Bloomberg

Figure 8.20 Pilots train with simulators to learn how to operate commercial jets without risking passengers' lives.

Software

CORE ALERT Software

Modelling and simulation programs are specifically designed to allow the user to create models and then test the models in a simulated environment. This type of software often relies on very complex programming in order to simulate realistic scenarios in real time. In a car simulator, for example, if a corner is taken too quickly, the driver is instantly thrown sideways, feels the corresponding return forces in the steering wheel and hears the squealing of the tyres.

INFOBIT

The Swiss Federal Institute of Technology in Zurich intends to build a Living Earth Simulator that would aim to model both Earth and the details of its societies in detail by 2022. At the cost of about $1.3 billion, the simulator will track everything from financial transactions to individual travel itineraries, from medical records to carbon dioxide emissions.

ACTIVITIES

Identify

1. How does parallel processing provide a computer with more 'thinking power'?
2. Why do more complex simulation programs require significantly more memory space than simpler versions you may find on a standard desktop computer?
3. What is a simulator?
4. Identify the types of situations where simulators are often applied.
5. Explain the difficulties associated with simulation.
6. List four components of a flight simulator.

Analyse

7. Compare two hardware devices that are used to collect images for simulators.
8. Why do car simulators tend to use full-sized automobiles whereas flight simulators rely on a replica of a cockpit?

Investigate

9. Investigate what other types of simulators are used for training and education. Describe the advantages of these simulators.
10. Morton Heilig was a pioneer of virtual-reality arcade games. He believed films could simulate the human senses of sight, sound, scent and touch. His research led to Sensorama, an arcade attraction he designed and patented in 1962. Investigate Sensorama and describe the experience it simulated.

8.6 Advantages and limitations of models and simulations

While the increasing capabilities of hardware and software have improved the accuracy of modelling and simulations, they should not be regarded as perfect. Computer models and simulations represent an approximation of a real-world object or idea – they are not infallible.

Climate models

Climate models are the best tools we have for projecting the future climate. The mathematical equations used in climate models are based on well-established laws of physics, such as conservation of mass, energy and momentum. The design of new models will help researchers understand how climate change may have an impact on droughts, floods, cyclones and other disastrous weather events. If emissions from burning fossil fuels continue unabated, for example, it is feared extremely high temperature and humidity levels could make much of the world essentially uninhabitable for human beings.

Climate models use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface and ice. They are used for a variety of reasons, but their main purpose is to represent current and past climates, as well as observed climate changes.

INFOBIT

There are two major questions concerning climate models – can they accurately reproduce the past and can they successfully predict the future?



Alamy/Ian Pilbeam

Figure 8.22 Computer-generated climate models and simulations promise to significantly improve our ability to predict long-range climate trends and to tackle a wide spectrum of other environmental challenges, including rising sea levels.

Reliability

Despite their importance, climate models are not considered to be totally reliable when it comes to predicting climate change. Given the complexity of the global climate system, it is not surprising that there are some discrepancies between the climate changes simulated by models and actual observations. Weather models and simulations must simplify a very complex climate system.



Nasa

Figure 8.21 Climate models attempt to reproduce and predict the ways in which climate behaves from day to day, from season to season and from year to year. For example, scientists use computer models to predict how the loss of sea ice in the Arctic will affect the Earth's temperatures.

There will continue to be a limit to the extent that climate can be predicted, largely due to the limited existing understanding of the climate system and to the limited capabilities of computers to simulate all key climate factors. Climate models and simulations must therefore be used with care and their results interpreted with these considerations in mind.

Training and education

One of the main advantages of modelling and simulation programs is their ability to allow users to model dangerous situations safely. Consider the advantages of flight simulators:

- various flying conditions can be presented to the pilot safely; for example, poor weather or night flying
- emergency situations can be simulated without danger; for example, frozen runways, fog or engine failure
- landing procedures at different airports can be simulated safely
- the reactions of the people in the simulators can be watched closely, and new tasks can be set for them in real time
- no fuel is needed and there is no risk to aircraft or crew of fire or explosion.

However, it is important to remember that, while computer models can accurately represent real-world objects and situations, they are not perfect. As is the case for a physical model, the success of a computer model depends on the level of understanding of its designer and the capabilities of the computer equipment used. A computer simulation can never compare to the real thing. You can never fully account for the human factor. For example, a pilot's reactions in front of a computer may differ from those that occur during a real-life crisis, and it is difficult to design simulation software to cover every eventuality, such as extreme and unexpected conditions.



Thinkstock/Paul Brennan

Figure 8.23 Have you ever taken a ride on a roller-coaster and wondered how such a thrilling and sometimes frightening experience can be enjoyed safely? A model designed by an architect or engineer is where it all begins.

ACTIVITIES

Identify

1. Why should computer models and simulations not be regarded as perfect?
2. What are climate models?
3. Identify the data required to produce an accurate weather forecast.
4. List four advantages of flight simulator programs.
5. List three reasons why there will always be a limit to the extent that climate can be predicted.

Analyse

6. Discuss the reasons why a computer simulation can never compare to the real thing.
7. 'You can never fully account for the human factor.' Discuss the significance of this statement in relation to modelling and simulation.

Investigate

8. There are those who argue that because climate models are not completely accurate, we can ignore their predictions. Investigate and evaluate this argument in light of some of the predictions that have been made regarding climate change.
9. Motor manufacturers have for some time been fitting air bags as a safety feature in cars. Discuss the reasons why a computer simulation is used to test air bags in crash conditions.
10. You don't have to ride a real roller-coaster to enjoy the thrill. Using specialised games and other applications, you can design a model of a roller-coaster on your computer and watch it work. Use the Internet to locate a suitable program that will allow you to model and simulate your own roller-coaster.

8.7 Using modelling and simulation programs

Data for model and simulation programs often has to be changed in order to make a variety of predictions. For example, a business can try out different strategies by changing the variables.

Variables to ensure accuracy

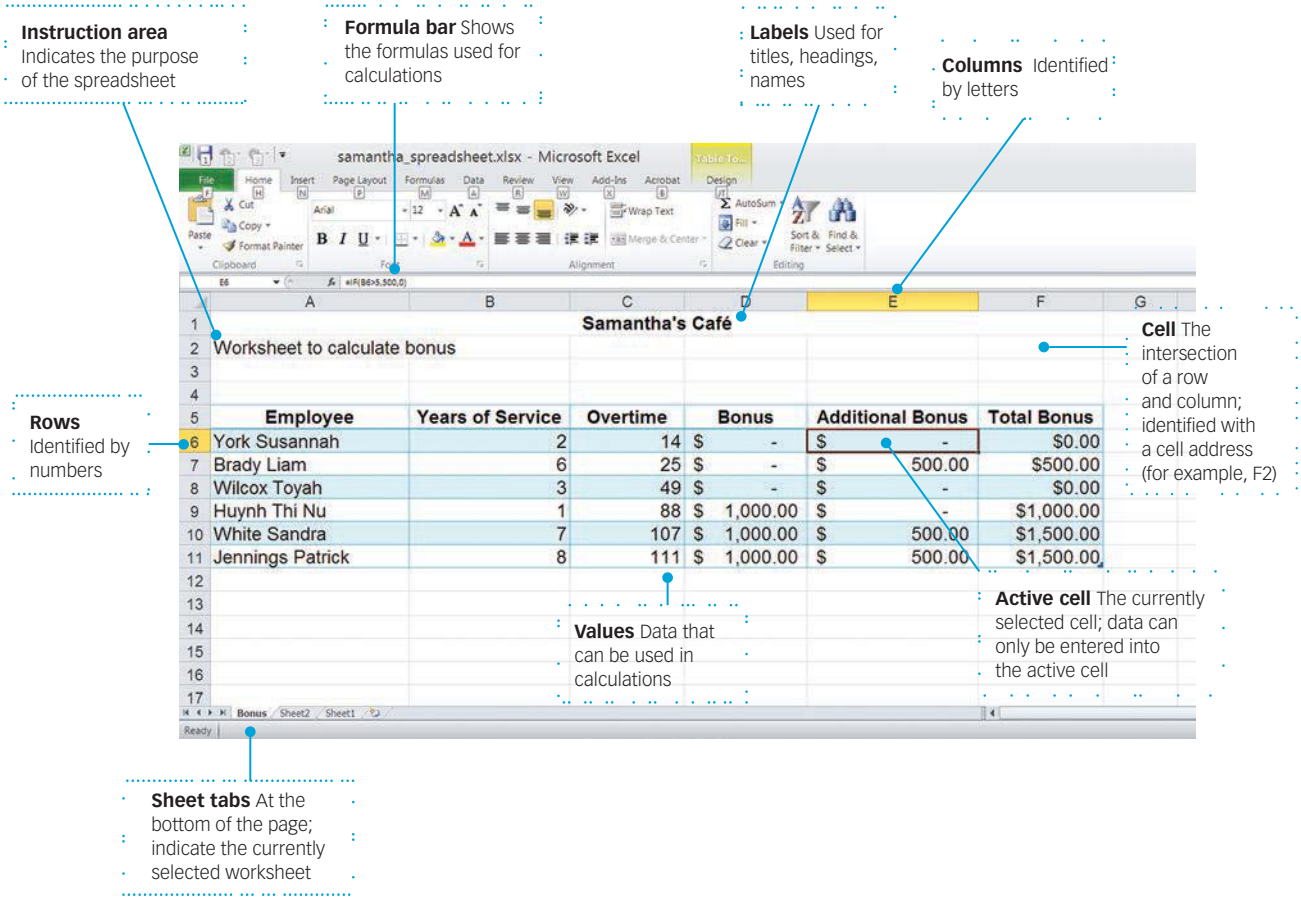
Consider the case of a cafe owner who wants to observe the effect on the business of a 7 per cent wage increase for her staff. She can simulate the likely outcomes of this strategy by using a financial model. If she is not comfortable with the initial simulation results, the variables can be changed until a satisfactory prediction is made. Adjusting the data in this way increases the likelihood that the model will accurately represent the desired effect on her business.

Spreadsheets

A spreadsheet is a program that uses rows and columns to organise, store and make calculations from data. Spreadsheets have various uses in many different environments. In business, spreadsheets can be used to present reports, make financial predictions, and create charts and graphs. A teacher or educator might use a spreadsheet to compute grades, track student assignments or assign marks for completed work. Spreadsheets make the calculation of this information very easy.

INFOBIT

The first electronic spreadsheet, VisiCalc, is arguably responsible for the transformation of the personal computer from a hobbyist's toy into a global phenomenon.



Employee	Years of Service	Overtime	Bonus	Additional Bonus	Total Bonus
York Susannah	2	14	$ -	$ -	$0.00
Brady Liam	6	25	$ -	$ 500.00	$500.00
Wilcox Toyah	3	49	$ -	$ -	$0.00
Huynh Thi Nu	1	88	$ 1,000.00	$ -	$1,000.00
White Sandra	7	107	$ 1,000.00	$ 500.00	$1,500.00
Jennings Patrick	8	111	$ 1,000.00	$ 500.00	$1,500.00

Figure 8.24 The basic elements of a spreadsheet

TASK 2

Petrol cost simulator

1. Open a new spreadsheet and save it as 'Cost of Trip Simulator'.
2. Click in cell C2 and type: 'Cost of trip simulator'.
3. Format cell C2 as bold, Arial, font size 18.
4. Click in cell B4 and type: 'How many kilometres (return trip) will you travel?'
5. Format cell B4 as bold, Arial, font size 12.
6. Click in cell E6.
7. Format cell E6 with a yellow background and a black border.
8. Click in cell B8 and type: 'How many kilometres per litre does your vehicle normally use?'
9. Format cell B8 as bold, Arial, font size 12.
10. Click in cell E10.
11. Format cell E10 with a yellow background and a black border.
12. Click in cell B12 and type: 'How much does a litre of petrol cost?'
13. Format cell B12 as bold, Arial, font size 12.
14. Click in cell E14.
15. Format cell E14 as 'Currency', with a yellow background and a black border.
16. Click in cell B18 and type: 'The cost of your trip will be'.
17. Format B18 as bold, Arial, font size 12.
18. Click in cell F18, type in this formula: '=E6/E10*E14' (the = sign must precede all formulas in a spreadsheet), and press Enter or Return.
19. Format cell F18 with a blue background and a double-line black border.
20. Remove the gridlines from your spreadsheet.
21. Format cells A1:J1, A1:A20, A20:J20 and J1:J20 with a green background.
22. Insert a graphic of a car into the bottom right of your page.
23. Use the Internet to select a car and find out how many kilometres it travels per litre of petrol.
24. Enter this data into the spreadsheet.
25. Enter the current price for a litre of petrol.
26. Find out the distance of the following return trips:
    - **a** Sydney–Melbourne
    - **b** Sydney–Canberra
    - **c** Sydney–Adelaide
    - **d** Adelaide–Darwin
    - **e** Perth–Brisbane.
27. Enter these distances into the spreadsheet to determine how much each trip will cost.
28. What if the price of petrol increases by 5 cents per litre? Modify the formula in the appropriate cell to show how this will affect the cost of your Perth–Brisbane trip.
29. Save your spreadsheet.

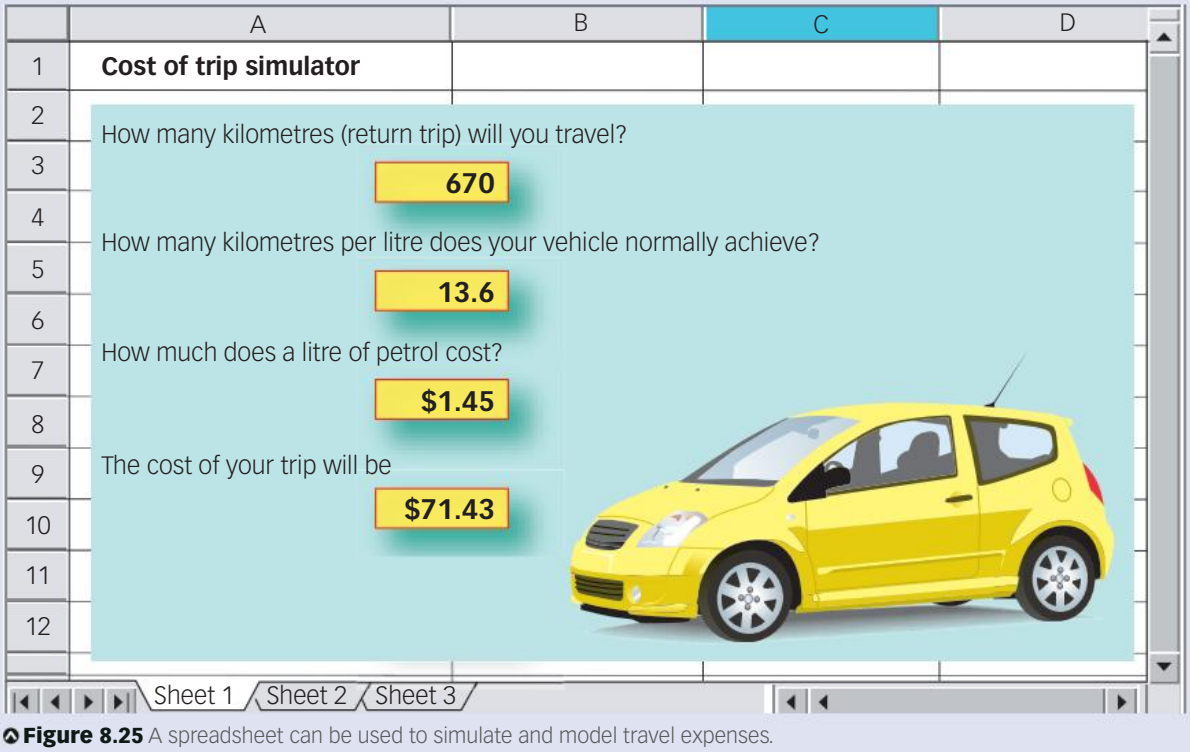


Figure 8.25 A spreadsheet can be used to simulate and model travel expenses.

CASE STUDY

Spreadsheet model

Simulation 1: Imagine a cafe owner (let's call her Samantha) is considering buying a van for her business. The asking price for the van is $16 000 and Samantha needs to take out a loan for this amount.

She decides to design a spreadsheet model of the loan in order to calculate her monthly repayments.

	A	B	C	D
1		Samantha's Van		
2				
3	Worksheet to calculate repayments			
4				
5				
6	Interest Rate	Length of Loan(mths)	Loan Amount	
7	9%	24	$16, 000	
8				
9				
10				
11		Monthly Repayments	$1, 648.00	
12				
13				
14				

Figure 8.26 This spreadsheet represents the first simulation of Samantha's loan and indicates she will have to repay $1648 per month for 24 months to pay off the loan.

Simulation 2: The 9 per cent interest rate is not fixed and Samantha is concerned about the effect on her monthly repayments if the interest rate increases. What-if predictions are a function of spreadsheets that allow choices to be tested and results to be observed before a real decision is made.

What if the interest rate for the van loan increases, for example, to 11 per cent?

	A	B	C	D
1		Samantha's Van		
2				
3	Worksheet to calculate repayments			
4				
5				
6	Interest Rate	Length of Loan(mths)	Loan Amount	
7	11%	24	$16, 000	
8				
9				
10				
11		Monthly Repayments	$1, 917.00	
12				
13				
14				

Figure 8.27 This what-if simulation indicates that Samantha's monthly payments will increase to $1917 if the interest rate rises to 11 per cent.

Simulation 3: **Goal seek** is a function of spreadsheets that is used when the desired output of a calculation is known, but the input value is not. In other words, goal seeking works by determining the final figure first and working backwards from there. We can use Samantha and her loan to make this concept clearer. She has decided she can only afford to repay a maximum of $1500 per month. This will place restrictions on the size of her loan and choice of van.

	A	B	C	D
1		Samantha's Van		
2				
3	Worksheet to calculate repayments			
4				
5				
6	Interest Rate	Length of Loan(mths)	Loan Amount	
7	9%	24	$14,560.00	
8				
9				
10				
11		Monthly Repayments	$1,500.00	
12				
13				
14				

Figure 8.28 This goal-seek simulation indicates that if Samantha limits her monthly payments to $1500, the maximum loan amount will be $14 560.



Shutterstock.com/Art Konavalov

QUESTIONS

1. Identify the feature of a spreadsheet that allows choices to be tested and results to be seen before a real decision is made.
2. Explain the purpose of a goal-seek function in a spreadsheet.
3. How did the use of the goal-seek function affect Samantha's maximum loan amount?

TASK 3

IF function

Samantha has decided to use a spreadsheet to calculate the Christmas bonuses for her staff. She wishes to offer a bonus of $1000 to staff who have undertaken more than 50 hours of overtime. To do this, she will use an IF function. The IF function determines whether a certain condition is true or false; it is one of the most useful features of an electronic spreadsheet.

1 Open a new worksheet and enter the data as follows:

	A	B	C	D	E	F
1			Samantha's Café			
2	Worksheet to calculate bonus					
3						
4						
5	**Employee**	**Years of Service**	**Overtime**	**Bonus**	**Additional Bonus**	**Total Bonus**
6	Jennings Patrick	8	111			
7	Brady Liam	6	25			
8	York Susannah	2	14			
9	Huynh Thi Nu	1	88			
10	Wilcox Toyah	3	49			
11	White Sandra	7	107			

Figure 8.29 The IF function allows for decision making in a spreadsheet. In this scenario, it will help Samantha determine the Christmas bonus for each staff member.

2 In cell D6, enter the following formula: =IF(C6>50,1000,0). This formula allocates $1000 to those employees with more than 50 hours of overtime, and $0 to those who do not meet this criterion.

3 Cell D6 should now contain $1000. (You may need to format the cells in column D as currency.)

4 Click the small square at the bottom right of cell D6 and drag your cursor to D11. This is referred to as fill-down and will place relative formulas in the remaining cells. (Search for 'fill formulas into adjacent cells' in the spreadsheet's help feature if you are having difficulties.)

5 Samantha now wishes to pay an additional bonus of $500 to staff members who have worked at her cafe for more than five years. Enter an IF statement into cell E6, which will perform this calculation.

6 Use the fill-down feature to place corresponding formulas in cells E7–E11.

7 In cell F6, use a formula to add the total bonus for each employee.

8 Use the fill-down feature to place corresponding formulas in cells F7–F11. Format the cells as currency.

9 Use a sum formula and the fill-down features to calculate the total bonus for all employees. Format the cells as currency.

10 Save the spreadsheet as bonus_spreadsheet.

INFOBIT

Each cell in a spreadsheet may contain three data types: values, labels and formulas.

Look-ups

Look-up tables are useful when you want to compare a particular value to a set of other values. Let's say your teacher wants to assign grades to students based on the following scale:

- below 50 E
- at least 50 but below 60 D
- at least 60 but below 70 C
- at least 70 but below 80 B
- 80 or above A

As soon as your teacher enters a mark for a particular student, the mark will be compared to the values in the look-up table and the spreadsheet will automatically assign a corresponding grade.

ACTIVITIES

Identify

1 Outline the purpose of changing data in model and simulation programs.
2 What is the definition of a spreadsheet?
3 Identify three common uses for spreadsheets.
4 Identify the function of a spreadsheet that determines whether a condition is true or false.
5 Identify two advantages of spreadsheet programs compared to paper-based alternatives.

Analyse

6 How could the goal-seek function in a spreadsheet help you save?
7 Explain how spreadsheets may be used in business and education.

Investigate

8 Describe three simulation programs and list the variables that they use.
9 Investigate and make a list of areas and occupations where spreadsheets are used.

Review questions

8.8 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: The Game of Life

You are to research and report on a simulation called the Game of Life, a famous example of artificial intelligence.

The Game of Life is not really a game at all. It is a 'cellular automaton', and was invented by Cambridge mathematician John Conway.

This game has become widely known and was first discussed in an article by Martin Gardner and published by *Scientific American* magazine in 1970. The game consists of a collection of squares that, based on a few mathematical rules, can live, die or multiply. By starting the game, a square either disappears (dies), multiplies (is born) or stays where it is (and lives). The game can also be simulated using grid paper, pencil and eraser.

THE FOUR RULES OF THE GAME OF LIFE

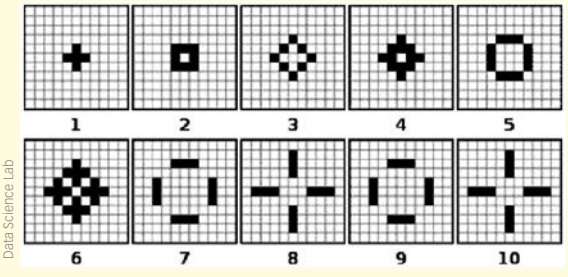
For any space that is 'populated':

- each cell with one or no neighbours dies, as if by loneliness
- each cell with four or more neighbours dies, as if by overpopulation
- each cell with two or three neighbours survives.

For any space that is 'empty' or 'unpopulated':

- each cell with three neighbours becomes populated.

Check the patterns below and see how the sequence obeys the rules above by working through these 10 generations:



Data Science Lab

Defining and analysing

Weblink

1. You will research the Game of Life and then try to create a starting pattern lasting for as many generations as you can. It is like creating a race of people and keeping them going for as long as you can! Go to http://infosoftwaretech.nelsonnet.com.au to link to the Bitstorm website to obtain the stand-alone free application.
2. Install the Game of Life on your computer or mobile device and read the instructions. Describe and explore the rules.
3. Discover how John Conway first came to invent this game.
4. Experiment with the predefined patterns (usually in a drop-down menu) using your software. Record what happens to each of these patterns.
5. Make your own patterns and test them.
6. Choose a favourite pattern. How many generations does it last before it becomes still or disappears?
7. What happens most often in your games? Do generations of creatures die out, stay still, grow larger or endlessly alternate between patterns?
8. Go to http://infosoftwaretech.nelsonnet.com.au to link to 'A large collection'.

Designing

Weblink

1. Can you find a starting pattern that always dies out, no matter how many separate organisms there are to start with?
2. Can you find a pattern that stays exactly the same?
3. Can you find a pattern that switches between patterns; that is, a pattern that changes to another in the first step and then changes back to itself?
4. Try the following well-known patterns and say what happens to each:
   - The pulsar
   - Blinker
   - Toad
   - A glider.

Producing

Discover a pattern for the Game of Life that lasts through the most generations before it stays still or dies out. Take a screenshot of your results.

Evaluating

Write a response to the following question asked by Paul Callahan:

'We can see that [the Game of] Life, simple as it is to describe, exhibits much of the complexity of our own universe. Could living creatures evolve in a sufficiently large Game of Life universe if we waited long enough?' (http://www.math.com/students/wonders/life/life.html)

Project 2: Organising a tour

You will use several software applications – spreadsheets, expert systems, word processors and graphics editors.

You may already have some experience of the processes that take place when developing a computer-based project. Essentially, you will have to adopt the role of a band manager to ensure the tour runs on schedule and is a financial success.

Defining and analysing

You have just been employed as the manager of your favourite band (or musician or recording artist). The band members are currently in England and have decided they want to embark on a two-week tour of Australia. The tour will comprise one concert in each of the following cities: Sydney, Brisbane, Melbourne, Perth, Adelaide, Hobart, Canberra and Newcastle. As manager, you are responsible for a number of tasks.

1. **Budget:** Create a tour budget that takes into account all expenses associated with the tour and will allow a variety of financial simulations to take place.
2. **Itinerary:** Assemble a touring itinerary that includes one concert in each city as well as all other activities you arrange.
3. **T-shirt and poster:** The band members know you have very good graphic skills and have asked you to design a band T-shirt and poster for the tour.
4. **General information:** The band members (assume for the purposes of this project that they have never been to Australia) have also requested some general information about Australia, including its Indigenous culture, history, geography, climate, language and major attractions.
5. **Expert system:** The band wishes to create a loyalty program for its fans. Three types of membership will be offered: platinum, gold and silver. Discounts are offered on band merchandise according to the number of tunes members purchase using the download feature on the band's website. Once a member joins the rewards scheme, they are entitled to silver membership and a 5 per cent discount on merchandise. Once they have purchased 20 tunes, they become gold members and receive a 10 per cent discount. Platinum status and 20 per cent discount is achieved once 50 tunes have been purchased.

Designing

1. **Budget:** A spreadsheet is needed to manage the running costs of the tour and to forecast potential profits or losses. Sketch a simple pen-and-paper model of a spreadsheet that will keep track of your band's budget. Some expenses are already known to you, including:
   - insurance $8500
   - equipment transport and road crew $11 000
   - manager's wages $5000
   - band allowance $4000
   - miscellaneous expenses $1000

   Use the Internet to research the costs associated with air travel, accommodation, car hire, visits to places of interest and any other expenses you think may arise.
2. **Itinerary:** You have asked the band members what they would like to do in their spare time on tour and they have nominated the following activities and places of interest: a museum, an aquarium, surfing (including a lesson), horse riding, a cruise on Sydney Harbour, parasailing and hot-air ballooning. You must research and calculate the cost associated with these activities (multiplied by the total number of band members) and include them in your budget. Make a list of all the concerts and activities, as well as the corresponding dates.
3. **T-shirt and poster:** Sketch three possible designs for your T-shirt and poster.
4. **General information:** Gather information about Australia. You may wish to include pictures. (Remember to keep a record of all the sources you have used.)
5. **Expert system:** Create the if–then rules for the expert system; for example, IF tunes purchased are greater than or equal to 50, THEN discount is 20 per cent.

Producing

1. **Budget:** Implement your design using an electronic spreadsheet program. Enter the expenses listed in the design stage, as well as other expenses you have researched. Produce a pie graph that displays all your expenses as a percentage of the total tour costs.
2. **Itinerary:** Use a suitable application (for example, word processor, project management software) to create an itinerary. It should include details about every day of the tour. Use a structure that appeals to you visually and organisationally. Create a header at the top of your itinerary with the destination and the full dates of travel.
3. **T-shirt and poster:** Use a graphics program to create a T-shirt and poster.
4. **General information:** Compile your information using a suitable program. You may wish to create a digital presentation or design a pamphlet.
5. **Expert system:** Download an expert system shell, such as ES-Builder, and enter the if–then rules and other relevant data.

Evaluating

1 **Budget:** Your spreadsheet should be designed to easily determine the financial success of the tour. Each ticket sold will generate a profit of $35. Use your spreadsheet to answer the following questions:
   - How many tickets will need to be sold in order to cover expenses?
   - What if ticket sales are slow and the band decides to spend $5000 on extra promotion? How will this affect the number of tickets required to cover expenses?
2 **Itinerary:** Examine the itinerary. Are there enough activities included in every day to keep the band members from becoming bored? Have you tried to include too many activities in one particular day? Are you happy with the design? Give your itinerary to a classmate to determine how quickly and easily it can be understood.
3 **T-shirt and poster:** Show your T-shirt and poster to other students in your class and ask their opinion of your designs.
4 **General information:** Print or present the information you have collected about Australia and ask a classmate to evaluate it in terms of how engaging or interesting it is.
5 **Expert system:** Run the expert system and use it to help determine the outcomes for the three scenarios (platinum, gold and silver) outlined in the defining and analysing stage.

Additional content

Motion capture

Motion capture (or mocap) refers to the process of recording movement and converting that movement into a digital model. It is used in a variety of areas, including video games, movies, sport and medicine. Game development is perhaps the biggest driving force behind motion capture technology due to the immense competition in the market.





Alamy/Moviestore Collection Ltd

Alamy/Moviestore Collection Ltd

Figure 8.30 Motion capture is being used more and more in the film industry, particularly for the creation of animated characters that move realistically. *The Polar Express* used motion capture to allow Tom Hanks (pictured) to perform as several distinct animated characters.

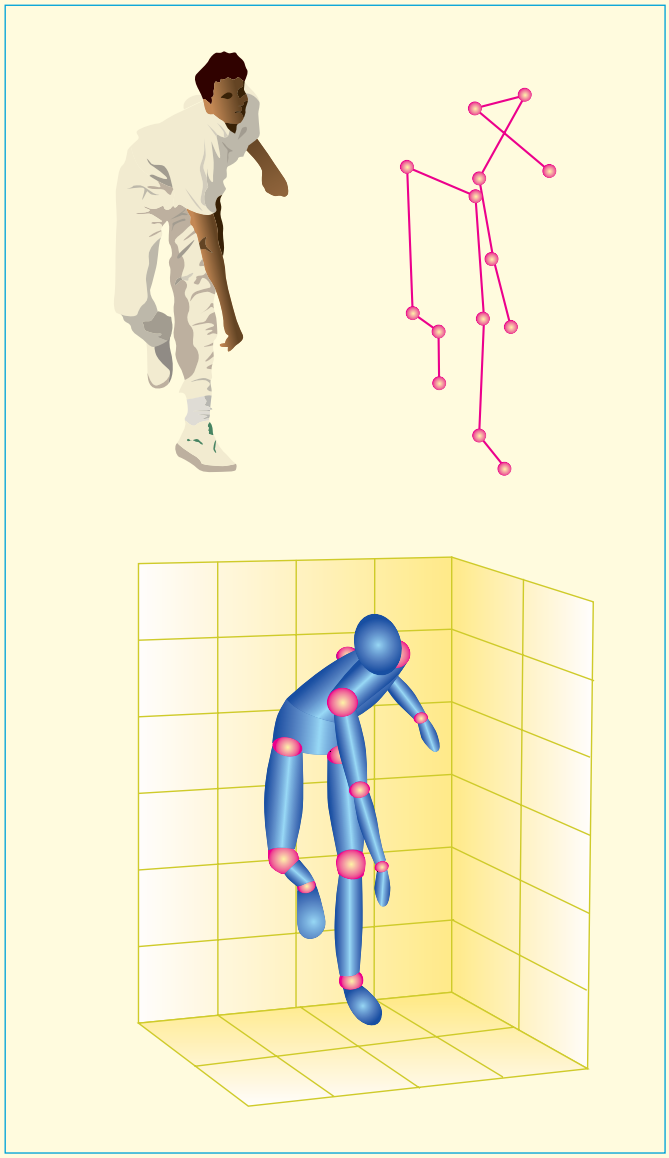


Figure 8.31 Motion capture technologies help prevent injuries in sport and are also used as a coaching tool.

Macros

Macros initiate a series of instructions and are often used to automate repetitive tasks in an application program such as an electronic spreadsheet. The usual way to create a macro is to 'record' it. That is, you carry out a sequence of actions and instruct the spreadsheet program to remember them.

The spreadsheet program will ask you to assign a shortcut key to the macro. Try to use a shortcut that is not already in use by the program; for example, Ctrl+C (Windows) or Cmd+C (Mac) will already have been assigned to the Copy command. You can then 'run' the macro to automatically repeat the actions recorded.

Record a spreadsheet macro

The diagrams for this activity refer to Microsoft Excel.

1 Open the bonus_spreadsheet you created earlier in this chapter. We are going to record a macro that will sort the employee overtime data in ascending order.

	A	B	C	D
1			Samantha's Café	
2	Worksheet to calculate bonus			
3				
4				
5	**Employee**	**Years of Service**	**Overtime**	**Bonus**
6	Jennings Patrick	8	111	$ 1,000.00
7	Brady Liam	6	25	$ -
8	York Susannah	2	14	$ -
9	Huynh Thi Nu	1	88	$ 1,000.00
10	Wilcox Toyah	3	49	$ -
11	White Sandra	7	107	$ 1,000.00

Figure 8.32 Bonus spreadsheet

2 Select the View tab on the ribbon at the top of the page.



Figure 8.33 Select the View tab.

3 Click Macros.
4 Click Record Macro.
5 Enter a name (without spaces) and a shortcut key. The shortcut key will override default shortcut keys while the spreadsheet that contains the macro is open. Therefore, avoid assigning commonly used shortcut keys to the macro; for example, Ctrl+C and Ctrl+V.

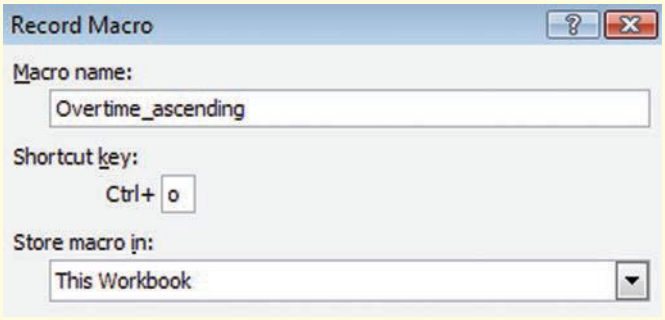


Figure 8.34 Enter a macro name and a shortcut key.

6 Click OK.
7 Perform the macro. Highlight cells C5–C11. With the data tab at the top of the page selected, click Sort A–Z.

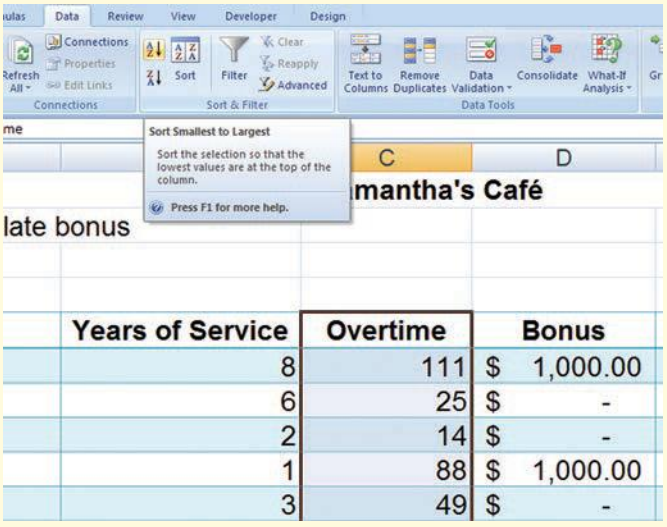


Figure 8.35 Sort the overtime data in ascending order.

8 Select the View tab on the ribbon at the top of the page.
9 Click Macros.
10 Click Stop Recording.
11 Test the macro by reorganising the data and selecting the shortcut key.
12 Save the spreadsheet.

OPTION 9 Authoring and multimedia

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- what multimedia is
- where multimedia is heading
- the types of multimedia products
- multimedia data types
- how to author software systems
- how to plan a multimedia product
- multimedia issues and people.

You will learn to:

- define, describe and assess multimedia products
- recognise multimedia data types
- manipulate multimedia data types
- select appropriate multimedia authoring software
- survey users and describe a target audience
- identify the purpose of a multimedia product
- use appropriate design principles, including interface design
- research and develop multimedia content
- create a storyboard and script
- design, produce and evaluate a multimedia product for a given purpose.

Key terms

Decision table authoring
multimedia authoring using a large decision table where all objects and their possible actions are defined and organised

Flowchart authoring
multimedia authoring where each media element is represented as an icon with logical flow lines between them

GUI (graphical user interface)
provides interaction between user and computer screen; the best known GUI is WIMP (windows, icons, menu and pointer), but other types also exist

Hierarchical
form of non-linear navigation or storyboard layout with a branching tree-like structure

Hypermedia
any media type (text, graphics, audio, animation or video) that allows interactivity, typically by using a touchscreen or mouse

Hypertext
text linked to related information

Linear (sequential) navigation
form of interactivity in which items are accessed sequentially, in a definite order

Multimedia
presentation of information using any combination of at least three of the five basic digital media data types

Non-linear (random or direct) navigation
interactivity or storyboard layout in which any desired data item may be accessed directly

Prototype
basic working model, not necessarily complete, designed to show a project's appearance and functionality

Storyboard
map or plan of a final product showing each screen, important screen elements, their placements and the links between them

T_Visionarium: An interactive multimedia cinema and database

When the doors to the T_Visionarium open, viewers experience what it might be like to step inside a giant visual search engine.

The University of New South Wales Centre for Interactive Cinema Research's T_Visionarium is the world's first 360-degree 3D (stereoscopic) cinema. Inside, the viewers are surrounded by hundreds of 3D video clips swirling around them on a huge cylindrical screen that has an area of 120 square metres.

The experience is like a 3D IMAX theatre-in-the-round. However, wearing 3D glasses, the viewers are not only able to move about but also to change the flow of images that unfold around them.

For T_Visionarium, 28 hours of digital free-to-air Australian television was captured over a period of one week. This footage was then converted into a large database that contains more than 20 000 video clips.

T_Visionarium uses the UNSW iCinema Centre's Advanced Visualisation and Interaction Environment (AVIE). The AVIE is a 360-degree cylindrical cinema screen that the viewer stands inside. The T_Visionarium is an interactive visual database, and it allows the viewer to select from the entire range of digital video clips. It then merges clips chosen by the viewer into the universe of images that are already encircling the screen.

All the images are projected in stereoscopic 3D, using a bank of data projectors mounted on the ceiling. Video clips are displayed and distributed around the huge circular screen and 'hang in space', surrounding the viewer and filling the space of the cinema. It is even possible to 'walk through' these clips as the viewer travels from one side of the theatre to the other. Using a special remote controller and interface, the viewer can select, rearrange and link these video clips in whatever way they wish, simply by 'picking up' a clip in the air and dragging and joining it to another clip.

Each clip is tagged with descriptors (metadata) that define its properties. This information includes the gender of the actors, the main emotions they are expressing, the pace of the scene, and actions such as standing up, lying down and telephoning. To give just one example, a viewer can choose an emotion and a colour (say 'fear' and 'red') and each clip that matches these descriptions will 'gather in the air' in front of the viewer. Those that do not have these qualities sweep and hang in space behind the viewer.

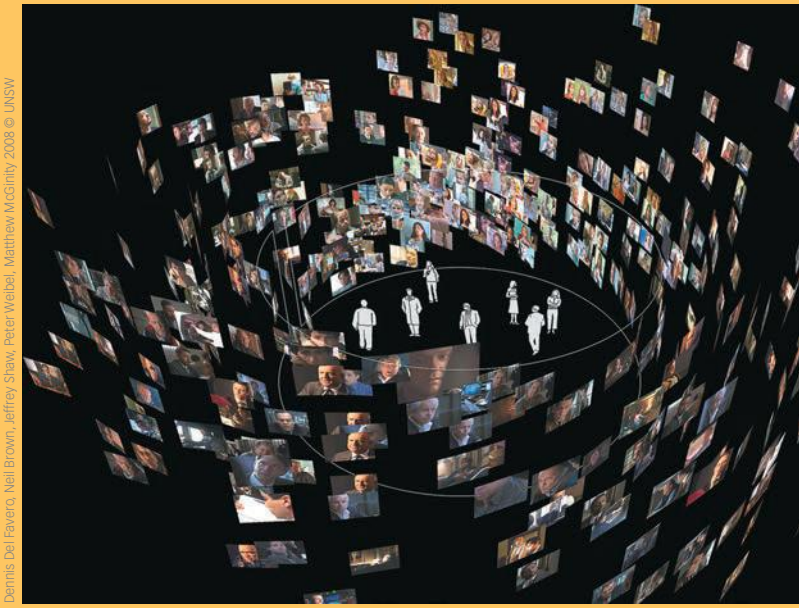
To see the T_Visionarium in action, go to http://infosoftwaretech.nelsonnet.com.au and follow the link.

Weblink



The University of New South Wales/Oliver Strewe

Figure 9.1 Once inside the T_Visionarium, viewers are surrounded by hundreds of 3D video clips.



Dennis Del Favero, Neil Brown, Jeffrey Shaw, Peter Weibel, Matthew McGinity 2008 © UNSW

Figure 9.2 A remote control enables the user to select and arrange video clips by 'moving' them through 3D space.

QUESTIONS

1. In one paragraph describe the T_Visionarium project and one technical advance that it features.
2. How does the use of 3D technology assist in this project?
3. Comment on the following statement: 'Interactive cinema is blurring the boundary between audience and screen that has stood firm since cinema's dawning more than a century ago.'

9.1 A digital revolution

The term **multimedia** was in use long before the arrival of the desktop computer. It first appeared in the mid-1960s, when it was used to describe the still and moving images that were projected alongside the music being played at a New York artist's Christmas party.

What is multimedia?

'Multimedia' is an overused word, and has been applied to almost any digital media project or event. In your course, multimedia will refer specifically to the presentation of information by a computer and any combination of three or more of the following five types of digital media:

- text
- graphics
- audio
- animation
- video.

Computer-based multimedia presentations usually have a sixth element: interactivity. Clicking a computer mouse on highlighted text or a graphic can transport the user to related information on another page or screen, or allow them to manipulate an object in some way. Media that are interactive in this way are known as **hypermedia**.

Any one of the five major multimedia elements can be given this kind of interactivity and turned into hypermedia, although most hypermedia links are text-based. When you click on the highlighted words on a web page containing text, you are following a link called **hypertext**.

We could say that any book that has both graphics and text is a multimedia product when viewed on a computer, but we usually restrict the term to products that have at least three of the media types, and especially to those that involve interactivity.

Multimedia offers us a powerful way of organising and displaying words, pictures, sounds, animation and video. It also gives a choice of what can be viewed in a way that older single-medium products could never offer.

INFOBIT

In the 1990s Jonar C Nader, in Prentice Hall's *Illustrated Dictionary of Computing*, suggested that we will see the day when newspapers have disappeared and cinemas will have been turned into parking stations attached to holographic, virtual reality cyber-interactive multimedia theatres. At least one of these predictions seems very close!



Wikipedia (public domain)



Shutterstock.com/mama_mia

Figure 9.3 Apple's iPhone® and iPad™ are both true multimedia devices. Each supports all multimedia data types along with many forms of interactivity using online distribution methods such as the iTunes store.

ISSUES

CORE ALERT Past, current and emerging technologies

Imagining our multimedia future

In recent years, computer games have become more realistic. The images are more detailed, the animation more believable and the sound effects more dramatic.

However, looking even further, we can imagine what the future might offer.

Photorealistic, real-time images can't be far away, and some companies are now close to producing true (even better than surround sound!) 3D sound – where a noise seems to come from the appropriate point in space, relative to the listener.

After that, true 3D images that do not require viewers to wear special glasses won't be far behind. Displays will provide true peripheral vision, with microphones and earphones built in.

Imagining further, we can assume that there will be a system that can generate smells, and others that will give us sensations of texture and temperature (such as fur, sandpaper or water). Then we can begin to imagine that people are suspended in 3D fields so that even the inner ear can be fooled into seeing the world differently, as imagined in the film *Minority Report*.

And, sooner or later, someone is going to come up with a safe way of making digital connections to human nerve cells. Instead of fooling the senses, we will bypass them completely by plugging our computer directly into the spinal cord, telling the brain exactly what sensory input it is receiving, right down to the last detail.

Is this the logical end? Nearly – with this kind of virtual reality, we're still talking to the brain through the senses, which means that everything must be processed and interpreted before it gets to the mind. What if, instead, we were to bypass the senses completely and transmit data directly to the brain? It would be the ultimate in virtual reality – a system so powerful that it would let us interface directly with the human imagination!

Is this final vision for technology ever likely to be developed?

Well, yes, it is. In fact, it was invented in Mesopotamia some 5000 years ago. It is called text!

There is one conclusion we can reach from all this. We can play all the graphic-intensive games we like, but so long as we can read, there's always something better!



Fairfax Syndication/Alan Moir

Figure 9.4 In your lifetime?

QUESTIONS

1. What is the main point that the author is making here?
2. Do you agree that the printed word can be a richer experience for our senses than digital virtual reality?
3. Compare the experience of reading a good story or listening at night to a radio drama with a multimedia production viewed on a computer.

ACTIVITIES

Identify

1. Name the five multimedia elements.
2. What is the name given to the navigational media elements in multimedia?
3. What is one method of creating multimedia?

Analyse

4. Describe a multimedia product that you have viewed as a member of an audience. List the multimedia elements used by the designers and identify whether they were computer-based or non-computer-based. Discuss how effective you found the event.
5. A famous Chinese proverb is: 'I hear and I forget, I see and I remember, I do and I understand'. Do you agree? In the case of multimedia, we might add a fourth element. How would you complete the following: 'I experience and I …'?

Investigate

6. All modern computer operating systems (OS) use multimedia elements as an important part of their graphical user interfaces (GUIs). Examine both the latest Windows® OS and Macintosh® OS. Use columns with the headings 'Text', 'Audio', 'Graphics' and 'Animation' to collect examples from each operating system.
7. Using your answer for question 6, add a column for interactivity. Repeat the exercise for a mobile touch device OS, such as Android or Apple's iOS.

9.2 Types of multimedia products

Multimedia comes in a variety of different forms. When you are surfing a favourite website or prowling corridors looking for enemies, you might not realise that you are using multimedia.

It can be helpful to group multimedia projects into categories – the three main ones are education, entertainment and information.

Educational products

Educational multimedia products can often have a greater impact on learning than a simple lecture or talk, but some people argue that they do not allow the user as much opportunity to use their own creative thoughts, as they work on so many senses at once. We should see such products as a useful additional resource, and not as a replacement for personal interaction between teachers and students.

Interactive CD-ROMs, DVDs and the Internet

Multimedia resources have been used in classrooms for many years, but today, with the growth of the Internet and its increasing speed, ease of use and availability, CD-ROMs and DVDs (digital versatile discs) are being used far less to deliver multimedia content.

One of the earliest and most popular multimedia titles on CD-ROM (compact disc read-only memory) was Microsoft's encyclopaedia, Encarta®. For the first time, students could access not only text, but also video clips and sound bites of significant moments in history – along with a strong American bias.

Many students were tempted to copy and paste passages of text from articles and submit them as their own work. However, this became harder with the growth of plagiarism-detection tools for teachers, such as Turnitin. The growth and popularity of Wikipedia has also meant less use for these reference works.

In the past, products produced on behalf of the NSW Board of Studies (BOSTES) have won awards for multimedia innovation. One educational CD-ROM, *Exploring the Nardoo*, allowed students to investigate the effects of human development and activity on a river over decades. Students sampled water quality using an on-screen interactive personal digital assistant, listened to contemporary audio and video broadcasts, used simulations and then prepared a talk for the class by collecting multimedia elements.

Today's students can interact directly with a wide range of educational multimedia products online, which combine all five media data types to illustrate various topics.

Multimedia presentations

Applications such as Microsoft's PowerPoint® and Apple's Keynote® allow users to produce slides with interactive elements, such as animations, weblinks, animated text and digital movies. Most students have listened to many PowerPoint presentations and used it to present work to their classes.

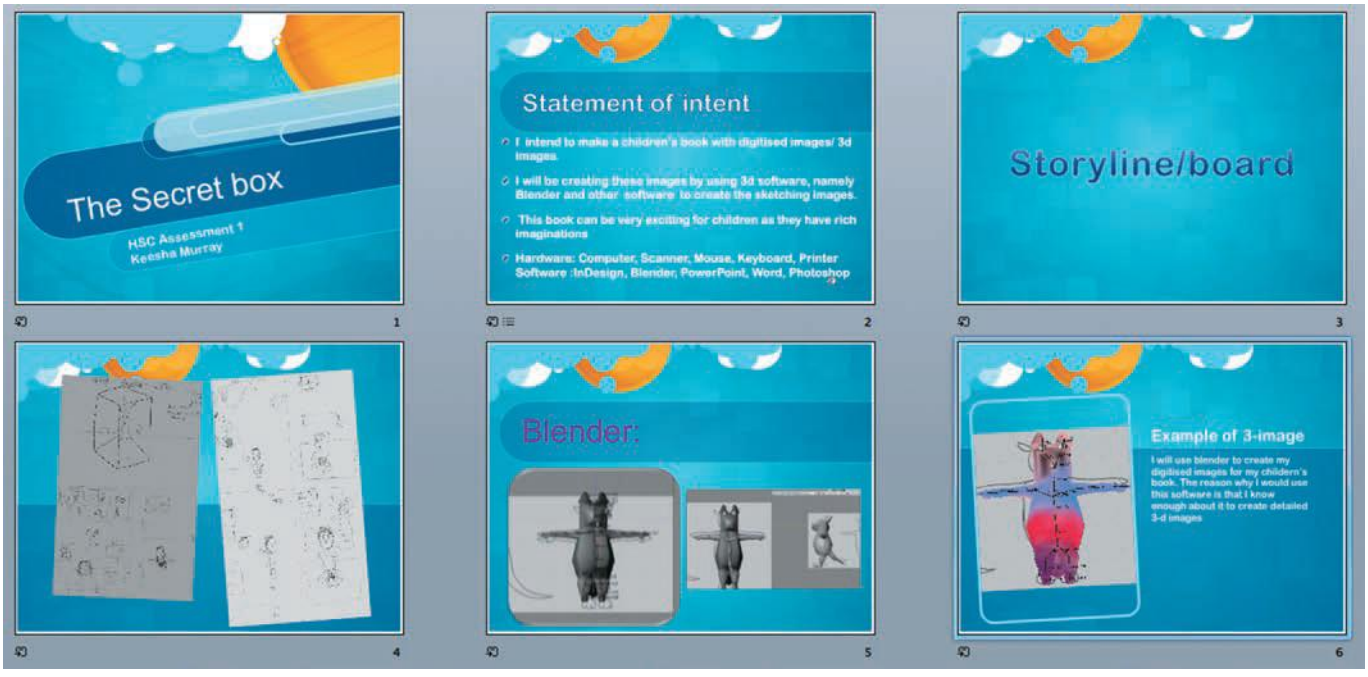


Figure 9.5 Presentation software such as PowerPoint® is the most widely used type of multimedia application, but other authoring tools can produce far more sophisticated multimedia work.

Although PowerPoint can be used effectively to add visual interest to talks, there is a danger that users will only use the templates provided, resulting in presentations that end up looking very similar. Prezi, which uses zoom and motion, is an alternative presentation tool, but its overuse can have the same result.

You will discover in your practical work for this option there are other authoring tools that can be used to produce far more exciting and sophisticated multimedia work.

Computer-based training

Computer-based training (CBT) uses interactive computer displays involving multimedia to help users learn about a topic, operate machinery or teach skills to others in the workplace. One advantage of CBT is that users can retrace their steps in a complex operation as many times as they wish.

Once a template has been created, material can be added or modified easily, which offers significant time and cost savings when future training materials are being developed.

Java applets included in web pages are now a popular multimedia teaching tool as they bring practical concepts to life.

CBT can also encourage learning as it allows the use of timed multiple-choice questions.

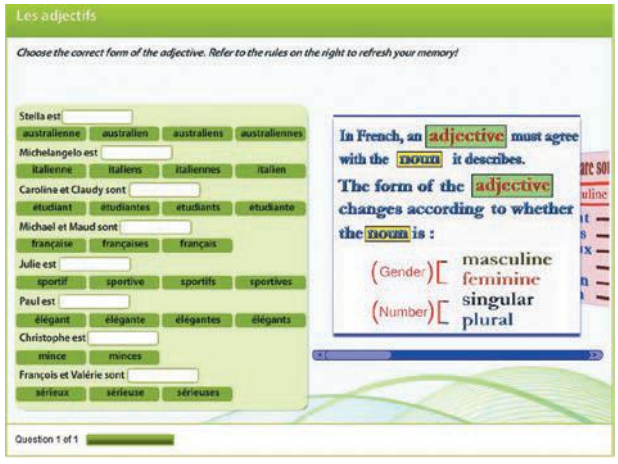


Figure 9.6 Computer-based training in action. Students select and drag answers on-screen to test their knowledge.

Entertainment products

Entertainment has often been the reason for advances in computing, and multimedia is an example of this. Games have been one of the most popular applications of multimedia – ever since the days of two-dimensional platform games and computerised versions of popular board games.

Multimedia games

Today's games have also entered the third dimension, where the user controls the camera angle as well as the character's direction and speed. These games have dramatic and realistic sound effects, offer complex puzzles to solve and immerse the player in a real-world environment.

Brøderbund's Myst® and Riven™ were among the first examples of stunning realistic detail – objects move, dials turn and levers operate. Even items of furniture were carefully crafted, using 3D computer modelling.

As gaming consoles (such as Sony Computer Entertainment Inc.® PlayStation®, Wii and Xbox) have become more sophisticated, the realism of graphics and level of interactivity have increased. Using the Xbox 360 Kinect motion sensing device, players can kick a ball, play tennis or control a movie using only body movements.

Interactive DVD movies

The higher capacity of DVDs over CD-ROMs encouraged many changes. DVDs offered additional video sequences to those seen on the big screen and on-screen menu selections that allowed the viewer to interact with the plot, actors, writers and producers. However, DVDs are being increasingly replaced by online interactive products.

Interactive digital television

Interactive digital television allows the audience to become part of the total home entertainment experience. The viewer can control the camera angle for sports broadcasts and choose alternative endings for favourite soapies.

Online streaming services

Devices and services such as ABC iview, Apple TV, Netflix, Google TV and Android TV, allow consumers to use an HD TV set to view photos, play music and watch video originating from Internet services or a local Wi-Fi network.



(AP)via AAP/Apple

Figure 9.7 Apple TV

Augmented reality

Augmented reality (AR) is a real-time view of a real-world environment through a technological device, supplemented or overlaid by computer-generated media such as text, audio, animation, video, 2D or 3D graphics.

These overlays, known as expressions, can be triggered by markers (as in figure 9.8), by location (when the user approaches particular coordinates on Earth) or even by gestures.

There are many educational titles using AR.

An impressive example is Londinium, a free app for mobile devices from the Museum of London and the History Channel where users excavate ancient London using an interactive map, to discover artefacts and recreations of early London using live action.

Another is NASA's Spacecraft 3D, where detailed interactive models of actual spacecraft can be rotated in 3D space and examined, triggered by an image of the surface of Mars.

Osmo, winner of *Time* magazine's Invention of the Year for 2014, recognises letters forming a word for the displayed image. The front-facing camera uses a mirror to view letters placed in front of the tablet and augmented reality to interpret their shapes instantly. Players compete to be the first to place their letters and teachers can design their own word and picture libraries online. Other educational modules are available that extend these functions.



Figure 9.8 Augmented reality: a 3D origami model appears over a printed marker in a student's senior school multimedia project.



Figure 9.10 Osmo, winner of *Time* magazine's Invention of the Year for 2014, recognises letters forming a word for the displayed image.





Figure 9.9 Londinium, from the Museum of London and the History Channel, allows users to excavate ancient London using an interactive map by 'digging' (rubbing) on the screen.

Information products

Information kiosks

In many museums, human guides have been replaced by multimedia touchscreen information kiosks, specially designed for public and semi-public places. Job agencies, hospitals and exhibitions also use these information kiosks.

Information kiosks save money on help desks and allow people to search for information at their own speed. They also save embarrassment as people try to find answers to questions they feel they should know. Touchscreens and a logical interface are important for any successful kiosk.

Electronic books and magazines

Electronic books were among the earliest examples of computer-based multimedia and were initially designed to determine if people would choose to read books using a laptop computer screen.

The Living Books series provided a colourful environment for young children in which almost every object was hyperlinked to animations. An electronic version of the novel *Jurassic Park* (The Voyager Company, 1991) stated on the cover: 'Enjoy this tale of high technology in a fittingly high-tech way on your computer'. However, an introductory comment from the publisher admitted: 'We are not yet sure whether this form of electronic book will prove popular in the future'.

There have been many electronic magazines (e-zines). Text-based stories are combined with sound, animation and video, and are usually supplied via the web – a kind of marriage of printed magazines with TV and radio. However, not many of these e-zines have been successful.

Tablet devices, such as the iPad, have challenged traditional book publishers. Its touch interface and convenience has ushered in a totally new form of ebook that blurs the boundaries between books, magazines and newspapers. For these formats, publishers consider multimedia content as soon as they start to plan their titles.

Authoring tools are available that allow home users to develop their own interactive titles for touchscreen tablets and self-publish on sites such as Apple's iBooks Store.

INFOBIT

Sydney's Powerhouse Museum used a multimedia kiosk to allow visitors to build and explode their own fireworks! Visitors first watched a video clip on pyrotechnics theory, then selected the chemicals, the quantities and the casing and finally lit it and stepped back. Their choices matched the final correct visual effect shown as a video.



Alamy/Iain Masterton

Figure 9.11 Once readers get used to the features available in digital books, many are not content to read text alone. They begin to expect hyperlinks, audio, video and other multimedia content. Newspaper companies are still adjusting to this expectation.

Multimedia databases

Multimedia databases are used to catalogue media elements in a production. The designer of a multimedia product can assign keywords and ideas to video or graphical elements so they can be rapidly identified and retrieved. These databases are used in advertising, product catalogues and executive information systems.

Schools have begun to establish digital photographic registries of students and to use them in attendance systems. The students swipe bar-coded identity cards, which then display their photo and record their arrival and departure times.

One exciting example of a true multimedia database is the T_Visionarium (see page 113).

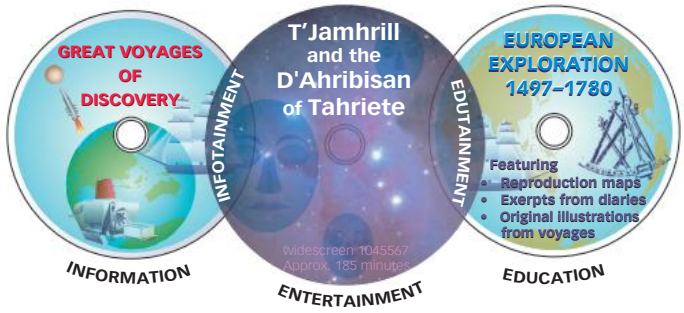


Figure 9.12 The main categories of information, education and entertainment often overlap. Find a multimedia title to fit each of the categories 'infotainment' and 'edutainment' shown above.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

Where is multimedia heading?

Although early multimedia users purchased CD-ROMs and DVDs, it is now impossible to separate multimedia from the Internet.

Both the World Wide Web (WWW) and interactive multimedia are based on the principle of hyperlinking. As Internet bandwidth speeds increase, the five elements of multimedia have become easier to use on the Internet.

We can see this by looking at software sales. Adobe's popular multimedia authoring software Flash has the features necessary for Internet use, such as vector-based images and small file sizes, but requires a stand-alone application and a browser plug-in. Adobe's newer product Edge attempts to overcome some of these disadvantages.

Television is also turning into a multimedia medium. Viewers can make their own choices of factual content, camera angles and special clips.

The first mobile phones with their small screens, jerky simple images and tinny sound remind us of the early days of multimedia on desktop computers, which followed a similar evolutionary path. Mobile phone users now own a true multimedia communication device using all five multimedia elements – text, graphics, animation, video and audio – but it is interactivity that is the smartphone's most powerful feature.

Johannes Gutenberg printed the first book, a Bible, in 1455. A copy at the time cost three years' wages. With its slate-sized screen, Apple's iPad™ and similar tablets now challenge even the basic concept of a book. Its applications allow a level of interactivity and involvement that Gutenberg could never have imagined. Interactive Google maps allow the user to view street scenes for any address, travel to any place on Earth, view it from space and then zoom to observe cars and people – even to dive under the seas to explore its underwater mountains and valleys. A book on the human body allows interactive dissection of the body's organs and viewing of a beating heart stripped back to its layers. The iPad can be held up to the night sky, its location determined and the names of the constellations superimposed on the scene. We can only begin to imagine the huge range of applications that will be used in the future in school classrooms. The tablet has been described as the first personal portable interactive whiteboard.

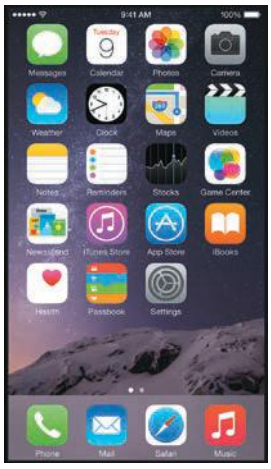
QUESTIONS

1. Why has Adobe's Flash application been such a popular tool in the production of multimedia and why is its popularity now decreasing?
2. Describe the types of interactivity that would be helpful to viewers using interactive television.
3. Use your imagination to invent a useful educational application for a tablet device. Describe it and add some sketches of its screen.



Shutterstock.com/Lukiyanova Natalia/frenta
Shutterstock.com/Sam Dcruz
Shutterstock.com/riekephotos
Corbis/Lebrecht Music & Arts
Apple

Figure 9.13 Information has been recorded and displayed in many forms over thousands of years, ranging from early cave paintings to signs drawn on the ground, cuneiform, hieroglyphics and scrolls. Johannes Gutenberg printed his first book (a Bible) in 1455. The idea of the book remains, but has now evolved into an electronic display, such as the Kindle or the iPad.



Wikipedia (public domain)

Figure 9.14 The main categories of information, entertainment and education can be seen in this selection of apps on an iPhone® screen. Can you decide how each app would be classified?

Other multimedia products

Multimedia has touched so many areas that sometimes it is difficult to decide in which category an example should be placed. A new word is often coined by combining categories, such as edutainment (education plus entertainment) and infotainment (information plus entertainment).

Edutainment refers to media that are designed to educate while being entertaining. Maths Invaders and Where in the World is Carmen Sandiego? were two early software titles that included game elements as part of the learning process. Both are still available.

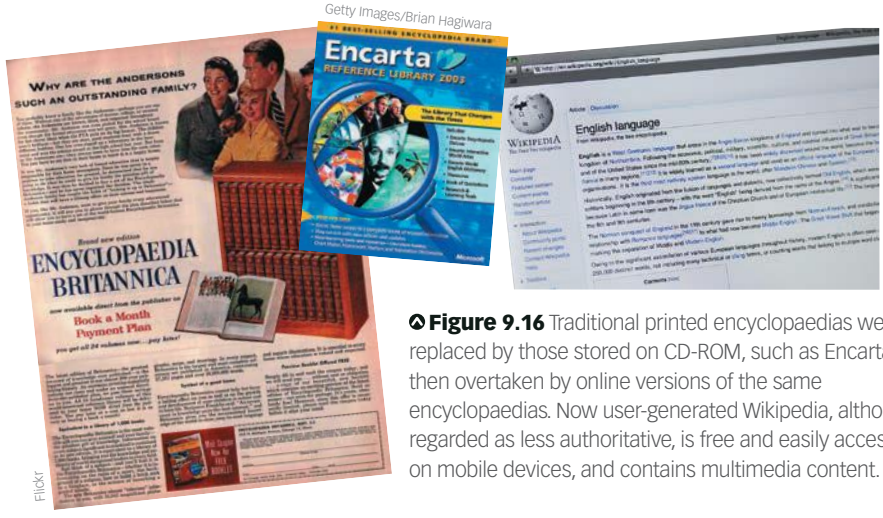
Infotainment refers to multimedia that blends information and entertainment content. It is sometimes known as docutainment (documentary plus entertainment), as it is frequently used to refer to television documentaries that cover serious issues in an entertaining way. Infotainment is being more frequently used as interactive whiteboards in school classrooms make it easier for teachers to display this type of multimedia.



Prezi.com

Figure 9.15 Prezi provides a creative alternative to the traditional PowerPoint presentation.

Getty Images/Brian Hagiwara



Flickr

Alamy/NetPhotos

Figure 9.16 Traditional printed encyclopaedias were replaced by those stored on CD-ROM, such as Encarta, then overtaken by online versions of the same encyclopaedias. Now user-generated Wikipedia, although regarded as less authoritative, is free and easily accessible on mobile devices, and contains multimedia content.

ACTIVITIES

Identify

1 Identify and describe the major multimedia categories of information, education and entertainment.
2 Find a multimedia example of each of these categories for desktop/laptop computers and describe its function.
3 Find a multimedia example of each of these categories for tablets and describe its function.

Analyse

4 What do you think is the most popular category of multimedia currently in use? Why do you think this is so?
5 One major problem in using Wikipedia is that it is not curated by experts in a field as most other encyclopedias are. Find out what the word 'curated' means and suggest a response to this issue.
6 Computer-based training (CBT) has been treated as a separate category in the section above. In what ways would a CBT multimedia title be different from other educational titles?

Investigate

7 Find a website that includes interactive multimedia content that simulates the planimeter, a nineteenth-century tool used by mathematicians, and another that simulates the operation of the central processing unit (CPU) of a computer. Follow the instructions on the site for using the planimeter and write a paragraph explaining what a planimeter does.

9.3 Multimedia data types

CORE ALERT Data handling

The five central elements of multimedia are text, graphics, audio, video and animation. When interactivity is added to one or more of these, it is known as hypermedia. A highlighted word on a web page that links to another destination is known as hypertext. Hypertext is the most common form of hypermedia.

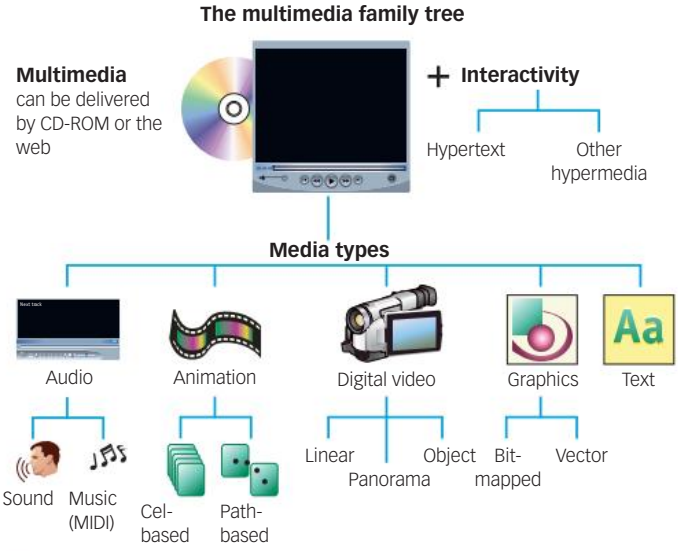


Figure 9.17 The data elements of the multimedia family tree

Processing power

The different multimedia elements do not make equal demands on a computer's processing power. Video is the element that places enormous demand on the processing power of a computer. It is an issue for designers because each frame is like a single graphic and each must be loaded and displayed and removed before the next frame is presented.

The different sizes occupied by each multimedia element in terms of the content of a typical multimedia DVD can be seen in figure 9.18. More detail about each of the data types can be found in chapter 11: Digital media.

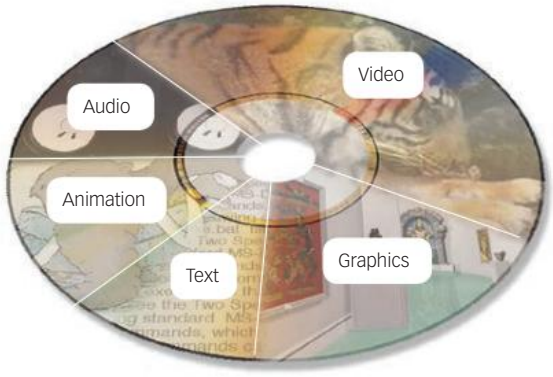


Figure 9.18 Relative sizes of the various data types in a typical multimedia production

Text

Text is data that consists of strings of printable characters separated by white space characters (non-printing characters). In its raw form, it is a series of zeros and ones grouped into sets of eight bits, called a byte, using ASCII (see chapter 4: Data handling).

Text is an important element in multimedia, but can be overused by beginners. A designer needs to keep in mind how the final multimedia title will be displayed. The computer screen is not a book, and viewers will soon become tired of reading long blocks of text on a screen. Many PowerPoint presentations suffer from screens that have too much small text for an audience to be able to read easily. As a guide, try to use at most five lines of text, no smaller than 30 points in size. It is also wise not to overuse animated effects, as they can become very distracting (and even annoying) for an audience.

In multimedia work, text can be used in a variety of ways. It can be:

- a scrolling box (use sparingly)
- spoken aloud by a synthesised voice
- an animated heading in a three-dimensional design (also use sparingly)
- hypertext
- bulleted lists
- synchronised with music in the form of karaoke
- transcribed using voice recognition
- searchable tracks that form the 'chapters' of a product
- captions for movies in multiple languages.

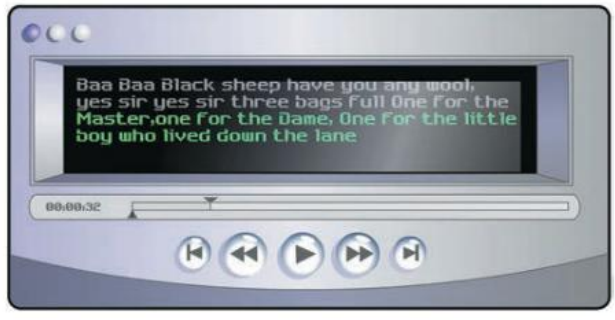


Figure 9.19 Text is used in a karaoke track to display the song lyrics while audio data plays the music.

Hypermedia

Interactive multimedia is controlled by the user, who makes decisions about it. This normally involves some form of hypermedia, such as clickable text, graphics or animation.

Hypertext on the Internet is simply text that acts like a button. When the highlighted or underlined text is clicked with a mouse, or touched with a finger on a touchscreen, it transports the user to a related item such as a page of text, an image, a movie, an animation or an application. Collectively, these hyperlinked types are known as hypermedia.

Hypertext was invented long before the Internet. It was during the late 1960s that Ted Nelson first came up with the concept of words that had their meanings attached. Later, Tim Berners-Lee conceived the idea of documents being linked electronically to help researchers.

'Hyper' means 'greater than'. Hypertext is therefore text with an added meaning connected to it. We learn more about this in chapter 12: The Internet and website development.

Graphics

A computer graphic is a static (still) pictorial representation of data that can either be bitmapped (a paint graphic) or vector-based (a draw graphic). Graphics can be created as two-dimensional images (2D), three-dimensional solids (3D) or even presented as 3D virtual stereo images, viewed with special glasses in 3D movies – see figure 9.21.

2D bitmapped graphics

Bitmapped images are also known as paint graphics. Each pixel (picture element) in the image is stored in the computer's memory using binary digits (either a 1 or 0) to represent its colour. This data forms what is known as the image's bitmap.

A regular screen displays 1024 × 768 (= 786 432) pixels. As each of these pixels requires 24 bits to display any one of its 16 777 216 (= 2^{24}) colours, it is clear that a single image that fills your screen would have a large file size and demand a lot of storage.

Various methods of compression have been invented to try to overcome this problem, which is particularly important when using images on web pages. Large graphics have long download times, as most readers would already know. More detail is provided in chapter 4: Data handling and chapter 11: Digital media.

One widely used 2D software application is Adobe® Photoshop®, a well-known bitmap-based application ideally suited for the manipulation of photographic images. This software can be used to reduce a bitmapped image to a suitable size for use in a web page, by using compression techniques.

2D vector-based graphics

Vector images are often known as draw graphics. The image is stored in the computer's memory as an object, using a mathematical formula. For example, a straight line would be recorded with only two coordinates – a starting point and an end point – with other information such as the thickness, pattern and colour of the line being stored in separate codes. This data is known as the image's primitives and can be stored by the computer in much smaller-sized files than is the case with bitmapped images.

Vector graphics have short download times and so are very popular on web pages. One animated vector format widely used is Adobe Flash.



Figure 9.20 A 2D vector graphic from a student's Flash-authored animation

3D images

Three-dimensional imagery is important when creating realistic multimedia images – after all, we live in a three-dimensional world! Techniques have been developed to help us sculpt solid objects using a mouse, and these are discussed in chapter 11: Digital media.

Using vector representation, it is possible to add a third coordinate and represent points in 3D space. These wire frames can then be lit, rendered and even rotated on screen using a mouse. See the 'In action' article on the UNSW T_Visionarium at the start of this chapter for an example of 3D combined with interactivity – a complete multimedia experience.



Thinkstock/Bill Fehr

Figure 9.21 Popular movies are often shown in 3D and use glasses with opposing polarised lenses to deliver different images to each eye.

Audio

Movie producers know how important audio is for making emotional contact with an audience. The impact of sound is often underestimated. Watch how quickly a class of students stops talking and pays attention to the image on a screen when dramatic music begins!

Audio on a computer is digital data that represents sounds, including voice, music, sound effects and background noises.

You can test the impact of sound for yourself by listening to an ad on TV without looking at the picture, and then again looking at the picture with the sound turned off. Which had the most emotional impact on you? Perhaps this explains the continuing popularity of radio in an age of more sophisticated technologies.

Professional sound or audio engineers are hired from the motion picture or radio industries whenever high-quality sound is required for multimedia. The goal of the audio engineer is to create a sound landscape that can make audio the most compelling element of a multimedia production. Sound should be seen as a second level of communication that is equal to the visual elements.

It is interesting to compare the background sounds and effects used in early games with those used now. Today, we hear the rustle of leaves, bird sounds and the splash of water – a full palette of stereo sound, rather than just the beeps and crashes of earlier games.

There are two main types of digital sound – digitised sound files and musical instrument digital interface (MIDI) files. Both types are used extensively in multimedia titles.

More detail on these two digitising techniques is provided in chapter 11: Digital media.

Digitised sound

Real-world sound is recorded with a microphone. Sound waves cause a mechanism in the microphone to vibrate, which then converts them to electrical signals. These are unsuitable for use in a computer as they contain a continuous signal made up of constantly changing frequencies and volumes (that is, they are in analog form). An ADC (analog-to-digital converter) chip is needed to change the continuous analog signal into the zeros and ones of the binary system.

The process of converting an analog signal to a digital one is called digitising. Analog sound (from a microphone) is digitised by taking samples at regular intervals and measuring the volume (amplitude) of the sound. This is represented by an 8- or 16-bit number, depending on the accuracy required. This is called the sample size. The number of samples taken per second is known as the sample rate. Ten seconds of digitised sound normally takes up 1 MB. Compression techniques, such as MP3 (MPEG Audio Layer III) encoding, can help to reduce these large file sizes.

MIDI

The second way to store audio is by using MIDI. MIDI does not store real-world sounds. Instead, MIDI files contain digital descriptions of sounds produced by the musical instruments in the software or hardware and are predefined in digital form.

Data contains descriptions of the instrument, duration, pitch and timing of each note. A number of instruments can be combined.

We saw above how much space digitised sound occupied. A 10-second MIDI file would occupy approximately 4 kilobytes (KB) – many times smaller.

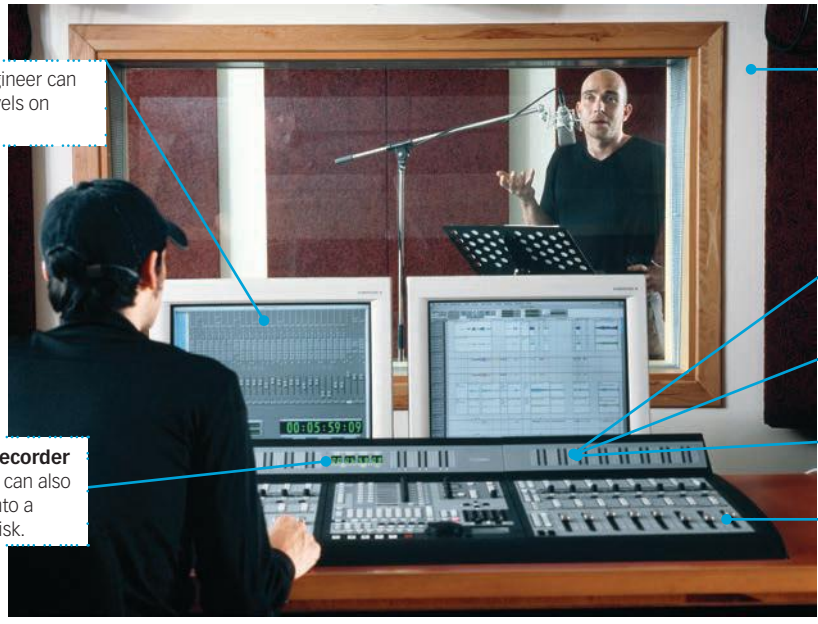


Figure 9.22 An analog audio signal is converted to digitised sound.

Animation

Animation has been with us for more than 100 years. It is best described as the illusion of movement generated by a series of still graphics that are rapidly presented to the eye, each slightly different from the previous one.

Animation depends on a characteristic of the brain and the retina called 'persistence of vision'. The rapid presentation of images results in 'afterimages' being seen by our brains for a short period after the actual image has disappeared. The result is that we see rapidly changing drawings as though they were changing smoothly.

In cel-based animation, a skilled animator draws key frames, showing the important changes in the character's appearance, while other animators draw the gradually changing positions between them, a process known as tweening. However, animation software such as Flash can automate this process. Flash can be used to create the correct in-between frames to give the illusion of smooth animation.

In path-based animation, a single still image is moved along a mathematically predefined path. The start, end and path of the motion are determined and computer software simply moves the object along this path. This type of animation is often used in interactive games.

These two types of animation are sometimes combined. When animated cel-based frames move along a predefined path in a looping sequence, more complex animations are created.

Flash offers three types of tweening: shape, motion and classic tweening.

3D animation

The creation of 3D animation progresses through at least four stages. The lowest level is the wire-frame model. The next stage uses mathematical techniques to hide the wire-frame lines, providing a more realistic and solid view of what the object will look like. In the third stage, shading, shadowing and colour are added and the object begins to look more real. In the fourth stage, rendering, realistic surfaces are created. The final object can then be animated in the same way as a two-dimensional animation.

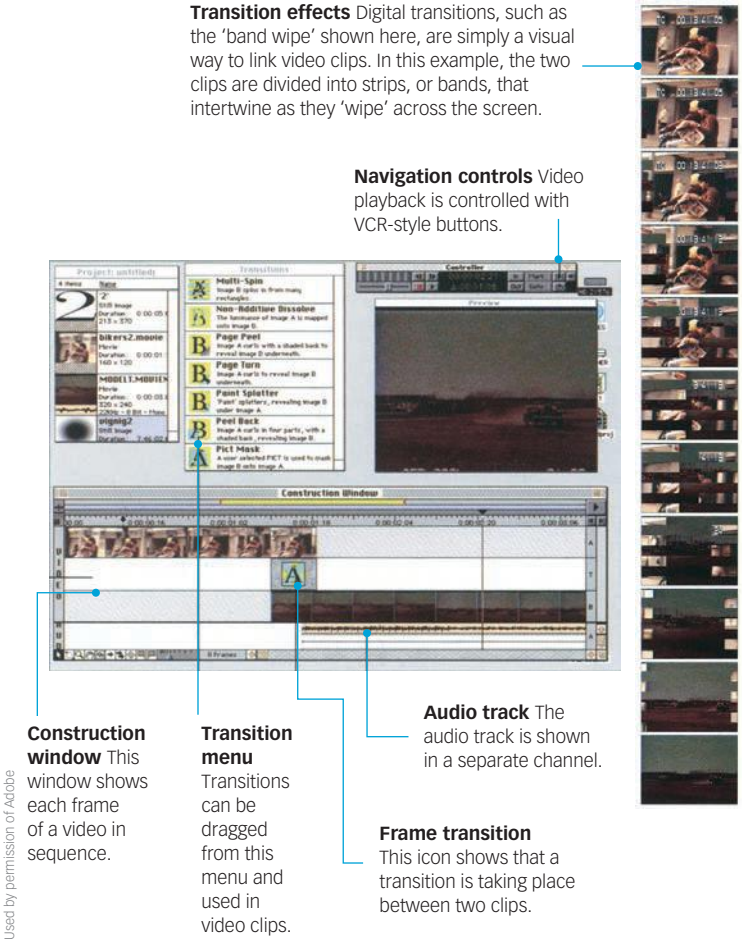


Figure 9.23 Popular digital video editing packages, such as Adobe® Premiere®, allow each frame to be separately manipulated.

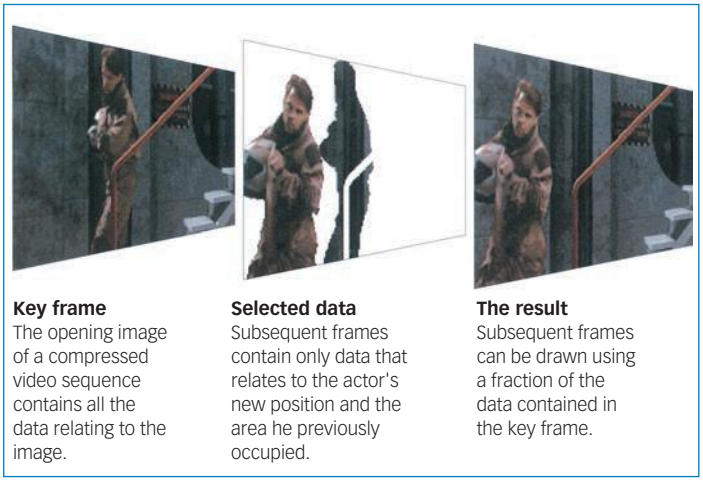


Figure 9.24 To compress video for multimedia, frames contain only the data that has changed from the key frame, greatly reducing the file size.



Figure 9.25 Path-based animation created using Adobe® Director®

Used by permission of Adobe
Used by permission of Adobe

Video

Video is made up of separate frames of sequential bitmapped graphics that are displayed rapidly to create the illusion of movement. Compression techniques are often used to reduce file size.

To use video, a computer requires it to be digitised. A VCR (video cassette recorder) uses analog data – a continuously changing signal, whereas DVDs contain binary digital signals – using just zeros and ones. Digitised moving images are usually captured by digital video cameras.

Video can include standard video (digitised video), virtual reality panoramas (interactive video), virtual reality objects (interactive video) or 3D stereoscopy (where the viewer wears special glasses).

A 3D film creates an illusion of depth. A special movie camera records the image from two angles (or alternatively, digital images may be created on a computer) and special projectors and glasses are used to view the effect. Although 3D films have existed since 1890, they did not become popular until relatively recently.

Editing

Editing for multimedia involves the careful planning of the interactions between video and other media. Video editing packages, such as Adobe® Premiere® or Final Cut Pro, allow each frame to be manipulated separately. Transition effects can be added to join separate clips; titles and credits can be added to movies; and special effects can be added to individual clips using software such as Adobe® After Effects®.

Each frame in a digital movie is a separate bitmapped image. Movies would play very jerkily on a computer if each frame had to be processed in sequence by the CPU and moved to the video buffer in the computer.

Specialist software, such as QuickTime or Windows Media Player®, uses compression techniques to lessen the demands of rapidly processing such huge volumes of data.

One common compression technique is to record only those parts of an image that change from one frame to the next (the delta data). Another is to use a smaller window to display the movie.

When game creators film their movie segments, they pay attention to such details as these and avoid 'busy' backgrounds, which would increase the number of pixels that would have to be redrawn in each frame.

A difference between watching a DVD multimedia title and a video played on a VCR is that a DVD allows users to access any scene instantly, rather than having to move sequentially from the start. We can navigate to any chapter of the movie with a single click.

It is this difference that makes interactivity possible – an important characteristic of multimedia.



Apple.com

Figure 9.27 MIDI audio composition showing instruments and on-screen keyboard for composition

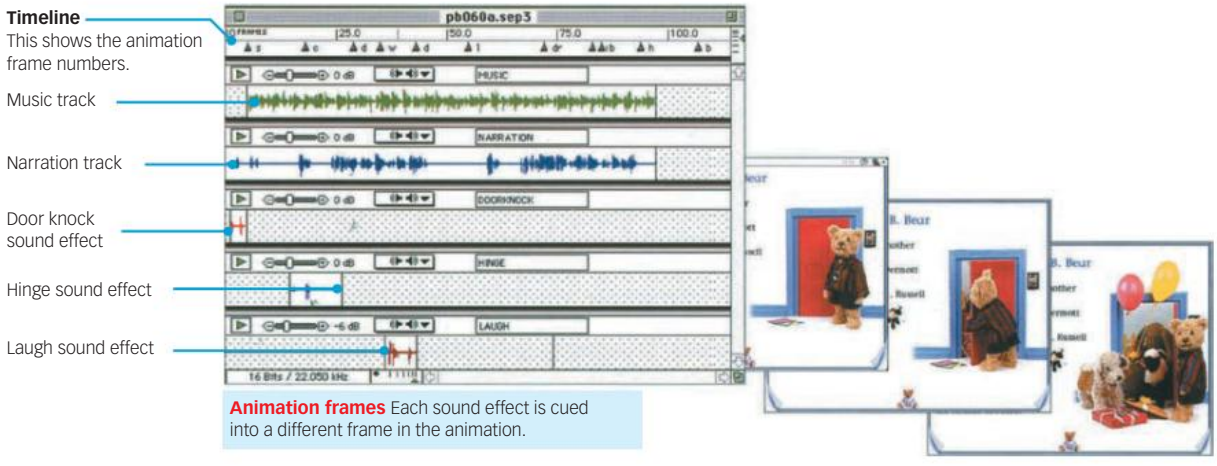


Figure 9.26 Multimedia uses layered audio tracks built up from separate sound files, either as digitised waves or MIDI. Sound effects can be cued to animation.

PEOPLE

CORE ALERT People

People in multimedia

There are defined tasks that must be accomplished in any multimedia project. In larger projects, these tasks have clear job descriptions, but in smaller projects one person might handle a number of jobs (this is called multiskilling). The major job roles in the industry include:

- business, financial and legal experts, who handle copyright and intellectual property, cash flow, contracts, royalties and licensing
- the project manager, who coordinates the budget, schedule and resources of the project
- the creative director, who supervises the design of the project and looks after the work of the writers, editors, artists, animators, musicians and programmers
- content experts, who know a subject area well and are concerned with the accuracy of the content
- the creative team, which includes writers, editors and researchers, who create the content; graphic designers, who lay out screens, design icons and establish colour schemes; illustrators, who create the diagrams, maps, cartoons and drawings; photographers, who may also scan and process images; audio professionals, including musicians, voice talent and sound designers; and 2D and 3D animators, who use modelling programs and rendering packages
- the technical team, which maintains software and hardware, makes sure that software is updated and working, ensures that networks are operating correctly, solves operational issues, and may also help to solve storage and file format issues
- information designers, who are skilled at organising large amounts of information
- information programmers, who use multimedia authoring packages or who might develop a software tool of their own.

QUESTIONS

1. Draw eight circles on a page, fill each with the name of one of the job categories listed in the panel and write a one-sentence description of that task.
2. Imagine a multimedia project, then draw arrows to show which groups will need to communicate with groups in other circles. Make the thickness of your arrows correspond with the amount of communication likely to be needed during a typical multimedia project.
3. Describe the multimedia product that this team could produce. What would be the task of each of the experts involved?

INFOBIT

James Cameron's movie *Avatar* was the first commercially successful 3D movie and is among the most profitable movies of all time.

ACTIVITIES

Identify

1. State four different ways in which text can be used in multimedia systems.
2. What is a key frame in animation and how is it used?
3. Name the two types of audio files used in multimedia.
4. Describe the process of tweening in animation, and illustrate it with the use of diagrams.

Analyse

5. The MIDI audio format typically produces very small file sizes. Explain why this is so.
6. List the five separate elements in order of increasing processing demand for an average DVD-based multimedia product and state the reason for your placement of each.
7. Find out the origins of the term 'cel', as used in animation.
8. Video presents particular problems in authoring multimedia. What are these problems and what methods can be used to overcome them?

Investigate

9. Use the web to find out about:
   - **a** the earliest non-computer animation – what was it about and who created it?
   - **b** the first full-length digital movie created entirely on computer.
10. Explore the websites for Adobe Flash Player, QuickTime and Windows Media Player. List the features, interfaces, sizes and merits of each, paying particular attention to the full list of media types that each one can handle. Research and decide which is the most widely used of these formats.
11. Synchronisation of sound and video is a technical challenge in multimedia. Research a software technique used to achieve this.

9.4 Multimedia hardware

CORE ALERT Hardware

Although many exciting advances have been made in the hardware used to author multimedia, backup and display hardware can be the most important for the success of a project. A computer crash can destroy a project.

Hardware for storage and backup

Losing weeks or months of detailed creative work would be a disaster, so it is essential to back up work. This task is usually done on a network server.

While a multimedia title is being built, the separate working files are stored on the local hard drives of computers.

A second copy of the working files should be kept locally in case of file corruption. A third copy should be stored separately (in case of hard disk failure or computer theft) and a fourth copy should be kept off-site (in case of fire or other disaster). It is vital that regular backups are made of the work. External drives can be used because of their large capacity, but the files are often very large, and so backups are usually performed at night. These backup copies should be kept up to date. An out-of-date copy is not much help in regaining last week's work.

If the organisation uses a network, the separate working files for each team member can be backed up to a central server. Workers (and school students) should still keep their own backup copies as added security, but it is the responsibility of the system administrator to back up daily and to keep copies off-site as well.

Optical discs

How can we store the final multimedia title? This has always been a big problem with multimedia.

The file sizes are very large and the ability of even the best storage media to keep up with the data transfer rates required has been an enormous problem. One disc can hold a huge amount of text, but one full-screen photographic image can take up the equivalent of 150 000 words.

Storage technology is undergoing rapid change at present. It is likely that the popular optical drives such as DVDs will not survive these changes, just as the humble floppy disk is now almost useless in the world of multimedia, where files are nearly always much larger than its capacity of 1.44 MB. It is now many years since Apple Computer first decided to build their iMac® without a floppy disk drive and more recently dropped built-in optical drives as well.

Flash memory in the form of USB sticks stores many gigabytes and is now cheap and convenient. Many laptops are still equipped with optical drives that combine the ability to read and write on both DVDs and CDs.

DVDs are a cheap storage medium – around 50 cents per disc – and so can be included free on magazine covers, but their days are numbered. They are very slow compared to a hard drive, and their storage capacity is now considered small.

A CD has a capacity of 700 MB and can run video, although this would be of very limited duration, while a DVD stores up to 4.7 GB of data (or twice that, if it is dual-layered) on discs 12 cm in diameter. Blu-ray discs are likely to be the last example of physical storage media before most storage shifts online. Their normal capacity is 25 GB per single layer, but they can store up to 200 GB. They are read by a blue-violet laser of short wavelength, whereas a DVD uses a red laser.

Hardware for output display

Common hardware for displaying multimedia includes the following:

- Liquid crystal displays (LCDs) place liquid crystal between two polarising sheets. A current is applied at various points, changing the light transmission characteristics of the crystal at that point. These displays were primarily used in laptop and hand-held computers, but are now common on desktop computers. They give out no heat, radiation or glare. Active matrix LCD displays are clearer than regular LCD screens, but are more costly to manufacture. In an LCD display, the image is backlit using a cold cathode fluorescent lamp (CCFL). LED screens use light-emitting diodes for the backlighting and consume much less power, but they are still LCD displays. See the explanation and illustration in figure 2.4.
- Cathode ray tubes (CRTs) or visual display units (VDUs) control three focused electron beams – one each for red, green and blue – striking tiny phosphor dots of pixels on the coated surface of a computer monitor and causing them to glow briefly.
- Plasma displays use tiny coloured fluorescent lights that are illuminated to create an image. Each pixel is made up of three fluorescent lights – red, green and blue – as in a CRT. The intensities of the different lights vary to create a full range of colours. The advantages of plasma displays are that they can be made very wide and thin, with an image that remains bright from every angle. Plasma displays are very costly.
- Early touchscreens used a matrix of infra-red beams in front of the screen to locate a finger position and

translate this in the same way as a mouse pointer. Such screens are popular display devices in public areas such as museums. Nowadays, touchscreens are widely used in mobile multimedia devices. In these devices, touch is monitored by sensing small electrical currents in screen layers.

- Data projectors contain a digital light processor (DLP), with 500 000 separately controlled mirrors, used in combination with LCD technology. The computer screen image can be projected onto a wall, providing a large display for an audience. These projectors are getting smaller and cheaper, and can turn a lounge room into a mini-theatre.
- Interactive whiteboards (IWBs) include both input and output features for multimedia display. These boards have resistive or electromagnetic surfaces and sense the position of a pointer, allowing the user to control a projected cursor in the same way as a mouse. Newer versions use the projection device to sense cursor position and so dispense with the need for the special surface.
- Speakers use a coil of wire to produce a magnetic field, which rapidly pulls a cone of cardboard or foil in and out to produce sound waves.
- Head-up displays project an image onto a small screen inside a helmet or other surface. These can be used in the entertainment field as virtual reality (VR) display devices or by pilots. However, users experience a sense of immersion in the VR world, which can be disorienting.



Photo by Alice Mcbroom

Figure 9.28 Interactive whiteboards have both input and output features for multimedia display.



Corbis/Masterfile/Stephoto

Figure 9.29 Nintendo's Wii: one version of virtual reality

INFOBIT

Some DVDs do not last as long as old VHS videotapes because of 'DVD rot', which is caused by deterioration of the disc surface and poorly-designed cases. It is possible that our generation will leave less information about ourselves for those who come after us than the ancient Egyptians, Babylonians and Romans who wrote on stone and papyrus!

ACTIVITIES

Identify

1 Name and briefly describe three multimedia display devices.
2 Identify two types of touchscreens.
3 Explain why one backup copy of a multimedia project under development should always be kept off-site.

Analyse

4 For each decade of personal computers, commencing with the 1970s, identify and describe the most popular storage hardware for a multimedia title.
5 Describe the strengths and weaknesses of the types of touchscreen technologies.
6 Construct a table that summarises the advantages, disadvantages, features and cost of the following display devices: CRT, LCD, plasma and data projectors.

Investigate

7 Choose one example of online multimedia using the web. Write a review of the site suitable for a computer magazine (about 200 words, word-processed).
8 Research how touch is sensed on a tablet or mobile phone. Use a diagram to illustrate this technology.

9.5 Authoring software systems

CORE ALERT Software

Multimedia authoring or multimedia programming can be used in the production of multimedia titles.

Multimedia authoring uses high-level graphical user interfaces and software, which takes care of the complicated coding that hides behind the work. Multimedia programming involves 'real' complex computer languages like C and Java and needs experienced programmers to create the product. The programmers need specialist programming knowledge and must be able to write detailed code.

Because multimedia programming is so difficult, most projects use dedicated authoring software to create multimedia products (such as the project you will create) – a user-friendly, prepackaged multimedia version of regular computer programming.

Authoring software methods

If you were asked to invent a way of creating and organising a new interactive game similar to Doom or the latest game from Sony or Nintendo, what concept would you come up with for an authoring tool? Keep this concept in mind while you read on.

Authoring software can fit many styles, but four main types will be described here. These separate types are known as paradigms. (A paradigm is simply a pattern or way of doing something.)

The first method is based on stacked cards or slides, the second is like a stage play that takes place over time, the third is modelled on a flowchart, and the fourth uses a table that has all the possible decisions worked out in advance.

Stacked slide authoring

Early computer-based multimedia titles were based on the concept of the traditional set of family slides, designed by the user and arranged as a 'stack'. These could be viewed on a computer screen with clickable buttons for navigation. However, the stack of slides was not restricted to text and various media elements could be included. PowerPoint and Prezi both use this approach.

In this method, buttons allow us to follow our interests, answer questions or explore at our own pace, rather than simply following the slides in their order in the stack. We can step out of the queue of stacked slides at any time, and jump in again whenever we want to in order to continue viewing elsewhere.

Apple® HyperCard® was the first popular authoring tool for home computer users based on this method. Developed in 1984 by Bill Atkinson at Apple Computer, it allowed ordinary users (without programming experience) to produce sophisticated interactive projects on their own computers.

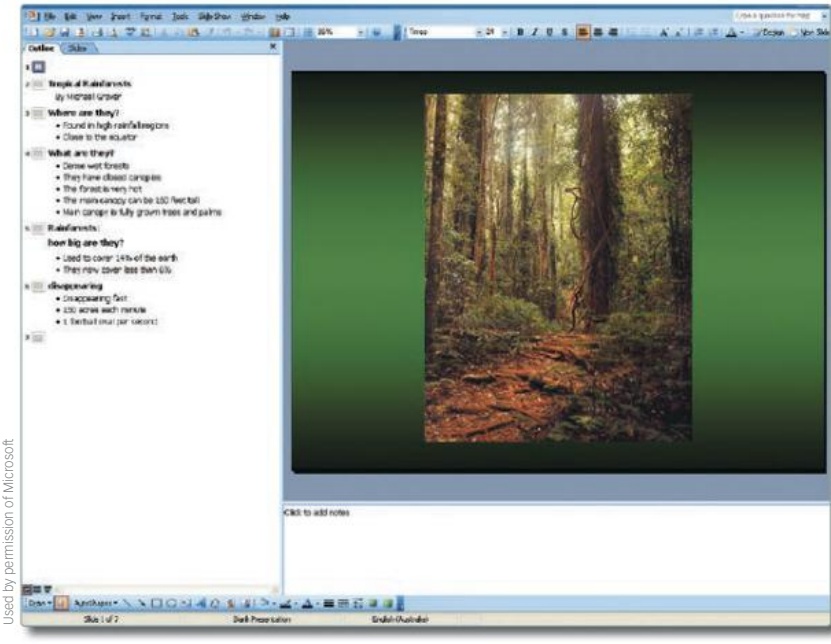
PowerPoint is easily the most widely used multimedia authoring tool today, although most people would not recognise it as being one, as it is usually a simple series of sequential slides with little or no interactivity.

However, PowerPoint is not a full multimedia authoring software package, even though it has many of the features of such software. It allows a presenter to produce professional-looking screens with interactive buttons, timed transitions, the ability to combine all types of media, connect to the Internet and start up other applications on the computer.

PowerPoint is also an excellent planning tool for the creation of rough demonstrations of a big multimedia project. This preliminary design is called a **prototype**.

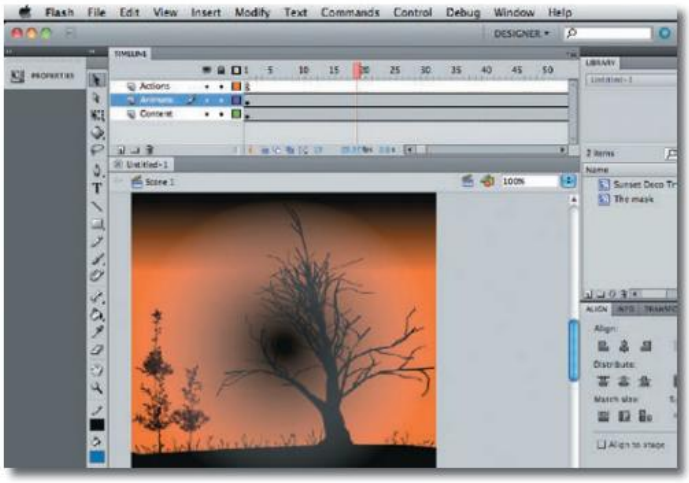
Stage play/timeline method

The stage play is the second approach to software authoring (this is also called the timeline method). The media elements, such as sound, movies or graphics, are treated as though they are the cast members (actors) in a play and follow a script, entering or leaving the stage or waiting for a user interaction (such as clicking a button). This is known as stage play (or timeline) authoring.



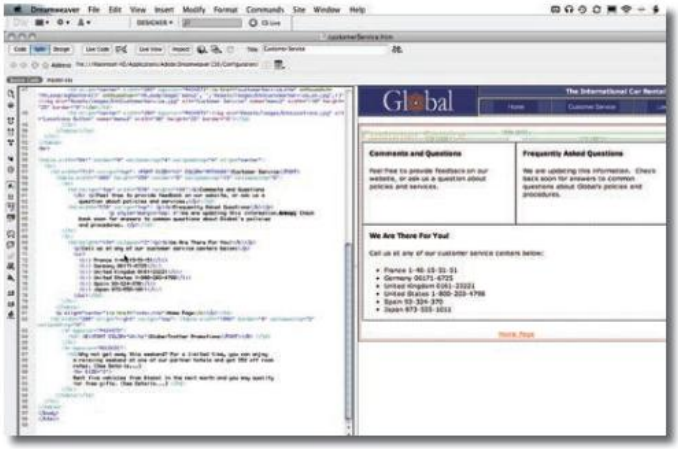
Used by permission of Microsoft

Figure 9.30 PowerPoint slideshows are an example of the basic slide approach to multimedia authoring. PowerPoint's linear slide-based presentations are the only encounter that many people have with multimedia authoring systems.



Used by permission of Adobe

Figure 9.31 The Flash interface, showing its stage play/timeline approach. Such authoring software usually includes a powerful scripting language. Find out the names of these scripting languages in both Flash and Director.



Used by permission of Adobe

Figure 9.32 The Adobe Dreamweaver interface, showing the split design and code views. Note the hypertext markup language (HTML) code in the panel on the left.

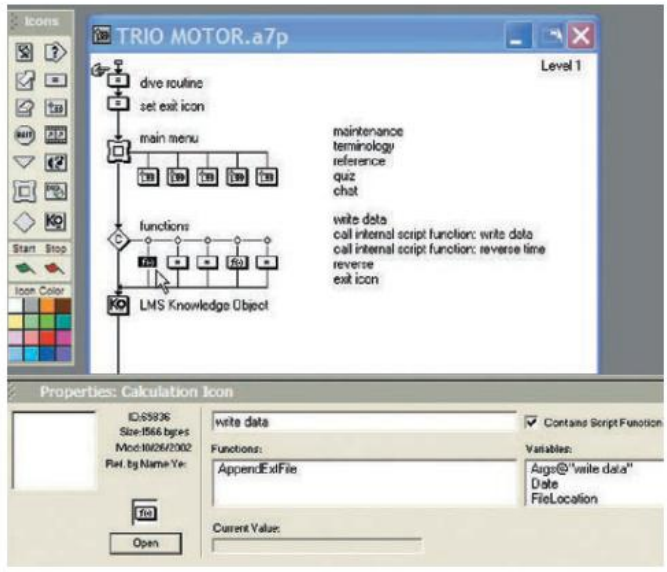
INFOBIT

Prezi (see figure 9.15) is an alternative presentation tool to PowerPoint. However, like PowerPoint, it can be easily overused and, for some, its sweeping movements can induce motion sickness.

An indicator travels along a timeline containing many parallel tracks, each of which represent the actions over time of one of the various cast members.

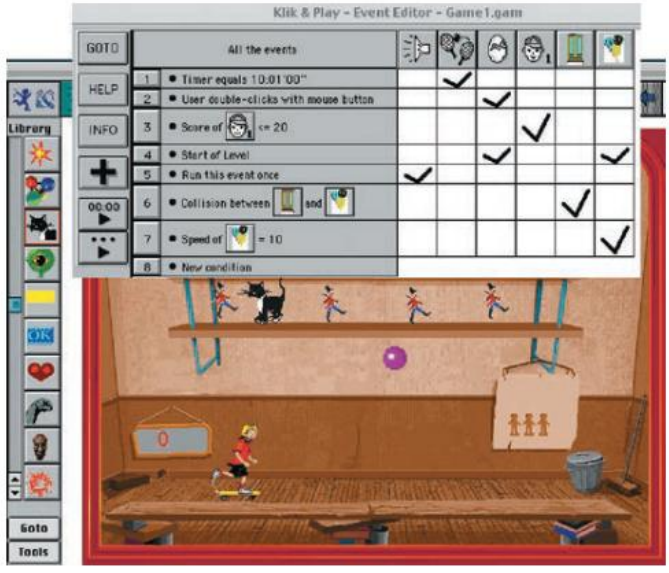
By examining these tracks vertically, it can be seen which of the cast members are active on the stage at any one moment. The indicator stops whenever a script instruction tells it to await user interaction, such as a mouse click or a rollover.

Popular examples of this type of authoring software are Flash, Edge and Director, with their in-built scripting languages, all of which have been widely used to produce media-rich interactive projects.



Used by permission of Adobe

Figure 9.33 The Adobe® Authorware® flowchart approach to multimedia authoring



Klik & Play

Figure 9.34 The Klik & Play interface, showing the decision table approach to multimedia authoring

Flowchart method

Flowchart authoring certainly suits multimedia, as each media element is represented as an icon and there are logical flow lines between them. However, it is not used as often as other methods. One multimedia authoring tool that does use this concept is Adobe® Authorware®.

It tends to be the quickest of the methods (in development time) and so is best suited for projects that have a short development time.

Many people find the use of a flowchart to plan a project to be a logical approach, and one major advantage is that it enables complicated navigational paths with lots of decision points to be seen at a glance.

Decision table method

What if all the rules had been decided in advance and the user was then let loose on the screen? This multimedia programming approach suits interactive multimedia games and is the pattern behind the game design software Klik & Play.

With this software, there are two ways of creating games. In the first method the designer selects an active object (such as a spaceship) and defines its movement during game play (for example, increasing a score or losing a life). The second method (**decision table authoring**) gives the designer much finer control and results in more complex games. It uses a large decision table in which all objects and their possible actions are defined and organised.

Choosing the best applications

In this multimedia module it is important that you experience at least two of the methods mentioned during your studies. Your school is likely to concentrate on one of these methods for your practical work.

There are literally hundreds of different multimedia authoring software packages available for both Windows and Macintosh – and many are free or can be downloaded as time-limited trial versions. PowerPoint could be a good starting point for experimenting with some interactivity, using buttons. However, if you want to attempt something more advanced, use Flash, Edge, Director or Dreamweaver – but it might be preferable to save Dreamweaver for your web design work and learn one of the other authoring applications for now.

You should keep in mind that professional authoring software is typically taught in training institutions over many weeks. So don't expect to become a multimedia expert overnight – but now is a great time to start!

Special modules

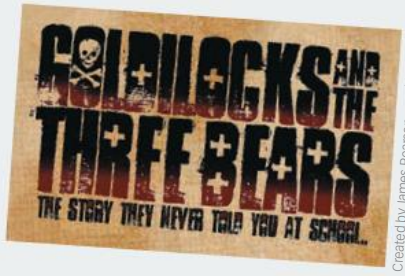
If you were to examine a typical authoring tool, you would discover separate modules for creating some of the multimedia elements that you would need. For example, Flash has filters and effects as well as pre-built behaviours, while Director has a painting module, a vector module, the ability to create animations and a text editor. Director has added the ability to create three-dimensional solid objects and animate them. You could create most of your media inside any one of the professional authoring software packages, but you will usually get better results by recognising that each of the elements has particular modules that are best suited for its development, using that module for that element and then importing your creations.

CASE STUDY

CORE ALERT Projects: design, produce, evaluate

A modern-day Goldilocks

Planning



Created by James Pearson, used by permission

1 Inspired by the concept of traditional paper fairytale pop-up books, Year 12 student James Pearson decided to adapt the well-known fairytale *Goldilocks and the Three Bears*. James believed that interactivity was the key to engaging the audience.

Defining and analysing

2 Rethinking the traditional characters of the bears, the author decided to base his on popular culture and give them each a different personality. Goldilocks had broken into the bears' home and so the decision was made to turn her into a high-class thief! She would always be trying to steal from the bears' house and the bears would always be trying to stop her.

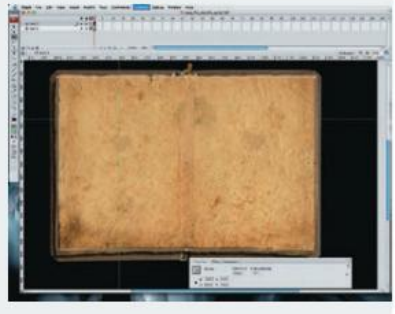
3 The plot was written out in point form, a storyboard constructed and decisions taken as to when it would be appropriate to incorporate built-in games. At this stage, the author decided it would be fun if the user could choose between role-playing either Goldilocks or the bears, so this meant the use of a **hierarchical** storyboard. The original story was reread and research begun into suitable audio and graphics that could be used.



Created by James Pearson, used by permission

Designing possible solutions

4 The author chose a parchment background and decided on the concept of an old book as his design theme. This determined the choices of colour palette and font style, as they had to be consistent with this theme.

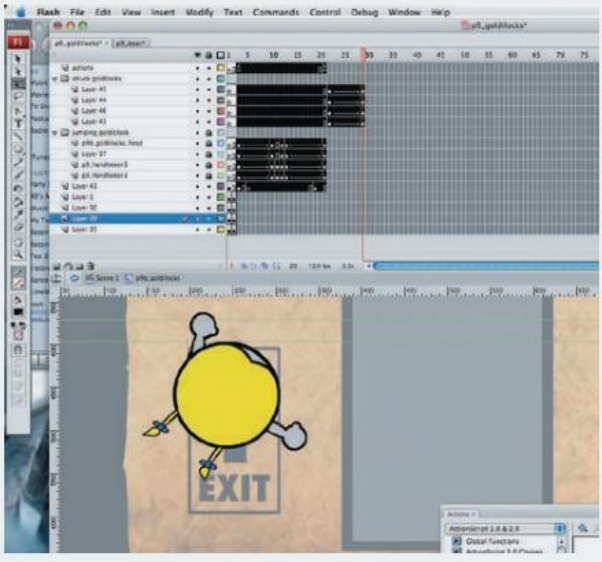

Created by James Pearson, used by permission

5 Adobe Flash was chosen as the authoring software and a non-interactive opening sequence (called an 'attractor') was created. This sequence involved audio, text, graphics and animation.



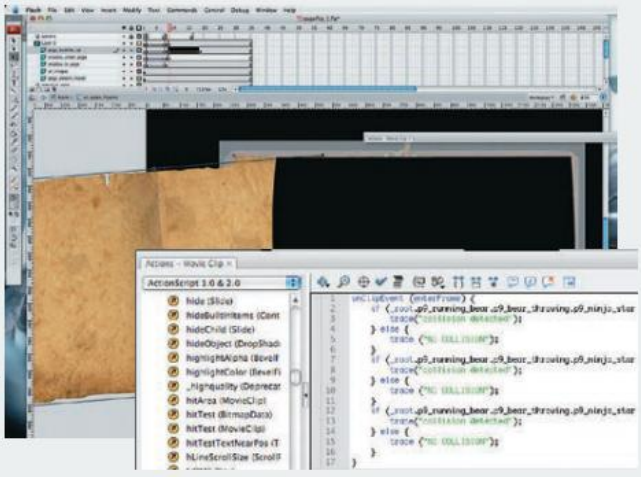
Created by James Pearson, used by permission

6 James sketched his bears using the drawing tools in Flash. He designed interactive games that could be included in the project. He collected and created sound effects and music, using Audacity and royalty-free sounds. He created the necessary animations, drawing each image frame by frame, but he also used tweening. These all became members of the project's library. Finally, he created and coded the games using ActionScript in Flash.



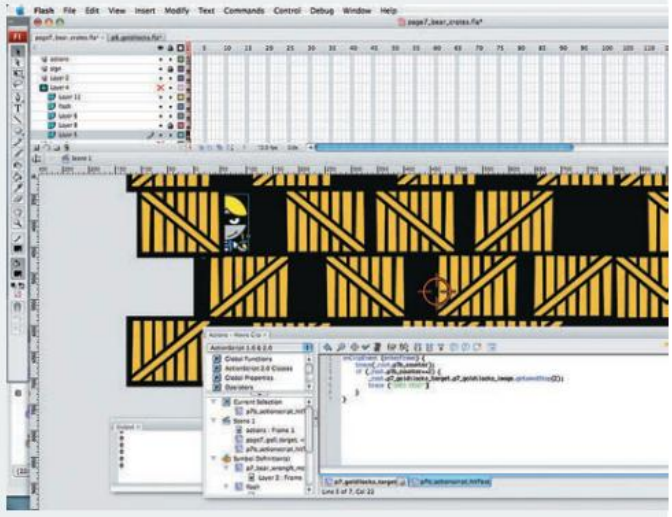
Created by James Pearson, used by permission

7 James decided that the project should 'feel' like a book, so he learnt how to code realistic 'page-turning', using Flash's built-in scripting language, ActionScript. Throughout this stage he documented the problems he faced and solved, and noted others that he still had to work on.


Created by James Pearson, used by permission

Producing solutions

8 All the assets that had already been produced were now assembled on the stage, and James then set about creating others that were needed. Symbols were placed in their correct positions on the project's timeline. Buttons and interactivity were both created at this point.


Created by James Pearson, used by permission

Evaluation

9 With the project effectively completed, James asked his teacher and his fellow students to test his project, and they suggested some improvements. He rejected some suggestions, and then decided to prioritise the rest into high, medium and low. That done, he started to work on the high-priority ones, and then moved on to the medium- and low-priority changes. After he had taken in all the suggestions, he had the users again test the project, which resulted in some final changes, after which he confidently submitted the proposal.

10 Go to http://infosoftwaretech.nelsonnet.com.au and follow the link to play this great game!

Weblink

QUESTIONS

1 List in point form the main steps that are involved in each of the stages of this project.

2 View the final project. Name the multimedia elements present and identify two examples for each element.

3 Construct a storyboard on paper that will accurately represent the navigation of this project.

TASK 1

Acquiring the five multimedia data types

Working on your own, acquire each of the five data types as outlined below. This activity forms the first step in preparing for your final project for this option chapter. Your teacher will advise you of the preferred software application to use in each.

1. Choose a recent movie that you have enjoyed.
2. Text: Use a word processor to create a synopsis (summary) of the story, list the names of the actors, describe the background of the director and record the year in which the movie was made.
3. Graphic: Find a copy of a promotional graphic for the movie, import it into a bitmap software package and creatively manipulate it in some way.
4. Audio: Find and store a short piece of music from the film or an audio clip from the soundtrack.
5. Animation: Create a short personalised animation that can become your own 'trademark'.
6. Video: Find a short promotional video clip taken from the movie.

TASK 2

Building a prototype of your project

A prototype is a basic working model of a project that is not yet complete. It gives the author and the audience an idea of what the final project will look like. It is also useful as it identifies problems and their solutions early in the development before a lot of work has to be redone.

This task will help you prepare your final project, as outlined at the end of this chapter. It will be a multimedia project based on a movie of your choice: actors, synopsis, clips, photos and reviews.

1. Familiarise yourself with at least two of the following presentation packages: Microsoft PowerPoint, Apple Keynote, OpenOffice. Compare the features of each. Which do you prefer? Which do you think produces the better results?
2. Create rough screen designs for the home page and for the other pages.
3. Create a rough storyboard for your project.
4. Add the text, graphic, audio, video and animation collected in task 1.
5. Build the prototype.
6. Test the prototype on other members of the class and ask your teacher for their views.
7. Present the prototype to the class (optional).

TASK 3

Authoring multimedia using the stacked slides method

Create a set of slides, cards or screens in a linear sequence that will illustrate and explain each of the methods outlined in this section. Using navigational buttons, the user will view them in the order you arrange them. You can use any appropriate slide-based authoring software, but suggested software is Microsoft PowerPoint, Apple Keynote or OpenOffice. Each slide will have only one or two buttons: 'Back' and 'Forward'.

Remember that most slide-based software will allow you to build non-sequential projects, but here we will focus on a sequential arrangement.

TASK 4

Authoring multimedia using a zooming presentation method

1. Explore the Prezi presentation website and their free Nutshell phone app and select three examples of educational presentations that showcase Prezi's strengths as a presentation tool.
2. Create a presentation that summarises this section of the text.

INFOBIT

One of the earliest attempts at interactive books was made by the Voyager Company in 1991. Viewers could read *Jurassic Park* on their computer screens and also click on the name of a dinosaur to view a drawing of it or hear its supposed roar.

TASK 5

Authoring multimedia using the stage play/ timeline method

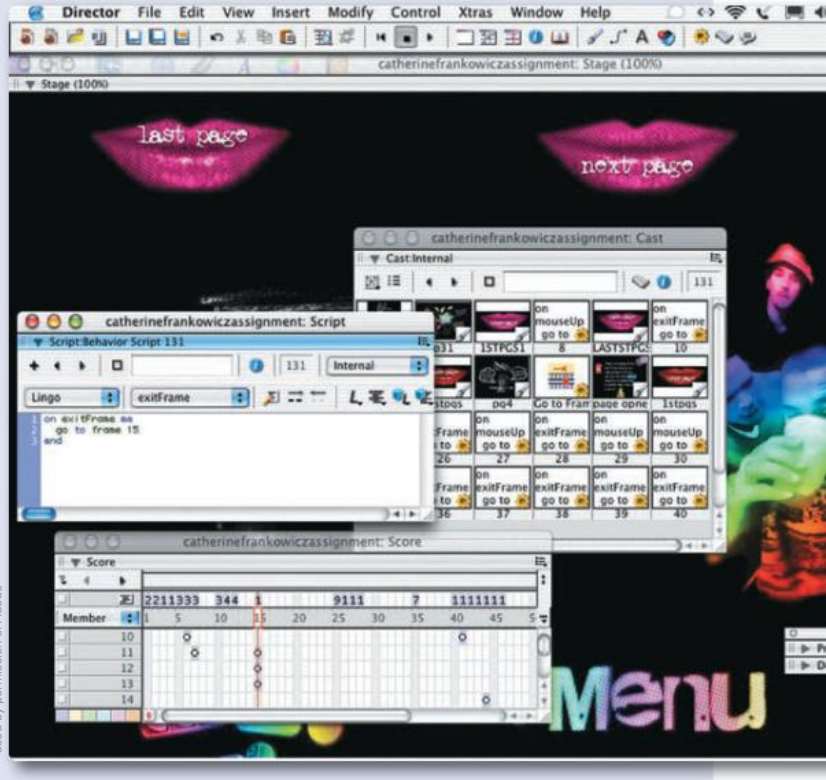
Create an interactive project to illustrate each of the elements of the stage play/timeline method of multimedia authoring:

- general layout of the interface
- timeline
- stage
- cast members
- score
- any other special tools available in your software.

These words can become the navigational buttons on your home page.

You will need to acquire screenshots for your authoring software before you begin. Text can be animated and given tween effects. Graphics can appear slowly. Videos can play and be controlled. Each segment will play and then pause until the user selects a return to home button. Use any appropriate timeline-based authoring software.

1. Create a storyboard that represents each segment of the timeline as a single rectangle, showing all navigational links.
2. Acquire all assets.
3. Build the project.
4. Add sound effects, such as button clicks and musical tracks or effects for each method.
5. Test the product on other members of the class and ask your teacher for their view.
6. Present the project to the class (optional).



Used by permission of Adobe.

Figure 9.35 The Adobe Director interface shows its stage play approach to multimedia authoring, using cast members, editing tools and script windows.

ACTIVITIES

Identify

1. State the differences between multimedia authoring and multimedia programming.
2. Identify and describe the four main authoring methods that you have studied.
3. State the tools that you would expect to find in a complete multimedia authoring environment (software).

Analyse

4. Name four commercial examples of multimedia authoring software and find the cost of each.
5. Why would a multimedia author choose a programming environment rather than an authoring one for a multimedia project?
6. Decide which method would be better suited for the creation of a video adventure game and justify your answer.
7. Choose which method would suit a multimedia CD-ROM for training people in the use of photo-developing equipment in a photographic laboratory and justify your answer.

Investigate

8. Examine carefully at least three multimedia products and determine the method used to author each one. These may be stand-alone products or web-based. The class could combine their results to determine the most commonly used authoring method.

9.6 Developing a multimedia product

CORE ALERT Projects: design, produce, evaluate

Creating a commercial multimedia title involves many people working with specialist software over a long period of time. An expensive task such as this takes a lot of careful planning.

There are four major stages in any project development:

- defining and analysing the problem
- designing possible solutions
- producing solutions
- evaluation.

Even when developing a small-scale project as part of a course at school, it is important not to rush any of these stages and to carefully plan the resources allocated for each stage to make sure that the project can be finished.

Defining and analysing the problem

Stating a clear goal and purpose

In this early stage of the development, it is important that the team of people who are building the title not only understand exactly what they are being asked to do, but also agree on how the project should look and what it should contain.

- The goal of any multimedia project must be carefully stated from the very beginning, as it is the foundation of all work that follows.
- This goal must be shared and understood by everyone involved in the production. If individuals have different ideas about the project, they will start pulling in different directions as the work progresses.
- The purpose of the multimedia product must be established. Is the purpose of the product to inform, educate or entertain?
- Try to state how the user will be changed as a result of your product.

End-user needs and target audience

The main reason that products exist is to satisfy the needs of their users.

- Before starting any work on a multimedia project, it is essential to know who is the target audience and what are their needs.
- The production team must consider such issues as the age, education and cultural background of the audience.
- A survey can be taken, or interviews conducted, to find out the direction that the project should take. One important technique is to invite a small group, known as a focus group, to answer prepared questions. These might include:
  - What are your favourite multimedia titles?
  - What would make you want to keep using the title?
  - What features would you like to see in the final product?
  - Where would you like to use it – on a hard drive, mobile device, CD-ROM or on the Internet?

Resources

Resources are an important component of any project.

- Decide if the author or team has the technical skills to complete the project. Will outside help be needed?
- If they are working in a team, do they have the necessary organisational skills?
- Check that there are adequate resources (both human and IT) to complete the project: money, technical ability, hardware, software and time.
- Projects usually have an impact on users, so it is important throughout to consider the social and ethical aspects of the project.
- The team will complete the following project plan:
  - What? – the purpose and the goal
  - Who? – the audience
  - How? – processes, techniques and resources.

INFOBIT

British Telecom researchers working on 'active skin' technology have predicted that calls will be made from tiny mobiles embedded in stickers or tattoos on the skin. Keyboards, music players and TV screens with Internet access can be implanted in people's arms and legs, remaining invisible until needed.

Designing possible solutions

A valuable way of checking the validity of a complex multimedia concept is to create an early working prototype, using presentation software (such as PowerPoint), which can give a quick result.

- At this second stage, use storyboarding and a prototype to complete an outline of the concept of the project. For example, an icon might represent a navigational link to a module that has not yet been designed. In some projects, the prototype becomes the actual starting point and evolves into the final project. However, in most cases it is simply used as a planning tool.
- The team meets to discuss the project and decide on a timeline. Do they have the organisational skills to complete the task? Can they get on together? Is someone able to act as leader or group facilitator? Various tasks are assigned to designers, editorial and production teams.
- At this stage, many of the designs and plans exist only on paper. The editors begin to research content and the designers begin to experiment with screen layouts.

Too many students do not spend enough time on this stage, and rush to design a final product too quickly, before their ideas and directions have been properly formed. A multimedia project is like a journey, with the concept forming the journey's destination and the plan being the map showing how to get there.

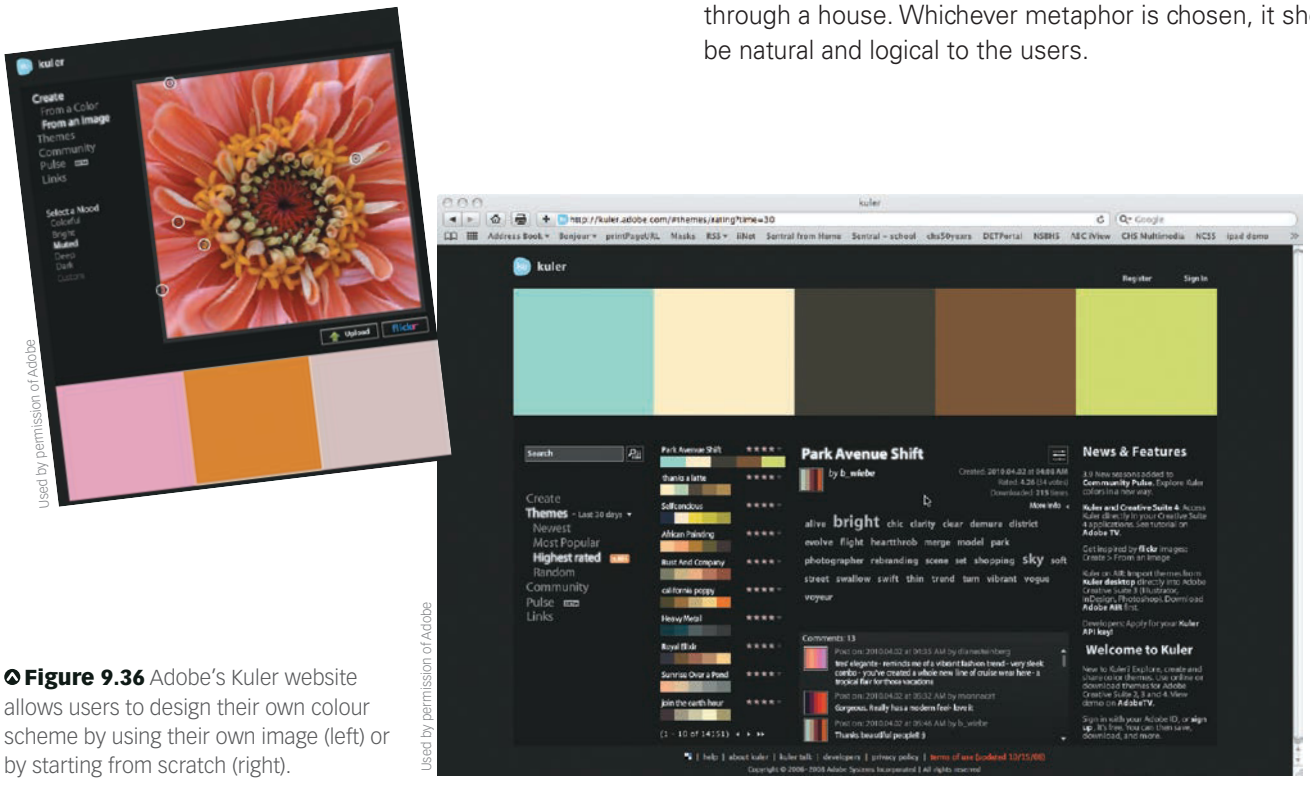


Figure 9.36 Adobe's Kuler website allows users to design their own colour scheme by using their own image (left) or by starting from scratch (right).

GUI design

We have already talked about the importance of a clear and logical interface. One of the challenges is to offer the user an enjoyable experience with as much control of their multimedia environment as possible.

In the early days of computing, before the mouse was invented, even adventure games had to be played by typing written instructions on the screen. Users would be given a set of scenarios labelled with the letters A, B and C; they would type their choice and the game would continue. There were no graphics.

The invention of the mouse and the then new ability of the computer to display pictures and interactive elements via a **GUI (graphical user interface)** changed games forever. The most common GUIs are WIMP (windows, icons, menu and pointer) and touchscreen, but many others exist.

Most interfaces depend on a metaphor. A metaphor is created when something is based on a second object, or imitates it. The metaphor for the Macintosh interface created in 1984 imitates the idea of an office desk (hence the term 'desktop' for a computer window). Microsoft copied it when it created its Windows operating system and this resulted in a court case between the two companies that went for many months. The final judgment was that the concepts of trash cans, menus and office desks were common ideas, available to anyone, and could not be copyrighted under United States laws. Apple lost the case.

A computer interface might also be modelled on a street map metaphor, a fun park metaphor or even a walk through a house. Whichever metaphor is chosen, it should be natural and logical to the users.

GUI design principles

Keep the following GUI guidelines in mind when working on your project.

- Consistency: Users expect that different applications will have similarities, which means that knowledge about one product can be transferable to another. Consistency in screen design is one of the most important principles of all.
- Manipulation: People want to be in charge of their actions. Objects should be moveable whenever appropriate and invite interaction.
- See and point: Actions and navigation should be easily recognisable on the screen. A user should not have to consult a manual.
- Feedback: A click on a button should result in some response that lets the user know that the desired action has taken place: a sound or a change in the appearance of the button is important.
- Forgiveness: If users make mistakes, they should be able to undo them and not be locked into a screen from which there is no return.
- Aesthetics: The design should be appealing to users. Objects should not clutter the screen. White space is important and too much text should be avoided. The colours chosen should be planned in advance. (This is known as the colour palette.)
- Functionality: Navigation should be clear, and commonly used buttons should be readily accessible.
- Voice: Which person or voice will you use? A multimedia title written in the first person (I) makes the user feel part of the action, as in an interactive game. The second person (you) makes the user feel as though they are part of a conversation. The third person (they) can suggest detachment and make a project seem official or authoritative.

Storyboards and navigation

Careful planning of the structure is important in complex projects. A **storyboard** is a map or plan of the final product. It represents each screen, each screen element, their placement and the links between them. These links are usually shown as arrows, indicating the direction of travel.

It is important to provide the user with a quick path to the home screen and not leave them at a dead end.

The three main storyboard layouts for navigation are linear or sequential, hierarchical and composite or network.

- Linear/sequential: The path is a single one that can be followed either forwards or backwards. Users cannot make jumps. When we are viewing videotapes or movies, we are using **linear (sequential) navigation**. We usually watch movies from start to finish. On videotape or film, you cannot reach that favourite scene in *Shrek* where the little bird explodes, without going past the rest of the movie first – even if you fast-forward.
- Hierarchical: In this non-linear navigation form, users choose which 'branch' of an imaginary tree they might wish to move along. Interactive multimedia games (such as those available for desktop computers, PlayStation or Xbox) depend on this. On a DVD, you can skip to any scene (chapter) you like. It is possible to view a movie's alternative endings, see out-takes, examine a character in depth, or hear background information in a documentary.
- Composite/network: This is a general all-purpose term where no obvious pattern of navigation exists. It may be a mix of the linear and hierarchical layouts. Any part of the multimedia product can be linked to any other. Users can freely explore any one of many possible paths through the product.

We have seen that a multimedia product can have either linear or **non-linear (random or direct) navigation**, or both. The choice made by a designer will be influenced by the purpose of the product.

If you wish to display a set of images of a trip in the order in which they were taken or show the proof of a mathematical theorem, a linear structure would be the better choice.

However, if you were writing an adventure game where the user has to make choices, or designing a simulated jukebox for your favourite music, a non-linear structure would be better.

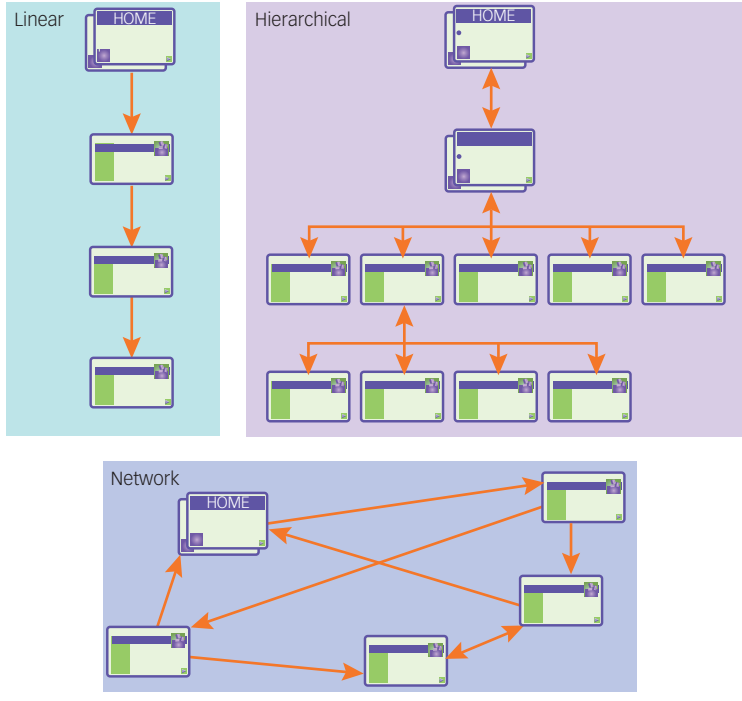


Figure 9.37 Three possible storyboard navigational layouts

Scripts

A script can be a written description of the content of a multimedia title, or it may be presented in storyboard form, or both. Often it is produced before any actual content has been created. A script allows a team of designers to form the same vision of what a final product will look like.

The script may record the dialogue to be heard or describe the actions of actors, as well as describe other content, such as visuals and interactivity.

In multimedia work, the term 'script' can also have another meaning. It refers to the programming language used by the multimedia designer. These languages are known as scripting languages and are used when the multimedia author wants more control over what is going to happen in the project. Well-known examples are ActionScript (used for scripting in Flash) and Lingo™ (the scripting language used by Adobe Director). Often these scripts come prepackaged as built-in behaviours in the software for users who do not wish to learn programming codes.

An example of such a scripting language is the following, which causes an action when the mouse button is let go over the object:

```
on mouseUp
  sprite(10).member = member 'Dimmed'
end
```

Screen design

Different screen designs are possible for the same material and the choice often depends on the target audience. Some guidelines for good screen design are:

- place items in the same position on each screen (the back button should not 'jump' as screens change)
- limit the number of fonts used in your typeface and make them compatible with different computers
- avoid displaying all words in upper-case letters and pay attention to the justification of your type (left, centre, right or full)
- be consistent in how you provide user feedback (don't have some buttons in the form of rollovers and others as simple clicks unless they have different purposes)
- use colour carefully – pastels are a good choice if someone needs to look at your screen for any length of time, or use bolder colours for important elements
- lay out elements with a careful use of white space
- do not overuse borders.

The two central principles that should guide you are consistency and ease of use.

Look around at other multimedia products and observe the screen designs that please you. While you are learning, try to imitate the qualities that you like.

Effective multimedia has:

- clearly expressed content
- well-chosen use of multimedia elements
- logical navigation
- an intuitive interface
- good screen design principles
- attention paid to storage requirements and delivery platform processing speeds.

Content for the multimedia products

Each of the five data types are created or acquired in different ways.

Copyright is an important issue here. Data or programming code must not be stolen, and even if permission is granted for its use, the original authors must be credited with its creation. To ignore this is really stealing another person's ideas, creativity and intellectual effort.

Larger amounts of text are usually created in a word processor and then imported.

Graphics may be created in dedicated draw or paint software and imported into a multimedia authoring program, created inside the authoring software or bought as collections of clip art and stock photography libraries.

Audio is usually created either by digitising a microphone recording (analog), or by using MIDI input devices.

Video is captured with digital video cameras or by digitising analog video. Audio is often integrated with video material.

Animations can be created inside authoring software, but most are imported from external sources. Motion capture technology can be used to provide the raw data for the movement of a wire-frame character. This technology uses special input devices on an actor's body, which translate into movements of a digital creature. A detailed description of this process appears in chapter 11: Digital media.

Once all the required data (text, audio, graphics, animation and video) has been collected or created, the required authoring software and player engine for processing this input should be chosen, and the final form of the output is decided.

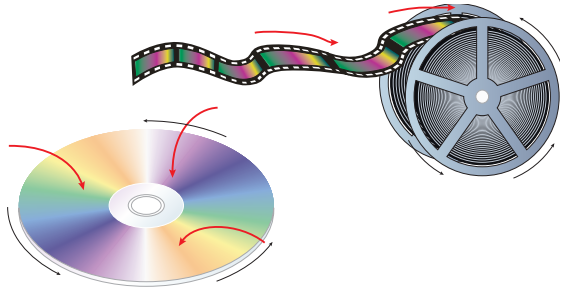


Figure 9.38 Film and tape must be read in a linear fashion, whereas data online and on hard drives, flash memory sticks, CD-ROMs and DVDs may be accessed 'instantly' from any point.

Producing solutions

Manipulating

All five data types may be edited, and there is appropriate software for each. For example, audio software such as Audacity can be used to create special effects such as echoes, fades and pitch changes. Photoshop offers a range of editing possibilities for graphics. Apple® iMovie® and Pinnacle (Windows) allow sophisticated editing of video for students and home users, while Apple® Final Cut Pro® or Premiere can meet the needs of professionals.

In this fourth stage, the designers assemble the separate resources into a working product, using multimedia programming and/or authoring software to create the final title.

Unexpected technical challenges may arise at this stage, and these will need to be solved. The final size of the project might need to be reduced to meet size restrictions in delivery (such as the bandwidth limitations of the Internet or the storage capacity of a CD-ROM). Perhaps the media collected takes up more space than is available or takes too long to download from the web, and compression will have to be reconsidered. The computer may not have sufficient memory or be fast enough for the chosen authoring software.

Now that the project is being assembled, it might also be necessary to develop other digital material that had not been thought of earlier. If the design stage has been carried out thoroughly, such extra work should not become a serious problem.

The technical or programming team may need to finetune the product to allow it to work smoothly on all platforms and computers. Consumers often use older machines and will expect the title to work on these.

Storing

Data for multimedia can occupy large amounts of storage space on a hard drive. However, it is possible to use DVDs, external hard disks and USB flash drives for backup external storage. These offer the convenience of being both portable and light, but not all these are equally reliable. You may wish to discuss this issue with your teacher.

Displaying and distributing

Professional multimedia design studios make great use of networked computers and centralised servers to store the required data. Any designer can then access the data they require and import it into the module they are authoring. This is important as more than one designer or programmer in a large project might wish to use the same item (such as a company logo).

A centralised database can track the use of each item, which is useful for the legal department who might have to clear copyright with the owners, or arrange payment of royalties.

INFOBIT

Thomas Edison's team created the light bulb by making thousands of prototypes, and then selecting the best. Coming up with the idea of the light bulb was the simple part! This method is still used today in many multimedia projects.

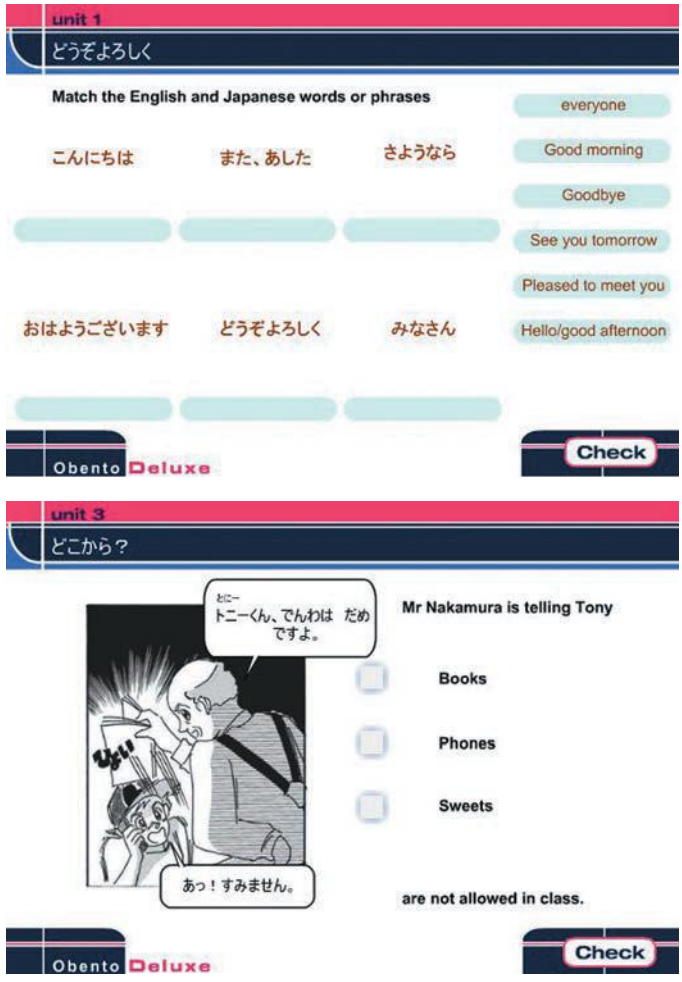


Figure 9.39 Screen and interface design should be appropriate. Here are two designs for interactive multimedia products dealing with language learning.

Evaluation

Testing begins by making sure that the designer knows how the target audience will react to the project. The development team tests the project first, followed by the users. It is important for users to explore the project without interference.

User comments will mean revisions and improvements before the final publishing takes place. One method of evaluation is to constantly watch or even videotape people using the product. If you hear them saying to each other something like 'Wait … it's doing something' or 'So now

what do I do?', your project is probably not giving the user enough feedback.

There are three main types of testing used for multimedia projects:

- Interface testing asks users to comment on prototypes early in the project, and then later to suggest improvements to the design.
- Navigation testing makes sure that all links go to the right places.
- Functional testing checks if the final product meets the original design specifications. The title is tested on different platforms, using different screen sizes and resolutions.

Final careful testing is vital. This is the final version of the product before mass duplication begins. A mistake now (even a spelling error) would be very expensive.

A useful motto is: Test early and test often! Then test later and test often!

INFOBIT

In 1985, most people were astonished to find that an entire book with sounds and graphics could fit on one 1.44 megabyte (MB) floppy disk!

Reporting on the project

The last stage involves the design team completing their documentation on all stages of project development so that new designers understand the decision-making process. This stage also involves technical writers writing user manuals and implementation manuals. Other specialists may write support material for educational purposes, such as worksheets and teacher guides.

INFOBIT

Douglas Engelbart invented several user-friendly information access systems that we take for granted today, such as windows, hypermedia and groupware. His most famous invention was his 'X-Y position indicator for a display system' – the prototype for our computer mouse. He did not patent this, however.

ISSUES

CORE ALERT Issues

Legal and social concerns

Social and ethical issues are covered in more detail in chapter 7: Issues. Here the focus is on some important issues in the area of multimedia.

Copyright

The *Copyright Act 1968* (Cwlth), amended in 2010, controls the right of authors and artists to ownership of their creative and intellectual property. Remember that using graphic images or video without permission is stealing unless it is permitted under special copyright provisions.

Software piracy

Full-version multimedia authoring software is expensive to purchase, but it is also very expensive to develop. Every copy used illegally deprives the creators and publishers of their income.

Social implications

Apart from ethical issues, multimedia has important social implications as well. It has the ability to change the way people live, learn and work, which places a responsibility on those who design multimedia to consider the effects of their work on society.

Convergence of technologies

The merging of separate technologies is a trend already well under way. Multimedia technologies are becoming available in places they would never have been seen previously. The mobile phone, the Internet, the DVD player, the MP3 player and the TV can all deliver and display multimedia.

Limitations in technology

At present, the availability of multimedia products on the Internet is limited by restrictive bandwidths. Other bottlenecks can be experienced within an organisation's intranet. The limitation of bandwidth is lessening, however, and Internet delivery of multimedia will become commonplace.

Review questions

QUESTIONS

1. Which of the above issues do you believe will most affect your life in the next 10 years?
2. Which of the above issues do you believe needs to be acted on more strongly by the government? Outline the reasons for your answer.

9.7 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: An interactive product

You have been commissioned by an agency producing interactive products to create an interactive multimedia project that will motivate awareness of the Universal Declaration of Human Rights.

Overview

Your project is to select five of the 30 articles that make up the United Nations Universal Declaration of Human Rights, design an interactive interface and produce content that will illustrate and explain each of these.

Although each of the articles you choose to feature will be different, they should have similar design features. Use consistency in design, use of colour, navigational cues and sound.

You should document your progress.

Defining and analysing

1. Read the outline for section 9.6 on page 136.
2. Select five of the 30 articles that make up the United Nations Universal Declaration of Human Rights found on the United Nations website. Decide how you will explain and represent each of your five choices – images, video, animation, audio, text. Consider the type of interactivity you will use. Record these details.
3. Research the history of how these articles came to be agreed on by the countries represented at the United Nations General Assembly and what Australia's role was in their creation. Make notes on this research.

Designing

1. Create a storyboard as a guide in planning this project. Record on each element a label stating the type of interactivity, if any. Have the teacher approve your storyboard.
2. Choose the software approach you will take: Flash, a web design application such as Dreamweaver, PowerPoint, Prezi, Adobe Edge Animate or an online website design tool.
3. Collect or design all your assets (content) ranging over all five media types (text, animations, audio, graphics, movies). You may use online resources or video, images or audio you create yourself.
4. Use your chosen software or use PowerPoint to assemble a prototype of your project. Think carefully about the content of each page and the overall look and feel of the project. Are you using a consistent design, colour scheme and fonts?
5. Decide how the user will interact with the various elements in your project (see 'Defining and analysing').
6. Have the teacher approve your prototype when complete.

Producing

1. Create your product and program the interactivity. You will be marked on each of the multimedia data types that you include in your product.

Evaluating

1. Perform repeated testing with users and improve your product based on user feedback. Record these results.
2. Perform your own evaluation of your product. Record these results.
3. Document problems faced and solutions found.

Project 2: A personal e-portfolio

Your project is to build your own e-portfolio that showcases your talents, and displays and explains your best digital work.

Overview

Electronic portfolios are a great tool to use to showcase work over the life of this course and future ones. They overcome the challenge of having lots of separate items in different places, all needing separate applications to view them. Anyone can view the work with Adobe's free Reader.

A portfolio can serve as an excellent résumé and a useful accessory in job interviews. Once started, your e-portfolio can easily be expanded over time with new work.

You will use Adobe Acrobat Pro to create a media-rich interactive electronic PDF (portable document format) portfolio. A PDF portfolio consists of multiple files assembled into a single PDF. The files in a PDF portfolio can be in different formats and created in different applications. For example, text documents, email messages, spreadsheets, Flash SWF files, computer-aided design (CAD) drawings and PowerPoint presentations could all be used.

Defining and analysing

The original files still exist but are joined into one file accompanied by user-friendly navigational and viewing tools. Files can be created in other applications and converted to PDFs using those applications and then added to this PDF portfolio, or they can be included in their raw format, thus needing the original authoring software for viewing by a user from within this portfolio.

It is important to understand the difference between a PDF portfolio and a PDF document. A PDF portfolio is a container for documents, but it isn't a document itself. Files can be left in their native format or can be first converted to PDF format.

You create a PDF portfolio in Adobe Acrobat by using the File>Create>PDF Portfolio command.

Adding video, sound and interactive content transforms PDFs into multimedia communication tools that enhance the experience of viewing your work.

The user does not need to open and close each file one at a time, but is presented with your whole body of work in one place and in a single package.

Most people are not aware of the wide range of file types that can be converted into PDFs. If a file cannot be converted, it can still be included in an Acrobat portfolio. In this case, it will be opened by its own application, which of course must be installed on the user's computer. It is important to understand that files can be left in their native format or can be converted to PDF format.

Designing

1. First create a storyboard representing the structure and files and any links you plan to include between them as well as any external links.
2. Next select all the files you want to include in your portfolio and place them into a single folder.
3. Decide which files will be internal and which will be externally linked. Record these decisions.

Producing

1. You create a PDF by converting other documents and resources to portable document format or by including the unconverted document, which will require the user to have the application that created it (for example, MS Word). If a file is open in its authoring application (such as a spreadsheet that is open in Microsoft Excel), you can first convert the file to PDF without using Acrobat. However, Acrobat offers more conversion options to optimise quality and file size.

Adding media

Inserting a media file into a PDF document is different from adding it directly to a PDF portfolio. Make sure you understand the difference.

PDFs can include Flash, QuickTime, MP3, MPEG and Windows Media files, among others. You can play these files directly from the page or activate them from a link or a bookmark. Each multimedia file includes a play area from which you can activate the media. The play area typically appears on the PDF page as an image or a rectangle, but can also be invisible.

Include active web pages

You can use Acrobat either to create a link to existing web page files or a link to their uniform resource locator (URL), or capture them and convert them into a PDF for viewing offline. When you convert a web page to PDF, the HTML file and all its dependent files, such as JPEG images, Adobe Flash files and cascading style sheets, are included.

Use File>Create PDF>From Web Page.

Or in Firefox use the built-in PDF creation tool in File>Print.

Create links

Links in a PDF document can have actions associated with them. They can be linked to play multimedia or visit a website.

You can link from one part of a PDF document to another part of the same document. You can link one PDF document to another in the same portfolio.

Create bookmarks

Create bookmarks to jump to a destination in the PDF, another document, or a web page.

2. Ensure consistency in design of your interface and in your choices of colour palette, fonts, styles and naming of files.

Evaluating

1. Perform repeated testing and refine your designs. Record your own evaluation.
2. Repeat user testing and document user evaluations.
3. Document the problems faced, the solutions found to these and the tasks accomplished in your project.

Project 3: A movie synopsis

Your project is to author an online multimedia project in the form of a website to feature a movie of your choice.

Overview

The project should cover each of the following:

- actors
- synopsis/outline of the plot
- reviews from newspapers and magazines
- short clips from the movie or weblink
- photo gallery of actors and scenes
- background information on the director
- any other special features.

If possible, you should use a team approach for this task.

Note: The following steps are written for a team. If you are working alone, interpret these as referring to yourself.

Defining and analysing

1. Form a team to complete the project. Try to identify team members who have the various abilities needed for each task – some who are good at design, some at using software, some at organisation, and so on.
2. Agree on the project requirements and then write a statement to describe them, including the name of the film. Suggest additions to the requirements, or perhaps parts that cannot be completed by your team. Decide on the method (authoring software system) you will use for your project. Decide on the interface and navigation type. Word-process and print out your statement.
3. Your teacher will approve your final written statement by signing it. This sheet will form the first part of your documentation for the project.

Designing

1. Construct a storyboard, print it out and have each member initial it.
2. Create or acquire the required input data – text, audio, graphics, animation and video. Manipulate these items into the form required in your design. Locate relevant web pages. If you have divided the project into modules for different people, these people will need to meet regularly to make sure that their work is consistent with each other and can be linked up later. If you are using this approach, appoint one person to be in charge of the overall navigation and the home page. Decide how the final project will be tested.
3. Build the prototype using PowerPoint. You can use placeholders for the graphics and brief phrases instead of full text. At this stage, you do not need to use final designs for graphics or include all navigational elements. The writers need to research the text, audio, graphic, animation and video content, and the designers must design the screen layouts.

Producing

1. You may wish to produce a web-based project. Many tools exist for this. WordPress and Squarespace are good choices that use ready-made templates, and Adobe Muse is easy to learn but allows more flexibility.
2. Assemble the separate resources that were created in the last stage into a working product, using your authoring software. (If appropriate, your earlier prototype can form the basis for the final product.) This task would normally be completed by dedicated programming members of a team. However, in this option, it is important that all team members experience this. The team might need to finetune aspects of the product to allow it to work smoothly.
3. Links can be provided to web pages that contain trailers for the movie.

Evaluating

1. Team members test the project.
2. Other users test the project and comment on it. Their comments will mean changes, revisions and improvements. Cover each of the following: interface testing, navigation testing and functional testing. Gather feedback by asking each student to record their vote from 1 (poor) to 5 (excellent) for each of the five multimedia elements of your project.
3. The team completes their documentation of all stages of the process. Include a record of the problems faced, the solutions implemented and the tasks that each team member accomplished.
4. Present your project to the class.

INFOBIT

Commercial testing of multimedia is often automated. One available piece of automated checking software clicks on every pixel on every screen to ensure that no stray unwanted buttons have been left over in the design process.

Additional content

Innovation in a selected data type

Research in detail a selected data type and extend your knowledge of it in one of the ways suggested below. You can then integrate it into a multimedia product that showcases these more advanced acquired techniques.

- Select one of the following data type activities for your extension:
  - Text: Use highlighted text, in the form of karaoke, to synchronise with audio content at the base of a video clip, or else have the text spoken aloud.
  - Hypermedia: Create advanced rollover features for multimedia navigation.
  - Audio: Use advanced audio editing software to manipulate digitised sound, or create your own MIDI sequence, or compose your own sound using music composition software.
  - Graphics: Create a 3D graphic and either render it or use advanced graphic manipulation techniques to create a 2D graphic of your own.
  - Animation: Create a 3D animation.
  - Video: Use advanced editing software, such as Premiere or Final Cut Pro.
- Use the Internet to research skills and techniques associated with your choice of data type activity. Collect digital examples of outstanding work of that type and create a PowerPoint presentation of your research, with these examples included as downloaded graphics, animations or video.
- Your advanced digital media will become a digital type that can be included in a multimedia project. Use multimedia authoring software to develop a multimedia title that showcases your advanced digital work, following the outline provided in section 9.7.

10 OPTION Database design

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- collecting and storing data
- processing and analysing data
- presenting information
- integrating data with other applications
- expert systems.

You will learn to:

- define database structure
- create a database
- edit, search and sort a database
- import and export data
- design, produce and evaluate a project.

Key terms

Database
organised collection of related data

Data dictionary
table showing field names, data types, field size and validation rules for each file in the database

Field
cell in a table that holds a single item of data

File
alternative name for a table in a database

Flat file database
stand-alone table of data such as can be created in a word processor or spreadsheet

Foreign key
primary key from one table that is stored in another in order to link the tables

Form
used in a database application to display one record at a time on the screen

Key field
holds a primary key (or foreign key) in the data table, and is used to link data between the tables

Primary key
number or code that uniquely identifies each record in a table

Query
search for data that meets certain criteria

Record
collection of data about one item in a database

Redundancy
repeated data in a database

Relational database
database with several separate tables linked by key fields

Report
presentation of data for printed output

Validation
check of the data to see if it is reasonable and lies within a predefined set of values

Verification
check of the data source to see if it is correct

IN ACTION

CORE ALERT Data handling

Data at the supermarket

Every day, millions of items of data are processed in supermarkets around the world. We are all familiar with the bar code that is attached to all products in the store, but have you ever thought about the chain of events that is triggered as each bar code is swiped past the scanner at the checkout? In fact, a number of processes are begun to change this seemingly simple item of data into significant and meaningful information. Firstly, the numeric equivalent of the bar code is sent to the store's database to retrieve data about the item – most importantly, the name and price of each item. The display screen at the checkout lists the items that the customer has bought and the final total owing.

If the customer uses the EFTPOS (electronic funds transfer at point of sale) terminal to pay for the shopping, the banks are instructed to transfer money from one account to another. Details of customers and their transactions will be held in the banks' databases. The supermarket's accounting software will need to keep a record of the purchase, including customer details and the total amount.

Loyalty cards are often used to assure the customer that the supermarket is grateful for their patronage. However, in applying for the loyalty card, people have to supply their name and address. This data is then used for market research; for example, analysing the shopping habits of the individual.

Floor managers also have portable devices that can read bar codes of products and a keypad to check prices and stock levels on the shelves. Goods need to be ordered and delivered from the manufacturers and warehouses, usually in large delivery trucks. Predictions need to be made ahead of time about extra demand for certain products; for example, flowers for Mother's Day and chocolate eggs for Easter.

At the end of the day, the data in the database can be analysed – the floor manager knows how many items need to be replaced on the shelves, the store manager knows how many items need to be reordered from the distribution warehouse and the sales manager receives the feedback on any promotion that the store has been running. As the customer, you have a record of your purchases in the form of the shopping docket.

Many consumers are now using online services to do their shopping, often for groceries but also for clothes, holidays, gardening products and music. In each case, data needs to be stored and processed into information for the customer, supplier and manufacturer.

All these operations are possible because the data is organised and stored in databases. In this chapter, you will learn how information and software technology is used to build and maintain databases like these in a wide range of situations.



Thinkstock/Ryan McVay

Figure 10.1 Data input at the supermarket occurs both at the checkout, to identify products bought, and at the shelves, to check pricing and stock levels.

QUESTIONS

1. Draw up a table to identify the data about items for sale in a supermarket.
2. When an item's bar code is swiped at the supermarket checkout, what process must happen for its price and name to be displayed to the customer?
3. There are many stages involved to put products on the supermarket shelf. Draw up a table to identify as many stages as you can. Include a list of people who would be involved in each stage. What data needs to be used at each stage?
4. Why do many stores use loyalty cards? What advantage is there for the business owners?
5. Many supermarkets now encourage customers to use self-checkouts. Is this a good idea? Discuss this with your class.
6. Investigate how many people in your class use online shopping. What products do they buy, and from which companies?

10.1 Database development

We live in an information age. Our lives are made easier by having volumes of information at our fingertips. We rely on information to save time in the shops, in the library and travelling long or short distances.

The purpose of a database

We learn to find the information by looking in books or searching the Internet. Sometimes we find the information we need on a display screen at an airport terminal or on a printed slip from an automatic teller machine (ATM). However, we can only hope to find the information we need if it is where we expect to find it – and that means being organised.

A **database** is an organised collection of data. We rely on databases in many situations to provide us with the information we need in our daily lives. Sometimes these databases are simple and easy to build; at other times, they can be very complex.

Building a database

To start building a database, we might think of collecting several items of data about one particular idea or project or topic, and organising it into a table. This could be a table of data about your school textbooks, such as author, title, subject, price and publisher.

In many cases, when the volume of data becomes very large, it is useful to put the database onto a computer. A school library, for example, would have more books than your personal library and so would rely heavily on a computerised database.

This has several advantages:

- The data can be organised and therefore accessed more easily.
- Storage space for the data is greatly reduced.
- Human errors in collecting and accessing the data can be avoided.

You have probably used a word processor or spreadsheet to organise data into a table. Tables of data like these are actually simple databases called **flat file databases**, as all the data is in one table. In more powerful databases, we can use specialised software to edit, sort and search the data as well as displaying it in different ways. This software is part of the database management system (DBMS).

Databases themselves are not often easily visible to the user – neither large commercial ones, such as in a bank or supermarket, nor ones that may be in use at your school. However, we probably interact with them several times a day. The interfaces are designed to be user-friendly, which means that they are easy to use and we can access the data quickly. Consequently, we are often not aware of the enormous amount of work involved in collecting and organising the data. We will understand more about this as we work through this chapter.

Components of a database

Flat file databases contain a single table of data. However, by organising this data into more than one table, we can keep the plan much simpler. Think about the school library database. We would need a table of data about the books plus a table of data about the borrowers. A third table would record the loans of books by students. They obviously have different types of data, so we need separate tables.

We can link the tables so that we can display more details about the students or the books on loan. Organising the data in this way makes the database a **relational database**.

Tables in a database are often referred to as **files** – a collection of information about one type of object. One database might contain several files.

INFOBIT

Samuel Johnson (1709–84), author of *A Dictionary of the English Language*, said: 'The next best thing to knowing something, is knowing where to find it'.

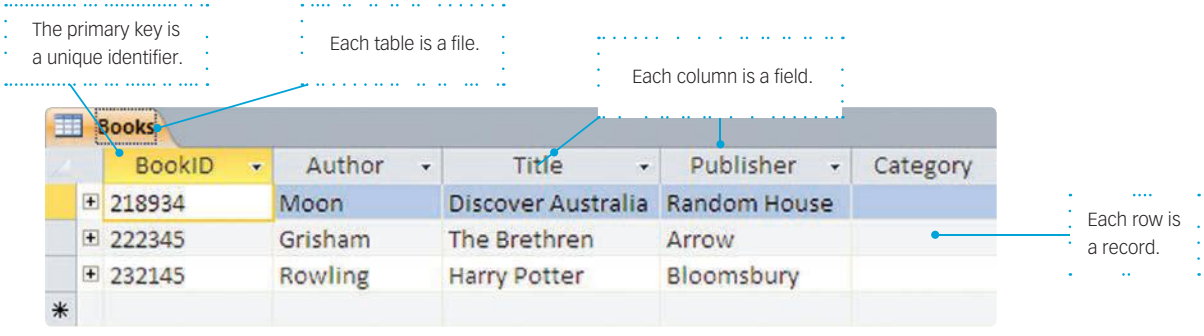


Figure 10.2 A books file in a library database displayed as a table

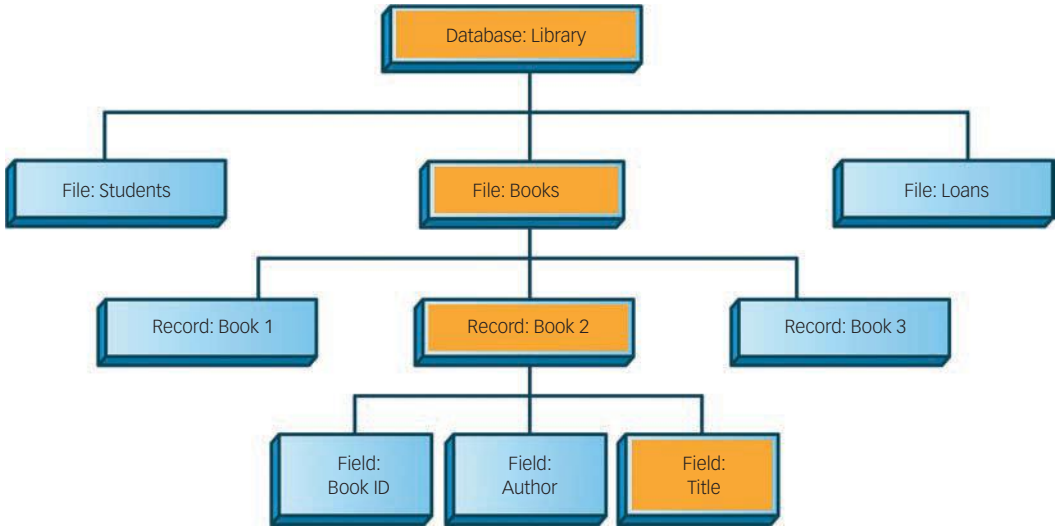


Figure 10.3 The hierarchy of components in a database structure

A database file is a collection of **records**. A record is the information about one object in the file, such as one book or one student. Records are usually viewed as rows in a table. Each record is divided into **fields** that hold a single item of data about the object. A field might hold the book's title or publisher. Fields are usually viewed as columns in a table. Figure 10.3 shows this hierarchy as a chart.

Figure 10.4 shows how the structure of a database is like a filing cabinet. The hierarchy of a database describes how it contains one or more files (or tables), and each file is made up of several or many records, one for each individual object. Each record is made up of individual fields that hold the items of data about the object.

It is important that we also include a field in each file to hold a unique identification code for each record. This field is called a **primary key**. A library may have several copies of the same title, or two books may have similar names. If each physical book has a unique number code or ID, it cannot be confused with any other book.

INFOBIT

Some databases are designed to be closed or 'read-only'. This means that it is not intended that the data will be altered by the user. For example, the database that is issued by the Australian Bureau of Statistics after each census would not require updating.

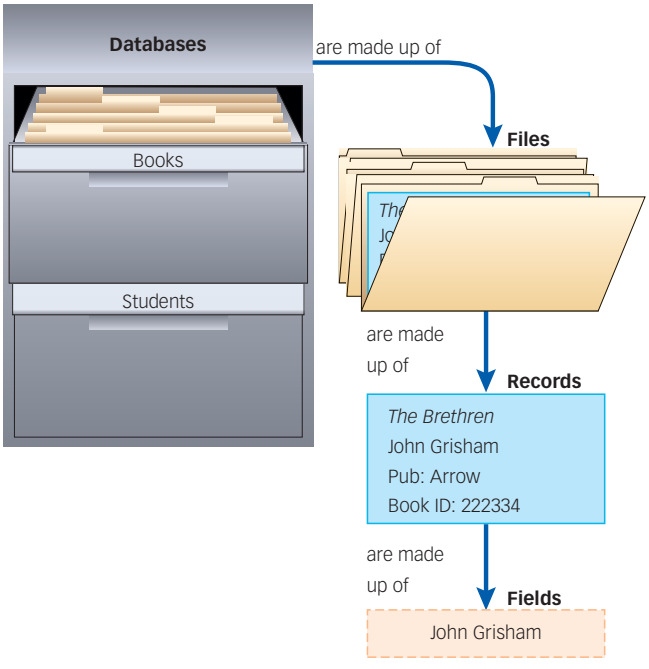


Figure 10.4 A database is like an electronic filing cabinet.



Figure 10.5 The ISBN (International Standard Book Number) is a unique identifier of a publication.

Turning input into output

CORE ALERT Data handling

The output from a database can help business managers with problem solving and decision making, or they can supply single items of information to users halfway around the world.

One of the most important factors for a well-designed database is how the data is organised; that is, which data goes into which table or field, and also what type of data it is. This must be decided at the design stage, before the database is built.

Now that we know how data is organised and stored into files in our database, let's look at the software that allows us to access the data. The database management system (DBMS) allows us to manage the data in the database tables – to organise, edit and display it in a format most convenient to us. We can view the output in a **form** on the screen or as a printed **report**. The DBMS helps us to change the data into meaningful information.

Data and information

Data refers to raw facts, including text and graphics. These are the items we store in the tables of the database. However, information has some meaning to it and is used by people for a specific purpose. Using the DBMS, we can search for particular data and perform calculations on it, thus obtaining useful information from the raw data. We may want to know, for example, how many books written by a particular author are in the library.

Forms and reports

In addition to choosing the data we want displayed, we can also choose how we want the data displayed. We may be happy with just the listing on the screen, or we may need to present our output as hard copy in a formal report. Figure 10.7 shows different users of the database and how their needs are different.

Forms are usually used for data input and quick searches for a single data item. They display one record at a time on the screen so that data can be easily read or edited. New records are created this way as well, with an empty record being displayed on the screen, waiting for input.

Reports are usually used for data output. Although the layout is designed and previewed on the screen, they are intended for printing hard copies of large amounts of data.

The layout of both forms and reports is important for the end user. We shall look at this again later in the chapter.

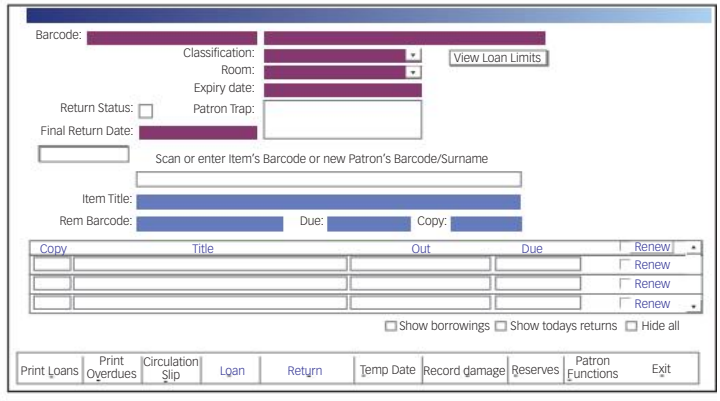
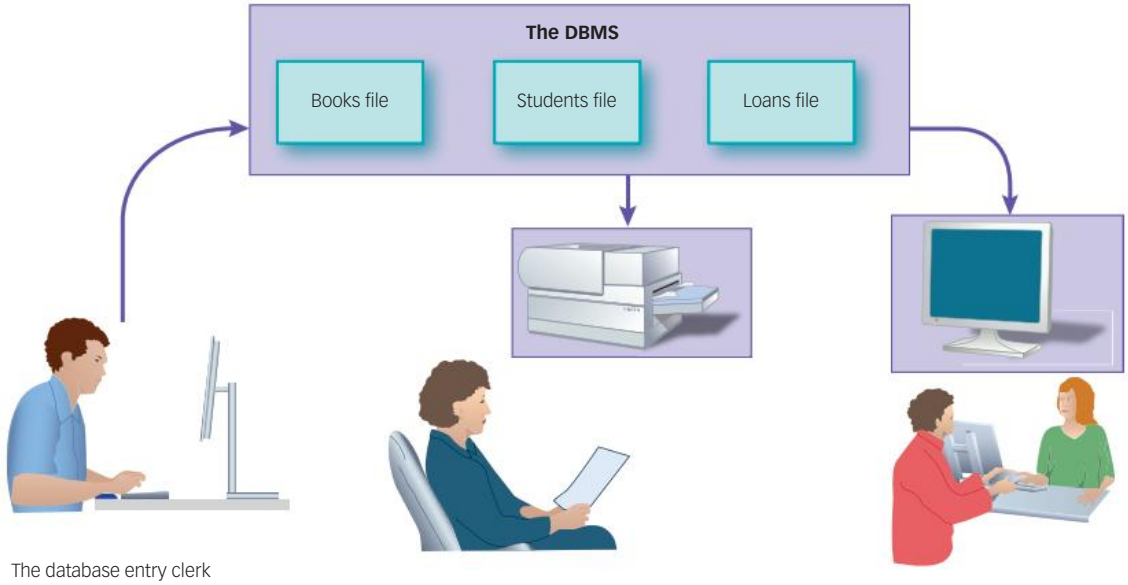


Figure 10.6 Data entry form for a library loans desk



The database entry clerk inputs the data about all the books in the library.

The library manager needs information as a printed report.

At the loans desk, output is displayed on a monitor.

Figure 10.7 Turning input into output using the database management system. The database is accessed by users with different needs. How is the manager's need different from the loans assistant's?

Types of data

Most data that we enter into the tables is text or numbers. We might, for example, list a book's author and its price as required data for our database. Numeric data can be formatted as currency or dates if required.

As processors become faster and storage space becomes cheaper, other data types such as graphics and audio files can be included in databases. A photograph of each student or a soundtrack of a CD could be useful information in some situations. You should remember, though, that all the data is stored in memory and secondary storage in digital form, so large graphics or audio files will use a lot of storage and processing power.

The Boolean or logic data type indicates a true/false type of value. This might be used to indicate whether a book in the database is on loan or whether a return is overdue.

Field Name	Data Type	Field Size	Example
Student ID	Number	7	2001335
Family Name	Text	30	Smith
First Name	Text	20	Mary
Date of Birth	Date	7	25/04/87
Year Group	Text/Year	2	10

Data dictionaries

CORE ALERT Projects: design, produce, evaluate

Before a database is built, it is often helpful for the database designer to create a **data dictionary** to illustrate and describe the fields and data types that will be required in the database. Specific amounts of memory will be allocated by the DBMS as field size, depending on which data type is chosen for the field. For example, a text field may have 20 or 200 bytes (characters) allocated, while an integer may have only 4 bytes.

It is essential at this point that the data be organised correctly in the different tables and that data types are appropriately assigned. As the project progresses, it is more difficult to implement major changes in the design.

Some DBMSs create a data dictionary for you automatically, and some prompt you to allow one to be created for you. You can also define formatting and **validation** rules for input data in the data dictionary. A table similar to the one in figure 10.8 is commonly used for this purpose.

We will look at the idea of data validation in the next section.

Students

Field Name	Data Type	Description
Student_ID	AutoNumber	Code allocated by School Administrator e.g. 890243
Family Name	Text	
First Name	Text	
Date of Birth	Date/Time	Format dd/mm/yyyy
Year Group	Text	E.g. Year 9

Figure 10.8 Data dictionary for a student's file, as a table and as seen in Microsoft Access

ACTIVITIES

Identify

1 What is a database? What is its most important function?
2 Describe some of the advantages of using a database.
3 What is the DBMS? How is it different from the database itself?
4 List some of the databases that you would use in your daily life.
5 How is a field different from a record?
6 List the common data types. Which of these can be stored in a database?
7 Draw up a table to represent a file of data about products in a supermarket.

Analyse

8 What is the difference between a flat file database and a relational database?
9 Why do we need to separate data into the different tables in a relational database?
10 What is a primary key used for in a database? Find out how you are uniquely identified in your school's administration system.
11 You would expect a hardware store to have a computerised database. What is the advantage of this for the owner? How would it benefit the customer?
12 In the data dictionary for the student's table in figure 10.8, what does field size refer to? What are appropriate field sizes for text, number and other data types in your DBMS?

Investigate

13 The ISBN of a book is a unique identifier for a particular edition. Who controls their allocation? Are ISBNs issued for electronic copies of books?
14 Look at the data types available in your database software application. List them and give an example of each. Can your database software store integers and decimal numbers? How are they different?
15 Find out if you can use look-up lists for data entry in your database application. What are they and why are they useful?

CASE STUDY

Information in an emergency

Doctor Zoë Knights is a specialist in accident and emergency medicine, and works in a variety of hospitals around Sydney. She needs to access and communicate information about patients quickly and accurately. When a patient first arrives at the emergency department, the triage nurse allocates a category number to indicate which cases are most urgent. This helps Zoë to prioritise patients.



Alamy/CulturalEyes - AusGS2

Figure 10.9 Emergency vehicles help with the need for speed.

The reception staff enter all relevant details into the hospital administration system (HAS) database. If the patient has not been admitted to the hospital before, they will be allocated a medical record number (MRN). This identifies the patient throughout the time they are in the hospital, and will be used again if they are admitted in the future. Alternatively, the patient's record can be found by searching for their name and date of birth.

After treatment, Zoë types her diagnosis into the computer, as well as any instructions for further care. The patient may be sent home, admitted to a medical ward or prepared for surgery.

Some patients might need a computed tomography (CT) scan, a blood test or other tests or treatments. These results can be entered directly into the patient's record by the radiologist or the pathology laboratory. It may be critical to refer back to this information while the patient is undergoing further treatment. This information might be needed for a consultation with a specialist in another hospital or another

CORE ALERT People

town. CT images in the database can be viewed remotely by authorised personnel and options for treatment discussed.

In addition to the important medical notes for each individual patient, a database is built for the entire Australian hospital system. This allows analysis of data over many years, such as the number of patient admissions and the types of emergencies that were treated. This data will affect the funding of the hospital systems and planning for the future.

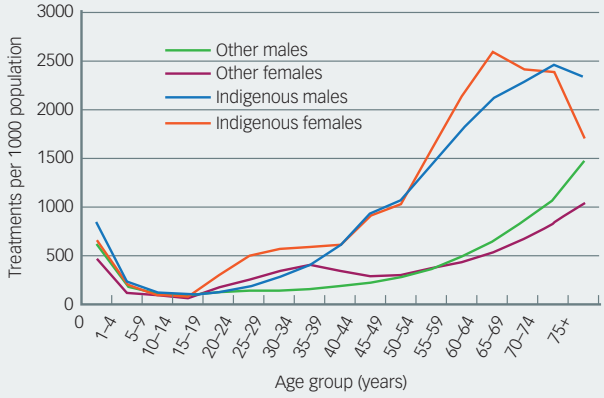


Figure 10.10 Collecting data in the emergency department enables decisions to be made about future needs.

QUESTIONS

1. Why does Zoë need to access the hospital database quickly?
2. Who is responsible for entering the patient's details onto the hospital's database?
3. Why is it important for the patients to have a unique identification number in the database?
4. How are specialists in other hospitals able to view the CT images? Why is this an advantage?
5. Visit the Australian Institute of Health and Welfare (AIHW) website and discuss the range of data that is contained in the National Hospital Morbidity Database (NHMD).
6. Look at the graph in figure 10.10. How do you think this data was collected? What does it tell you about the number of treatments for older people? What do you think could be done about this?

TASK 1

CORE ALERT Projects: design, produce, evaluate

Creating a database

You are going to use your database application software to store the contact details for your friends, relatives and business contacts. Figure 10.11 shows a sample database table, using Microsoft® Access®. For further help in using this or any other application, you can access help files or tutorials on the Internet.

1 List the data to be included in the database.

2 Open your database application. Name and save your database as 'Address Book'.

3 Create a new table. Select an appropriate name and data type for each field. Name will be text, birthday will be date. What data type will you use for telephone numbers and email addresses?

4 Include a primary key in each table. Some database software programs use a special data type, such as 'AutoNumber', which will automatically allocate a unique ID number for each record. Otherwise, you can allocate a unique number or code yourself.

5 Populate the database by putting data into the fields – enough for about 10 records. You can input your data in table view or in form view. Compare these two methods. How are they different? How are they the same? Which one is easier to use?

6 If possible, in the design view or data dictionary view, apply some look-up lists and default values to appropriate fields in the database. These might include the state or country in which your friend lives.

7 Make sure you save your work regularly.

8 Investigate how to use forms and reports for output in your database application software. Create a simple example of each.

9 Document your task to describe how you completed each stage. Include screenshots and a table to represent the data dictionary for the data file.

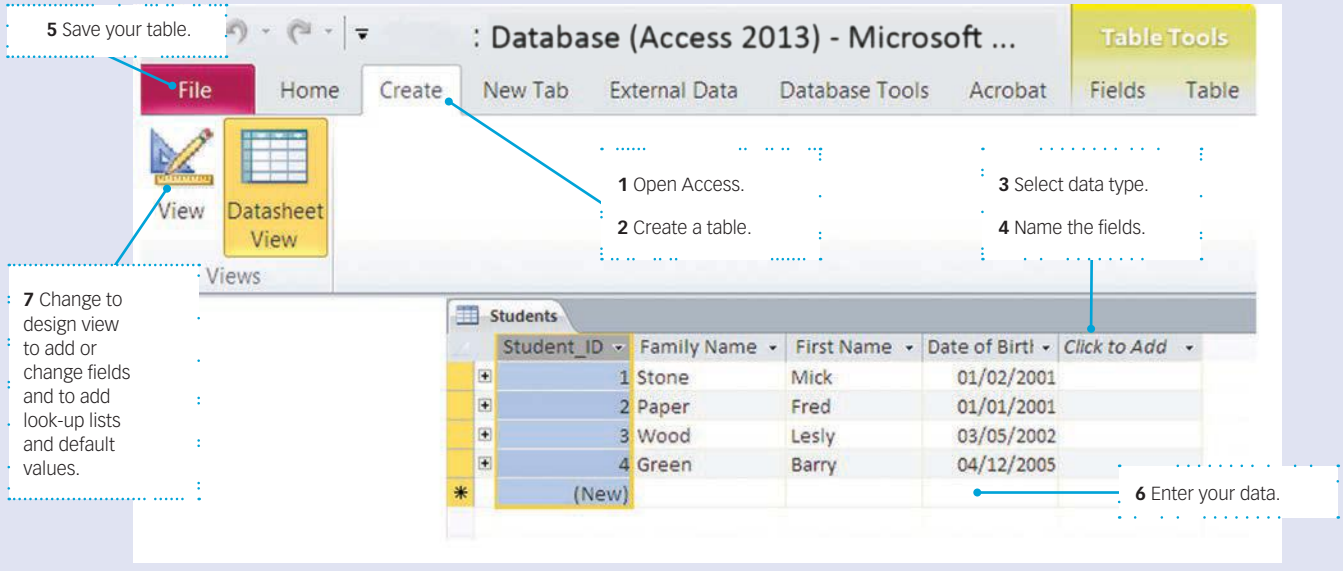


Figure 10.11 Creating a table in a database with Microsoft Access

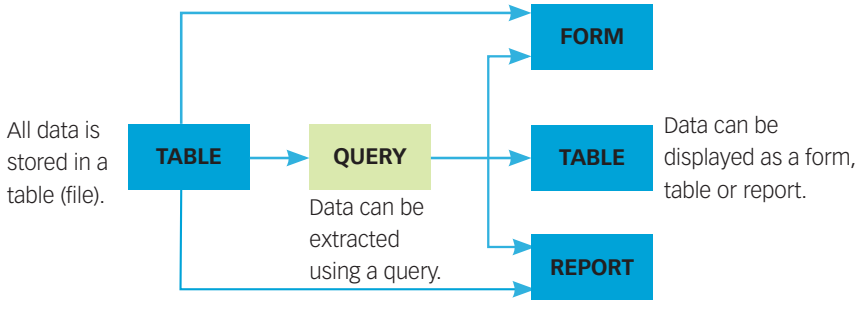


Figure 10.12 Data flow in a database. Data is stored only once – in the table or file. It can then be displayed in different ways using tables, forms, reports and queries.

10.2 Collecting, organising and storing data

CORE ALERT Issues

As part of the design process for building a large database, you need to decide more than just what data is required. You need to ask questions. For example: Where will the data come from? Who will be responsible for collecting and checking it? What fields will the tables have and what data types will be needed? Will the data be stored locally or on a server? In the design stage, you need to be quite clear about what the final product will look like and the functions it needs to perform.

Collecting data

In this section, you will look at some sources of data and some methods for collecting and checking it. There are several social and ethical issues concerned with these processes. Data needs to be accurate and current, yet people's privacy must be protected.

Data sources

Data is gathered from a wide range of sources and in various ways. Sometimes, it might seem a fairly simple task to collect data. To collect the data about books in your school library, you might walk around the bookshelves writing down the titles and authors' names on a piece of paper. You could then type the data into a computer using a keyboard. However, in larger projects, the system becomes a little more complicated. Figure 10.13 shows several situations in which data is being input to a database. Think about the types of data and how they are collected in these and similar situations.



Getty Images/SPL

Biometric security devices use biological characteristics to identify people. How does the computer know which person the data belongs to?



Thinkstock/Jupiterimages

Computers use specialised input devices to read information stored as optical marks, bar codes and special characters. Where would you see examples of this type of data?



Getty Images/PhotofUsion

Specialised terminals like this one make it easy to log restaurant orders. How has the nature of this person's work changed as a result of technology?



Alamy/Cultura Creative

Couriers use pen-based computers to log deliveries and record signatures.



Alamy/moodboard

Data collected in the workshop is transferred to the main database that keeps track of parts used.

Figure 10.13 Data is collected from a wide variety of sources for input to a database.

Some of the data sources that are commonly used are:

- transactions, such as at the ATM or EFTPOS terminals
- application forms, when applying for a job or joining a club
- questionnaires, in the government census or market research.

In some cases, data input will be automated, while in others, data entry clerks will be needed.

The examples given above are primary sources of data. The information is collected directly from the people involved in the generation of the data.

There are times, however, when data is gathered from secondary sources, such as newspapers or research documents. It may be a quicker and more convenient method of collecting data, but the data may not be totally reliable. In all cases, sources should be documented and acknowledged. If anyone needs to go back and check the data later, it should be easy to find, and copyright issues must be respected.

Data input devices

Everywhere you look, there are data items being processed – in the supermarket, the library, the bank and the fast-food outlet. Consider all the different hardware devices that are used to input the data about the products you are buying. As well as magnetic stripe cards and bar codes, we now use e-tags and smart cards to speed up transactions.

INFOBIT

The term 'data mining' originally described the legitimate collection of data in order to analyse hidden trends; for example, the occurrence of particular diseases in certain geographical areas. The term is now also used to imply secret collection of data about a person from their activity on the Internet.

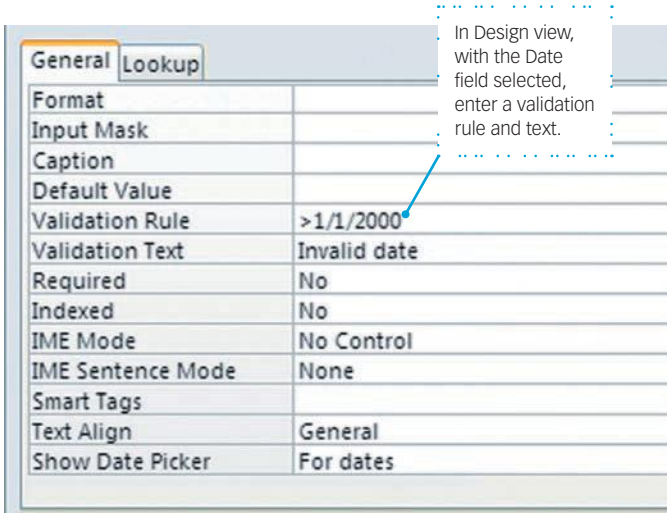


Figure 10.14 Creating a validation rule for the date of birth field in Microsoft Access

Due to the developments in this technology, data input has become fast and reliable. By avoiding human intervention as much as possible, time is saved and errors are reduced.

Checking the data

In the previous section, we looked at some automated input devices. These devices reduce the chance that an error will be made as data is being entered into the system. If the price of an item is incorrectly entered at the supermarket checkout, customers would not be pleased. The use of bar codes has increased customers' confidence that prices are correct.

Validation

Most systems have a range of validation processes to help maintain the reliability of a database. Validation checks if the data is sensible or reasonable. If we wanted to enter a date of birth for students at a school, we could assume that dates before 1980 would not be valid – as all students are less than 30 years of age. Figure 10.14 shows this being set in the field properties section of the data dictionary. Using default values and look-up lists also helps to reduce the chance of errors by minimising the amount of data that has to be keyed in.

Verification

Verification of data means that a check is carried out to make sure that the data is true. It is not always easy to check this. An incorrect date of birth may be entered for a student, within the valid range of values. To verify the date, the data entry clerk would need to check back on the source document, the application form or birth certificate.

When you log on to a network or website, you need to enter your username and password to ensure that you are the authorised person. Your password will be verified by comparing it with the original one stored in the database.

Bar codes and customer codes on invoices often include check digits to help with verification. The check digit is calculated by applying a formula. The input device can then apply the same formula to the input code and compare the answer with the check digit. The 'Past, current and emerging technologies' panel on page 158 explains more about this.

INFOBIT

The field of cognetics studies issues such as what causes a computer user to make mistakes, or what makes them comfortable with using a particular interface feature. Researchers have discovered that we can pay attention to only one thing at a time.

Organising data

One of the most important factors for a well-designed relational database is how the data is organised; that is, which data goes into which table or field, and how the tables will be linked. This must be decided at the design stage, before the database is built.

Tables

A table of data on its own could well be regarded as a database, since it is an organised collection of related data. If the database application contains just one table, it is referred to as a flat file database.

It is important to separate data about different types of things into different tables. In a library database, we would need to put data about books in a different table from data about students. This seems fairly obvious, as the data we collect about these two things are different.

However, consider the loans file in a library database. If we tried to put the student data and the book data into the loans table, we would soon realise that we would have to repeat data each time a student borrowed another book, or when a book was borrowed by a second student. You might try this for yourself to illustrate the point. The repetition of data in a database is referred to as **redundancy**, and careful thought is required in order to eliminate redundant data as far as possible.

Links

To avoid data redundancy, separate database tables can be connected by linking matching **key fields**. If the book catalogue database table for a library contains the unique code for each book, and a second table lists each person who has books out on loan, a link can be made between the matching book codes, so that the book details (title, author, date and so on) will not have to be duplicated. Key fields are used to link data between the tables. In the loans table, each book and student would be identified by their primary key.

Databases that are designed with links between the separate tables are called relational databases. These links give the DBMS much greater power to process the data in the tables. If the library loans table tells us that a particular book was borrowed on a certain date, the DBMS can produce the name and address of the student who borrowed the book.

When the primary key from one table appears in another table for purposes of linking the tables, the key is referred to as a **foreign key** in the second table.

Storing data

One of the biggest advantages of using a computerised database is storage space. Vast volumes of filing cabinets used to hold thousands of paper documents. Now we can carry thousands of megabytes of information around in our pockets, thanks to the availability of cheap portable storage technology such as external hard drives and flash memory drives.



Alamy/Milous Chab

Figure 10.16 The mirrored hard drives on a server can hold many terabytes of data. In the event of deliberate attack or accidental failure, the data remains recoverable instantly.

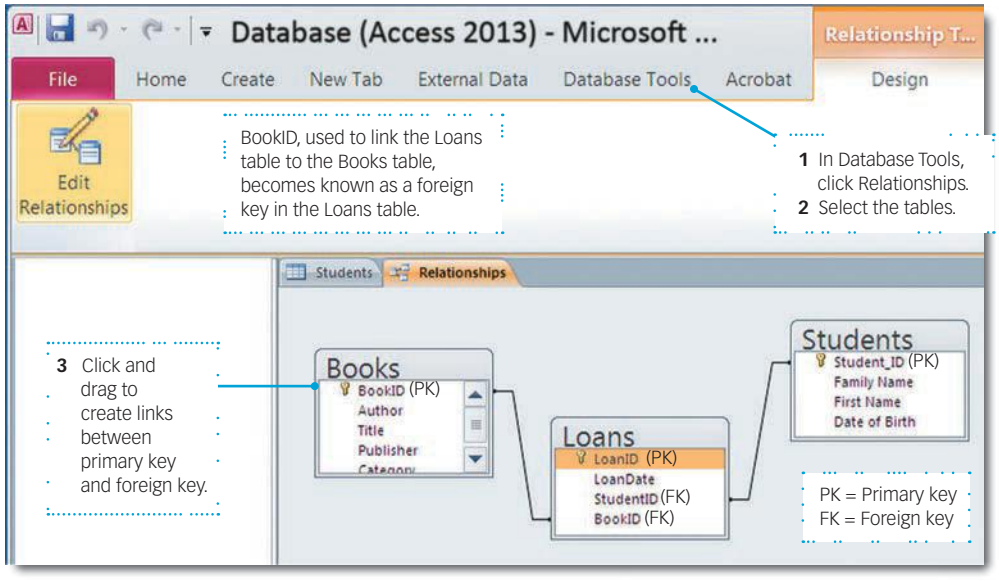


Figure 10.15 Organising the data into separate tables makes the database relational. Linking the tables makes data access easier.

INFOBIT

Museums are now using floor-to-ceiling video screens, interactive touch panels and digital sound to provide information about objects in their collections. Goggles and microphones can also enhance the immersive experience by allowing visitors to select options by eye-gaze and to question a database via speech-recognition technology.

It is important to remember that while you are working on your database, the software application and data files are in RAM (random-access memory). You should save your files regularly to your hard disk or network file server.

In banks and offices that deal with large volumes of data that change rapidly, backup files can be made every few minutes or even simultaneously to ensure that no data can be lost. Data that is accessed rarely can be stored in data warehouses.

Another advantage of storing databases on a network server is that it can be accessed by many people from different workstations or even in different countries. The data on the server needs to be secured by passwords and firewalls to prevent access by unauthorised people. If the data is sensitive or confidential, it may be encrypted, which means it is unreadable except for people with a special coded key.

Many people now use the Internet for buying and selling or banking, and they need to be sure that the data they create is stored securely.

INFOBIT

Data warehouses are used to deposit large volumes of data that are not needed immediately by a company, or that they intend to share with others.

PEOPLE

CORE ALERT People

Building and maintaining databases

Depending on the size of the project, the end user may build themselves a database, or a project manager may need to be employed to lead a team of experienced professionals to design, build and maintain the system. Consider what needs to be done to create large and complex databases such as those used by supermarkets and banks. The whole system needs to be carefully planned and designed. Data needs to be entered and security issues considered. As people begin to use the database, there will be an ongoing need to maintain and update the system.

Systems analysts are the people who plan and design databases for large commercial institutions. They must understand the purpose of the system and how it will be used. Systems analysts need to communicate effectively with management and with end users so that everyone's needs are met. They will also need to be well-qualified in technology and have a wide perspective on current trends and costs.



Thinkstock/Catherine Yeulet

Figure 10.17 There are many people involved in maintaining databases.

Database administrators are responsible for the maintenance of the database. They will need to ensure the data entered is checked or verified and that the data is secure. Backup copies may be made daily or even hourly and access to data is restricted to authorised people.

In some organisations, there needs to be continual input of data. A market research company may have conducted a survey in a shopping mall and then needs the data to be entered into its database. Data entry personnel need to have fast and accurate keyboard skills and a keen eye for detail. If data is delivered by telephone from customers, they need a polite and patient manner.

QUESTIONS

1. Identify the personal qualities needed for each of the jobs described above.
2. Look at some newspaper advertisements or online career searches to determine the qualifications and salaries for each of these jobs.
3. Search again the advertisements you found for personnel in the IT industry. Enter the details into a database. Use fields such as job title, qualifications, experience, salary offered, location, employer, contact address, phone number. Draw up a second table to record names of likely clients. How will you link the tables?
4. Imagine you are a systems analyst who has been employed by a firm of solicitors to design a database application. Draw up and explain a list of tasks that you will need to perform before you can design their database. What data will need to go into the database? Discuss what security measures you would need to implement in the system.

CORE ALERT Past, current and emerging technologies

Bar codes

Bar codes are a very simple way of encoding a small amount of data, typically a single number. They allow items to carry an identifying number, such as the product number found on supermarket goods, which acts as an index to a record in a database. This record can contain a whole range of information about the item, which can then be used for pricing in shops, stock control, progress control in manufacturing and personal identification in security systems.

There are many bar coding systems in common use; however, the EAN 13 is the one that we see most often in shops and supermarkets in Australia and Europe. EAN stands for European Article Number. An EAN 13 number is made up of 13 digits, in four groups.

- The first two digits form the country code (93 is the code for Australia).
- The next five digits are the manufacturer's or supplier's code.
- The next five digits are the product code and are allocated by the manufacturer.
- The last digit is the check digit.

Figure 10.18 shows the bar code for Dairy Farmers Shape™ milk. Country codes are allocated by international agreement. Each country is responsible for giving a code to every manufacturer who wants one. Each manufacturer can then decide how to use the five digits of the product code to identify their products.



Figure 10.18 The bar code for Dairy Farmers Shape milk

The check digit is the result of a mathematical calculation carried out on the other 12 digits and is added on to the end of the bar code. The method is as follows (the numbers for the illustrated bar code are in brackets):

- add the even position numbers and multiply by 3 (15 × 3 = 45)
- add the sum of the odd position numbers (45 + 28 = 73)
- subtract the last digit of the result from 10 (10 – 3 = 7).

When the bar code is read or keyed in, the bar code reader software repeats the calculation on the first 12 digits. The answer should be the same as the check digit that was read or keyed in. If it is not, the code has not been entered correctly and it must be re-entered.



Alamy/Robert McLean

Figure 10.19 While a traditional bar code is limited to 20 digits, a QR code can contain up to 4300 alphanumeric characters. What information do you think it will hold?

QUESTIONS

1. Find the bar codes from several different products, magazines and books. Check the country of origin. Make a table of the most common country codes.
2. Compare the manufacturer's code on similar products of different sizes. Are they similar or different? Why is this?
3. Check the check digits on several products using the EAN formula.
4. Find the formula for the ISBN check digit on your textbook. Why does this need to be an 'internationally agreed standard'?
5. Investigate the use of 'smart' labels that track parcels as they are being transported from supplier to buyer.
6. Find other situations where bar codes are used for fast and accurate data entry and checking.

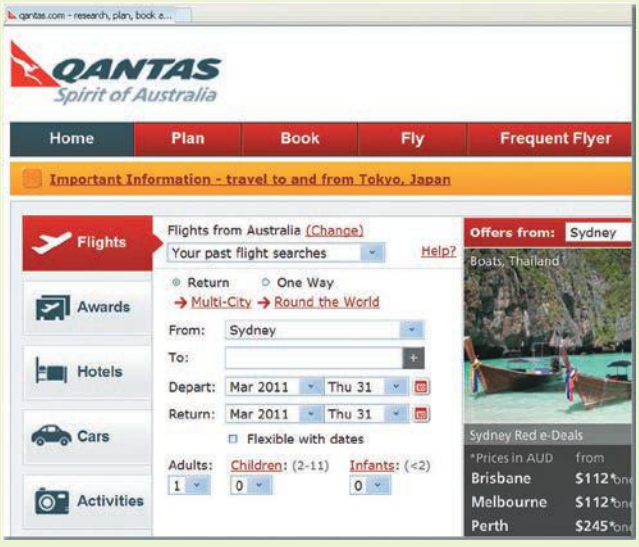
ISSUES

CORE ALERT Issues

Remote access

Today's technology allows users to access information instantly, from anywhere in the world at any time of the day or night. Users can interact with data through terminals, viewing and changing values online in real time. We check our bank balance, share prices and the weather. We shop, pay bills and book holidays. All this is possible because we can access these databases, stored on remote servers, over the Internet. Some schools allow staff and students to access data files and email accounts from home.

Large organisations may keep information on different computers around the world. An airline may keep all the personal information about its employees in one city and the flight schedules for the crews in another location. When compiling a roster for work schedules, it will need to access several related databases. This idea of distributed databases is often not visible to the user. With high-speed communications, we are often not aware that the information we are processing is being accessed and stored on a distant computer.



Qantas

Figure 10.20 Booking a holiday or a flight is easy to do online.

QUESTIONS

1. We assume we can have free access to large volumes of information over the Internet. Who pays for the development and maintenance of the databases that contain all this information? Give some examples to illustrate your answers.
2. With such large amounts of information stored all over the world, it is easy to lose sight of who actually knows our personal details. Discuss the idea of storage of information in the context of loss of privacy.

ACTIVITIES

Identify

1. List the common types of data sources mentioned in the text. What type of data is collected and what sort of input device is used for each?
2. Why is it important to document data sources?
3. What is the advantage of using automated data collection devices?
4. What is the difference between validation and verification? Give some examples.
5. What is redundant data? How is it eliminated?
6. What is meant by a 'key field'? What are they used for?
7. What are some of the most common methods of storing database files?

Analyse

8. If you were travelling on a train, and an official wanted to see if your ticket was valid, what data items would he check?
9. If you applied for a student concession card, what data would the authorities need to verify?
10. Find an application form that is used to apply for membership to a club or health fund. How would the data be entered into the database? What chance is there of human error?
11. Compare the file sizes of some of your databases. What effect does adding graphics to the data or headers have on the database file size?
12. Why is it important to eliminate redundant data from databases?
13. Why are backup procedures carried out so often in banks and large organisations?
14. Some backup systems need to be large, while others need to be portable. Draw up a table to compare methods of backup and give examples of where they might be used.

Investigate

15. Look at one of the websites that is used for purchasing items online. List the ways in which the amount of data to be entered is minimised, and other features that work to ensure accuracy of the data collected.
16. The Australian Taxation Office needs to check data that is submitted by taxpayers each year. It will use each individual's tax file number (TFN) to do this. Employers are required to record TFNs and banks strongly recommend it. Why is this necessary? Which other institutions ask for TFNs?

10.3 Processing and analysing data

CORE ALERT Software

In the previous section, we looked at the basic structure of a database. In this section, we will look at databases from the user's perspective. One of the most significant reasons for using computers to store information is that we can edit data, and search and sort large volumes of data very quickly and accurately.

Editing a database

The structure for any database should be decided in the design stage of a project. Once the data is entered into the database, there is usually little opportunity to change the field names and data types. However, one of the biggest advantages of using an electronic database is that the data it contains can be changed, updated and edited.

If you change your home address or telephone number, you would need to notify your school's administration department so that they can update their database. It is likely that their database is stored locally on the school's network file server or on the Department of Education's network. It would then be available to any person who has authorised access. In addition, new records would need to be created for students new to the school or the state.

Some databases need to be updated so frequently that they are made available to many users over the Internet. An airline would need to have the bookings file for its flights made available to many users at the same time. Special safeguards would be put in place so that a seat on a particular flight is not booked by two people in different places at the same instant. The record appropriate to a particular seat would need to be 'locked' from other users while anyone is working on it.

Sorting a database

Sometimes it is necessary to display records in a different order. In a library database, it may be convenient to have book records arranged in alphabetical order by author's name. However, if a student is looking for a particular topic, it might be better to have titles sorted by category.

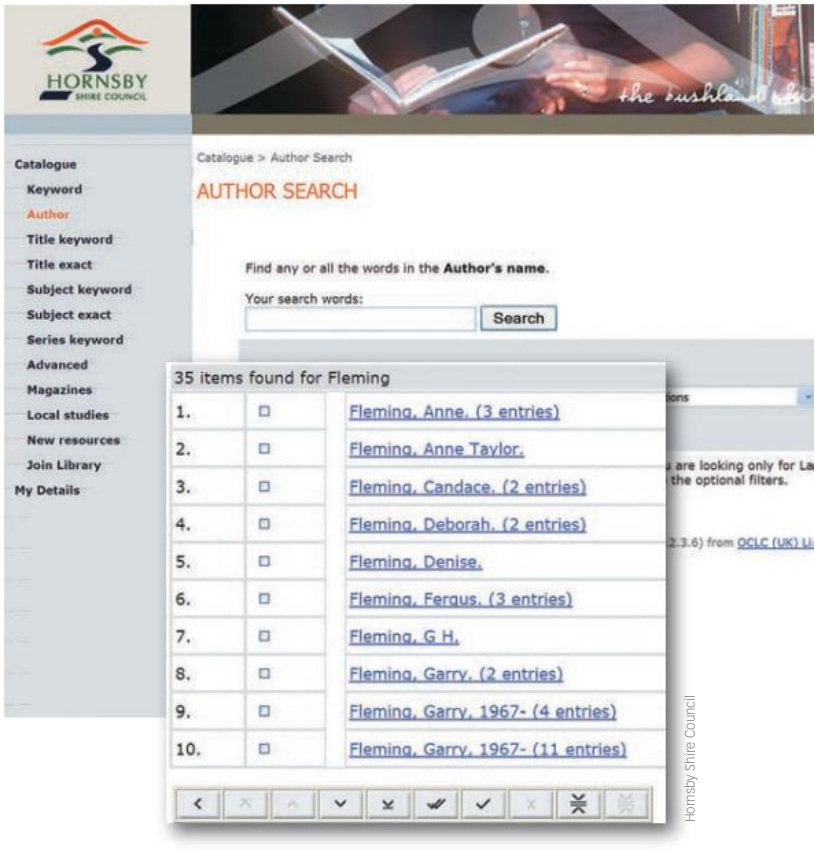
Figure 10.21 shows a grocery supplier's list, with products sorted first by category and then by product. This is known as secondary sorting.

In many database applications, sorting can be done on the original data table and also on the results of a search. It might be worth noting, though, that in sorting the data, we are only arranging how it should appear on the screen or paper. The way the data is arranged in memory or secondary storage is quite different from how we see it displayed.

Product ID	Product Name	Cost	Category
9	Chocolate Biscuits	$6.90	Baked Goods
11	Scones	$7.50	Baked Goods
12	Beer	$10.50	Beverages
15	Coffee	$34.50	Beverages
41	Cheddar	$20.55	Dairy Products
23	Mozzarella	$26.10	Dairy Products
24	Almonds	$7.50	Dried Fruit & Nuts
17	Dried Apples	$39.75	Dried Fruit & Nuts
5	Dried Pears	$22.50	Dried Fruit & Nuts
7	Walnuts	$17.44	Dried Fruit & Nuts
10	Marmalade	$60.75	Jams, Preserves
4	Rasberry Jam	$18.75	Jams, Preserves
19	Gnocchi	$28.50	Pasta
20	Ravioli	$14.63	Pasta
6	Curry Sauce	$30.00	Sauces
21	Pepper Sauce	$15.79	Sauces
22	Tomato Sauce	$12.75	Sauces

Microsoft Access

Figure 10.21 A grocery supplier's list sorted first on category and then on product name. Observe that items have been alphabetically sorted within each category.



Hornsby Shire Council

Figure 10.22 Searching the Hornsby Library catalogue

Searching a database

Look at the interface for the library catalogue search in figure 10.22. It allows the user to specify which records in the database to display and how they are to be displayed. Users can search the database for a particular book title or author. Alternatively, the user could enter a specific keyword, such as 'biography'.

In this fairly simple example, the search criteria is limited to one field at a time. In most database applications, we can design more complex searches, using more than one field or criteria, and we can specify which fields are to be displayed from the found records.

Often we just need to use a find or filter command to display the results of our search.

However, a database designer can create **queries** that can run more complex search criteria, and can be stored for repeated use. If a teacher regularly accessed the data for students from a particular year group who were also in a particular sporting house, this search could be set up and stored as a query.

Similarly we can specify searches using words like 'or' and 'not'. Often wildcard symbols such as '?' or '*' can be substituted for unknown letters, so if we want to find all surnames that begin with 'B' we could enter 'B*' as the data item to be matched.

Mathematical calculations

When designing outputs from the database, the user is not restricted to the fields stored in the database table. Most databases allow the user to perform calculations on the data.

We may wish to have the age of our students stored in the database. Obviously, the value of this data will change over time, and so it would make more sense to store the students' dates of birth rather than their ages. We can set up a calculated field to show the current age of the student by calculating the difference between the date of birth and the current date. Figure 10.23 shows how this is done in Microsoft Access.

Standard functions may also be used for groups of data, such as sum, average, minimum and maximum values, or a count of the number of items. We will look at some of these in section 10.4.

Creating a national DNA database

CORE ALERT Issues

There has been much debate on the idea of creating a database that could store the DNA of every person in the country. The obvious benefit for this is that it would allow easy identification of suspects involved in a crime scene. However, some people say that the inspection of DNA does not always lead to an accurate identification of an individual and mismatches have been common in the past.

More concerning is the idea that it is a simple procedure to collect or copy a person's DNA from a single cell left on a piece of clothing or glass. If this manufactured evidence were placed at a crime scene, a person could be falsely convicted of a serious crime.

Would the benefits outweigh the risks? Fast identification of disaster victims is always a concern for families and authorities. The DNA database would help to reduce the anxiety and grief surrounding such traumas.

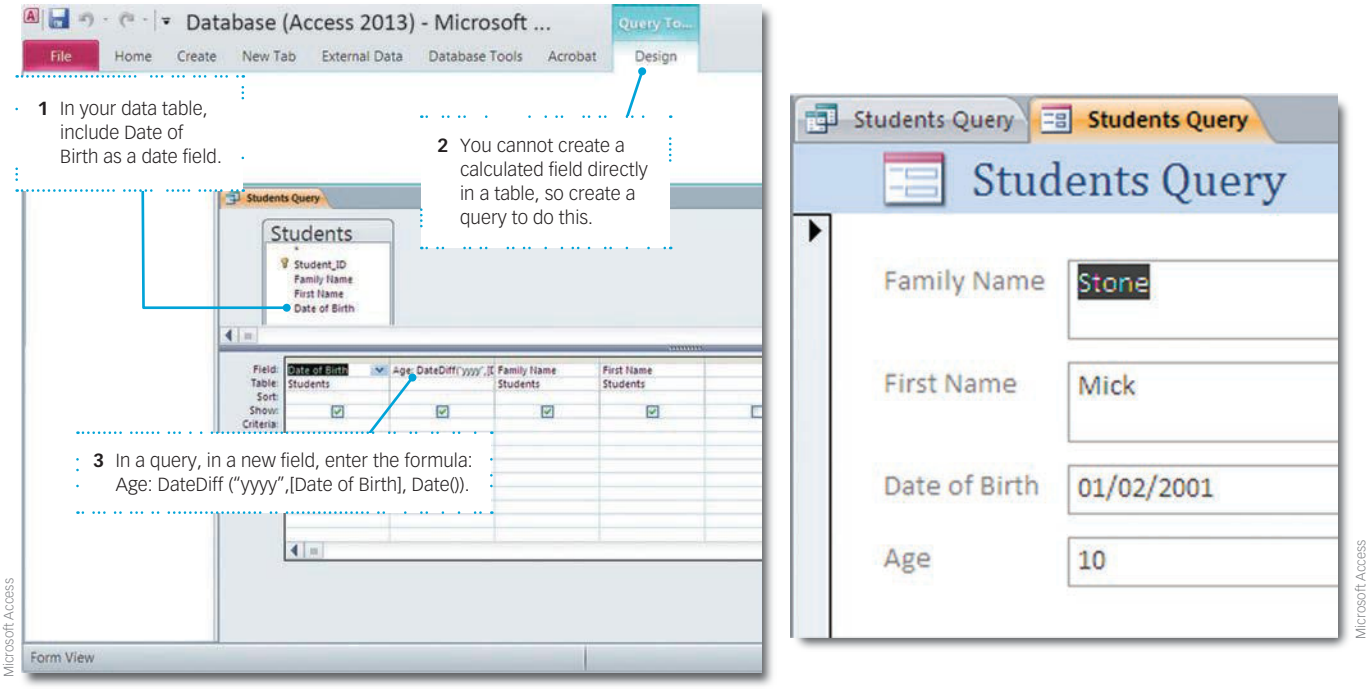


Figure 10.23 Calculating age in Microsoft Access. The result of this query is displayed as a form.

CASE STUDY

Australian War Memorial databases

The Australian War Memorial combines a shrine, a world-class museum and an extensive archive. The Memorial's purpose is to commemorate the sacrifice of those Australians who have died in war. Its mission is to assist Australians to remember, interpret and understand the Australian experience of war and its enduring impact on Australian society.

Anyone is able to use the site to search for collections of books, photographs and articles, as well as biographical databases that store data about individuals, awards and their fates. For example, you can find a list of all Australian soldiers who served and/or received honours in various wars, including the First World War, the Second World War and the Vietnam War.

CORE ALERT People

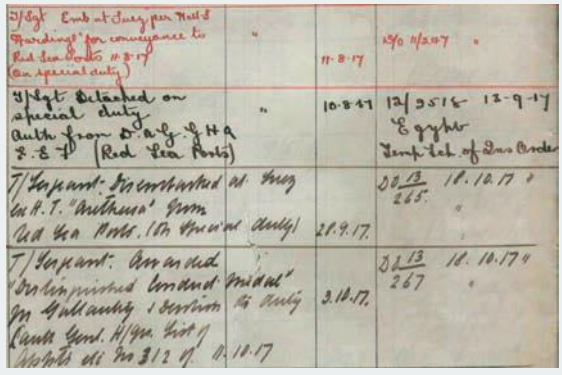
QUESTIONS

1. Visit the Australian War Memorial website's database collection. Research information about a family member, family friend or just a name on the list. See if you can create a significant biography about the person. Don't forget to acknowledge the sources of your data.
2. Discuss the privacy issues that might be involved with researching information about people online.
3. Visit the education section of the Australian War Memorial website and try some of the student activities.
4. Figure 10.25 shows a section from the service record of a particular soldier. How do you think the data would be stored in the electronic database application that you have used?



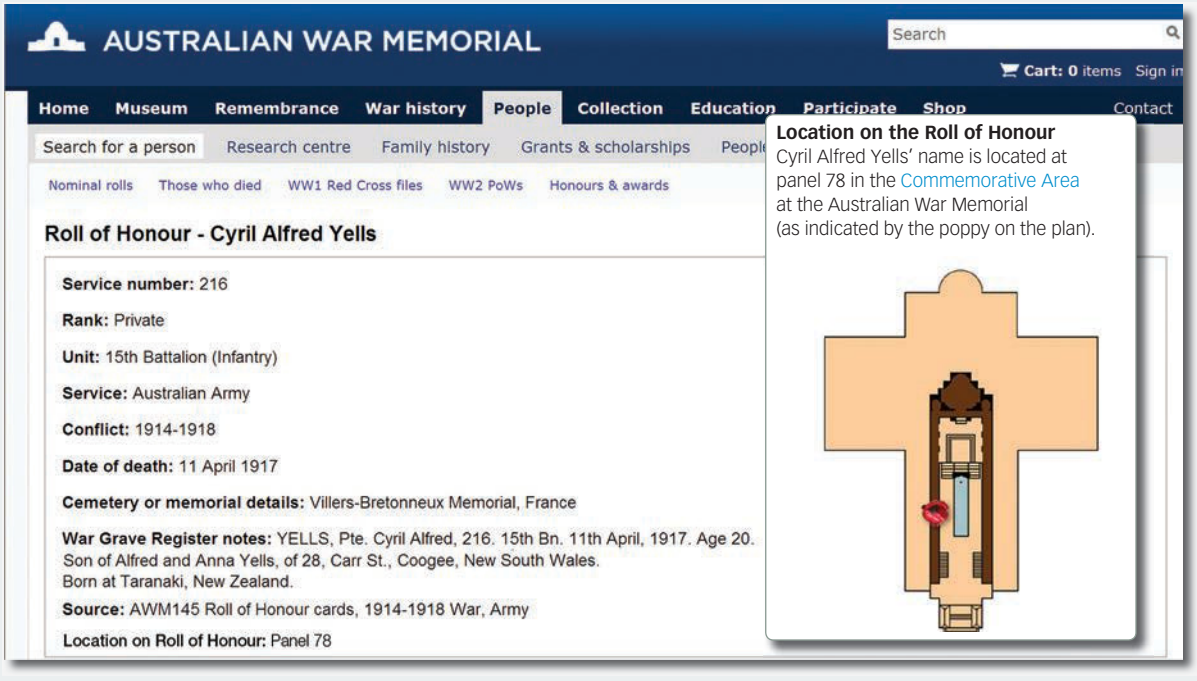
Dreamstime/Clearviewstock

Figure 10.24 The Australian War Memorial



Australian War Memorial

Figure 10.25 Data from the service record of Cyril Yells



Australian War Memorial

Figure 10.26 The service record of Cyril Yells from the Australian War Memorial database

TASK 2

Build and use a database

You are going to use your database application software to build a relational database for the Adventures for Rent company, which hires out a range of vehicles. Remember that you can use help files and other online tutorials to find out more about your particular database application.

Vehicle ID	Vehicle type	Transport mode	Number passengers	Cargo Capacity	Rental price
1062	Helicopter	Air	6	500	$1,250.00
1955	Canoe	Water	2	30	$5.00
2784	Automobile	Land	4	250	$45.00
0213	Unicycle	Land	1	0	$10.00
0019	Minibus	Land	8	375	$130.00
3747	Balloon	Air	3	120	$340.00
7288	Hang glider	Air	1	5	$17.00
9430	Sailboat	Water	8	200	$275.00
8714	Powerboat	Water	4	175	$210.00
0441	Bicycle	Land	1	10	$12.00
4759	Jet	Air	9	2300	$2,900.00

Create and organise a database

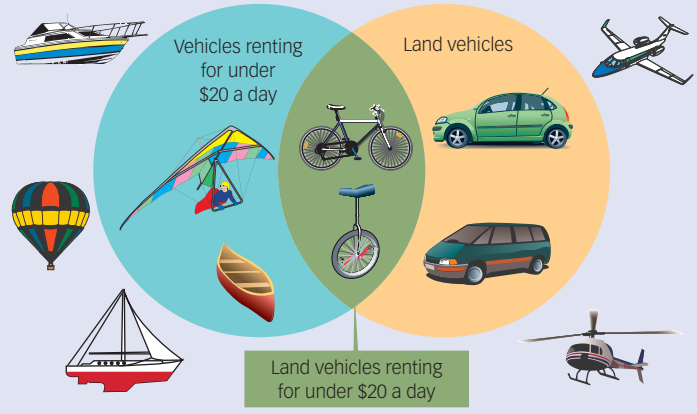
1 Open your database application. Name and save your database as 'Adventures for Rent'.

2 Create three tables – for vehicles, customers and bookings. Select an appropriate data type for each field. Include a primary key in each table. You may choose to include some graphics data too.

3 Add some format and validation rules into your data dictionary.

4 You can enter data into your database using table/list view or using a form. Apply a logo to the header of your form, and arrange the fields to give a customised look to your database. You might even be able to put a background to your form. Populate the database with about 10 records in each table.

5 Create links between your tables. The primary keys from the customer table and from the vehicles table should be linked to the fields with the same name in the bookings table.



This diagram shows the result of searching for land vehicles that cost under $20 per day to rent.

Figure 10.27 Rental vehicles from Adventures for Rent

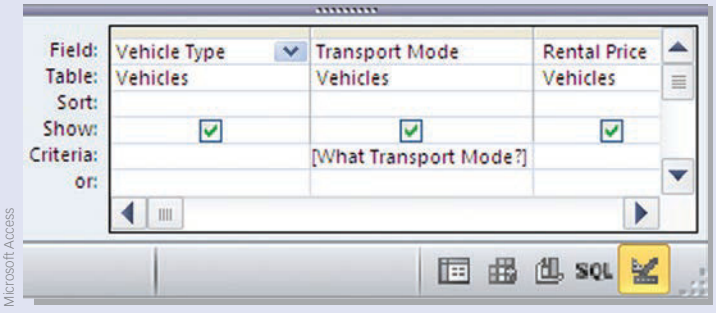
Edit, search and sort records in a database

6 Create a user form to input a new vehicle's details. Use a variety of input controls, such as look-up lists, validation checks and default values. Ask another student in your class to use this form to add new data to the database. Observe them and ask for feedback.

7 Sort the records in the bookings file (table) in descending order of date.

8 Create a query to find all the records in the customer file that have a surname beginning with 'B', using a wildcard character. Apply the sort function in the query design dialogue box. Run the query to make sure it works correctly.

9 A parameter query is where the user can enter a value for the search criterion at run time (see figure 10.28). Create a parameter query that can be used to find specific transport modes under a certain price.



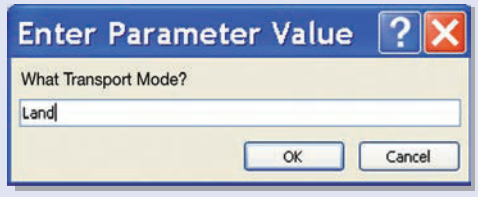


Figure 10.28 Creating a parameter query in Microsoft Access

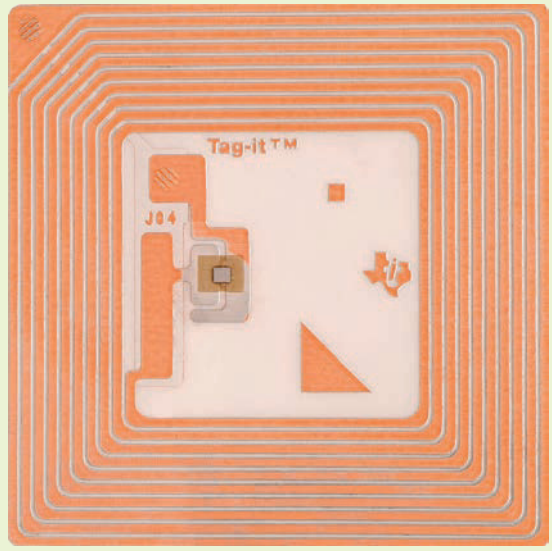
Tracking the products or tracking the customers?

Until recently, members of the public have been protected by privacy legislation from retailers who might use databanks and analysis to track and widely share the information they gather about customers' shopping habits. In the future, however, customers may be slowly desensitised to sharing their information, because in doing so, they will be rewarded with discounts on products or will receive faster or more personal service. Already the rewards of loyalty programs, such as shopper cards and frequent flyer points, are enough to allow retailers to build profiles of their customers by tracking their purchases. This enables them to tailor marketing and advertising programs to fit the individual preferences of their customers.

An e-tag used by vehicles for road tolls works with radio frequency identification (RFID) technology. When the vehicle passes under a toll gate, the tag will be 'called' by the reader that is on the gantry over the roadway. This will cause the e-tag to send a response – the account number associated with the tag. This all happens in a matter of milliseconds.

Auto-ID is a worldwide coordinating group for the RFID industry. The group plans to embed RFID tags, tiny radio-emitting tracking devices, in all consumer goods, including clothes, household electronics and packaging such as aluminium cans and cardboard boxes. The tags have already been used in Sydney to trace workers' uniforms, by beef farmers to track livestock, and to monitor the temperature of fruit and confectionery.

Privacy advocates are alarmed about the RFID technology, which could enable businesses to collect an unprecedented amount of information about consumers' possessions and movements.



Alamy/Chris Pearsall

Figure 10.30 RFID tags work by reacting to a reader's electromagnetic signal. Data on the tag can be changed or locked.



Newspix/Glen Campbell

Figure 10.29 Radio frequency identification tags. These tags can be as small as a grain of sand and attach to any product.

QUESTIONS

1. Why do retailers offer loyalty programs to their customers? Could this practice be considered unethical by some people?
2. RFID tags were originally intended to track products during manufacture and delivery. Discuss how these tags would help in this situation.
3. Why are some people becoming concerned about the use of these tags? Is there a way to compromise so that they can be used by the retailer but with customer privacy still protected?
4. Discuss other situations where the tracking and automatic identification of people or animals might be useful.
5. Investigate the current developments in RFID applications and how they work.

INFOBIT

In tomorrow's world, digital storage may be so cheap and sensors so small that we will live 'documented lives', wearing tiny 'life cams' that create video and data streams of our entire life experiences. The information will be stored in databases and auto-archived for instant access at any time.

Macros

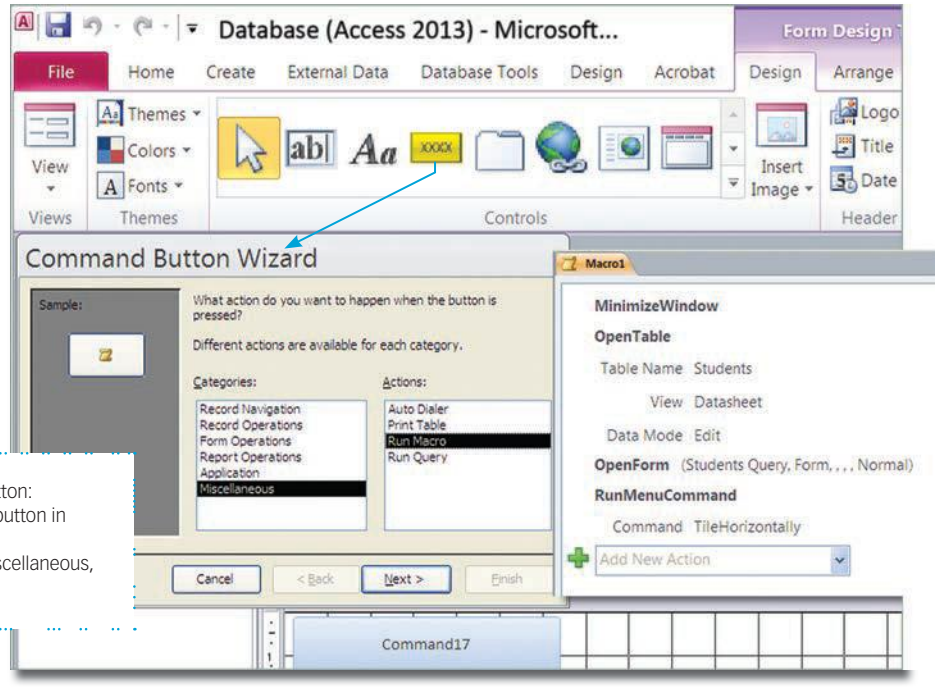
CORE ALERT Software

A macro is a series of tasks that we want to group together so that they can be run one after the other at the press of a button.

A macro is an object like other objects available in Microsoft Access (tables, forms, queries and so on), except that you create the macro to automate a task or series of tasks.

Macros become particularly useful when the tasks need to be constantly repeated. In designing our database, we may want to click a button on a form so that it displays a message before it moves to another form. This involves three separate tasks – display a message, close first form, open second form. If we group these tasks together in a macro, they can be run one after the other at the click of a button.

The tasks to be carried out in the macro can be defined in a dialogue box, or they may be recorded directly as the user performs each step. Figure 10.31 shows a typical dialogue box for defining the tasks in a macro. The macro is then usually attached to a labelled button on the user interface or assigned a keyboard shortcut. You might also get a macro to run automatically on opening a database. For example, you may want a user menu form to open automatically when the database is opened.



To add the macro to a button:
1 In Design view, draw a button in the footer of a form.
2 In the wizard, select Miscellaneous, Run Macro.

Figure 10.31 Creating a macro in Microsoft Access. The macro is then attached to a button on a form.

ACTIVITIES

Identify

1 After the data is entered and stored in a database, what three processes can we perform on the data?
2 What characteristics of the database are decided at the design stage? Why is it important to get this right?
3 List three examples of databases in which data is edited frequently.
4 What is meant by 'sorting' a database?
5 What is meant by secondary sorting?
6 What is a query in the context of a database? Why are they so useful?
7 What criteria could be used to search a library catalogue?
8 Why shouldn't you store a person's age in a database?
9 What is a macro? Why are they so useful?

Analyse

10 What is the difference between a query and a filter in searching a database?
11 The sports department at your school may need to calculate students' ages on 31 December of each year as only students of a certain age are allowed to compete in carnivals and competitions. Describe how you could make your database application perform this task.
12 Give three examples of calculations that can be carried out by databases.
13 Name two ways in which a macro can be used in a database.

Investigate

14 Construct arguments for and against the idea of having your whole life recorded in a database. It may contain health and education records, travel and professional details. How would this be of benefit to an individual? What would be the drawbacks?
15 If a text field containing numerical data is sorted, it may result in a different order than if it was defined as a numerical data type. Try this for yourself as an experiment. Enter some numbers between 1 and 200 into a text field, then the same numbers into a numeric field. Sort the data on each field. What happens? This is a consequence of how the software represents the individual characters in memory.

10.4 Presenting information

It is important to remember that data stored in databases should be easily accessible to the end user. Database designers and administrators should always have the end user in mind as they design, build and maintain the database. In section 10.1, we looked at a library loan report. The database designer has to consider how the end user of the database will use the information, and in what form it should be made available.

Reports

A report is a way of presenting data as a printed document. It will usually contain quite a large volume of data for use by management. The data may be generated directly from a table or, more often, it would be the result of a query from several tables.

Various design elements, such as text, pictures, lines and boxes, can be used to enhance the appearance of a report and improve communication of the information.

Database software makes it possible to organise the way the data is laid out on the printed page. In design mode, headers and footers can be inserted for the whole report and for individual pages. A report header might contain the report name and the company logo. The footer on each page might contain the page number and perhaps the date. If the number of columns is large, landscape orientation could be used. Grouping the data can also make it easier to understand the information presented. Such presentations of data are often referred to as summary reports. They can be quite useful for users who do not want to wade through pages of detail. For example, at the library, the manager might need a report that summarises the information about which types of books have been popular and so will only need to see category of book and total number borrowed.

Forms

In a database, forms are used for viewing and/or editing one record at a time on the screen.

The graphic design features are important in presenting the correct interface to the user. For example, the wording and size of text would need to be chosen carefully. Database designers must put careful thought into what the users will see on the screen. This plays a major part in making the database user-friendly and ergonomically sound.

Figure 10.32 shows a form for recording bookings made with the Adventures for Rent company. It is a very simple design and the links to other parts of the program are clear.

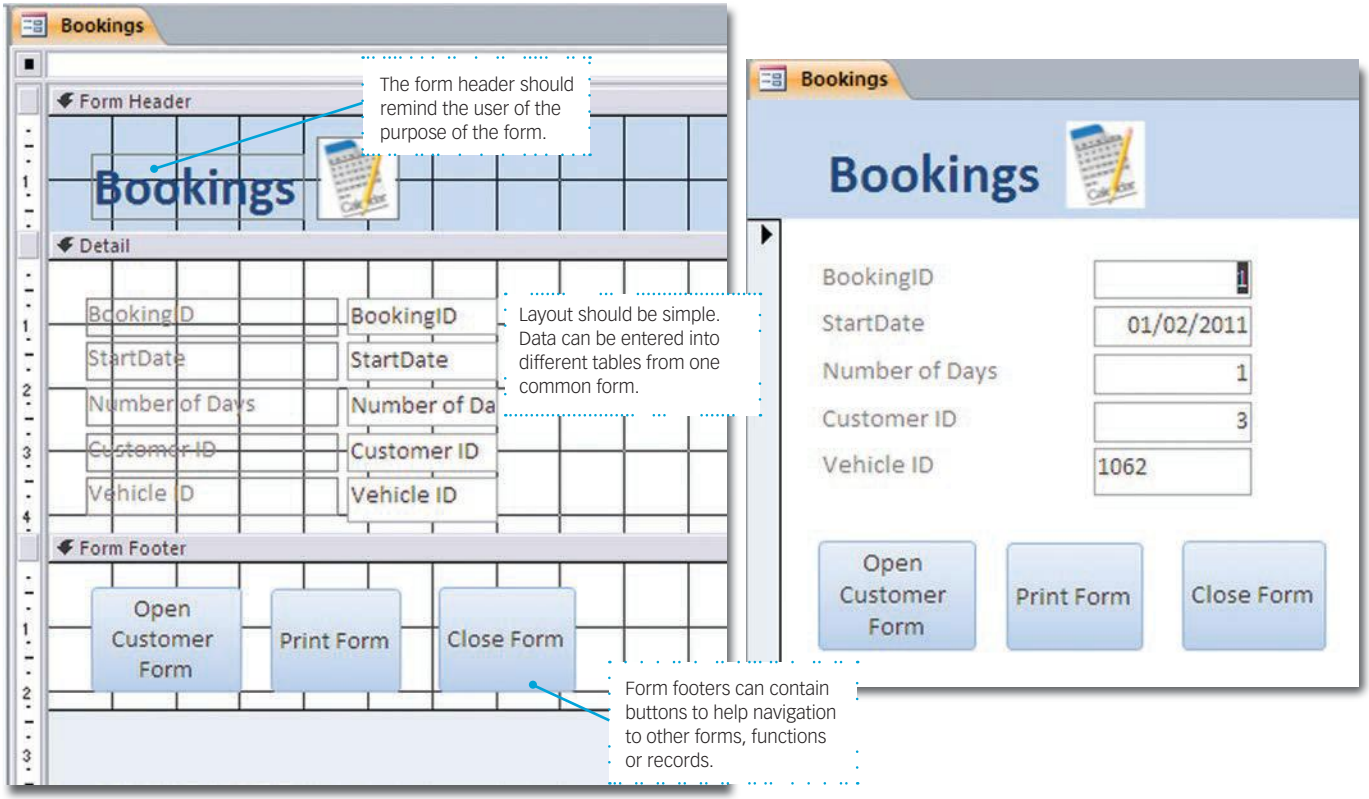


Figure 10.32 Booking form for the Adventures for Rent company. Why is it important for the layout to be simple? What other controls could be used to keep data entry simple?

TASK 3

Producing reports and forms

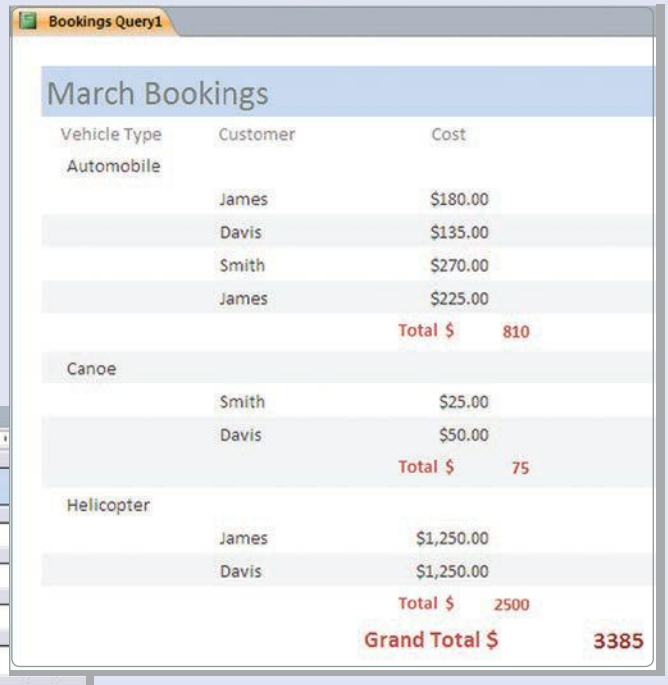
The following tasks relate to the Adventures for Rent company. You may need to use the help files in your database application or an online tutorial to complete some of these tasks.

1 Design some forms that could be used for data entry and/or viewing individual records. They should contain headings and buttons to link to other forms. You may need to consider separate forms for entering data about new customers, vehicles and bookings.

2 Prepare a series of reports that could be used by the owner to list the customers in alphabetical order, or by postcode or by the type of vehicle they hired. Insert a company logo in the report header and a function to display the current date in the page footer.

3 Develop your report further to display how many customers hired a particular type of vehicle, using a calculation function. Display the data as a chart in your report.





(dummy acks text)

Figure 10.33 A report created for the Adventures for Rent company. A query was used to find the data from the original files. The final report is shown on the right-hand side.

ACTIVITIES

Identify

1 What is the main purpose for building a report?
2 Where does the data come from that appears on a report?
3 Why are reports usually prepared for printing as hard copy?
4 In what ways can reports be formatted to improve communication of information?
5 Why are reports divided into header, data detail and footer? What information is displayed in each section?
6 What is the main purpose of a summary report? How are they produced?
7 Why is a report classed as having an output function? Is a form input or output or both? Justify your answer.
8 What features of a screen interface make it easier to use a database?

Analyse

9 A supermarket docket lists store information as well as items bought by the customer. In what way can this docket be classed as a report from a database? Which parts of the docket represent the header, the body and the footer of the report?
10 Reports are often output to pre-printed stationery. Why is this sometimes a better option than designing the headers in the database software?
11 What happens when user interfaces are difficult to use? What does being user-friendly have to do with ergonomics?

Investigate

12 Most motor vehicle service departments give their customers a printed report listing parts used and jobs completed for each vehicle serviced. Try to find an example of one of these and design a database that could produce such a report. What is the advantage of such a report from the customer's viewpoint? Why does the service department use pre-printed stationery to print the report?
13 Look at the user interface on several devices in your local shopping centre – ATMs and supermarkets in particular. Draw a sketch of several examples and indicate what design features have been used to keep the interface user-friendly.
14 Database designers often build a prototype user interface. What is a prototype? Sketch a prototype for a travel centre that specialises in cheap flights to the United States.

10.5 Integration

Current software allows us to transfer data between different applications and often on different types of computers. This means greater flexibility for using data in different contexts.

Importing existing electronic data

Most database applications are able to store graphics, sound or video clips in their data tables. Even though these files have been created in a different application, the database software is able to work with it by importing the data. It is also possible to establish links between the database and these media files, rather than import the files themselves. This has the advantage of keeping the database file sizes smaller, but it may restrict the portability of the application.

Many software packages now have options to integrate personal information, such as appointments, phone numbers and to-do lists, with email functions. Mobile phones and tablets may allow you to share information with your office-based computer and between software applications.

If a business needed to upgrade its database by having to re-enter all its data from the keyboard, it would be an enormous task. Fortunately, many software programs can understand each other's data, as long as it is in a common format; for example, delimited text. The delimited format can take various forms. One of the most common is the tab-delimited format, which uses the ASCII tab character to separate each field and a carriage return to separate each record in a database. Files can be interchanged between spreadsheets and databases using this technique.

Delimited text means that a text file contains words or fields that are separated by the 'tab' key press or by a comma, while records may be separated by the 'Enter' key press.

Data in many applications can usually be converted into plain text by removing all of its formatting. This option is commonly found in one of the menus of the application window, either as a 'save as' or an 'import/export' command.

Exporting data for other uses

Saving data in the delimited text file format is a useful way of transferring or exporting data between different database applications. However, some databases also allow you to transfer or link data directly to another type of application, such as a spreadsheet or presentation software. In this way, data can be presented as charts or as web pages.

Figure 10.35 shows how a mail merge function is useful for customising letters and producing mailing lists from a database. A chain of retail stores is planning a special promotion on a particular item. From their database, they can identify all customers who have spent a significant amount of money in their stores. A personalised letter including an offer of a 15 per cent discount might encourage the customer to visit the store once again. The mail merge option may also be used to print the labels for the mailouts.

There is often a mail merge wizard in a word processor that will help you through the practical steps.

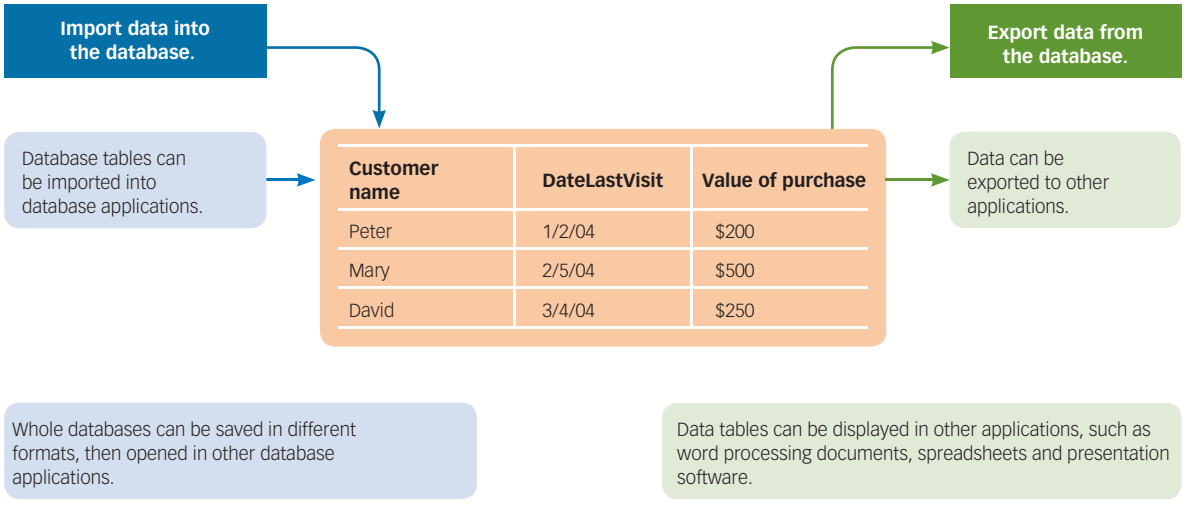


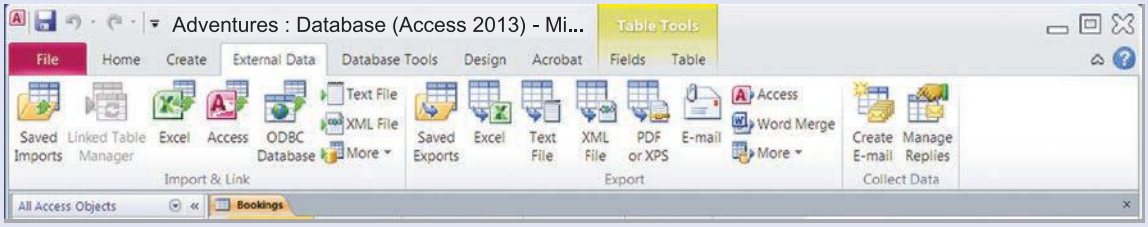
Figure 10.34 Data can be imported from and exported to a variety of applications.

TASK 4

Importing and exporting data and mail merge

In this task, you are going to import data from an electronic address book into a database, and then create a mail merge document. You will also create a chart in a spreadsheet using data exported from a database.

1. Create a table of data, such as a list of your friends, their addresses and phone numbers, in a word processing application or spreadsheet. List at least 10 people. Save the document.
2. In Microsoft Access, examine the import and export functions on the external data ribbon as shown in figure 10.35. Explore how some of them work.
3. Import the data from your Word document or spreadsheet. Alternatively, you could import this data from your Outlook email address book or from an existing database.
4. Using the Word merge function, create a form letter in a word processor to invite your friends to a party or excursion. Mail merge the data from your database and save the document. Figure 10.35 shows a form letter for the customers of Triton Markets.
5. Export data from a suitable database table to a spreadsheet. Choose one that contains numerical data. You could use the database from a previous exercise in this chapter. In your spreadsheet, create a chart and use some of the maths functions. How do the database and spreadsheet compare in terms of analysing numerical data?



Triton Markets Special Promotion

Word-processed letter

Dear <Customer Name>

As a valued customer, we would like to invite you to take advantage of our special promotion this month. Our records show that you last visited us on <DateLastVisit>. We hope you were pleased with your purchase. Since your custom is so highly valued <Customer Name>, we are offering a discount of 15% off your next purchase.

Please call in and see us soon. This offer expires one month from today.

Yours sincerely
John Smith
Area Sales Manager

Database data is inserted into each letter automatically.

Customer name	DateLastVisit	Value of purchase
Peter	1/2/04	$200
Mary	2/5/04	$500
David	3/4/04	$250

Figure 10.35 Mail merge allows us to personalise letters to customers and friends.

ACTIVITIES

Identify

1. What is the advantage of linking media files to a database rather than importing them? What is the disadvantage?
2. What is meant by 'delimited text'? How is it commonly used?
3. What is the advantage of saving a document as a text-only file?
4. How does a mail merge function work? List the steps that you would need to create a mail merge document.
5. What are the advantages for a marketing manager in using a mail merge option?

Analyse

6. Some schools or clubs might use a mail merge option to print mailing labels. When would this be useful?

Investigate

7. Consult the help files in your database application to see if it is able to store sound files and video clips. Which file formats does the application support?

Review questions

10.6 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: Medical centre database

Overview

Many benefits come from having important data available at opportune moments. Information about our health is important in providing accurate diagnoses, and doctors rely on accurate data held in their databases. In this project, you are required to design and build a database for a medical centre. The database will need to match the needs of the users: the doctors, the receptionists and the management/owners of the business.

Defining and analysing

1. Identify the issues you need to consider. Who are the users? What elements are to be included? How is the finished project to be presented?
2. What are the factors that will impact on your solution? Time? Money?
3. What ethical implications will there be in this scenario?
4. Interview people who work in this area. If you have an opportunity, visit your local medical centre and observe how data is captured and secured.

Designing

1. Apply all the design features that you have learnt about during this topic. Manage your project effectively by planning, communicating and documenting. Document your first ideas by describing what you think are the key issues in creating and maintaining a database for a medical centre.
2. For inputs, you will need to organise your data into tables, and link them. Produce a data dictionary. Use different data types and validation rules.
3. Design some user interface forms for data entry, searches and reports.
4. Build a prototype and have it evaluated. Ask your peers to try it first, then teachers, parents, siblings and friends.
5. Do you know anyone in a medical centre who might be willing to try it out? Write down some questions that they might answer for you, such as particular comments about the outputs of the database, how easy it is to use or the screen design.
6. You might also observe the testers to see if they are clear about navigating through the database.

Producing

1. If you built a prototype in the design stage, you may decide to develop this further, or you may need to start on a whole new design for your database. In either case, you will need to document your decision – what you decided and the reasons for your decision.
2. Before you build your database, you must know exactly what data to include in your design and how it will be organised. Required forms, queries and reports must have been documented, along with user interfaces and controls. After this, creating the database should be straightforward.
3. Populate the database with appropriate data in the tables. Create some sample forms, reports, queries and a startup form with some navigation buttons on it. A mail merge feature will be a useful addition.
4. Produce a user manual. Be sure that you explain clearly what your application can do and how to do it.

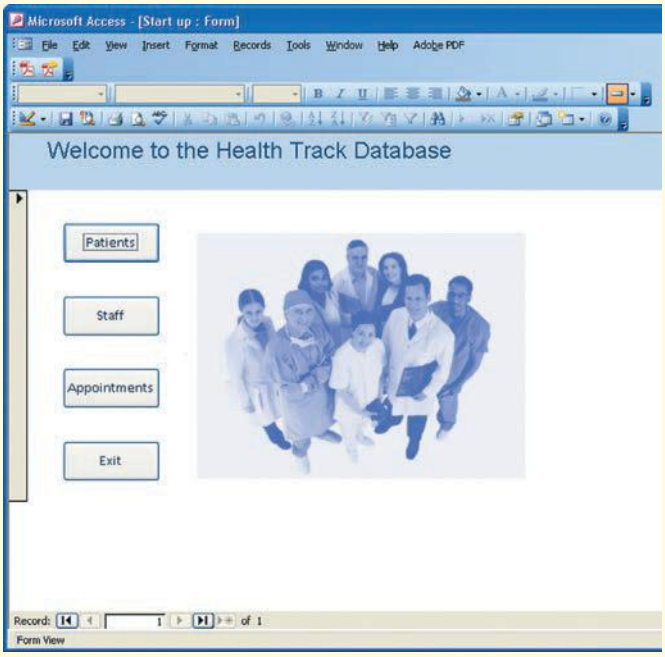


Figure 10.36 A startup form for the database

Evaluating

1. You should have a list of evaluation criteria already documented. Explain how these criteria have been met by your project.
2. Hopefully, you will have had many opportunities to test your application during its development, so you will know that it works. If there are any serious limitations, you should discuss them in your documentation.
3. Report on the various groups who have tested your finished project. Include the documentation that records their feedback.

Project 2: Convict database

Overview

Between 1788 and 1850, the English sent over 162 000 convicts to Australia in 806 ships. The first 11 of these ships are today known as the First Fleet and carried the first Europeans, the convicts and marines who would settle in the country. As more research is completed, it is important to make this information available in a structured and editable form – a database.



Getty Images/Universal Images Group

Defining and analysing

1. You will need to download a delimited text file of data about some of these convicts. A quick Internet search will take you to the University of Wollongong's website, where you will find such a text file. The data can be downloaded free of charge from the website, provided it is for non-commercial use. Alternatively, you may acquire a similar file from another source.
2. You are required to create an interface to the data that is quick and easy to use.
3. You will also create a mail merge function to represent a letter to a person who is asking about a particular convict.

Designing

The users of your database will need to be able to access the data in various ways and with specific needs.

1. Design a form layout with a clear interface. Use the header areas for titles and logo and keep this consistent throughout the project. Imagine it may be used daily with a touchscreen interface in a museum. Consider colour scheme, placement of fields and buttons, font size and so on.

Producing

1. Open your database application and import the tab-delimited text file of the First Fleet convict data.
2. In the table, add field names and change data types as appropriate.
3. Create some forms to present the data in an appropriate format. Include a startup form.
4. Perform a Sort function on Value of Crime – who committed this crime, and what was it?
5. Of the convicts in your database, who was the last person to die and what year was it?
6. Create queries to find all convicts who were under the age of 21 when they left England, and those who were convicted of stealing. Save these queries.
7. Produce reports to present the results of the queries you have created. Format them appropriately.
8. Create a Mail Merge function:

Create the following letter in a word processing document.

> Dear Researcher
>
> I can confirm that we are in possession of the record of the convict named * who was convicted of * on the date of *.
>
> It appears this person arrived on the ship * and died in *.
>
> I hope that this helps you with your research.
>
> Regards
>
> Database Administrator

Complete the data merge by inserting the fields Given Name, Family Name, Crime, Date of Trial and so on in the appropriate positions in the letter. Select only the first six records in the database.

(Don't print all your letters!)

Evaluating

1. Ask your fellow students to evaluate your design. Prepare a list of evaluation criteria for them; for example, effectiveness of the interface, whether the sort and search buttons worked well. Ask for suggestions for improvement.
2. Based on the previous question, complete a short written evaluation report.

Additional content

Expert systems

You have studied a variety of databases in this chapter and seen how useful they are for storing data. However, expert systems take this idea a lot further and apply some 'intelligence' to the data that a database contains. Compare the work of a mathematician to that of a carpet layer. A mathematician can tell you the formula to calculate the area of the floor, but it would take an experienced carpet layer to recommend what type of carpet would be required. So an expert system can use a large volume of facts from a database, apply some rules and put forward some conclusions.

INFOBIT

Expert system development comes from the area of artificial intelligence and does not use conventional programming techniques.

What are expert systems?

An expert system is a software application that simulates the knowledge of a human expert. Just as you might take a medical concern to your doctor or a car problem to your mechanic, you could alternatively use a software application to give you some advice.

You would need to answer questions on the computer to provide some facts about the problem. The expert system would then process these facts to provide a possible answer to the problem.

For example, if your car doesn't start one morning, you might ring the mechanic. He would ask a series of questions, and then draw some conclusions.

Question	Answer	Conclusion
What happens when you turn on the headlights?	They light up	Battery is OK
	They do not light up	Battery is flat
	They light up, but dimly	Battery is low
What happens when you turn the key?	Nothing	Battery or starter motor is dead
	Engine turns slowly	Battery is low
	Engine turns normally	Battery is OK
What does the fuel gauge read?	Empty	Out of fuel
	Not empty	Fuel level is OK

Figure 10.37 Consulting an expert about a car that doesn't start

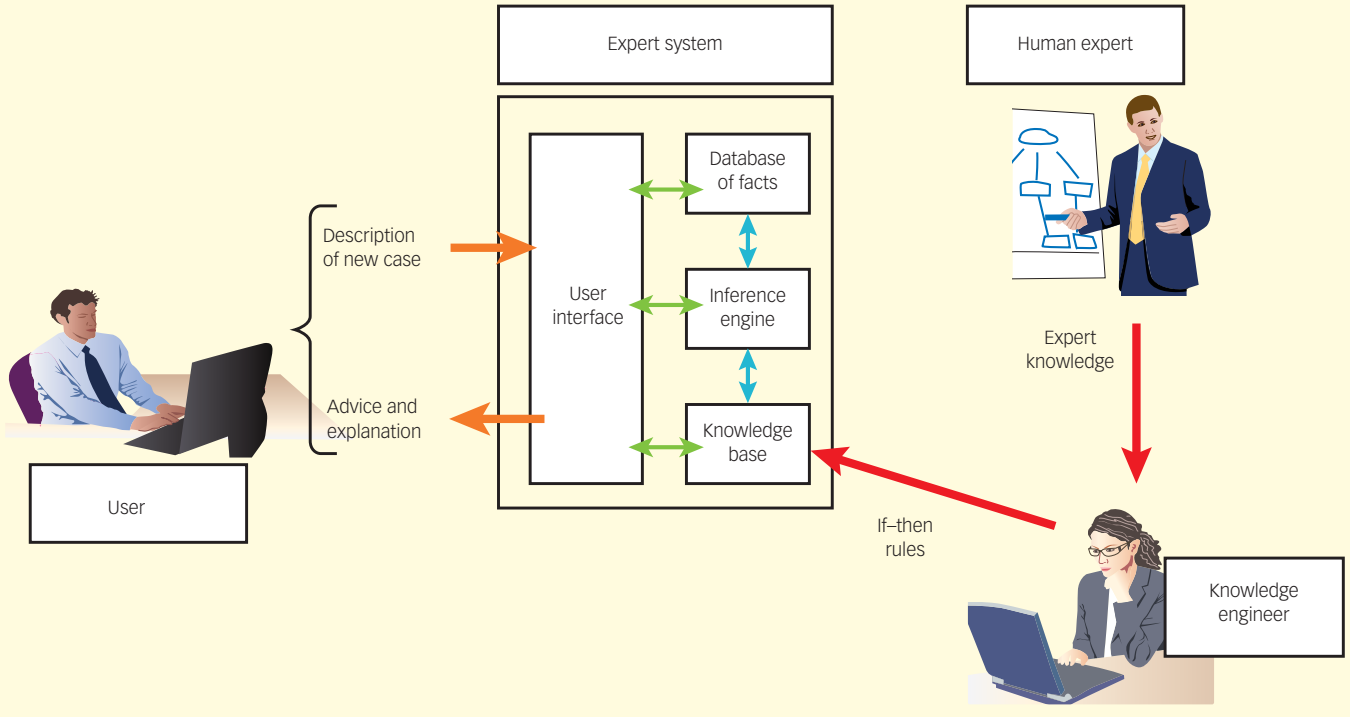


Figure 10.38 Components of an expert system

What are they used for?

Expert systems give people access to expert knowledge when a human expert is not available or it is too costly or inconvenient to consult one. Some of the first expert systems were developed in the medical field. However, their use is now being applied to help train people and to provide expertise in a wide range of applications, such as a research scientist, lawyer, medical consultant or farmer.

American Express uses an expert system to automate the process of checking for fraud and card misuse. Factory workers can find parts, tools and procedures for maintenance jobs, reducing time and cost by a large factor. Some Microsoft packages contain expert systems for diagnosing printer network problems.

However, it is most important that expert systems are used with some awareness of the reliability of the system. Medical diagnosis on the Internet may not be a good idea if someone is suspected of having a heart attack. Consulting a human expert is sometimes a better option.

How are they created?

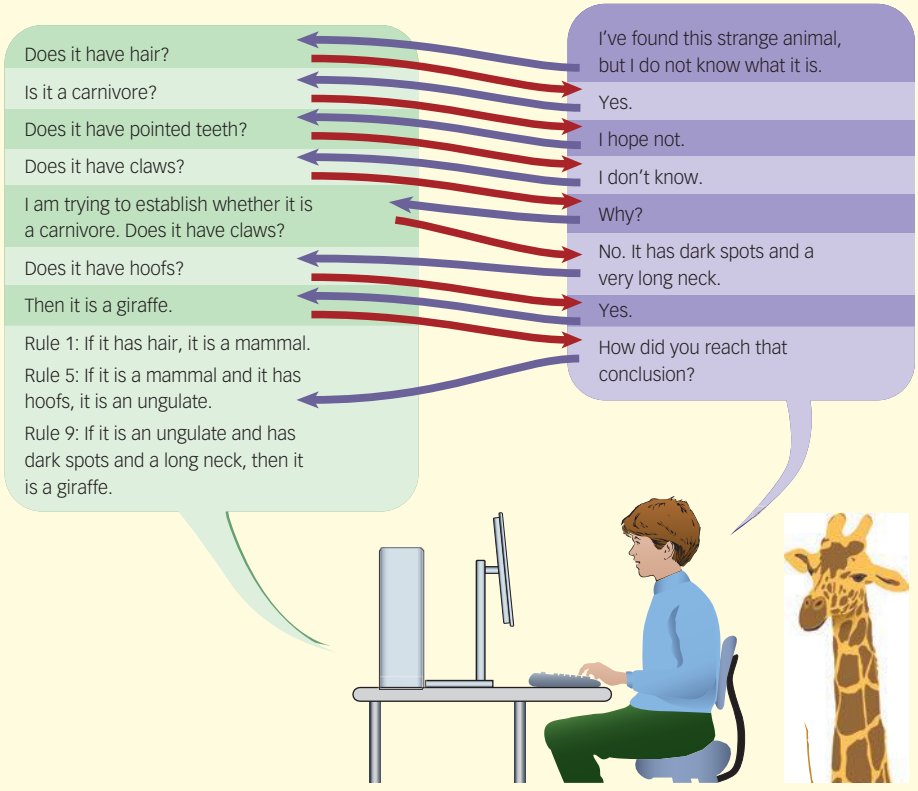
Just like the expert car mechanic in the earlier scenario, software applications can be programmed to draw conclusions by asking the user for facts about the problem.

Firstly, a human expert has to be consulted, so that the logic of the scenario is understood. A knowledge engineer then programs this information into if–then rules; for example, 'IF the headlights turn on, THEN the battery is OK'.

These rules are stored in the knowledge base. A programmer can then build an interface for the user, to present questions and collect the answers. These answers are stored in a database of facts and then processed by the inference engine to provide a conclusion.

Other features may be added to the program to make it more effective. Certainty factors may be programmed into the decision process. For example, in the above scenario, if the headlights are fairly dim, the 'battery is flat' conclusion may be given a 50 per cent factor rating. A second feature that may be included in the system is an explanation mechanism, whereby the processing of the logic is explained to the user.

Some expert systems can expand their own knowledge bases by observing how humans make decisions. Consider an experienced aircraft engineer who has to test a piece of equipment. An expert system might observe, or it might be told, the steps that need to be followed. At a later time, a less experienced engineer could be prompted to follow the same logic that the expert system had learnt from the previous person.



11 OPTION Digital media

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- the purpose of digital media
- types of digital media products
- data types for digital media
- manipulation techniques for digital data
- digitisation of data types
- file formats
- factors affecting file sizes
- display and distribution of digital data
- development of digital media products
- people and issues involved in digital media
- social, ethical and legal issues
- current applications of digital media.

You will learn to:

- define digital media
- assess a range of digital media products
- recognise and select different digital media data types
- describe the purpose of a digital media product
- explain and perform digitisation of a selected data type using appropriate hardware
- select and use appropriate file formats
- discuss and manipulate factors that affect file size
- examine the display and distribution of digital media products
- select and deliver digital media products for a targeted audience.

Key terms

Analog data
data with signal size that can vary continuously

Animation
rapid display of a series of images, each one slightly different from the one before it, to create an illusion of movement

Audio
digital data on a computer representing sounds, including voice, music, sound effects and background noises

Codec
algorithm to compress and decompress a data file, usually audio or video; compression may be either lossy or lossless

Colour palette
colours available for displaying an image

Computer-generated image (CGI)
3D (or sometimes 2D) computer graphics used to create three-dimensional creatures as characters in movies

Graphics
static (still) 2D or 3D pictorial representations of data that can be either bitmapped or vector-based

Morphing
gradual transformation of one image into a different image

Musical instrument digital interface (MIDI)
audio format made up of digital descriptions of the instrument, and duration, pitch and timing of each note

Optical character recognition (OCR)
software process involving use of a scanner to convert a scanned graphic into a text file

Rendering
creation of lighting effects and addition of textures to a 3D image

Text
data involving strings of printable characters separated by white space characters

Video
separate frames of sequential bitmapped graphics shown rapidly to create the illusion of movement

Warping
manipulation of a single image by distortion

Wire frame
skeletal outline of a 3D image made up of both its visible and hidden edges

Creating a 3D world in *Avatar*

James Cameron's *Avatar* sparked new ways of thinking about making movies. Artists used new digital tools to carry out the performance capture, animation and photorealistic rendering needed to create *Avatar*.

Designing: Building James Cameron's new world required a visual tool. The art department and production designers used Photoshop to produce artwork to convince studio heads the project was possible. Adobe After Effects was used to place flowing camera moves and dissolves on the still artwork.

Artists used Photoshop to create storyboarding and very high resolution matte paintings and textures used for the 3D computer graphics (CG) environments, vehicles and creatures. Thousands of digital images were taken as lighting and texture references, and these were catalogued in databases.

A huge stage was created in Los Angeles where motion-captured actors performed live while watching their matching CG creatures on-screen in a virtual world.

Producing: Companies around the world created the movie's visual effects shots, which were 75 per cent of the movie. Adobe After Effects was used to create stereoscopic 3D scenes for finished shots, motion graphics for the 3D holographic screens seen in the control room and heads-up displays for the vehicles in the film. In one scene, Jake Sully and an officer switch to a 3D hologram of the 'Home Tree', where the Na'vi people live (see figure 11.1). Using a green screen across the top of a table, one company modelled the imagined hardware inside the table and added projected graphics of the terrain. These graphics were designed in 2D in Adobe® Illustrator®, animated in After Effects and rendered in Autodesk® 3ds Max®. They also designed the screens for aircraft in Illustrator, and animated them in After Effects. The artist concentrated on animating for one eye and then 3D images were generated automatically, animating the other eye and creating the correct depth.

Even simple 2D shots become extremely complicated in stereoscopic 3D. When subtitling the stereoscopic 3D versions of the film, the subtitles must sit at the bottom of the screen in 3D space to avoid interfering with the 3D content.



Alamy/Photos 12

Figure 11.1 The three-dimensional hologram of the 'Home Tree'



Alamy/Photos 12

Figure 11.2 *Avatar* broke many box office records and won three Academy awards.

Adobe® Acrobat® Connect™ teleconferencing software was used for collaboration during production, allowing artists to control someone else's desktop through an ordinary browser.

Rendering: Today's audiences expect that visual special effects will be loaded with lots of detail. Weta's character Gollum for *Lord of the Rings* was the most complex CG for that time, but *Avatar* set another benchmark. These effects require large amounts of processing power and must be completed before the next scene commences. Producing a movie in stereoscopic 3D makes the files even larger.

Servers and render farms (thousands of CPUs devoted to rendering the individual frames of a movie) for *Avatar* ran up to 24 hours a day as the deadline neared. These servers contained 40 000 processors and 104 terabytes of RAM (random-access memory) and were cooled using water. Tens of thousands of dollars are saved by changing temperature by just one degree.

QUESTIONS

1. Use a two-column table to list all the software named in the article and provide a description of the purpose of each. Highlight each application that you have used in your course.
2. What reasons are given for the large amount of work put into creating still images of the world of *Avatar* during planning?
3. *Avatar* was not the first stereoscopic 3D feature movie. Why do you think *Avatar* was so successful, breaking all box office records?

11.1 The purpose of digital media

In the futuristic sci-fi movie *Minority Report*, Tom Cruise enters a shopping mall, and the unique 'fingerprint' of his iris is recognised by a laser. As he passes a shop, his image is projected on a flat digital shopfront billboard while a soothing voice greets him (using his own name) and invites him to purchase from the store.

Are these glimpses of the digital future of advertising? Will personalised messages soon be sent to users' phones as they pass near a shop, making a special offer available only for the next 30 minutes?

What are digital media?

The influence of digital media on each of us continues to grow, touching almost every part of our lives. These changes have been made possible by our ability to represent the real world in digital form.

We live in an analog world, but computers live in a digital one. The analog images we see, the shapes of the letters forming the words we read, or the sounds we hear are all **analog data** and can be thought of as a continuous waveform.

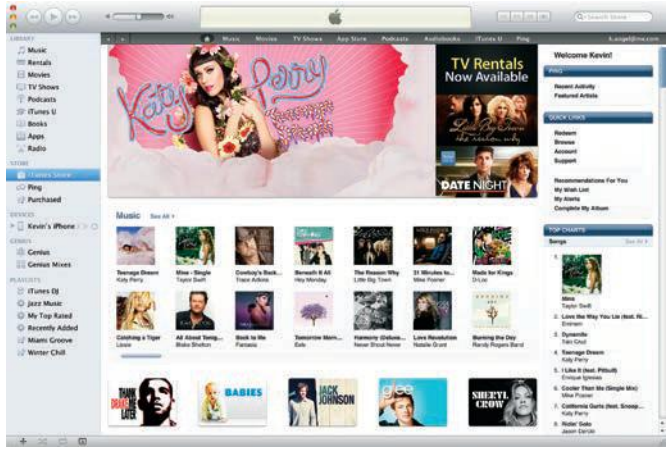
Digital data, on the other hand, uses exact, not continuous, quantities. Because computer circuits are built with switches that are either on or off, computers use binary data with just two digits: zero and one. This is the challenge of representing real-world analog data in digital form – changing continuous real-world analog data into sequences of just zeros and ones.

The main forms into which digital data can be grouped are **text**, **audio**, **graphics**, **animation** and **video**. These are known as the basic digital media types. The word 'media' (singular: medium) can be confusing because we use it also to refer to the medium on which we store data (magnetic, optical, paper) as well as the medium by which we transmit data (cable, radio waves, copper wire). In this chapter, we use the word 'media' to refer to the five families of data types commonly used to represent real-world information. Sometimes hypermedia is also considered to be an additional media type.

Any digital sequence of zeros and ones stored on the hard drive of a computer can represent text, audio, graphics, animation, video or even specialised data such as information about a player's progress in a video game. Interpreting these sequences is one part of the computer's tasks.

Digital techniques appear everywhere: martial arts expert Bruce Lee has been recreated as a **computer-generated image (CGI)** actor for a starring role 30 years after his death; mobile phone users access any one of thousands of specialised applications; a doctor operates on a patient remotely over the Internet; the end credits for movies list the names of hundreds of CGI artists and renderers; visitors explore a 'virtual' Louvre Museum in Paris on their computer without leaving home; programs control the special effects of stage plays; and digital media provides the raw material for computer-based online multimedia web pages.

Digital media offers to make us more creative and allows us to access data more efficiently, but it also raises concerns about privacy. These are issues we will cover in this chapter.



Apple Press image

Figure 11.3 Using iTunes, music tracks (along with other types of digital products) can be purchased, arranged in playlists, shared over wireless networks with others and burned to DVD. Here iTunes' Genius function has used complex algorithms to create personalised playlists and to suggest purchases by analysing music collections of users around the world (seen in the left panel).

E-music

Most music today is sold online. Audio tape cassettes outlasted other analog musical media such as vinyl records (still a niche market for dance DJs), but online digital music stores such as iTunes have become the main way of distributing music digitally.

The popularity of e-music has been great enough to worry large music publishers. When accompanied by a suitable YouTube music video, it also means that unknown performers can more easily gain access to an audience. E-music can be downloaded from the Internet, and the ease with which it can be obtained illegally has threatened traditional music sales and raised important copyright issues.

Apple's iTunes software, iTunes music store, iPhone, iPod, iPad and other online stores and portable digital music players allow users to buy and download thousands of songs online and easily store, organise and play them. Consumers can also create personalised playlists of similar music ('genius' lists), using complex algorithms that analyse the music belonging to other users around the world.

E-music is usually available in the MP3 (MPEG Audio Layer III) or AAC (Advanced Audio Coding) audio formats, which allow digital data to be stored with minimal loss of audio quality and with small file sizes. In the next section, we will look more closely at these formats.

Digital newspapers, magazines and ebooks

Printed newspapers are almost entirely produced using digital techniques. Journalists use digital text as they type their stories using word processors, and photographs are either digital or have been digitised by scanning. The layout of the pages for the printed version is created using DTP (desktop publishing) techniques. This is changing with news media companies offering digital-only versions of their newspapers and richly interactive magazines via subscription for online instant viewing on mobile devices or desktop.

Some websites allow users to create their own newspaper from favourite online sections of the world's press, then deliver these daily when they log on. Try this out for yourself – search the web for 'create your own newspaper' and have a go.

The advantage of digital editions is their ability to be constantly and instantly updated 24 hours a day, delivered very cheaply and searched easily.

Digital magazines are delivered and viewed on a mobile tablet device or a computer and can include filmed sequences, interactivity and special typographic effects – as well as the article itself in text form.

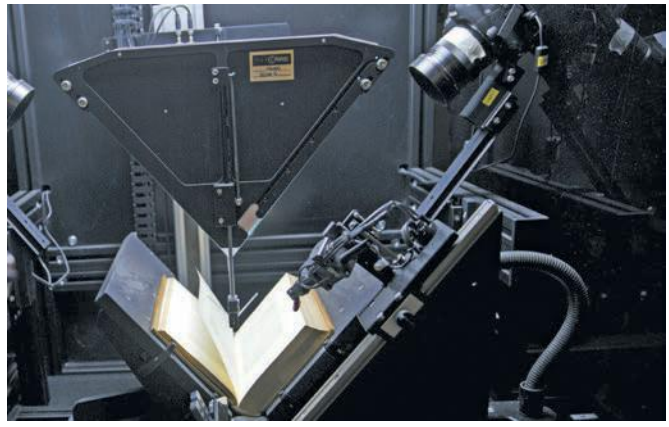
Digital books ordered from online bookstores can include interactive elements and social networking features so readers can share their opinions online. Apple's iBooks is an ebook application allowing users to purchase and read ebooks on one device and access them on any other device. Books can be reviewed, annotated, highlighted and sections shared with friends online. The device can also read them aloud to the user.

Google has scanned many millions of books and has even set the goal of scanning every page of all the world's books and making these digital versions available online, a practice that has raised copyright concerns and court cases for authors.



Apple.com

Figure 11.5 Apple's iBook application allows users to purchase and read ebooks on one device and access them on any other device.



Getty Images/AFP/Daniel Lauten

Figure 11.6 This automatic book-scanning machine can scan 1500 pages per hour, and even remove smudges at the same time.



AAP/Manu Fernandez

Figure 11.4 Traditional reading habits are imitated in the page turning feature on this touchscreen.

TV

ABC iview pioneered on-demand access to TV programs. Commercial broadcasters have followed the same path. These websites and apps allow viewers to catch up on missed free-to-air programs using their computer, a TV with web access or a mobile device. Programs are streamed on demand and at high resolution.

Interactive TV (iTV) has even more features, but has been slow to be adopted. It allows viewers to select such aspects as the camera angle at which they wish to view a game of football or an alternative outcome to a favourite drama or TV soap. Interactive TV has a similar level of interactivity to DVDs (digital versatile discs).

Games

Many of the advances made in digital media have been driven by the games industry.

Early computer games were played in shops and arcades and then, as home computers became widespread, their popularity increased further.

By 1982, specialised game consoles such as Atari were popular – there were 15 million in homes in the United States alone. In 1985, the Japanese ex-toymaker Nintendo launched its own entertainment system, with Sega following soon after. When Sega asked Sony to develop a CD-ROM (compact disc read-only memory) drive for its new system, this eventually led to the creation of the Sony PlayStation.



Figure 11.7 A selection of gaming consoles. From left to right and top to bottom: PlayStation (1994), Nintendo Wii (2006), Microsoft Xbox (2005), Sega Mega Drive™ (1988), Atari® 2600 (1977), Nintendo® GameCube® (2001).

Microsoft entered the field with its Xbox (using a hard drive for storage) and Nintendo with Wii (using flash storage). The Wii introduced a new approach to interaction by using an infra-red remote controller with spatial motion input. Apple's iPad has included all three: game, display and controllers, fully integrated in one hand-held device.

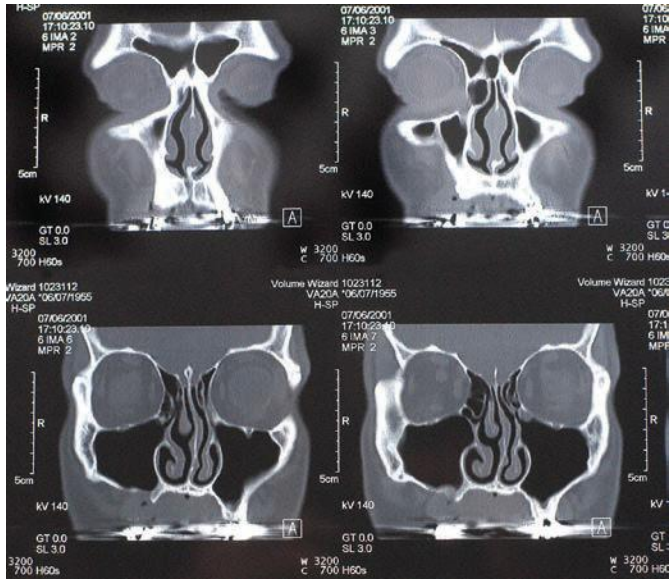
The Internet and shopfront-based gaming intranets provide many gamers with opportunities for playing computer-based network games against others.

Some players spend many hours in artificial environments known as MUDs (multi-user domains), where each individual makes decisions affecting other players.

Three-dimensional realistic characters, complex background sounds and greater attention to detail mean that game environments have become even more compelling. The military uses simulation software and digital games in its training.

Health

There are many examples of digital media products in the field of medicine. Today, if you were to have an X-ray or computerised axial tomography (CAT) scan, you could request a version in the form of a digital file.



Alamy/Directphoto Collection

Figure 11.8 A digital version of an X-ray scan presented on DVD

Digital hearing aids can be connected to computers, allowing patients to adjust the sound quality and sensitivity to suit their needs.

Surgeons have also used digital techniques to perform remote operations using the Internet, where they can select a camera view and angle to operate on a patient in another part of the world.

This exciting area of digital media will continue to evolve and will draw on the talents of a large range of digital professionals.

Commerce

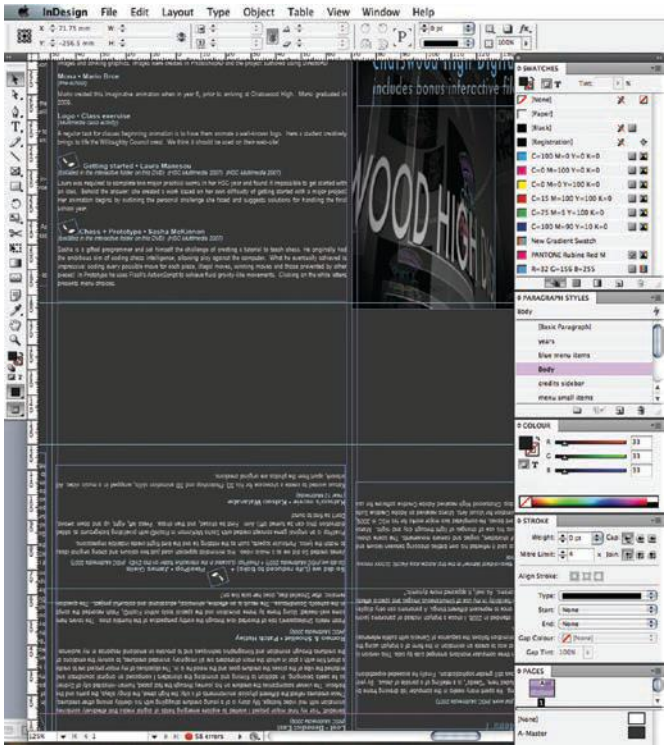
Feel like a soft drink to take on the train but are short of change? Simply phone up the vending machine on the railway station platform and it will politely dispense a can for you and debit your account.

Are you actually at the supermarket? How old-fashioned! Now you find and collect the items from the shelves, scan in their digital bar codes, and weigh and pack your shopping while customised digital ads scroll across the checkout screen. Perhaps next time you will order on the web!

Real estate agents create virtual digital journeys through houses offered for sale, using digital panoramic photographs.

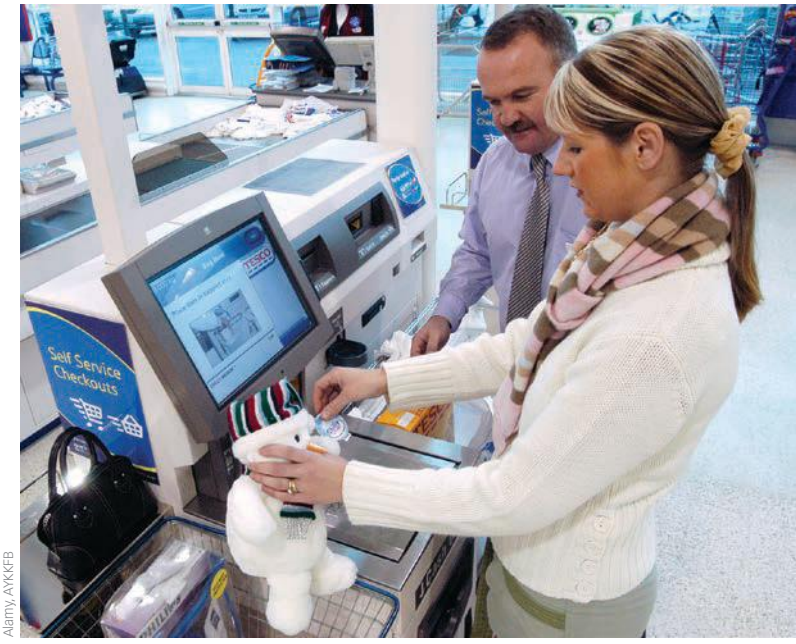
Mobile phones provide companies the opportunity to advertise to large audiences with customised MMS (multimedia messaging service) ads sent to consumers who have already shown an interest in a product. Flat-screen panels even advertise to captive audiences in toilet cubicles. Ads are 'pushed' to users while using applications on mobile devices.

All these examples illustrate how far the impact of digital media has reached, and this impact continues to grow.



Alamy/David Williams

Figure 11.9 Desktop publishing, such as this example of a DVD insert using Adobe® InDesign®, borrows the basic idea of a desktop arranged with clippings of text and graphics. The introduction of DTP software encouraged the acceptance of the graphical user interface (GUI).



Alamy AYKKFB

Figure 11.10 A self-checkout kiosk

TASK 1

Digital media in advertising

Your task is to examine the extent of digital media used in advertisements during an hour of prime-time free-to-air television. Your teacher will assign you a timeslot and a channel for viewing.

1 Watch the timeslot given for one hour and record each of the following details in table form:
   - **a** product advertised in each advertisement and its duration
   - **b** short phrase describing the content of the ad
   - **c** use of digital effects (text, audio, graphics, animation, video effects)
   - **d** total time of all advertisements over the hour.
2 Calculate the total percentage of time for digitally enhanced advertisements out of the total time for all ads.
3 Report back to the class. The class may add their data to a prepared spreadsheet or database where the results can be analysed and graphed.

ACTIVITIES

Identify

1 Identify two examples of digital media applications that have only been widely used in the past few years.
2 Identify a currently popular digital media product.
3 State one example of a digital media product in each of the following areas:
   - **a** arts and entertainment
   - **b** health
   - **c** commerce.
4 What is interactive TV?
5 What tools are available in ebooks that are not present in a printed book?

Analyse

6 Identify three digital media products and determine which data types are often found together in the same digital products.
7 Determine the current most popular digital game among your friends. Analyse what makes this popular compared to other games.

Investigate

8 Survey your class to find the most popular digital media game among students in their later primary years. Use your answer to question 7 to describe changes in digital games over the years.
9 Search for a site offering online grocery shopping. Select five common items and work out the cost. Compare the cost of using an online site (include delivery) with physically shopping at your local supermarket.

11.2 Types of digital media products

Digital media allow us to 'imagine' the unseen and this can lead to greater understanding of our world. Mathematical structures can be manipulated and viewed in three dimensions using stereoscopic glasses (see figure 11.26) and then printed in 3D. Satellite imagery from space can be enhanced using false colours to highlight the world's shrinking resources or the population explosion of our planet. The DNA molecule can be shown in animated action: forming, dividing and mutating.

Desktop publishing

The year 1985 became a very important milestone in the history of computing. That year, three technologies emerged that for the first time allowed any user to lay out and print professionally without the need to send work out to typesetters and printers: Apple's Macintosh computer (which first popularised the GUI interface), Adobe® Aldus PageMaker® (the first desktop publishing software) and an affordable laser printer. This was the beginning of desktop publishing (DTP).

Adobe's InDesign today includes features that expand its usefulness well beyond printing. Now DTP software allows creation of one layout to be delivered as a printed magazine, online as web pages or with interactivity for touchscreen mobile devices.

The DTP artist designs a template that forms the basis of the project. They decide on the typeface for headings, subheadings, body text and captions and prepare the column layout guides and master pages (content that will appear on every page). They collect the media required and devise buttons and interactive elements for the non-printed versions.

Word processors are missing many of the specialised tools available in dedicated DTP applications. One advantage of DTP is that the handling of text is far more flexible as all text is edited in resizable blocks. Another is that large image files are stored externally, allowing it to respond more quickly in a lengthy document containing many images (see figure 11.9). Other advantages are specialised interactivity and tools for arranging pages and chapters.

Graphical design

Still images can be created instantly using a dedicated digital camera or mobile phone camera. A user can then use image editing software such as Photoshop to modify the result. Blemishes can be removed, filters and effects applied and output formats selected. One impressive application of digital still imagery is Google's Street View.

Digital graphics may also be created using a computer. There are various approaches to creating graphics on a computer, and each one copies different traditional techniques.

Photographic paint software (such as Photoshop) models a photographer's studio. Draw software (such as Illustrator)

TASK 2

Desktop publishing

This task requires you to create a single page for a magazine aimed at a high school-aged audience to explain each of the digital media data types. You can use software such as Adobe InDesign or Microsoft® Publisher.

Here are the steps you will follow:

1. First decide on your content. Select images to illustrate your text. Store these separately in a folder on your computer. Type the text in your favourite word processor. In your written content, cover:
   - **a** each digital data type
   - **b** a graphic for each data type
   - **c** an introductory article summarising the ways in which digital media are used.

   Create any other graphical elements you wish to include on the page. Obtain others from the Internet.
2. Plan your layout on paper. Next, decide styles for the text body, headings, subheadings and captions. You must define in advance the fonts, sizes and styles (plain, bold, italic) for each of these in your DTP application.
3. Design a template or master page with column guides and decide the position of the graphics. Turn on text wrapping. Place a graphic on this master page and set its alpha setting low (a low number means high transparency) to create an interesting background pattern without being distracting.
4. Import the graphics and text, and type a heading.
5. Arrange the elements and edit the text so that it all fits on a single A4 page and print it out.

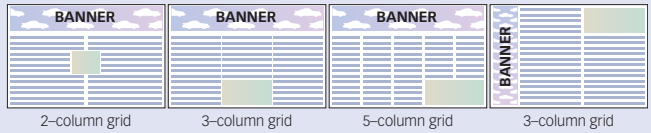


Figure 11.11 Some possible DTP layouts

models a technical illustrator's drawing board, and natural media paint software (such as Corel® Painter™ – see figure 11.12) models an artist's easel. There is overlap between these, as new features are being constantly added.

Images of 3D solids can be compared to a sculptor's studio. As we will see later in this chapter, this is achieved using 3D software (such as Blender or Autodesk® Maya®). Although originally used by architects and engineers, such software is now used extensively in the movie industry to provide powerful special effects.

Painting and drawing

We often imagine that artists producing digital images are computer experts. However, most artists see computer software as just another artistic tool where they 'paint with pixels'.

You should think of paint images as a grid of separate coloured dots (pixels) that make up the image, and draw images as a series of strokes and mathematical descriptions of basic shapes (such as a circle).

Artists use paint software such as Photoshop (see figure 11.13) to create images for magazine covers, posters, special effects for TV promotional images and display advertisements. It is also possible to use natural media software such as Painter, where the paint 'flows' like real watercolour or poster paint.

Free online graphics software is available, such as Pixlr, although these lack the advanced features of purchased applications.

There are many ways to acquire an image for paint software, but a common one is to begin with a scanned image of a photograph taken using an analog camera or an image taken with a digital camera.

An artist can use distortion, cloning, special filters and many other techniques to modify them.

Draw-type graphics use vectors and so can be enlarged many times without loss of quality (see figure 11.14). Shapes are not drawn with brush strokes but are selected ready-made and can be removed simply by pressing delete on the keyboard.

There are other terms for these two graphics types: paint images are also known as raster, bitmap or pixel-based graphics and draw images may be called vector, line art or object graphics.

The two types of 2D graphic applications now share more and more features, although there is no eraser, paintbrush or airbrush in draw software.

There are usually more special effects possible in paint software, as each pixel can be individually manipulated. Paint software offers many filters as well, and can create stunning special effects.



Corel Painter

Figure 11.12 In the natural media paint software Corel Painter, realistic paint and predefined shapes flow as if from a real brush, even more so when combined with a graphics tablet and pen.



Copyright Adobe Photoshop

Figure 11.13 Photoshop is the best known application for editing photographic images.

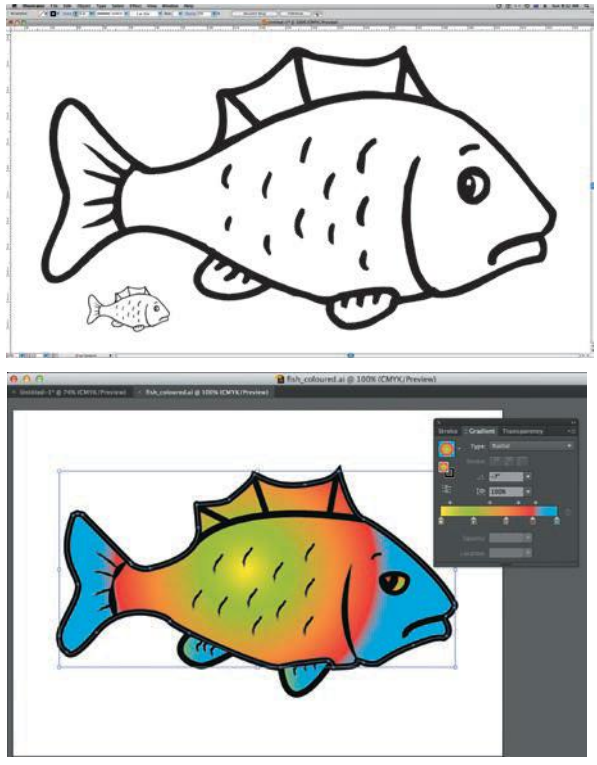


Figure 11.14 Top: This fish was copied and enlarged from a smaller one, showing how a draw image retains its quality. Bottom: The fish coloured using both radial and linear gradient fills.

INFOBIT

Render farms are trucks filled with computers used in parallel, and hired by film companies to accelerate the demanding process of digitally rendering each individual frame created for a CGI movie.

TASK 3

Using draw software

The most challenging tool to master in using draw applications such as Adobe Illustrator is the pen tool. Practise this by reproducing the outlines in figure 11.15. Make sure that Fill is turned off.

Select the pen tool. Straight lines are created by clicking. Curved lines are created by pressing and dragging. Ask your teacher to demonstrate these techniques.

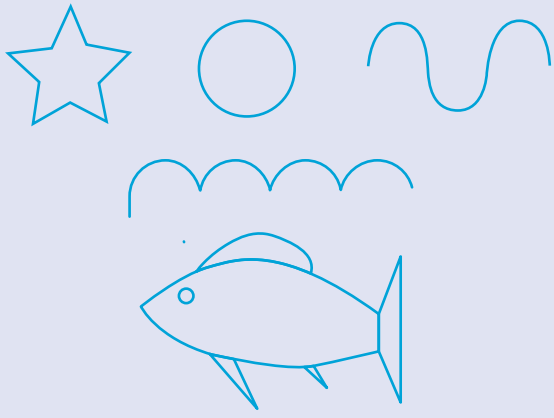


Figure 11.15 Create all these shapes using the pen tool.

Use a vector-based (draw) software package such as Illustrator to recreate the illustration in figure 11.14.

1. Create the basic shapes needed for the fish. Notice the blue line forming the outline of the fish body, which was achieved using the pen tool with a default line style and a 4 pt stroke. Other lines used various line styles and strokes.
2. Add graduated coloured fills to give an illusion of depth to the fish.
3. Save this file with the name 'yourname_draw'. We will later compare the size of this file to one produced using a paint package.
4. Extension exercises:
   - **a** Import a photograph of a room in your own house to a draw package and use it as a background to trace a drawn version over the top.
   - **b** If you have access to a landscape design tool, use this to design your own dream backyard.

TASK 4

Using paint software

Use a bitmap-based (paint) software package such as the paint tools in Painter or Photoshop to create the same illustration as in task 3.

1. Repeat steps 1–3 as in task 3, but use the paint tools to try to achieve a similar result.
2. Save this file with the name 'yourname_paint'.
3. Which task produced the largest file size – task 3 or task 4? Explain why.

3D graphics and 3D printing

Most three-dimensional graphics software allows the designer to see the object from each of three views: top, side and front elevation. A talented 3D artist can 'think' in this way and create the required shape.

Hardware exists that allows real-world objects to be scanned by lasers. The surfaces are read into the computer, which then creates an equivalent virtual digital shape. It is possible to scan a person's face and body using this technique. This equipment even records the surface colour data and reproduces the original object precisely, along with surface imperfections. Once the software has the shape expressed as digital information, it can be used to manipulate the object in endless ways.

There are many 3D creation software packages available. Try 3DTin, TinkerCAD, SketchUp or 123D Design as starters. These are free to begin with and have excellent introductory tutorials. After creating your design, it can be animated, manipulated or 3D-printed.

If you plan to do serious work in 3D, it would be good to experience a range of software rather than be an expert in just one. One of the most sophisticated is Maya. Maya costs thousands of dollars, but you can learn to use it yourself free of charge by obtaining the Autodesk Maya Personal Learning Edition (PLE).

Many thousands of 3D models are also freely available online. Look for inspiration in Google Warehouse or Thingiverse.

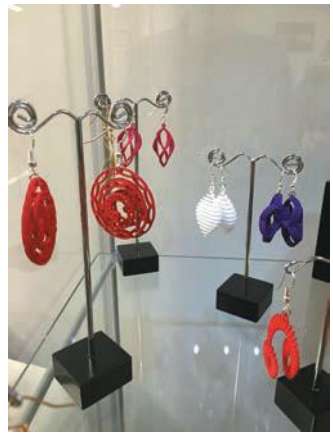


Figure 11.16 Examples of jewellery designed and printed using a 3D printer. Online services exist that allow you to upload your creation and then return your designs fashioned using your chosen material: plastic, platinum, silver, gold.

TASK 5

Using 3D design software and a 3D printer

Using high-end three-dimensional design software such as 3ds Max or Blender can be a steep learning curve. The idea of this task is for you to dip your toes into 3D design by using an introductory application such as SketchUp, TinkerCAD or 123D Design to create the house design below. Then, if your have access to a 3D printer, to print it.

If you like what you see, there's an even bigger world to explore!

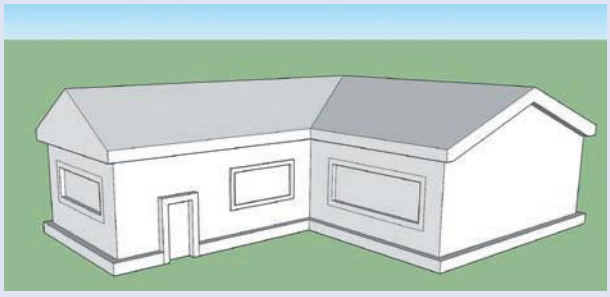


Figure 11.17a Final 3D model of a house using SketchUp

1 We will use SketchUp and illustrate the steps briefly here, but you may need to ask your teacher to demonstrate these in greater detail or use an online tutorial.

2 Create two adjacent rectangles and erase the joining line (see figure 11.17b).

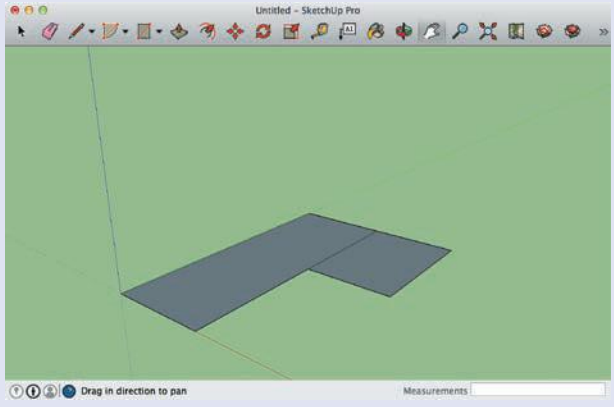


Figure 11.17b

3 Lift this base using the Push/Pull tool (see figure 11.17c).

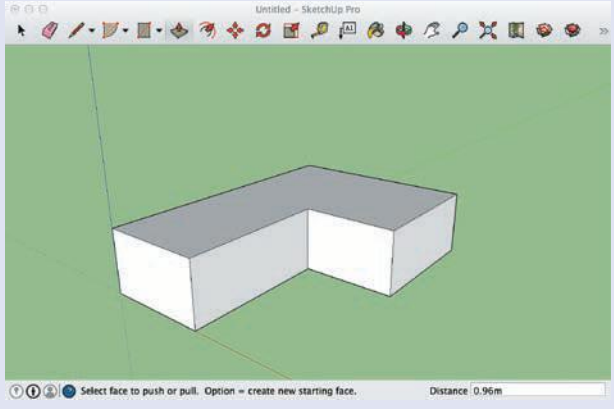


Figure 11.17c

4 Find the centre of the top front edge (a blue dot) and then, keeping the mouse pressed, locate the centre of the right back edge (blue dot). Then, keeping the mouse button down, return to the centre and click when you find the centre position. Continue to draw this line (shown in blue) to the centre of the right edge. Use the Line tool to draw the remaining short diagonal ridge (see figure 11.17d).

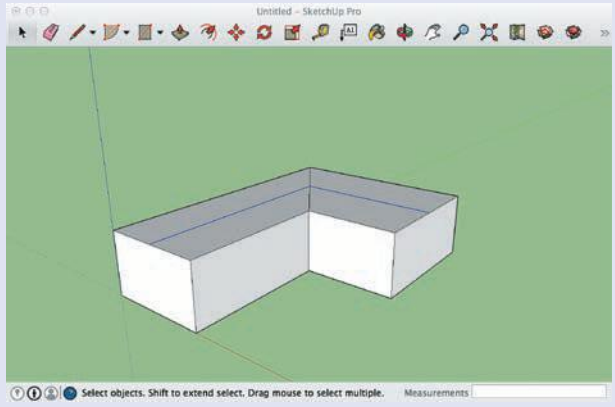


Figure 11.17d

5 Shift-select this new centre ridge and lift using the Move tool (see figure 11.17e).

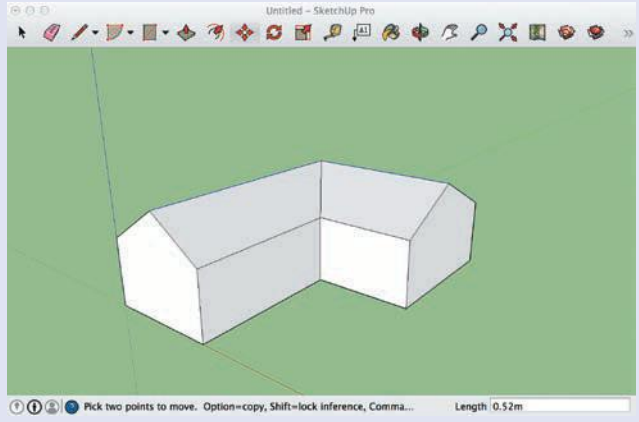


Figure 11.17e

6 Use the Orbit tool to look underneath your house and use the Offset tool to create an inset (see figure 11.17f).

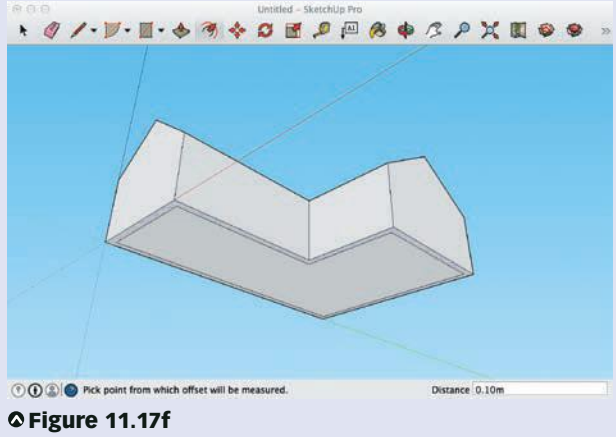


Figure 11.17f

7 Use the Push/Pull tool to lift this border to form the overhang of the roof. Use the Follow Me tool to create a ridge around the base of your house (ask your teacher for help if required here). Add doors and windows (using one or two insets). Finally, add materials as required (see figure 11.17g).

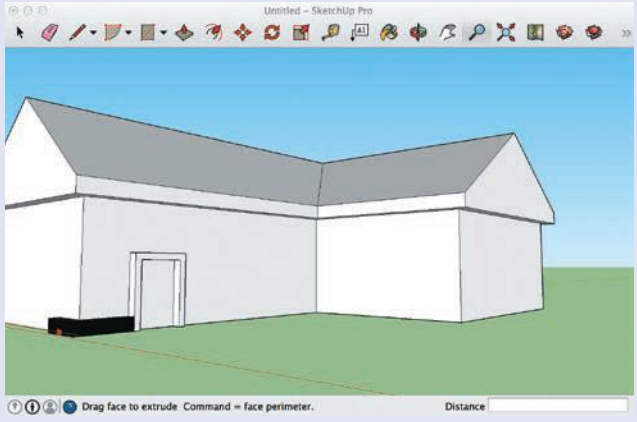


Figure 11.17g

8 Complete your software 3D house model by using SketchUp to add materials to its surfaces (see figure 11.17h).



Figure 11.17h

9 (Optional) If you are making a 3D-printed version, export (under File) your file in 3D .obj or .stl format and then import it to your printer's software. (We have shown this placed on the build platform of MakerBot 3D printer's application.) Then 3D-print your house (see figure 11.17i).



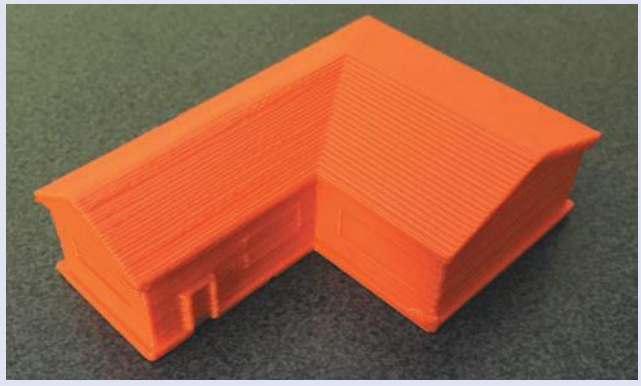


Figure 11.17i Top: House on the virtual build platform using software accompanying a MakerBot 3D printer. Bottom: A final 3D print of this house.

Cost	A reliable classroom printer can be purchased for well under $1500. More expensive ones do not always guarantee superior prints. How much can you afford?
Filament	Some printers use special spools of material with in-built chips or cartridges. This will prevent using cheaper filament. The most economical are 1 kg spools that can be wound onto smaller spools. Most printers use either ABS or PLA plastic. It may be wise to use PLA as the fumes are less toxic.
Hardware features	Is the print head self-levelling? Can the printer be paused mid-job? A metal frame means fewer adjustments. How heavy is the printer? Avoid requiring a trolley! How are filament jams or running out handled?
Software	Some software is easy to use but may offer fewer options. Is there a charge for the software or is it open source? Can it be used with other printers? How intuitive is it? Does it offer users the chance to experiment with settings? Will it build supports and 'rafts'? Can features be turned off?
Tech support	What support can you get? Forums, help desks?
Press and play or tinker?	Is the printer more suitable for tinkering or 'press and forget'?
Resolution	What is the minimum layer thickness offered? 100µ is great, 75µ is exceptional and 200µ is satisfactory but will appear coarser.
Build size	How large do you want your objects to be? A small platform will limit this but may be big enough for you and thus save money.
Camera and wireless control	Do you want to be free to walk away without worrying if the job has jammed, or wish to know when it has completed? Some printers have a camera built in and phone apps to monitor the job's progress. Some offer remote control of the printer via wireless network.
Connections	Do you need to have your computer permanently connected during a print job using a USB cable or does it offer SD card or even Wi-Fi connectivity as well?

Figure 11.18 Tips for choosing a 3D printer



Maya

Figure 11.19 The work interface and environment for Maya. Visit Maya's website and find out about this powerful 3D software.

Creating 3D images

Various techniques have been invented for creating 3D images. The most common technique uses a four-stage process. First, **wire-frame** shapes are created using the 3D software. Then mathematical calculations determine which lines to hide, providing a more realistic 'solid' view of the object. Next, shadowing and colour are added. The final stage is realistic **rendering** (Phong shading or ray tracing), where lighting, reflections and textures are added.

A second technique uses lathing. The shape of the edge of the object is drawn and the computer rotates this (in the same way as a spinning lathe shapes wood) about its axis to produce a solid.

A third technique uses extrusion, which looks as if a solid was pushed like playdough through a shaped hole.

A fourth technique uses sculpting and allows the user to 'sculpt' a lump of digital clay by using gestures with a mouse. Rotation of the mouse will raise or lower the surface and sideways movements will 'stretch' it. 123D Sculpt and Autodesk® Mudbox™ are both examples of such software.

A fifth technique uses a laser to scan a solid object, which then generates the data required for manipulating it as a 3D solid object.

Three-dimensional images are an important component in many digital media products. They are the basis of computer-generated images seen in movies, objects manipulated in virtual reality, in computer-aided manufacturing (CAM) and 3D printing (see later in this chapter) to produce prototypes before mass-produced manufacturing.



Disney/Pixar

Figure 11.20 Stages in developing a scene for the Pixar animation *Up*. From top: storyboard concept sketch; colour added; shading added; effects added; lighting added (© 2009 Disney/Pixar).

Creating realistic solid images is a difficult task and various methods can assist the artist. Viewing is usually done using perspective, to give an impression of the solid shape, but this is a difficult way to create the object. The biggest problem is that the artist is limited to drawing on a flat screen. One solution is to use colour to represent height. To create a high mountain, the designer simply uses paler colours for higher areas and darker colours for lower elevations. The software then creates valleys and ridges using these as height maps.



courtesy of Makerbot, New York

Figure 11.22 A MakerBot fifth-generation printer



ALoopingIcon, Wikipedia

Figure 11.21 A real object is copied using 3D scanning and 3D printing. The gargoyle model on the left was digitised using a 3D scanner and this 3D data was processed. The resulting digital 3D model, shown in the screen of the laptop, was used by a 3D printer to create a real resin replica of the original object.



Figure 11.23 A variety of 3D printouts. The companion cube and colour-changing heart were both designed by students.





Figure 11.24 Some 3D prints have overhanging areas, as in the case of this elephant, which must be printed with supports. These are designed to break away easily after the job is complete. The printer software has in-built algorithms that automatically calculate where these supports must be constructed.



3D console This console from Dorling Kindersley's Eyewitness Virtual Reality Cat was built as a 3D model.

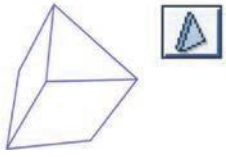
Basic shapes The designer uses 3D modelling software to create the wire frame for the console (left).



Sphere tool Inside the computer's 3D world, a perfect sphere is stored, but on the screen it is drawn with straight lines as a wire frame.

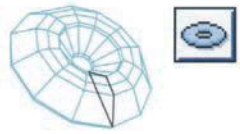


Cylinder tool The designer uses this tool to create the fluting on the side of the console and the struts that support the top.

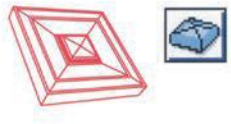


Extrude tool This tool adds simple depth to any flat shape. To make the top of the console, the designer draws a triangle and then stretches it into three dimensions.

Complex shapes As well as combining simple building blocks, the designer can use some advanced modelling techniques.

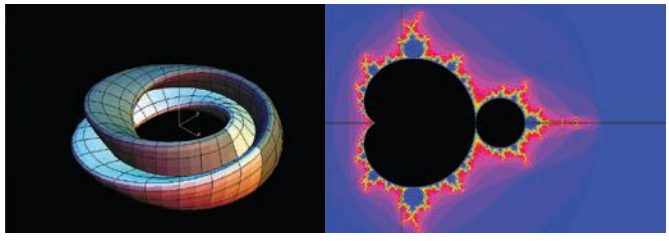


Lathe tool To make the console's pivoting centre, the designer uses the lathe tool, changing the starting point to the shape shown.



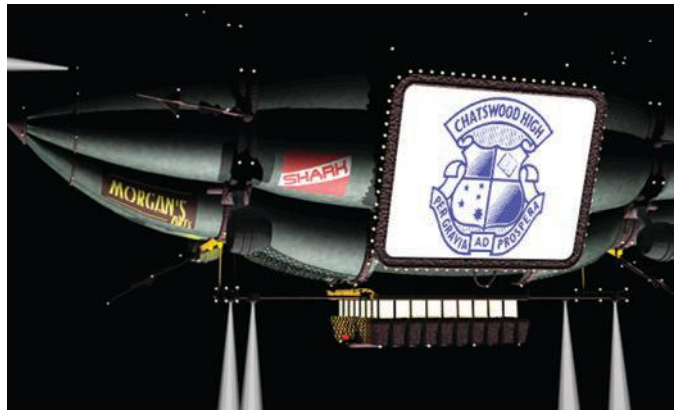
Freeform tool The designer can create a new shape from scratch by drawing cross-sectional blueprints on the screen.

Figure 11.25 The 3D console (top left) was created in stages, using standard tools in 3D modelling software and four of the 3D techniques described.



Richard Palais

Figure 11.26 The mathematical software 3D-XplorMath forms digital mathematical images. In this example, we see the difficult-to-visualise Klein bottle. The other image is the most famous mathematical creation of them all: the Mandelbrot set. Find out about the Klein bottle and the Mandelbrot set using the web.



Richard Palais

Figure 11.28 This blimp was created using 3D StudioMax by a Year 10 student. It is a single frame from an animation.



Figure 11.27 Photorealistic images like these can be created using digital techniques – but artistic talent is still needed!

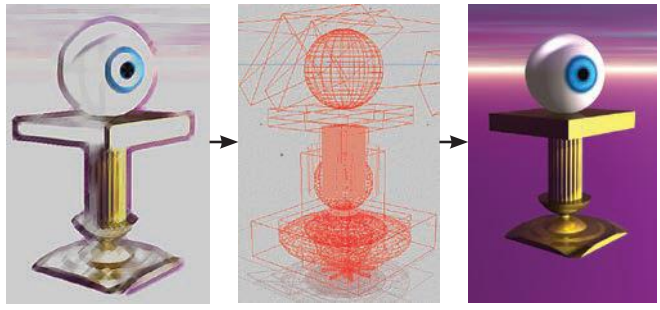


Figure 11.29 From left to right: an artist's concept sketch for an all-knowing eye as part of an upcoming game; a 3D artist's wire-frame model; and the final figure after adding texture and lighting.

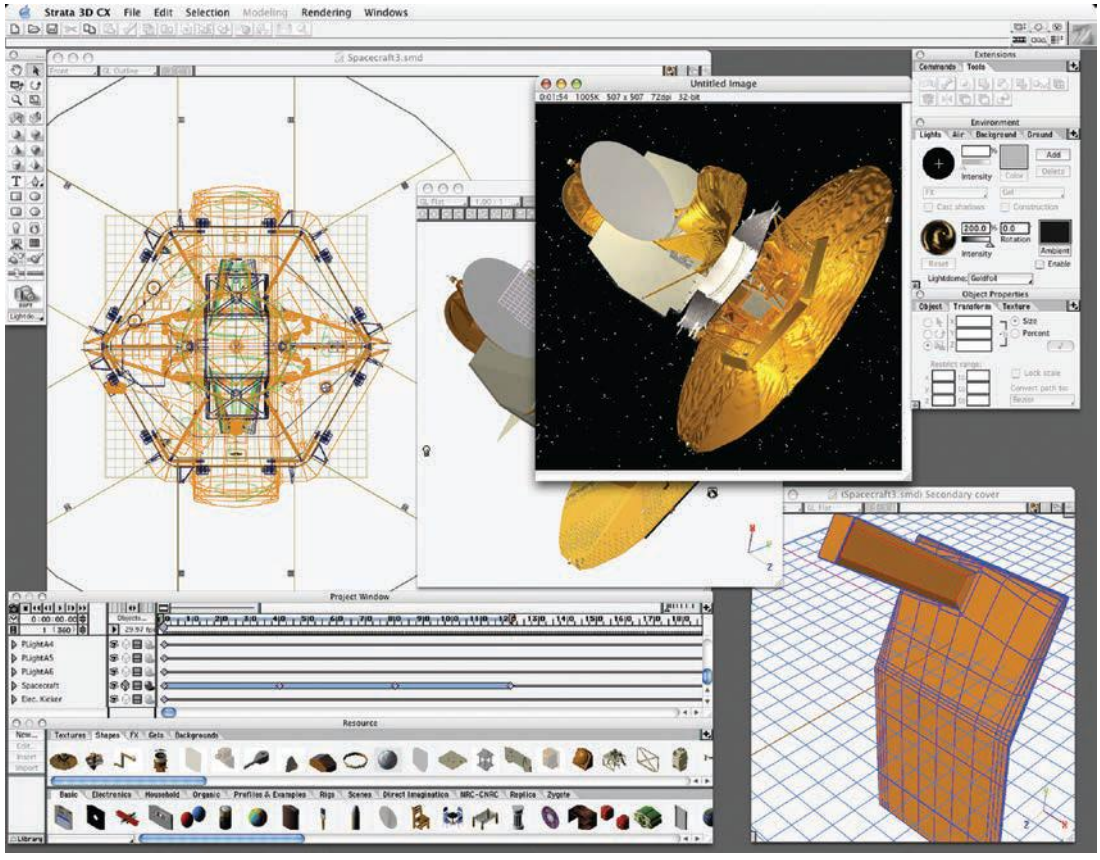


Figure 11.30 A spaceship shown as wire frame and final rendered object. The 3D artist uses at least three separate views during design: top, side and elevation (front).



Figure 11.31 No limits to your imagination! You can digitally create any world you like using the Bryce 3D graphics application.

INFOBIT

In the BBC TV series *Walking with Dinosaurs*, it was necessary for human beings to kick up the dust where the animals' feet touched the ground and integrate it with the 3D figures to make the scene more convincing.

Audio sequences

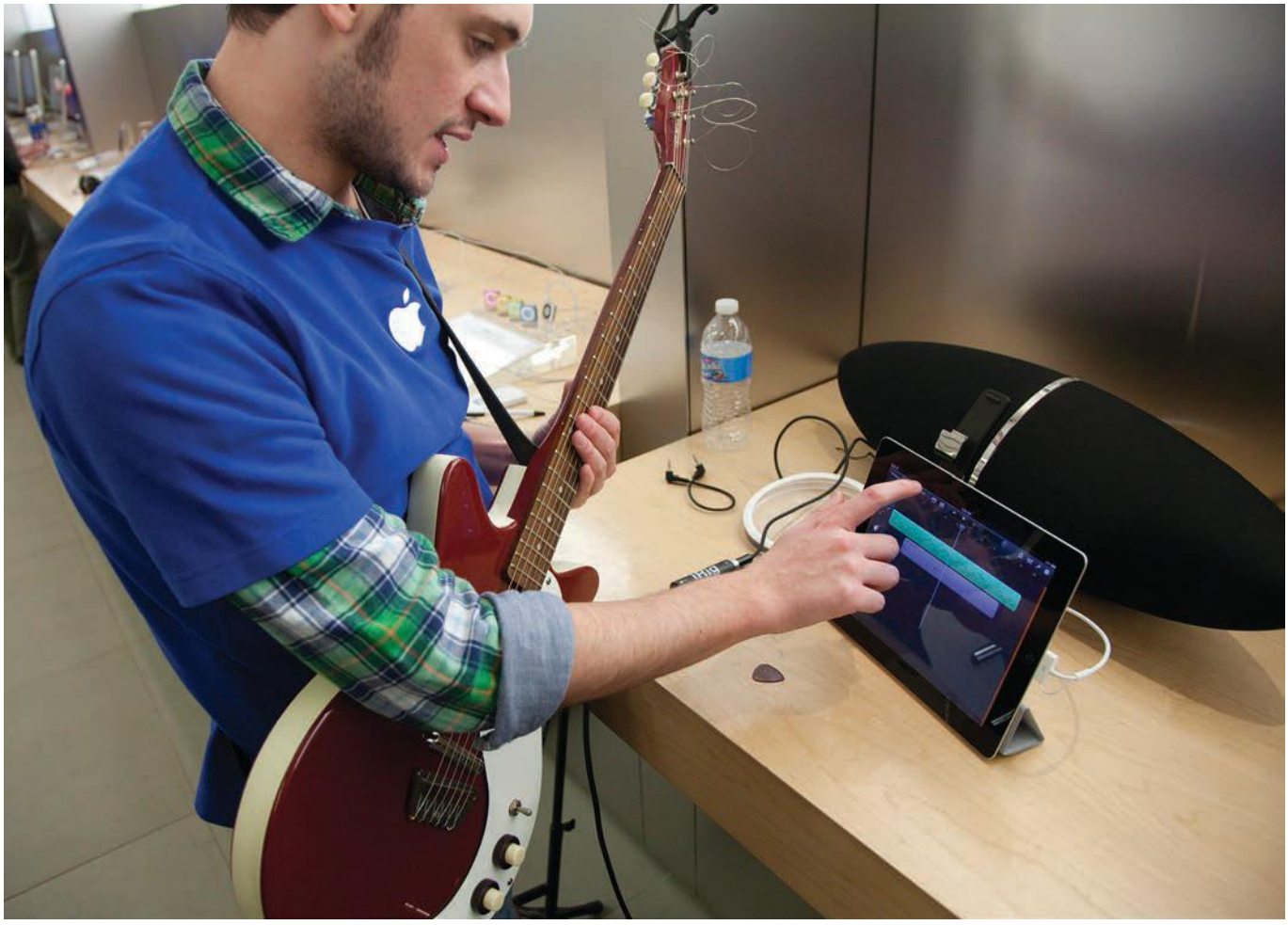
Audio is an important component of digital productions. Its emotional impact on the senses is often underestimated, and it can be the most important digital type used in your projects.

One problem faced by audio engineers is that computers play sound back through small, low-quality speakers, so the sound must be optimised. Sound editing software looks for waveforms that expand to the point where they distort, and any that exceed the distortion limit are smoothed out.

Audio sequences can be used for music, sound effects, to add commentary to a multimedia production, to accompany a slide presentation or to record the spoken word. Audacity® is a popular free application for recording and editing sounds.

The compact disc digital audio (CD-DA) standard was developed by Philips and Sony and introduced in Japan in October 1982. It added error correction data to fix errors in recording.

Audio CDs were designed to hold over an hour of high-quality stereo audio and the compact disc was the first consumer format to use digital techniques to represent audio. Digital music today, however, tends to mean online MP3 files.



Corbis/Brooks Kraft

Figure 11.32 GarageBand allows music composition, audio editing, instrument lessons, access to a large collection of prerecorded music loops as well as the ability to create and publish podcasts.

Musical instrument digital interface (MIDI) is also available. This format is the smallest in terms of storage required; however, it cannot be used to represent real-world sound such as speech. Instead, it uses codes to stand for predefined instruments, with additional data giving the pitch and duration of each note. Audio file sizes and compression techniques are discussed in section 11.4.

Musical compositions

Digital musical compositions are usually in waveform (WAV), audio interchange file format (AIFF), MP3, CD audio or MIDI formats. WAV and AIFF are widely used in multimedia authoring, while MP3 is used to record longer pieces of music, and MIDI is used where smaller file sizes are critical.

Composition software allows the composer to use an attached keyboard or software tools to create their own compositions. A sequencer creates and edits music generated on a computer. There is a great deal of overlap between these two categories of music software.

Popular music composition and sequencer applications include Avid Sibelius®, Apple® GarageBand® and Apple® Logic Pro and Sony ACID Music Studio™.

TASK 6

Using audio software

Use audio software to create an original piece of music lasting no less than 60 seconds. It should include at least two tracks (including both a software and a real instrument track), two different prerecorded loops (usually supplied as part of your software's library), a pan and a fade.

1. Select your tracks.
2. Place your tracks on layers and loop them as required.
3. Add a drum track.
4. Add pan and fade effects. Adjust volumes.
5. Export your file in MP3 format.

Animation sequences

Animation is the rapid display of still images. It is best described as the illusion of movement generated by a series of still graphics, each slightly different from the previous one, presented to the eye in rapid sequence.

Digital animation sequences can be either two-dimensional or three-dimensional.

The two basic 2D animation techniques are cel-based and path-based. In cel-based animation, a series of separate images is presented on an unchanging background. In path-based animation, an object is moved along a predefined path. Detailed descriptions of animation techniques appear in chapter 9: Authoring and multimedia. Our emphasis here is the creation of an animation.

Working through the in-built lessons included with animation software will help you learn about the different types of animation.

Animations where each individual cel is drawn individually and handpainted are part of the long tradition of Disney films, from *Snow White and the Seven Dwarfs* to *The Lion King*. However, even traditionally created animations now contain computer-generated segments.



Getty Images/J. Vespa

Figure 11.33 *Wallace and Gromit* was created by Nick Park using the 'claymation' (clay animation) stop-motion technique, as described in task 7.

The most basic method of animation in 3D is cel-based animation where small changes in movement are displayed rapidly to give the illusion of movement. This is very time-consuming, so motion capture is a popular alternative. With motion capture, an actor wears a pair of special gloves and a suit. Small movements are picked up by sensors and translated into movements applied to the computerised 3D object.

Full-length animations such as *Shrek* and *Toy Story* were created entirely using 3D digital animation techniques on a computer. Digital media products are used to create the rich textures of video games and the fictional 3D worlds in movies. *Avatar* took 3D animation one step further. Although not the first 3D movie, its realism and beautifully detailed landscapes are recognised as a breakthrough in stereoscopic 3D visualisation (see 'In action', page 175).

Virtual reality techniques use these 3D methods, but add interactivity. A doctor can operate on a person from a remote location using the same motion capture input devices used by the movie-making industry. A pilot can experience realistic scenery and special effects when learning to fly an aircraft. Virtual reality rides are part of every theme park, where users wear helmets with internal screens to create an artificial 3D world.

TASK 7

Animation (cel-based)

Stop motion using either time-lapse feature on a phone or suitable software

Create a short stop-motion animation using only a digital camera and any software capable of opening an image sequence. You can achieve some great special effects using stop motion.

1. Anchor the digital camera on a tripod or stand to keep it very still. Take at least 30 photos of a scene without moving the camera. For each photo, make a small change, such as an object slowly moving along a surface, or a person taking small steps. The changes must be small and sequential.
2. Use the built-in time lapse feature of Apple's iOS and an iPhone or use software such as Stop Motion Pro or import the photos into QuickTime or other movie-editing software as an image sequence. The images will already be automatically numbered sequentially by the camera. Display each image on screen for about 0.1 seconds.
3. View the final movie.

TASK 8

Exploring animation software

In this task, you will use Flash or similar software to animate a well-known company logo.

1. Select a well-known company logo. Prepare a storyboard for your animation, showing the movements of the logo clearly. Keep it simple.
2. Create layers, and send separate elements of the logo to different layers.
3. Use path-based ('motion' tweening) and shape-based animation to create movement.
4. Add a background scene throughout the animation.
5. Taking it further: add a music track!



Willoughby City Council

Figure 11.34 The Willoughby City Council logo. How would you animate it using Adobe Flash? A link to an example animation of this logo is provided at http://infosoftwaretech.nelsonnet.com.au.

Weblink

TASK 9

Advanced animation

In this task, you will use Flash or similar software to create an animation of an elephant, using the Bone tool, which is a lot of fun! Note: Later versions of Flash removed this tool, so you may have to use other software.

This tool allows inverse kinematics (IK) to be created, much the same as when you lift your hand in the air and your whole arm moves too, but through a smaller distance. You will create this kind of movement in an elephant's trunk, which you can use in a more complex animation later if you wish. You will find a link to Adobe Flash on NelsonNet.

1. The elephant's trunk is animated by drawing a bone armature over the shape of an elephant's trunk drawn with the Brush tool. Your drawing does not need to be highly accurate. The bones are drawn linked together. A new IK layer will be automatically created by Flash. Figure 11.35a shows what the vector shape looks like after the armature is added. Notice the root bone is the longest to create realistic movements.

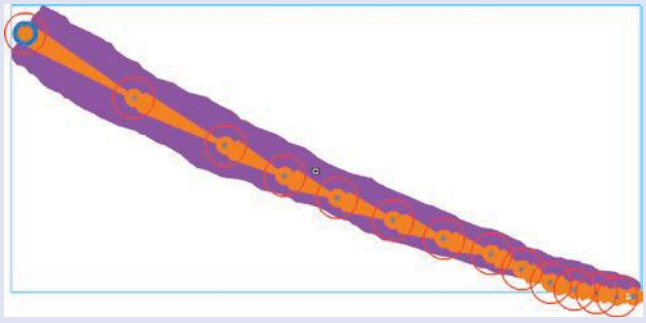


Figure 11.35a Elephant trunk shape showing completed armature

2. The next step is deciding how many frames the animation should be. We suggest you position the frame indicator at frame 60 and press F6. This inserts a second keyframe so that the trunk remains in the same position and means that when you create a looping animation it will begin and end smoothly by having the trunk return to its original position.
3. Position the frame indicator first at frame 15 and move your trunk armature (linked bones) to a new position by dragging the last bone in the chain. Do the same at frames 30 and 45 (see figure 11.35b). Flash will automatically create keyframes. Add small movements to other bones to add interest to your animation.

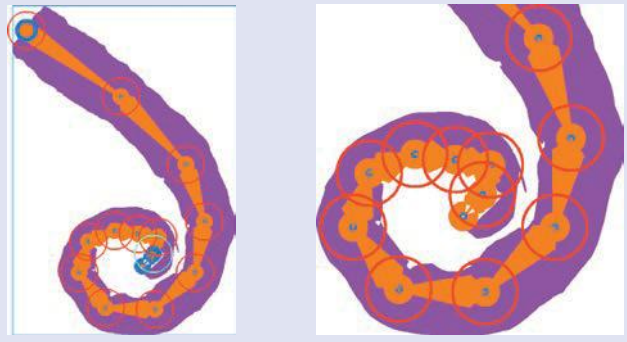


Figure 11.35b Left: Elephant trunk shape with completed armature. Right: Close-up of the IK bones aligned on the trunk.

4. Export your file as a movie.
5. Add the rest of the elephant and animate it!

Video production

Every day, proud parents across Australia are taping their children's special moments on digital video cameras, and will later edit them into a family home movie using movie editing software on their laptops or tablets.

Apple® iMovie® and Pinnacle® Studio™ are examples of software that allow professional-looking editing to be performed on home movies, complete with creative titles, transitions and sound effects, with only a little experience and training.

At the higher end, Adobe Premiere and Final Cut Pro are used by video professionals to digitally edit video. This has greatly simplified what used to be the tedious process of linear editing, where each edited section of film had to be carefully cut and added as the next segment of a master tape.

Digital or non-linear editing allows video segments to be moved around in the same way as sentences can be moved around in a word processor. Applications such as Adobe After Effects can add to moving images the same special effects available to the 2D artist in Photoshop – and many others.

The technical challenge of video

Video and animation use binary methods just as still images do, but place much greater demands on processing speed. The processor in the computer must move huge amounts of data very quickly to display frames without them appearing jerky.

A regular video requires 25 frames per second (fps) and even the poorest quality animation has a minimum requirement of 8 fps. The processor must therefore move nearly 2 megabytes of data every 0.04 seconds. This has been one of the greatest obstacles for digital media and many different solutions to the problem have been invented. None of them has yet completely solved the problem.

Some of the techniques used by developers to help reduce the amount of data required include:

- reducing the number of colours displayed
- reducing the size of the frame the video plays in on the screen
- combining pixels to represent them as fewer averaged colours
- recording only the pixels that change colour between frames and trying to create movies with minimal changes
- slowing the frame display rate.

All of these solutions lead to a loss of quality, and care needs to be taken about which technique to use and when.

Playing DVD video at high quality on a computer requires dedicated graphics cards for display, encoding and decoding.



AAP Image/Robin Esrock

AAP Image/Robin Esrock

Figure 11.36 iMovie and Premiere video editing applications

ISSUES

CORE ALERT Past, current and emerging technologies CORE ALERT Issues

‘Humanipulation’ and cyber actors

It is possible to recreate actors who have retired or died, and give them starring roles in new movies. Soon, an audience will not be able to tell the difference. A dead president shook hands with a living actor in *Forrest Gump*, and a Korean film-maker resurrected legendary kung-fu star Bruce Lee for a comeback.

Humanipulation refers to the process of taking images of living or deceased people and manipulating them using digital techniques.

At a recent Australian Effects and Animation Festival, a discussion was conducted with professional animators to decide if this practice was ethical.

Arguments against included:

- If an actor had never given permission for their image to be used in this way, then it infringes their copyright and privacy.
- The cost and effort involved are great.
- The manipulated performance may not be true to the actor’s real character or beliefs.

Arguments for included:

- There is an attraction in being able to continue to enjoy the actors we love in new roles.
- Money can be made from advertisements.
- There is an artistic and technical satisfaction in being able to achieve it.

QUESTION

Should we be able to use the likenesses of people who have died and give them roles in new films?



Alamy/AF archive

Figure 11.37 Forrest Gump rewrites history as he meets President John F Kennedy.

ACTIVITIES

Identify

1 Name two software applications used to create still graphics.
2 Name a free online alternative to Photoshop for image editing.
3 Name the digital media types that can be used in desktop publishing applications.
4 What is the purpose of a master page in desktop publishing?
5 What is the function of the pen tool in a draw application?
6 Name two common file formats used for each of the following media types: text, audio, graphics and video.
7 What do the letters IK stand for?
8 Name a software application that can create 3D objects that can then be printed.
9 What is the purpose of the perspective view of an object in a 3D application?
10 What is the greatest technical challenge in using video online?

Analyse

11 Analyse why you think there are so many file formats available for graphics when compared to other digital media.
12 Describe how desktop publishing differs from word processing.
13 Outline the stages in the creation of a 3D graphic for a movie.

Investigate

14 Use the web to identify three different techniques used to print in 3D. State one strength and one weakness of each.

11.3 Data types for digital media products

CORE ALERT Data handling

Each of the different data types used in digital media requires specialised knowledge and each can form the basis for a career. There are digital experts who only work in graphics, or only work in audio, and so on. The interview on pages 212–13 is with a specialist in 3D graphics. You can find detailed explanations of the different data types in chapter 4: Data handling, and this core chapter should be studied alongside this section.

Common file formats

File formats can be very confusing. Each of the digital media we have discussed can be stored in many different formats and your computer needs to know how to handle each. Knowledge of file formats can help to avoid problems when files need to be opened in different applications and on different platforms.

Text and hypertext

Text is the least demanding of the data types in terms of processing and storage. A large amount of text-based information can be stored using a small amount of memory. As discussed in chapter 4: Data handling, a code historically used to represent the alphabetic and numeric characters is known as the American Standard Code for Information Interchange (ASCII). ASCII uses seven bits (the eighth is used for various other purposes), which allows 128 different symbols to be coded – enough for the letters of our alphabet and some other symbols. ASCII is unsuitable for the characters needed for the many letters used in other languages. UNICODE is a modern standard that can represent far more characters and language scripts.

The most basic file format for storing text is .txt. Such a file can be read by almost any application capable of handling textual data. If paragraphing and simple formatting is to be retained, rich text format (.rtf) should be used.

Other ways of storing textual information are available. Portable document format (.pdf) files can contain graphical as well as textual data. This format is especially useful when you do not wish people to easily alter your original document or when you want to make sure of its appearance – particularly when sending a file for printing. A portable document format (PDF) file is a mathematical description of the appearance of the document and does not rely on fonts being present on the computer displaying the file.

Another popular use of text data type is hypertext, which we study in detail in chapter 9: Authoring and multimedia and chapter 12: The Internet and website development.

Hypertext is text linked to related information. When clicked with a mouse, it allows access to the related data.

TASK 10

Text data types

We will create four files using four different methods to represent text-based data, and compare their file sizes.

1. Select a page of a book consisting entirely of text.
2. Scan the page and save it in three forms:
   - **a** First, save the scan as both a TIFF (tagged image file format) file and as a JPEG file, using the filenames 'scan.tif' and 'scan.jpg' respectively. Refer to figure 11.39 for a description of these file formats.
   - **b** Second, use OCR software (OCR is also part of Adobe Acrobat) to translate the page into actual text and save this file as a word processing document.
   - **c** Open this word processing document and save the file as a PDF file called 'scan.pdf'.
3. We now have four digital files containing the same information, but using four different ways of representing text. Construct a table with headings showing each filename, file format, file size and comment on the advantages and disadvantages of each. Add a fifth row to compare these digital formats to printed text.
4. What would you judge the file size (in megabytes) of a 200-page book would be if it was stored as a word processing document compared to a plain text file?



Figure 11.38 Adobe's Acrobat Pro PDF portfolio allows many file types to be packaged as an e-portfolio.

Animation/video	
AVI	Audio video interleaved. A container format for digital video and audio under Microsoft Windows, it can also be played using other operating systems.
GIF Animated	Animated graphics interchange format. Based on GIF, this format allows individual frames to be displayed rapidly, one after the other. Commonly used on web pages.
MOV (QuickTime)	This is a multipurpose, cross-platform container format developed by Apple that can be used with most multimedia data types. It now also forms the basis of the MPEG-4 standard.
MPEG	Moving Picture Experts Group. A standard format for storage of digital video for all major platforms. It uses high (and lossy) compression by only storing the changes between frames.
SWF (Flash)	A popular format on the web for displaying interactive, vector-based animations with audio. It can also be used to represent 3D objects.
WMV	Video file compressed with Windows Media compression, a format developed by Microsoft.
Audio	
AAC	Advanced Audio Coding. A compressed audio format similar to MP3, but better at handling higher frequencies.
AIFF	Audio interchange file format. A sound format developed by Apple that stores 8- or 16-bit sound.
MIDI	Musical instrument digital interface. This stores musical data in the form of information about the musical notes and a selection from among numerous simulated instruments.
MP3	MPEG Audio Layer III. A subset of the MPEG video formats and a very popular audio format that can achieve 11:1 compression of files by only storing the audible spectrum.
WAV	Waveform audio. A sound format developed by Microsoft and IBM using a standard 44.1 kHz (kilohertz), 16-bit, stereo format.
WMA	Audio file compressed with Windows Media compression, a format developed by Microsoft, similar to the MP3 format.
Graphics	
AI	Adobe Illustrator's native format, a vector graphics editing program; composed of paths connected by points, rather than bitmap image data; commonly used for logos and print media.
BMP	Bitmap. This is the default bitmapped graphic format for Microsoft Windows computers, but can also be used on Macintosh. They result in large files with no compression.
EPSF (or EPS)	Encapsulated PostScript® format. This is a vector graphic format.
GIF	Graphics interchange format. Popular lossless compression suitable for bitmapped images of line art, and images with blocks of colour. Compression can be up to 2:1.
JPEG	Joint Photographic Experts Group. A popular graphics format that uses lossy compression of up to 100:1. Best for bitmapped photographs and images with continuous tones. It is commonly used on the web and in digital cameras.
PNG	Portable network graphics format. Lossless format created to provide a copyright-free image format and to support transparency.
PSD	Adobe Photoshop's native format. May include image layers, adjustment layers, layer masks, annotation notes, file information, keywords, and other Photoshop elements.
3D formats	There are many formats used to store and exchange 3D data files, but none as yet has become an industry standard. OBJ, 3DS (used by Autodesk 3ds Max) and DAE (Collada) file formats are common.
TIF (or TIFF)	Tagged image file format. A popular bitmapped format for printed publications and desktop publications. Some versions of this format allow compression.
SVG	Scalable Vector Graphics. An all-purpose vector format created mainly for the web.
Text	
ASCII (TXT)	American Standard Code for Information Interchange, also known as text (TXT). The standard format for exchange of text and numerical data.
DOCX	Unlike DOC files, which store document data in a single binary file, DOCX files are created using Open XML format, and contain separate files and folders in a compressed package.
HTML	Hypertext markup language. A text-based language with embedded tags that indicate the locations of images, audio and other files and attributes for text and layout display.
PDF	Portable document format. A format owned by Adobe Systems that preserves the appearance of text and graphics across platforms.
RTF	Rich text format. A format based on ASCII that retains basic formatting.
UNICODE	Can represent over 110 000 characters and is used to represent text written in most of the world's languages.

Figure 11.39 Popular file formats

Audio

There are two basic methods of representing audio in digital form: digitised sound files or MIDI files.

Sound is made up of continuously vibrating air particles striking our eardrums. Sometimes they vibrate rapidly and at other times slowly. This gives sound its changing pitch. Sometimes they vibrate greatly and at other times a little. This gives sound its changing volume.

Digitised sound

Digitised sound takes small 'slices' of an analog sound and represents these digitally. The faster these slices are sampled (sample rate) and the more digits available (sample size), the closer the digitised code is to the source signal. Standard audio sampling on CDs is at a rate of 44 kHz (that is, 44 100 samples per second), a size of 16 bits, and is in stereo.

There are many formats for digitised sound files and these are discussed later in this chapter, but the most common include .mp3 and .wav.

MIDI

A second way to store audio data is by using MIDI codes. The MIDI protocol was invented in 1982 and is an entire musical description language using binary code. The musician uses a device such as a keyboard to input the data. MIDI does not send actual musical notes, but sends information ('primitives') to describe them. MIDI files contain the descriptions of the instrument, duration, pitch and timing of each note. These are sent to a sound card or similar device.

MIDI files are much smaller than digitised sound files, but have certain disadvantages. They cannot store human speech or other day-to-day sounds. MIDI can only store the sounds of the instruments it has been preprogrammed to use.



Dorling Kindersley.

Figure 11.40 The MIDI studio equipment shown is the digital equivalent of a piano, full orchestra, recording studio and sound-editing suite.

TASK 11

Audio data types

In this task, you will compare a digitised audio file to a MIDI file of equal duration, using Audacity, GarageBand or any other suitable audio software.

1. Record a sample of an audio CD, exactly 10 seconds long, in MP3 format, and save it in a suitable format, such as WAV or AIFF.
2. Save this as three separate files using three sample rates by setting preferences: 11.025, 22.05 and 44.1 kHz (all 8-bit stereo). Give each a suitable filename.
3. Record a MIDI file, again exactly 10 seconds long, using about six instruments, and save it.
4. Compare the file sizes of all the files and explain the differences.

Graphics

2D bitmapped and vector graphics

As explained in section 11.2, draw and paint graphics use different techniques to represent images and so require different file formats. The file format chosen to store a graphic can be very important to a designer. A common example is a graphic designed in Photoshop. If it is to be used in a desktop publishing application for reproduction in the school magazine, a suitable format is TIFF (.tif), at a resolution of 300 dpi (dots per inch).

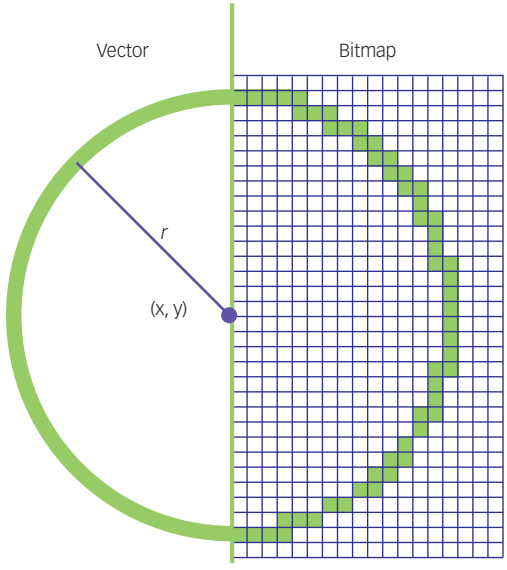


Figure 11.41 A draw and a paint image, both depicting circles. The draw image is a vector shape and uses a mathematical equation to represent a circle. The paint image remembers each pixel to create the circle's circumference.

If the same graphic is to be used in a web page (where standard screen resolutions are 72 dpi), suitable formats are JPEG (.jpg), PNG (.png), which retains transparencies, or GIF (.gif). These formats keep file sizes to a minimum.

If the designer wishes to edit the image again, the file should be retained in the original Photoshop (.psd) format to preserve the separated layers in the image. See figure 11.39 for a list of other common formats.

A draw application such as Illustrator must store mathematical data for descriptions of actual shapes (primitives).

Compression can be an important technique for reducing the large file sizes for graphics. This is discussed in more detail later in this chapter.

3D graphics

The production of three-dimensional imagery is important in creating real-world images.

If we take a 2D graphic and add a third dimension, depth, it is possible to represent points in three-dimensional space. These points form wire frames that can be given surfaces and rendered, lit and manipulated on the screen using a mouse.

Three-dimensional formats are thus required to save data describing the location of all points of a model in 3D space, the lines joining them, the surfaces formed between these lines and descriptions of the types of materials used for the model's surfaces.

Many file formats exist for storing 3D data.

Video

Handling video presents digital media workers with their greatest challenge. The main issues are the large files produced and the need for high processing speeds. This is discussed in more detail in chapter 4: Data handling, as well as chapter 9: Authoring and multimedia.

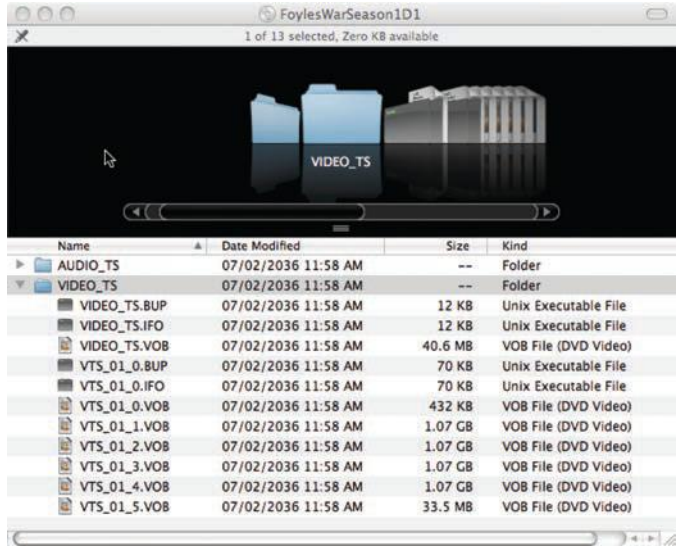
Original filmed sequences may be shot on film or analog videotape and will first need to be digitised and compressed.

When a digital video is stored on DVD, it takes time to be read from the disc, and then the computer's processor has to decompress the data as it plays. The video that is written to a DVD is encrypted in MPEG-2 format.

A DVD player contains hardware to uncompress these MPEG-2 video files in real time in order to display the image. Compressed audio files are also written to the DVD, then uncompressed and played in sync with the video to reproduce the movie.

A DVD movie contains two folders, VIDEO_TS and AUDIO_TS. The VIDEO_TS folder contains all the compressed video and sound files, as well as the information that allows the player to access them in proper order. The AUDIO_TS folder is left empty for DVD-video, though it is used for DVD-audio discs. The VIDEO_TS .IFO and .VOB files are the first items that the DVD player will access, and generally contain the menu, subtitles and viewing angles.

Popular formats for delivering video include .wmv, .mov, .mpeg and .avi. See figure 11.39 for details.



Name	Date Modified	Size	Kind
AUDIO_TS	07/02/2036 11:58 AM	--	Folder
VIDEO_TS	07/02/2036 11:58 AM	--	Folder
VIDEO_TS.BUP	07/02/2036 11:58 AM	12 KB	Unix Executable File
VIDEO_TS.IFO	07/02/2036 11:58 AM	12 KB	Unix Executable File
VIDEO_TS.VOB	07/02/2036 11:58 AM	40.6 MB	VOB File (DVD Video)
VTS_01_0.BUP	07/02/2036 11:58 AM	70 KB	Unix Executable File
VTS_01_0.IFO	07/02/2036 11:58 AM	70 KB	Unix Executable File
VTS_01_0.VOB	07/02/2036 11:58 AM	432 KB	VOB File (DVD Video)
VTS_01_1.VOB	07/02/2036 11:58 AM	1.07 GB	VOB File (DVD Video)
VTS_01_2.VOB	07/02/2036 11:58 AM	1.07 GB	VOB File (DVD Video)
VTS_01_3.VOB	07/02/2036 11:58 AM	1.07 GB	VOB File (DVD Video)
VTS_01_4.VOB	07/02/2036 11:58 AM	1.07 GB	VOB File (DVD Video)
VTS_01_5.VOB	07/02/2036 11:58 AM	33.5 MB	VOB File (DVD Video)

Figure 11.42 The files on a commercial DVD. Note the sizes and types of each file. Here the Audio_TS folder is empty.

TASK 12

Video

In this task, you will work with digital video in the development of an actual product.

Create a short video consisting of segments that are a maximum of 10–15 seconds long. Your video should demonstrate a secret skill, magic trick or show someone telling a joke. Use software such as iMovie, Premiere or Pinnacle Studio.

1. Form groups of four or five students.
2. Each person should plan and script their segment and practise it with their group.
3. The group films each segment using a digital video camera.
4. Each group uses video editing software to save and edit the segments into a digital video of approximately one minute, adding transitions, titles and background music.
5. One student edits together all the group videos from the class into a single short compilation and adds an opening title.

Digital media jobs

There is a wide range of digital media jobs. At one end are artists and at the other end are technical experts. To use one example, the singer or voice artist records the song or script.

Voice artists are often well-known actors who have clear speech and timing, skills at performing 'character' voices and the ability to synchronise their performances to the lip movements of animated characters. At the technical end of the process, the sound engineer would record and 'massage' the song or script to achieve the desired result.

Multimedia jobs are also relevant here, as digital media form the basis of all multimedia productions. These are treated in further detail in chapter 9: Authoring and multimedia.

Sound engineers

Like video editors, sound engineers perform most of their work in a sound studio after the actual recording has taken place.

This studio is insulated from any outside sound by using layers of sound-absorbing material, such as foam, air, rock wool and plasterboard.

If the sound source is analog (such as a voice captured from a microphone), the engineer first makes sure that the recording has been captured at the highest quality and that there is no background noise, hiss or distortion.

Graphic artists

Designers, illustrators, photographers and architectural draughtspersons have all been attracted to the digital tools available to them through the computer.

In the early days of computing, programmers created computer graphics, rather than artists. Today, digital media studios first look for artistic talent and then, if necessary, train the artist in the use of these new media.

The digital artist works in a similar way to a traditional artist, but uses a canvas with a grid of over 30000 tiny pixels.

Animators

Many animators still prefer to draw on paper rather than on screen, although their profession is being challenged by the techniques of realistic 3D computer-generated images.

In cartoon animation, teams of animators draw the individual frames of the action by hand – 25 frames for every second of animation. A 15-minute cartoon can take up to six months to create – a big commitment!

The skills required by digital animators are similar to those required by traditional cel-based animators – artistic skill, an understanding of animal and human movement, patience and attention to detail.

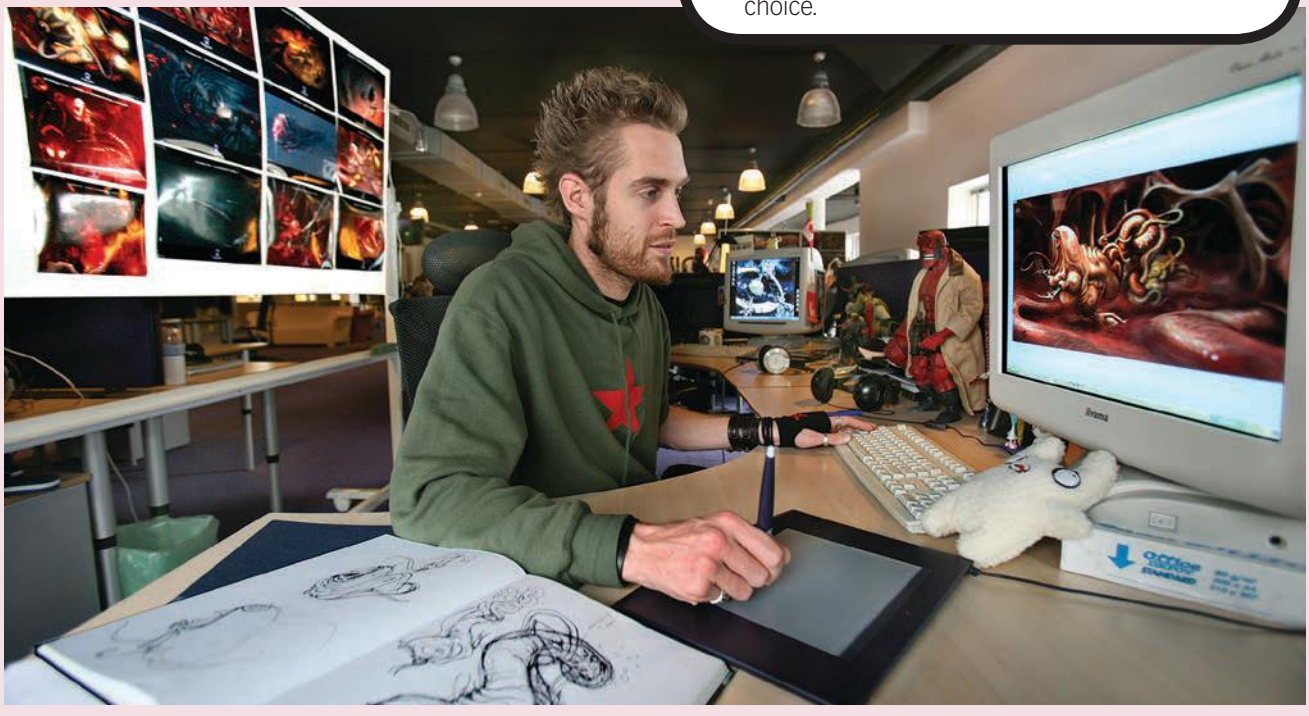
Video professionals

A video sequence is planned in detail using storyboards. Props are constructed, lighting is designed and the camera operators film the sequences with professional actors.

Video editing involves compositing, where backgrounds and other elements are added. If the final destination is a multimedia title, the video is compressed and authored.

QUESTIONS

1. If you were to select one of the digital media professions listed in this panel, which would it be?
2. Write a paragraph giving the reasons for your choice.



Alamy/Horizons WWP

Figure 11.43 A graphic artist at work

Animation

Animations can be saved using the same formats as for video. Flash has proved extremely popular for 2D animation, as it is a vector-based format and is well suited to the Internet, where bandwidth can be a problem. Flash's .swf format is thus a popular animation format, although it requires a dedicated plug-in for browsers.

INFOBIT

The CSIRO Analytical Research Laboratory is developing a method for searching image, audio and video files without the need for keywords. They have coined the word 'annodexing' to describe the process. If successful, it will have application in medicine and in police searches for faces.

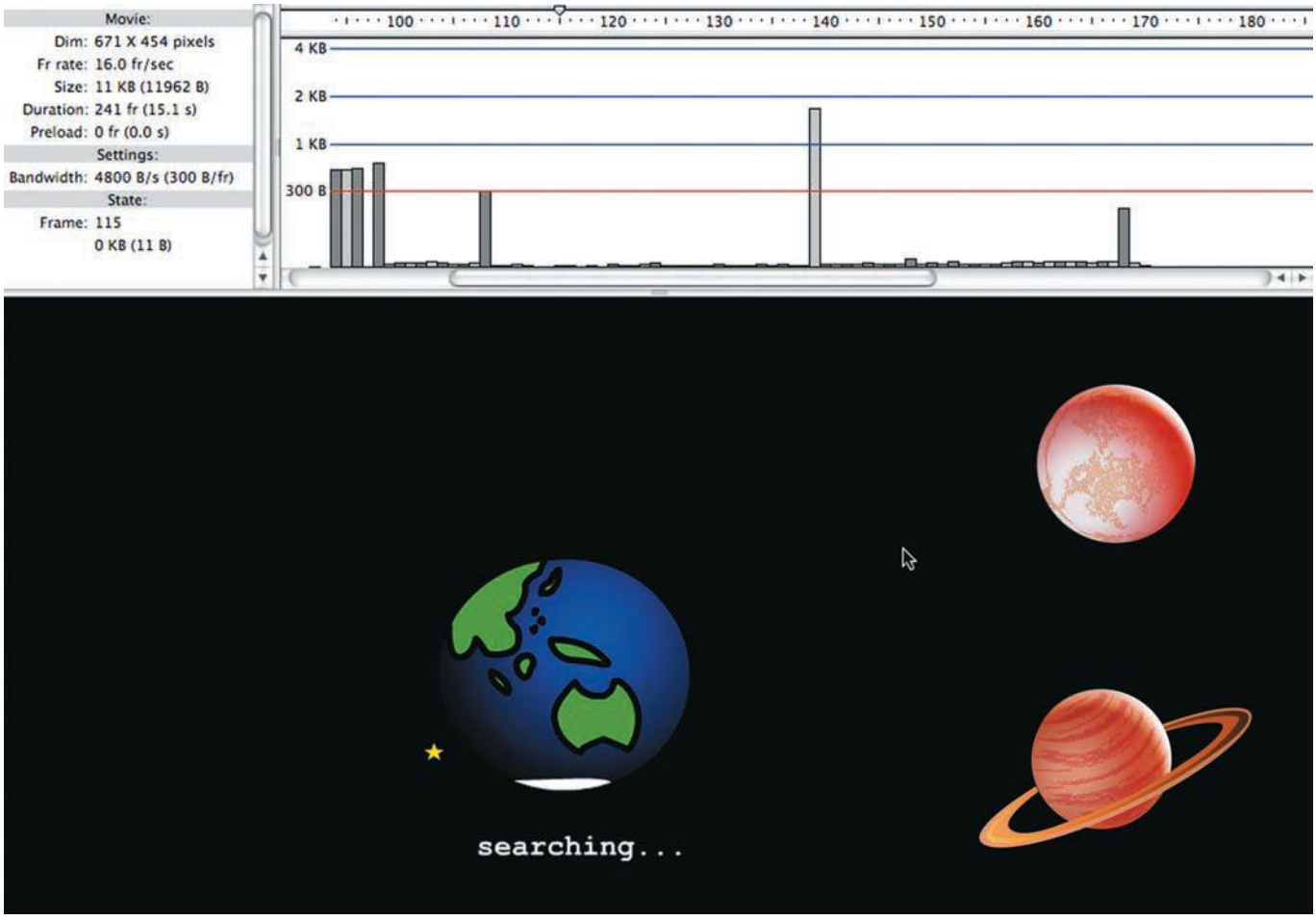


Figure 11.44 If bandwidth is limited, delivering an animation over the Internet can be a problem. Flash authoring software provides a graph as a debugging tool. As the animation is played, the developer can inspect the bandwidth required by each frame. As seen above, some frames have more activity or effects and require much more data to display them correctly.

ACTIVITIES

Identify

1. Identify the five digital media data types.
2. State the most common file format for each of the digital media types when delivered online.
3. State three common differences between the tools available in paint and draw applications.
4. Identify two types of digital audio.
5. Identify four jobs available in digital media.

Analyse

6. What are the two folders used in the DVD movie format?
7. What tool would you put on a wish list that was not available in your video editing software?
8. Explain the advantages and disadvantages of the two audio types of digital media.
9. Draw a diagram that illustrates the five digital media types and their subgroups.

Investigate

10. Select one example of each digital media type and display each one by creating five slides using PowerPoint.
11. Do you think there is another digital media type yet to be created, or have we invented them all? Argue your case.

11.4 Digitisation of data types

Computers occupy a digital world, while we live in an analog one. The conversion from analog to digital is called digitising. The device used to perform this function is known as an analog-to-digital converter, or ADC.

Digitising text

We have already seen how text is represented using ASCII, but how is text converted to ASCII? This depends on how the analog text is provided – in other words, the form the input takes.

Text may originate from typing on a keyboard (into a word processing program), scanning a printed page (using **optical character recognition (OCR)**), writing with a stylus pen on a touch-sensitive screen or graphics tablet (using handwriting recognition), or speaking into a microphone (using voice recognition).

Keyboards

Under each of the keys on a computer keyboard is a rubber dome. Pressing a key collapses the dome and changes the electrical characteristics between two metal tracks on the printed circuit board below it. These circuits are being constantly scanned hundreds of times per second for such changes, and when one is detected for more than a few passes, a scan code is generated.

Voice recognition

The microphone receives analog voice signals and adjusts these to take account of such variables as accent and microphone distortion.

Such measurements as volume, pitch and length are compared to a database of phonemes (the smallest sound units used to form words, such as 'duh' + 'oh' + 'guh' to form 'dog').

Optical character recognition

Optical character recognition is the software process of using a scanner to convert a scanned graphic image, such as that of a printed page in a novel, into editable digital ASCII characters. The scanned image of a page of text is a graphic rather than text, but after OCR is carried out, the text can be copied and pasted into a word processor.

The OCR software first looks at the white space in the image to determine where the text flows, then tries to match the pixel patterns of each printed character to its in-built library of letter shapes. If this fails for any letter, the more intensive process of 'feature extraction' takes place (see figure 11.46).

Handwriting recognition

The first consumer product to feature handwriting recognition was Apple's hand-held personal digital assistant known as the Newton. It was possible to write on the screen with a stylus, and letters were recognised and translated into editable text. It was even fairly successful at recognising cursive handwriting. Now there are many iPad and smartphone applications that perform this function.

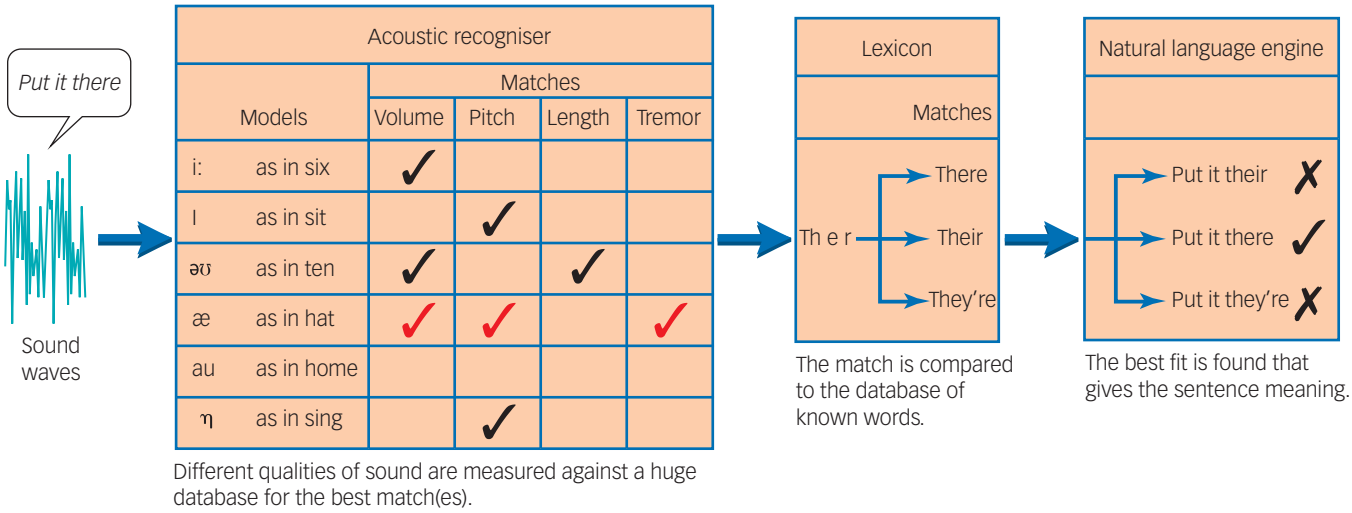
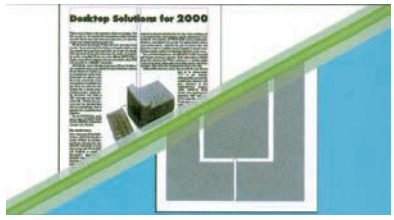


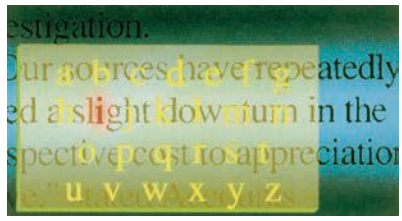
Figure 11.45 How voice recognition works



1 When a scanner reads in the image of a document, the scanner converts the dark elements – text and graphics – on the page to a bitmap.



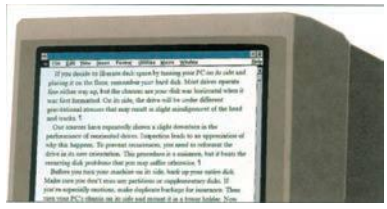
2 The OCR software reads the bitmap created by the scanner and averages out the zones of on and off pixels on the page, mapping the white space on the page.



3 In its first pass at converting images to text, the software tries to match each character through a pixel-by-pixel comparison to character templates held in memory.



4 The characters that remain unrecognised go through a more intensive process called 'feature extraction'.



5 Most OCR programs give you the option of saving the converted document in a popular word processor or spreadsheet format.

Figure 11.46 The illustrations show the stages in the OCR process. The OCR software has identified the shapes of individual letters and words on a printed page and then loaded these into a word processor as editable text.



Figure 11.47 Fingerprint identification (FID) software looks at the ridges to locate the centre of the print and the points where the ridges end or divide. This technology is also used to lock and unlock mobile devices such as smartphones.

INFOBIT

Fingerprint identification, known as dactyloscopy, or hand print identification uses software to compare two instances of friction ridge skin impressions from human fingers, the palm of the hand or even toes, to determine whether these impressions could have come from the same individual (see figure 11.47).

TASK 13

Text entry

In this task, you will test the effectiveness of your OCR software.

1 Type any short paragraph from this section into your word processor.
2 Copy and paste this paragraph into the same document twice. You will now have three copies. Change each paragraph to a different font, preferably one in a serif font (such as Times New Roman or Garamond), one in a sans serif font (such as Arial or Helvetica) and one in a decorative font (such as Comic Sans or Edwardian Script).
3 Print the page containing the three paragraphs.
4 Use a scanner to scan the page using OCR software. Record the number of errors (count words only) made in the first, second and third paragraphs.
5 Which of the fonts used in the OCR scans was the most accurate?
6 Taking it further: If you have access to handwriting recognition equipment (such as an iPad or smartphone application), write the paragraph as normal printed letters and count the errors in recognition.
7 Discuss whether you consider any of these input devices suitable for daily use.

Digitising audio

No digitisation is necessary for MIDI sound, as it is created in digital form in the first place. Analog sounds, on the other hand, must go through a conversion process.

Analog audio signals can be captured using microphones. The first microphones consisted of carbon dust held in a diaphragm through which an electric current was passed. As the sound waves struck the diaphragm and disturbed the carbon, this current was altered. Most microphones today contain a cone that vibrates in response to incoming sound waves. Magnets attached to this cone move and alter the current in a nearby coil of wire. These changes in current correspond to the sound waves. The small currents are amplified and sampled, as described in section 11.3. The sampled 'slices' are each averaged and finally coded digitally as a stream of ones and zeros. Digitisation is a three-step process: sampling, averaging each slice and coding each slice.

Digitising graphics

Bitmapped graphics can be digitised in a variety of ways: by drawing and painting with a mouse or a graphics tablet and stylus, by scanning or by using a digital camera.

A digitising tablet (also known as a graphics tablet) converts pen strokes into movements of the pointer on the screen. Most also respond to pressure and allow more 'digital ink' to flow when pressed harder, which is not possible using a mouse as an input device. A grid of fine wires in the surface of the tablet recognises the position and intensity (due to pressure) of the pen tip's magnetic field. The screen pointer moves appropriately to match these coordinates (see figure 11.49).

A digital camera uses an array of charge-coupled devices (CCDs) to sense the light striking their surfaces (see figure 11.50). These have filters ensuring each one senses only red, green or blue light. Voltages from these are sent to an analog-to-digital converter (ADC) and the digital data is stored in suitable format in the camera's memory. This storage device is usually a flash memory card.

Digitising video

Digital video cameras use the same digitising principles as digital still cameras outlined above, but need to process 25 frames per second (fps).

Frame grabbing is the process of capturing an entire frame of analog imagery and digitising it. Three factors affect the appearance of digitised video. These are the size of the window in which the video plays on the computer, how many times per second the video frame is updated (30 fps for TV) and how many colours are used to draw the image.

Video producers try to avoid busy backgrounds with lots of colours and actors wear costumes with few colours and avoid such things as reflective ornaments. The more colours that need to be handled, the more data is required for each frame, resulting in a larger video file, slower playback and lower quality in the final image.

Most digital video cameras store the large amounts of digital data at a high enough quality using flash memory or internal hard drives.

Edited sequences used for computer playback will have reduced quality after undergoing compression techniques such as MPEG.

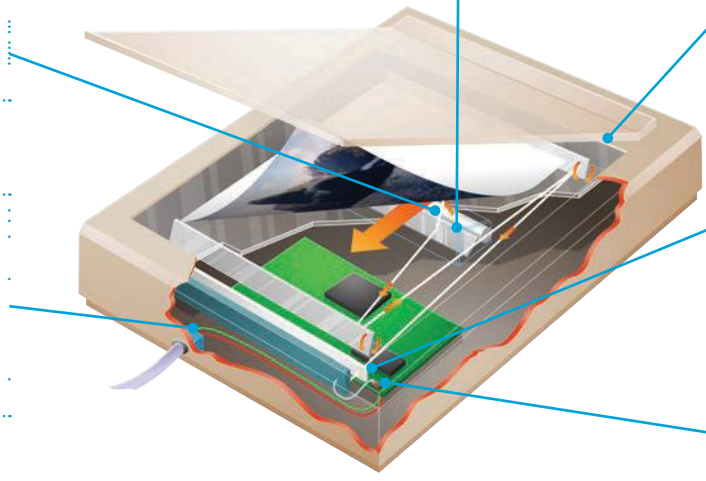


Figure 11.48 A flatbed scanner uses a series of mirrors to focus the image picked up by a moving scan head on a series of sensors. These sensors are light-sensitive diodes and translate the amount of light sensed into electrical current. The more reflected light, the greater the voltage.

Factors affecting file size

CORE ALERT Data handling

Video and audio produce much larger files than text or graphics. Without compression, there would only be enough space on a DVD for less than five minutes of video at television broadcast standard and it would take around three seconds to display each frame!

To put it simply, the challenge for video hardware is to process and display as many separate images as possible each second. Since an average graphic might be over one megabyte, this has presented computer engineers with their greatest challenge.

Memory size and processing speed

Large file sizes present problems in three main areas: space on storage devices, available memory in the computer and processing speed.

These large files not only have to be stored, processed and displayed quickly to provide the illusion of smooth motion in a video, they also need to be accessed from a hard drive, CD, DVD or other storage device. This not only involves reading the data, but finding it too – preferably within a millisecond!

One solution is to use file compression. A hard drive can read a compressed file much faster than an uncompressed one. Today's processors can decompress a file faster than if they had to process an uncompressed one. Compression is now a standard part of a computer's operating system.

Reducing file sizes

There are standard ways to reduce the size of a file and this depends on the data type being used, but the quality represented by the file's data may be sacrificed.

For a graphic, this may mean either lowering the image's resolution (fewer dots per inch), displaying fewer colours (reducing the **colour palette**), or reducing the physical dimensions of the image. For a video, the above techniques apply and it may also mean reducing the frame rate (the number of frames displayed per second) or storing only the data that changes between frames (the delta data), rather than the whole frame.

At the display end of the process, a small image can be disguised by pixel doubling (giving the impression that the image is now larger) or, in the case of video, by integrating its small frame into a larger non-moving frame to disguise its small size.



Dreamstime/Sikth

Figure 11.49 A graphics tablet and stylus

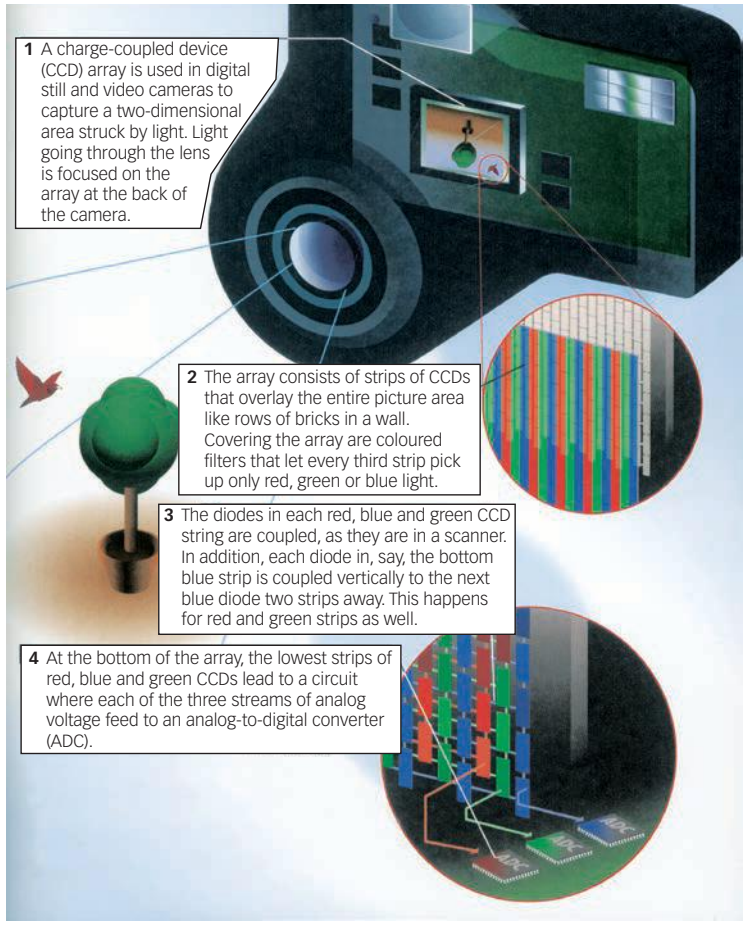


Figure 11.50 Digital still and video cameras need to process a lot of data simultaneously instead of a single stream. The solution is to use charge-coupled devices (CCDs), which use photodiodes connected like beads on a necklace.

Compression techniques

Compression for video and audio is handled using compression and decompression algorithms known as **codecs** (compressors–decompressors). The best of these are able to work with the computer hardware to decompress each video frame as quickly as possible.

Compression works by eliminating unnecessary data. Compression can be applied to any kind of file: text, programs, audio, images and video. It can reduce the size of a 15-megabyte (MB) video to 150 kilobytes (KB). The uncompressed file would be far too large to deliver to a screen fast enough or download from the web in a reasonable length of time, but the compressed file can be downloaded in a few seconds. For viewing, a decompression algorithm is used.

There are many codecs. Some are designed to reduce file size and others are designed to speed up file transfer over the Internet. These codecs have names such as Cinepak®, MPEG-4 and Sorenson®. Such products as QuickTime® and Windows Media® Player have many built-in codecs. Codecs can be lossless (high-quality, large files) or lossy (lower-quality, small files).

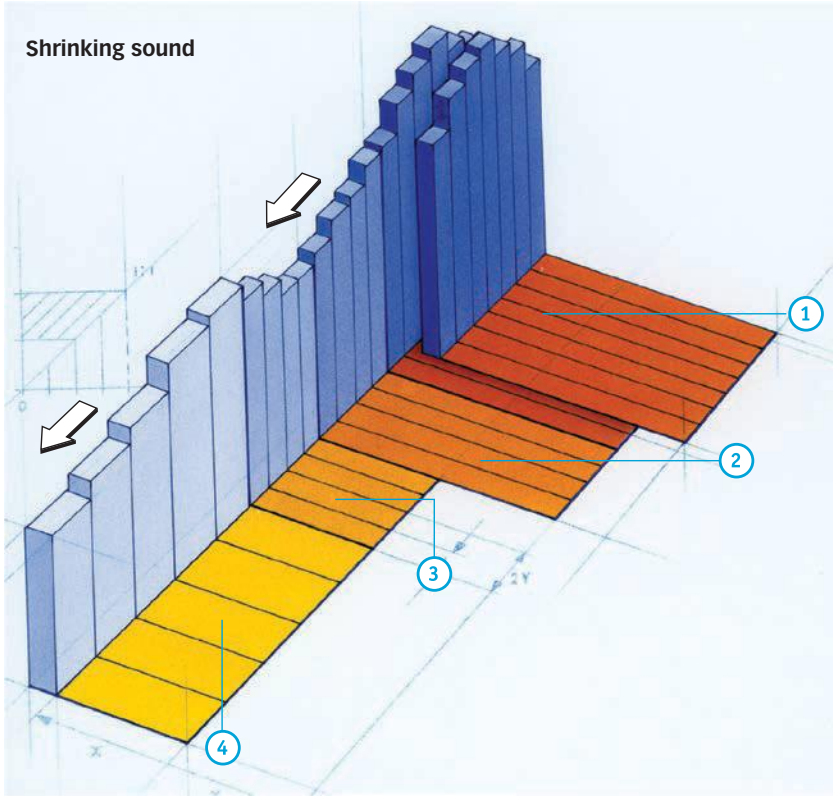
Lossy compression

The JPEG graphics format selects a range of pixels in the image that are nearly the same colour and bands them together as one colour. JPEG allows different levels of compression, and the higher the compression the more pixels that will be replaced by that colour. JPEG compression is known as a lossy compression technique as data and image quality are both lost in the process.

For a sound file, compression can involve reducing the sampling rate (the number of sound samples taken per second), making it mono rather than stereo (this will halve the size), reducing the sample size (the number of bits used to code the sound sample), or reducing the amount of data stored by not recording every frequency, as in the MP3 format. In many cases, the user will not be able to detect the lower quality in the sound, but we gain great advantages when using the data (see figure 11.51).

The MP3 audio format achieves compression by eliminating the frequencies that the human ear cannot detect. It involves loss of data, although no one would be likely to notice the reduced sound quality.

Video compression can use the methods already discussed, but there are other compression tricks available. Because adjacent frames of a video are usually only slightly different, a common method records only data that change between frames. This method is used for sound compression as well, where only the differences between successive sound samples are recorded, instead of the whole sample. MPEG compression for video is very powerful and can reduce video file sizes by up to 200:1.



While most multimedia machines can play stereo CD-quality sound, many titles use lower sound quality. Sound files can be made smaller by a factor of 16 or more, but unfortunately, the quality drops too.

1 **CD-quality stereo sound** At its best, multimedia sound uses 44 100 samples a second (each sample is shown here as an upright block) and uses 16 binary digits, or bits, to measure each sample.

2 **Stereo to mono** The simplest way to shrink sound is to combine the two stereo channels, left and right, into one mono channel.

3 **Half the bits** By using 8 bits instead of 16 to measure each sample, the sound file is made smaller still, but the result is a less precise, grittier sound.

4 **Half the samples** To shrink the sound file even further, half as many samples are used every second. This makes the sound 'muddier'.

Dorling Kindersley

Figure 11.51 How sound files are compressed

Video data can be recorded at fewer frames per second so that file sizes are reduced, making lower demands on the processor. The trade-off will be a lower-quality image that may appear 'jumpy'. The lowest possible frame rate for acceptable animation is 8 fps. Realistic motion requires higher frame rates and motion pictures use 60 fps. It is sometimes possible to see flickering when decompression fails to keep up in a video.

Lossless compression

The second approach to compression does not involve any loss of quality and is known as lossless compression.

For graphics, data can be examined for patterns of bits, and these are replaced by codes each time the pattern appears. Larger blocks of a repeating colour are recorded once only. The GIF graphics format uses a lossless compression algorithm known as LZW (Lempel-Ziv-Welch).

When the file is decompressed, these codes are replaced again by the original pattern of bits. In this way, the original information is restored perfectly.

TASK 14

Examining codecs

Find out which are the most popular codecs and whether they are lossy or lossless.

1. Use the Internet to search for information on codecs.
2. Visit the websites for Apple's QuickTime and Windows' Media Player and list the codecs supported for audio and video by these cross-platform products.
3. Use a copy of QuickTime to view a movie.
4. To see your codec options, export your movie (using Export, in the File menu) as a QuickTime movie. Choose Options and then Video Settings. The Sorenson® codec is recommended as a high-quality lossy codec for video and rendered animation. Find out why the Sorenson codec is recommended.

While most multimedia machines can play stereo CD-quality sound, many titles use lower sound quality. Sound files can be made smaller by a factor of 16 or more, but unfortunately, the quality drops too.



Figure 11.52 JPEG (Joint Photographic Experts Group) files are a lossy format. Nearly every digital camera can save images in the JPEG format. JPEG files degrade when repeatedly edited and saved. The JPEG format is also used as the image compression algorithm in many Adobe PDF files.

ACTIVITIES

Identify

1. Define the term 'digitising'.
2. Describe four techniques for digitising text.
3. State three methods for digitising a graphic.
4. Name one lossy and one lossless method of compression for graphics files.
5. Name a method of lossy compression for sound and video files.

Analyse

6. Outline one method used in lossy compression to reduce graphics file sizes.
7. Outline a situation in which each method named above for digitising graphical images would be the most appropriate.
8. Explain how sound can be converted from analog to digital data.
9. Explain why digitisation of MIDI data is unnecessary.

Investigate

10. Use the Internet to find out how LZW compression works and also describe one other lossless compression technique for graphics.
11. Research the different frame rates for cel-based animation, analog film, television and video, and present a summary in a table.

11.5 Digital manipulation techniques

Once text, audio, graphics, animation and video data are in digital form, there are many exciting techniques available to manipulate them, often with surprising effects.

Text manipulation

Once text is digitised, it is possible to perform all the standard word processing manipulations, making the word processor a far superior tool to the typewriter. These manipulation features include cutting, copying and pasting, drag-and-drop, typeface changes and spellchecking.

A magazine created using InDesign desktop publishing software can be exported to .swf (Flash) format with page turning included as a live interactive feature or exported as an online ebook.

Special software can take text and reshape and shadow it to create special text effects. The WordArt feature in Microsoft Word provides a basic version of this, but Photoshop, Illustrator and other specialist software allow far more extensive manipulation.

Most computers can help a person with a disability by speaking text aloud.

Audio manipulation

Digitised sound editing software allows endless possibilities for manipulation of real-world audio. Standard effects can be applied to segments of the sound from a prepared library (for example, stuttering, echoes, fade-ins, fade-outs, and pitch and tempo changes), or custom changes can be made using special editing tools. Clips are combined in a manner similar to video editing.

MIDI can be edited easily using its built-in tools. Have you ever played a built-in tune on a MIDI keyboard and changed the instrument selection while it was playing? The digital code for that instrument was being altered and the effect of the change can be dramatic. It is even possible to substitute a sampled sound from your own voice as a replacement for an actual instrument.

INFOBIT

To create the sound of fire, the sound engineers on the game Myst drove a car over gravel and then slowed down the recording. Falling bags of sugar can become footsteps and wet fingers sliding down a string attached to a plastic cup is a duck quacking.

TASK 15

Manipulating digitised sound files

Manipulate a digitised sound file and compare the file sizes of mono and stereo sound.

1. Use the Google search engine, or similar, and enter the words 'public domain + MP3 files'.
2. Download a stereo MP3 file. Ensure that it is free of copyright and in the public domain. Make sure it is a short clip (approximately 15 seconds and no more than 500 KB).
3. If you have access to full sound editing software, explore the various editing features. Try adding echoes and manipulating the volume.
4. Export the original file in any selected format.
5. Change the original file to a mono file and export it in the same format with a different name.
6. Compare the file sizes of the two exported files, stereo and mono.

Graphical manipulation

You are writing a story for the local environmental group and the only photo you have of yourself, taken by a friend, has you with your eyes half closed (or half open!). Paint software can clone a set of open eyes from another photograph to replace them. The local mayor wants a photo of the current local councillors. Unfortunately, two councillors are overseas. Paint software can add them into the image in their correct positions.

Professional-level paint software offers an amazing variety of ways to manipulate an image. Photoshop is the most widely used and popular image-editing application for Macintosh and Windows computers. It is so popular that 'photoshopping' has entered our language as a verb to describe this type of photo alteration. Figure 11.53 summarises the main tools available in this program.

TASK 16

Exploring paint software

Find out how each of the tools listed in figure 11.53 is handled in your paint software package and experiment with each of them.

Category	Tools and effects	Description of effect
Brush tools	Pencil	Draws a hard-edged line of any thickness
	Brush	Draws an anti-aliased line that blends with the background
	Airbrush	Applies a fine spray of colour like an airbrush
Edit tools	Smudge	Smears part of the image
	Blur/Sharpen	Reduces/increases colour contrast
	Dodge/Burn	Lightens/darkens part of the image
	Sponge	Reduces or increases saturation and contrast
Selecting	Marquee (rectangular, elliptical)	Selects regular-shaped parts of an image for manipulation
	Lasso (irregular, polygonal, magnetic)	Selects irregular-shaped parts of an image for manipulation
	Magic wand	Selects contiguous (connected) regions of pixels with the same colour (tolerance can be adjusted)
Masking	Mask	Selects an outline expressed as a greyscale image – selected areas appear white, deselected areas appear black, feathered edges are shades of grey
	Quick mask	Turns current unselected area into a mask, which can then be modified
Filling	Paint bucket	'Pours' the foreground colour or a pattern into an area bounded by pixels of one colour – a similar concept to 'colouring inside the lines', familiar to you as a child
	Fill	'Pours' the foreground colour or pattern into a pre-selected area
	Gradient	Fills a selected area with a multicolour gradient
Duplicating and erasing	Rubber/clone stamp	Copies the pixels from a specified area of the image to a new area
	Eraser	Reverts the selected area to the bare background colour
Undo	History	Reverts to a previous step in your work – the palette displays the steps taken in the order they occurred
Text effects	Type	Enters and edits text, and applies embossing and drop shadows
Filtering	Correcting filters	Blurs, sharpens, despeckles and so on
	Artistic filters	Draws an anti-aliased line so that the edges of the line are smoothed out
Mapping and adjusting colours	Threshold values	Converts each pixel to either black or white, depending on their brightness
	Posterize	Works like threshold, but divides all colours into a reduced number of colours
	Hue/Saturation	Adjusts the purity and depth of the colour
	Brightness	Adjusts the lightness or darkness of colours or shades
	Contrast	Adjusts the difference between the lightest and darkest colours or shades in an image
	Grayscale	Converts all colours to their equivalent greyscale shade
Compositing	Combining images	Uses selections or layers to mix two or more images together

Figure 11.53 A summary of the major manipulation tools available in Photoshop. Use Photoshop to explore each of these.

TASK 17

Photoshop

In this task, you will create a zany cartoon person composed of bits of fruit and vegetables, and practise digital graphics techniques.

1. Find pictures of fruit and vegetables from the Internet or other sources. Choose images that would be suitable for this project, such as a potato for a body, orange slices for ears, grapes or peas for eyes. Resize each of these if necessary.
2. Drag each image so they are all positioned in the one window.
3. Choose a base piece of fruit or vegetable to be the face.
4. Select a suitable fruit or vegetable for the eyes, such as a grape. Use the elliptical marquee to select the shape, then duplicate it and position them on the face.
5. Choose a piece of fruit or vegetable for the nose, such as a carrot or squash. Resize if necessary. Use the magnetic lasso to select it, duplicate it and drag it onto the face.
6. Choose a piece of fruit or vegetable for the ears, such as a slice of orange. Use the magnetic lasso to separate the flesh from the skin, duplicate it and position it on the face.
7. Choose a piece of fruit or vegetable for the mouth, such as a red pepper. Use the magic wand to select all the red pixels, duplicate and drag this onto the face.
8. Crop the final result.

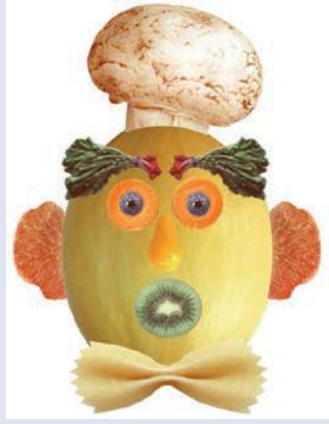


Figure 11.54 Selection tools at work – an improvement on Mr Potato Head®? Would you eat Mr Fruit Salad?

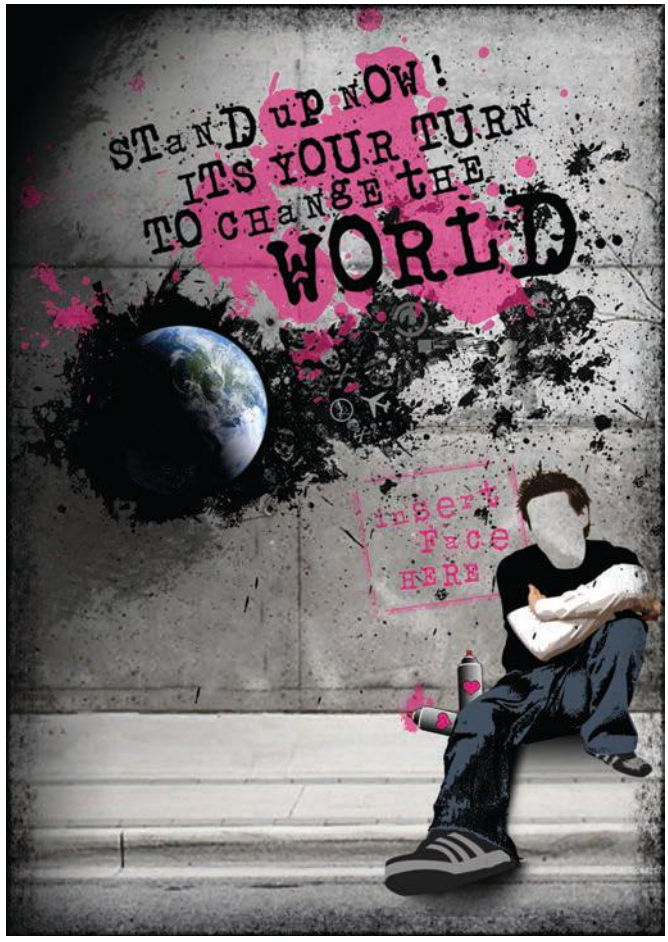
INFOBIT

Photoshop started life in George Lucas's company Industrial Light & Magic (the makers of *Star Wars*) and was used to convert images from one format to another. It was then purchased by Adobe for commercial sale and has since had features added constantly, having now become the world's leading image manipulation software.



AP Photo/Paul Sakuma

Figure 11.55 The many special effects available in photo manipulation software, such as Apple's Photo Booth, have made such image manipulation tools very popular. Built-in cameras in computers offer instant results.



Created by James Pearson, used by permission

Figure 11.56 This award-winning poster for Youth Week was created by a school student using Photoshop.

ISSUES

Digital manipulation

It is a simple matter for a digital photographer to manipulate an image in such a way as to make the changes undetectable. Models are given perfect complexions and prominent people are removed from photographs that show them in compromising situations. Frequently, portraits on the front pages of newspapers are reversed so that the subject is facing towards the text. Which of these changes are ethical and which are not?

The following is the ethics guide of the *Chicago Sun-Times* newspaper for image processing.

- Permissible:
  - dodging and/or burning in areas of a photograph without changing content
  - making overall improvements to improve reproduction
  - correcting technical defects in a photo by cloning
  - making colour changes to correct colour shifts and improve quality.
- Not permissible:
  - altering the basic reality of the photograph
  - removing objects from a photo
  - cloning pixels to create a new image
  - making radical colour changes.
- If a photo is questionable in taste, it must be discussed with the appropriate news editors.
- If a photograph has been radically altered, whether in the photo-taking process or in the electronic darkroom, it must be credited as a 'photo illustration'.

QUESTION

You are a photo editor for the *Chicago Sun-Times*. Write a letter to the chief editor pleading for permission, despite the ethics guide, to remove unwanted background from a photograph of a politician to make it more 'suitable' for the front page.

Advanced graphic manipulations

Warping and morphing

Warping is the manipulation of an image by distorting or transforming. The software technology behind such a process is not simple. When an image is stretched, some pixels must 'move apart', creating a gap. The new warped image must fill this gap in some way, and the software algorithms must analyse the colours of the pixels and interpolate, or insert, new pixels based on the original colours.

Morphing, derived from 'metamorphosis', is the transformation of one image into another. It requires two original images and the mapping of corresponding points on a mesh from the start image to the finished image. In-between frames are created by the software in a process known as tweening (from 'in between').

There are many examples of special software designed to achieve these effects, but a particularly popular one is included in Photoshop. You can also use Flash to achieve these effects using its shape tweening approach.



Thinkstock

Figure 11.57 'Want a dance?' Things are never the same after a warp.

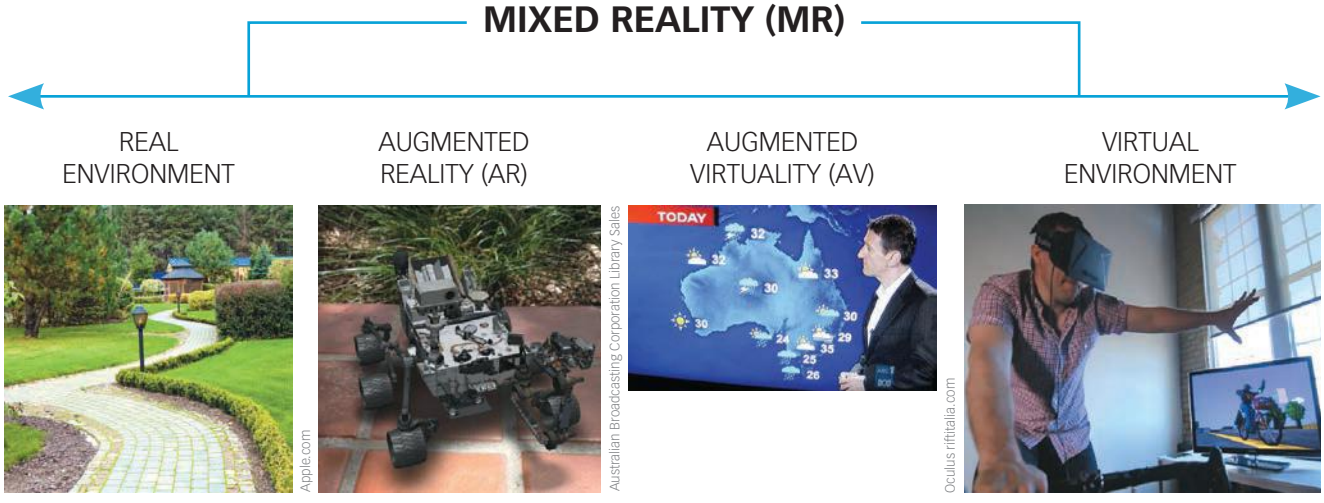
Mixed reality

When a gamer participates in an entirely artificial world created on a computer, they are part of a virtual reality (VR) environment. But this is just one end of a spectrum known as mixed reality. At the other end is the real world in which we all live. And somewhere in the middle is augmented reality (AR), which combines the real world with a virtual world.

Using a device such as a smartphone, AR places computer-generated layers of text, audio, animation, video, and 2D or 3D graphics over a view of the real world. These layers are usually triggered by a chosen image or a location.

INFOBIT

The word 'animation' comes from the Latin word *animatus*, meaning 'to give life'.



Shutterstock.com/majeczka

Apple.com

Australian Broadcasting Corporation Library Sales

Oculus rift italia.com

Figure 11.58 This diagram is known as Milgram's continuum of mixed realities. At the left end is the real world and at the right are completely artificial worlds created by computers. These are each illustrated by an example. From left to right: the real world; augmented reality – here the spacecraft is seen on the mobile device as if really there; augmented virtuality – the weatherman is superimposed over a virtual map; virtual reality – the user participates in a virtual world as an avatar.

Augmented reality is best understood by experiencing it. We suggest NASA's Spacecraft 3D app, Skyview, or ARSoccer as starters. AR has been around for many years, but has been very slow to be adopted. Furniture maker IKEA has adopted AR, and when their printed catalogue is placed on the floor, chosen furniture appears on a mobile device screen in full 3D, as if really there in the room.

CASE STUDY

CORE ALERT Past, current and emerging technologies

Creating augmented reality (AR)

By using prebuilt library items on a mobile device

One of the quickest and easiest ways to create an AR experience for yourself is to use an AR authoring application such as Aurasma or Augment, using a mobile device. We suggest you download Aurasma to a mobile device, such as a smartphone or tablet.

There are three steps to creating your image-triggered AR experience:

1. Create, upload and print your trigger (an image the AR app will recognise).
2. Create and upload your AR layer (an image, video or 3D model).
3. Use the tools in the AR app to associate trigger and layer. Now when you point your mobile device camera and scan the printed trigger, your layer will load and lock on your image. If your overlay is a 3D object, tilting the trigger will move the 3D object around in space.



Figure 11.59 A prebuilt animated Coke can dances in the AR app Aurasma, triggered by the image in figure 11.56.

For example, when you open Aurasma you will be led through these steps and provided with an in-built 3D overlay from Aurasma's library of models. Try it!

By creating your own AR using a computer application

Use a computer to locate Aurasma Studio, register and log in. Aurasma calls its AR experiences Auras.

There are five steps to creating an Aura in Aurasma:

1. Upload a trigger image. Take a picture of a suitable image and upload it to Aurasma Studio.

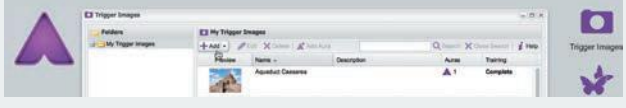


Figure 11.60a

2. Upload an overlay image or video. Select an image or a short video and upload it to Aurasma Studio.



Figure 11.60b

3. Create a channel for your Auras to go in. Every Aura must be placed in a channel, which helps organise your Auras. Create and name your first channel and make it a public channel rather than a private channel.

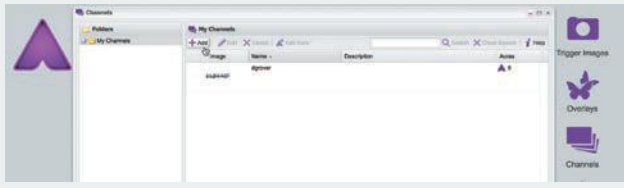


Figure 11.60c

4. Create your Aura and add it to your channel.

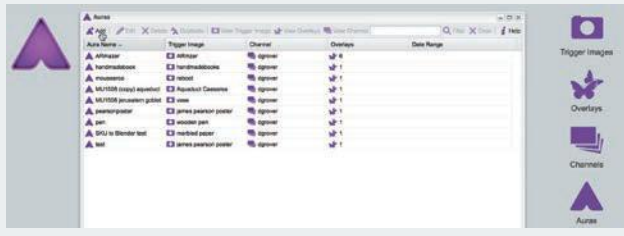


Figure 11.60d

5. View your Aura. Your content is now ready to view. If you set your channel to be public, open up Aurasma on your mobile device. In the menu, search for the name of your channel. Tap on your channel and 'follow it'.

QUESTIONS

1. AR technology has been available for many years. Why do you think it has taken so long to be widely used?
2. Find a desktop software application that can be used to create AR and use it to build your own example.

Video manipulation

Amazing effects are now available to home film-makers that would have been beyond belief in earlier times. It has now become easy for the home computer user to create their own movies using editing software available for desktop computers. The film is usually shot on digital movie cameras and stored on digital videotape.

There are five basic steps to editing a home movie: collecting and ordering the clips, adding transitions, adding effects (such as sepia tones), adding sound and adding titles.

Professionals would include other steps, such as colour grading, adding filter effects, and the compositing of live action with CGI. This last step is where computer-generated images are combined with live action sequences or other CGI into single scenes.

Professional editing is performed on advanced software such as Premiere or Final Cut Pro, where many more sophisticated effects are available. Digital video allows the use of special effects such as chromakey, where an actor is filmed against a coloured backdrop (often blue or green), which is removed before superimposing the actor over a new background.



Apple.com

Figure 11.61 Compare the interface of Final Cut Pro shown here with that of your school's video editor application.

CASE STUDY

Movie special effects

Luna Park in Sydney is the location for a night shoot for an action movie. One problem faced by the director is that the famous location is not easily identified unless the well-known face of Luna Park is visible. The face, however, is at the entrance to the park and cannot be seen from inside.



Figure 11.62 A frame of the original shot from inside the park

One solution is to change the appearance of the park using computer-generated special effects (SFX).

In this case, the crew shoots the park from inside and removes the tower on the left. They then insert into the background of the scene a reversed image of the face and the Luna Park name in lights.



Figure 11.63 The entrance face shot taken from outside the park at night



Figure 11.64 Rotoscoping lifts the tower and parts of the background out of the scene.

Other buildings (both real and CG models) as well as additional crowds, can then be added using techniques such as chromakeying and rotoscoping.

A scene like this shows how a director can change the look and feel of a shot. In this example, about 40 per cent of the final image is different from the original.



Figure 11.65 The final look of the shot

QUESTIONS

1. Use the Internet to find a description of chromakeying.
2. What was the earliest example of chromakeying in a major movie and what year was it made?

Animation manipulation

Animation is an illusion. It is produced by displaying rapidly a series of images, each one slightly different from the one before it. The eye 'sees' the effect as a smooth movement due to a characteristic of the retina and the brain known as 'persistence of vision'.

In cartoon animation, many drawings are required for every second of animation in order to give the illusion of movement. Each of these drawings must then be traced and coloured by hand. Digital animators use scanners and paint software to colour and digitise these images rather than the traditional painstaking method of taking photographs of each of the drawings on film.

In games, a technique known as sprite animation allows an animated graphic to move over a stationary background. A sprite is a character with preprogrammed sequences, such as running, jumping and fighting, which are called in response to user actions.

Most 3D games software use built-in software graphics engines that speed up the animation. Consoles such as PlayStation, GameCube™, Wii and Xbox include additional hardware to accelerate the process. To achieve real-time 3D requires technical shortcuts to be taken, such as using simple models with fewer shapes, rougher rendering techniques, and fewer frames in the animation. This can make such figures appear blocky and the movement jerky. Some 3D animators can capture the detail of human movement and make it look convincing. Modern movie-making demands more realism in the movements of its 3D CGI characters that can best be achieved using the motion capture technique. An actor performs the movements while wearing a suit with large dots on the actor's joints. These dots are then matched to the corresponding points of a stick figure on computer, and finally to a detailed 3D character.

Bringing it all together

The different media types need to be easily viewed, and software tools have been created that make this possible. You may think of .avi and .mp4 as video file types, but they are not. In fact, they are container formats, just as a .zip file can contain many different types of files. MPEG 4, Flash Video, QuickTime, AVI, Ogg and RealPlayer® (all cross-platform) are a few of the more popular container tools for playing the many types of digital media.

QuickTime (.mov files), a free download for both Macintosh and Windows computer platforms, was created to play digital video, but it can play many types of media: audio sound and MIDI, virtual reality objects and panoramas with hot spots, video with text 'chapters', karaoke, vector-based sprites, 2D and 3D animations, and web streaming audio and video. These can be on separate 'tracks' and yet play and be synchronised within the same window.

The name chosen for that product reveals the technical challenge – how to process quickly such large volumes of data. Such software allows export to many different formats (AVI, BMP, DV stream, Photoshop, Maya, JPEG, TIFF, FLC, QuickTime, WMP) and offers many types of compression for audio and video to reduce file sizes and allow smooth playback.

PEOPLE

CORE ALERT People

An interview with Dan Kripac, 3D visual special effects artist

Dan Kripac is an Australian special effects artist and works as a 'look development' supervisor for feature film visual effects.

A look development artist works as part of a look development team and prepares all the technical aspects needed to create the appearance of a 3D object. They often need to know computer programming and work with other team members, such as 3D artists.

How did you become involved in digital media?

In high school I wanted to be a traditional graphic artist. My interest in digital art began when my mother booked me into a visual effects production house for my Year 10 work experience.

What do you enjoy most and least about your work?

I really get a kick out of using a program or system that I've written and also seeing it used in production, especially as it often has a very visual outcome; however, the hours spent at work can be very great as a deadline approaches.

What work have you done in the past that has pleased you most, and why?

For *Quantum of Solace* I wrote a suite of tools that helped in the realistic rendering of human skin for our digital doubles used in some of the dangerous stunt scenes. These tools handle the way light scatters through different types of surfaces (called subsurface scattering) through the flesh and blood under human skin. I found the process of writing this software fascinating and the tools are still being used.

What would be your most recognised piece of work?

Apart from *Quantum of Solace*, I've had the pleasure of working on other high-profile films such as *Harry Potter*, *Return of the King*, *10000 BC* and *Superman Returns*.

What should a budding high-school digital designer do to develop their digital media skills?

The earlier you can start to build your intuition about composition, tone, colour, lighting or even movement, the more natural and easy you will find using a computer.

Developing an interest in activities such as drawing, painting and photography will help you build this understanding. The best way to start gaining experience with different software packages is to first sketch out an idea and then break it down into smaller bite-sized tasks.

What software do you use?

At work, a lot of our 3D workflow revolves around Maya, but we also use Side Effects Houdini® for some of the tricky stuff. To render out the images that get printed to film, we use Pixar's RenderMan®. And then to composite the generated 3D elements onto the live action background images, we use a package from Apple called Shake®. There are many other packages we use, such as Adobe Photoshop, Autodesk Mudbox, Maxon BodyPaint®, Pixologic ZBrush®, just to name a few. We also have a research and development department that creates additional software.

What would you suggest to someone who was interested in writing graphics software?

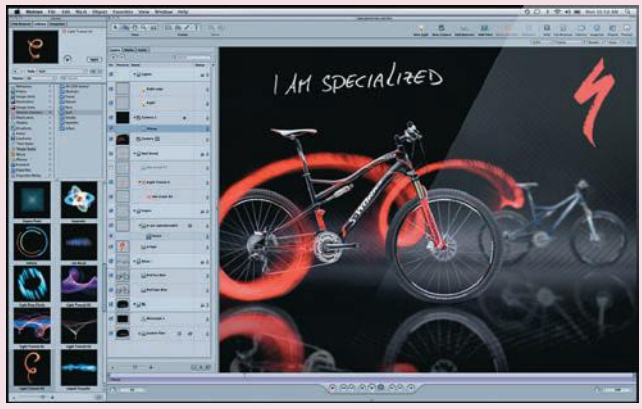
C++ is used for projects where speed is required or we need to interface with an application programming interface (API). C++ has a steep learning curve, so I would suggest learning Python or JavaScript as a first step. Python is free and is a really worthwhile place to start.

Is the computer platform used for the creation of digital media an important consideration for you and others?

Definitely. A lot of the high-end VFX industry around the world use the open-source operating system Red Hat Linux as their primary platform. We also mix in Microsoft Windows systems for certain artistic tasks and Apple Macs for our production and administration staff.

What is your prediction for what will become the standard medium of distribution and delivery of digital media over the next five to 10 years?

As Internet infrastructure continues to be upgraded around the world, the Internet will become the primary means for distributing and storing audio and visual media.



Copyright Apple Shake

Figure 11.66 The Shake interface used to composite live action with computer-generated 3D

If you could conjure up any advance in technology to assist your work in the field, what would it be?

The graphics processing units (GPUs) on standard computers are reaching the point where their power for certain computing tasks can beat the CPU many times over. Once the GPU and CPU share the same memory pool in a standard computer, we will see a huge increase in speed for many software applications.

QUESTIONS

1. Dan Kripac mentions a number of factors in this interview that he believes are important for the success of any digital media artist. List the ones that you believe could be your strengths.
2. Describe the different tasks people might need to perform under Dan's direction.

ACTIVITIES

Identify

1. Explain the difference between warping and morphing.
2. Identify four different methods of selection used in advanced paint software.
3. State a manipulation technique for text that could assist a person with a disability.
4. Describe possible manipulation techniques for digitised audio that might be used by the sound engineer for a band in a recording studio.
5. Name a manipulation technique for video used to combine a real-world filmed sequence with a background image.
6. What do the letters AR stand for?
7. Name an AR-based mobile game.
8. Describe the purpose of these five tools available in Photoshop: clone, magic wand, eyedropper, mask, marquee.

Analyse

9. Outline a process for compositing a photograph of a sunset over the ocean and a photograph of a full moon in the night sky.
10. Explain two methods of masking.
11. Explain how to use the cloning function in a paint software package.

Investigate

12. Write a full account of the steps involved in editing and emailing a short movie of a family holiday from video taken on a smartphone.

11.6 Display and distribution

The way in which we deliver the final digital product is influenced greatly by the audience. Early multimedia CD-ROMs were not as widely used as they could be because libraries did not have enough workstations to view them. In addition, many excellent educational products were not used because many teachers were technically challenged or had no easy computer access.

Display

As technology converges, more hand-held devices are using all the digital data types. Mobile devices capture and transmit photos and movies as well as audio and text. In many ways, the development of these mobile delivery platforms parallels the evolution of early desktop computers from simple text-based screens to colourful media-rich interactive environments.

Text can be displayed on a mobile device or computer, or heard via a speaker or headphones. Graphics, animation and video can be displayed on a CRT (cathode ray tube), LCD (liquid crystal display) or plasma monitor, or by using a data projector.

In the case of virtual reality, a special display device might be used, such as a screen inside a virtual reality headset. Mobile devices such as the iPod or iPhone can now store thousands of songs in MP3 format and the iPad can deliver compelling video and interactive content. Augmented reality requires a camera connected to a device such as a laptop monitor, tablet or smartphone and a suitable trigger.

If digital video is to be seen by a classroom of students, then a data projector or interactive whiteboard is convenient, whereas museum visitors might prefer a touch-sensitive screen as part of an information kiosk. A traveller might choose to view displays via a tablet or laptop screen. The audience usually determines the appropriate display method.

Distribution

Digital media need an easy, cheap and readily available method of storage and distribution. CD-ROMs became widely accepted when internal CD burners became standard equipment on computers and blank CD and DVD discs dropped in price to as little as 50 cents each. The same is now true for flash (USB stick) memory.

Both these media are limited, as only one person can access them at a time. They also cost money and it is inconvenient to distribute and update them. Soon, virtually all digital media will be delivered directly via wireless or 4G phone networks to mobile devices, or to homes via direct telecommunications links such as optic cable. This is referred to today as the broadband network and in the past as the information superhighway.

Interactive television, e-commerce, online services such as magazines, newspapers, online books and theatre bookings are all examples of this trend.

Does copying a song from a CD that you own onto an MP3 player breach copyright?



Apple.com

Figure 11.67 MP3 players such as these iPods can store many thousands of songs.

ISSUES

Virtual reality

It is possible for a surgeon to conduct an operation on a patient from a remote location using interactive digital media. Few people would raise ethical objections to such applications, provided that the technique is reliable and accurate.

However, it is also possible to simulate human behaviours, including strong violence, so realistically that it could be argued that the only difference between it and the real thing is that human beings are not physically injured. It is less certain whether the user is being psychologically injured. Many people argue that exposure to such realism, and participation in it, desensitises the user to violence in real life.

VR clearly raises the question of whether an act committed in our imagination should be made illegal if it does not physically affect another person. Constant exposure to certain images, thoughts, experiences and ideas may affect the way in which we see the world, and perhaps the way we act in it.

Should current laws judge those who perform these acts or should it be the authors and digital designers of this material who are judged instead?

QUESTION

List the issues and then debate them in your class.



Dreamstime/Paul Hakimata

Figure 11.68 Touchscreen tablets such as Apple's iPad have dramatically enhanced the display and distribution of digital products. Such tablets are versatile, compact and light. A tablet can contain PDFs of every textbook required by a student, provide email, word processing and Internet applications as well as any of the tens of thousands of specialist apps. The touchscreen keyboard can be a problem if extensive typing is required, although wireless keyboards can be used in conjunction with the tablet.

ACTIVITIES

Identify

1 Name four devices used to display digital graphics.
2 State one advantage and one disadvantage of each display device chosen in question 1.

Analyse

3 Identify and describe two methods of delivery of digital media that do not involve CD-ROM or DVD storage.
4 Select an appropriate display device for digital video for a shopping centre audience and justify your choice.

Investigate

5 Research and write a report on the origins and history of the VR game Second Life.
6 Find out the legal rights for a person wishing to pass their purchased digital music collection on to their children on their death.

Review questions

11.7 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: Mural mosaic

Using a lucky dip, you will be assigned a random selection of five Photoshop skills to produce a large-format wall mural as a whole class or individually, made up of A4 pages.

Overview

There are many skills associated with manipulating and modifying bitmapped images. These can involve filters, layers, alpha channels, resolution, a myriad of very different file formats, skills using selection, masking, transparency, printing and the varying demands of graphics destined for the web and multimedia applications.

Here you are assigned a task using a single image. Your best result is selected and combined with those of the rest of the class. By the end of the class, you will have created a wall-hanging comprising a mosaic of completed images.

Defining and analysing

1. You will lucky-dip for five tasks from a container with cards describing tasks you are to perform on a single image. Some examples are provided.
2. When you have the task cards, your teacher will show the class how to perform each of these or direct you to a suitable tutorial. Practise first! You can swap any task with another person.
3. Your teacher may supply a suitable image (class mural) or you may choose your own (individual mural). A single image can be scanned at sufficient resolution in order to occupy at least six A4 pages when printed. Either multiply standard printer resolution (normally 300 dpi) by the scale factor so your images will be at sufficient resolution or scan your image but set the scanner's scale factor to three or four times the image size (400 per cent).
4. Resize this image to be three times the width and twice the height of an A4 sheet. You can still use a smaller screen size percentage so you can view the whole image on your computer monitor.

Designing

1. Divide this single image into a pattern of six equal-sized sections and save them with image names containing the letters A, B, C, D, E and F and then enlarge each of these to A4 size.
2. Maintain the aspect ratio of each image in relation to the paper you will print on and its orientation. Consider the size of each image – make sure it fits on an A4 sheet of paper. It may be necessary to trim the printout before assembling the mural.

Producing

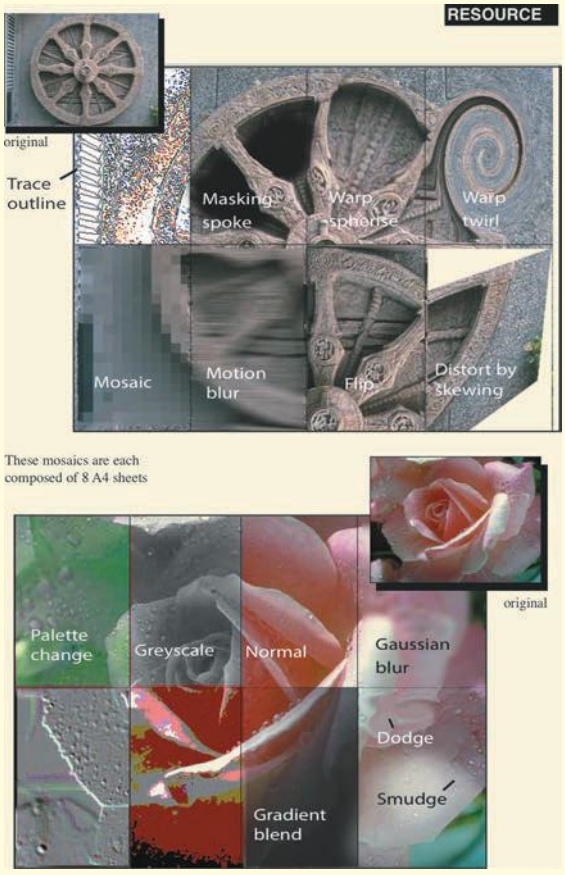
1. Perform your lucky-dip filter tasks on five of these six images. The sixth one is left unaltered to show the original image.
2. Printing takes place. Assemble all the images on the floor as separate mosaics and join them. Then fix the mural to the wall.

Evaluating

1. The class will decide in advance how this project should be evaluated.
2. The class will then evaluate each group's work.

Mural task cards

Experiment with various palettes, replacing some colours with others for a pleasing result.	Use an airbrush/spraycan or water droplet to add an effect.
Convert the image to 1 bit per pixel (just black and white).	Use a cloning tool to duplicate a part of the image.
Posterise the image to four levels.	Use a number of distortion filters.
Choose an embossing filter with different levels of embossing in different parts.	Rotate a part of the image.
Use a mask to colour an area in a solid colour.	Fill a part of the image with a pattern of your own.
Perform a gradient blend.	Alter the brightness and contrast of the image.
Add coloured text to the image.	Adjust the levels of R, G and B for the image.



Project 2: Short movie and poster

Use movie editing software to design, produce and evaluate a three-minute film on a theme of your choice, as well as desktop publishing software to create a promotional tri-fold brochure or poster to promote your movie.

Overview

We see so many movies that we set high standards when we watch anything on video. Include the following features in your video.

- Insert a title at the beginning.
- Use a fairly large number of shots. On any TV show, it is rare for the camera to stay fixed for more than 15 seconds. The director will cut between different angles to maintain interest. For example, the screen might show a boy's face while he's riding his bike, and then switch to a more mid-range shot of him on the bike.
- Use interesting angles for the camera shots – tilt it, or get low down or high up.
- Try some interesting transitions between the shots. Some shots might fade into others, some might spin into others, and some cut very simply from one to another in a quick chain.
- Create a good soundtrack, possibly involving narration and/or background music.
- Mix graphic stills or animations in with the normal video.
- Use titles or captions to identify people, places and things.
- Experiment with slow motion or fast motion to change the tempo.

Defining and analysing

1. Form a team of about 6–8 people.
2. Agree on a statement that clearly describes what you understand the project above is asking and outlines a synopsis (story) for your short film. All team members sign the statement. Have your teacher approve your final written synopsis by signing it. This sheet will form the first part of your documentation for the project.

Planning

1. Assign each person one or more of the following areas, although every person should observe the others as they work and any team member can suggest changes and help with any task:
   - casting director
   - desktop publisher
   - scriptwriter
   - storyboard
   - camera operator
   - director
   - editor
   - technical assistant.
2. Construct a storyboard for the project and have each member initial it to show they agree with the concept.
3. Work out the number of days you will allow for each stage of the project so that you can complete it with time to spare. Do not forget to allow time for careful testing and modifications.
4. Calculate the budget for your project and use a spreadsheet to cost it. Include such things as hire of equipment and tapes.
5. Decide on the hardware you will use to develop your project. What type of camera – analog or digital, or both? What platform for editing – Macintosh or Windows, or both?
6. Decide on the software you will use to edit your movie. Suggestions:
   - iMovie (beginner/intermediate) (Macintosh)
   - Premiere (advanced) (Macintosh/Windows)
   - Final Cut Pro (advanced) (Macintosh)
   - Final Cut Express® (intermediate) (Macintosh)
   - Pinnacle Studio (beginner/intermediate) (Windows).

7 Each of the following personnel needs to begin preparation:
   - The casting director chooses actors.
   - The scriptwriter word-processes the first draft and presents it to the group.
   - The storyboard designer refines the content and sequence of scenes.
   - The DTP layout person designs logos for the project and starts designing the pamphlet.
   - The camera operator obtains equipment and practises their camera techniques.
   - The director works with the scriptwriter to establish a final script.
   - The editor learns and practises skills in the editing software.
   - The technical assistant is ready to arrange any equipment.

Designing

1 Create or collect the required audio, graphics and video.
2 If you have divided the project into modules for different people, these people will need to meet regularly to make sure their work is on the right track and will be able to be linked up later. If you are using this approach, appoint one person to be in charge of the overall project and final edit.
3 The pamphlet or poster is prepared and modifications are suggested by the group.
4 The team completes their team documentation on all stages of the process.
5 Decide how the final project will be tested.

Producing

1 Edit the clips created in the previous stage into a suitable sequence.
2 The editor adds transitions, voice-overs, titles, sound and credits.
3 Additional footage is shot and included.
4 The final version of the pamphlet or poster is approved and printed.
5 The team completes their team documentation on all stages of the process.

Evaluating

1 Team members view the project.
2 Others view the project and comment on it. Their comments will mean changes, revisions and improvements.
3 The team completes their team documentation on all stages of the process. Include a record of the problems you faced, the solutions you found to these, and the tasks each team member accomplished.
4 Include your promotional brochure or poster with your final documentation.
5 Present your project to the class using the brochure as a handout promoting the clip. The class evaluates your project.

Project 3: Learning in 3D

In this project, you will form groups and choose from these suggestions to design a model for printing on a 3D printer:

- a house
- a puzzle
- a playing piece for a board game.

You will use any 3D printer to print your model in plastic.

Overview

3D printing can be deeply satisfying, and inspires problem solving and creativity.

The most common 3D printing method is an additive one where plastic filament is fed into a heated nozzle, melted and fused layer by layer to build the object. This is known as FDM (fused deposition modelling).

3D printing is highly popular, yet most owners of 3D printers never design their own objects, merely printing them from existing collections downloaded from online sites.

Defining and analysing

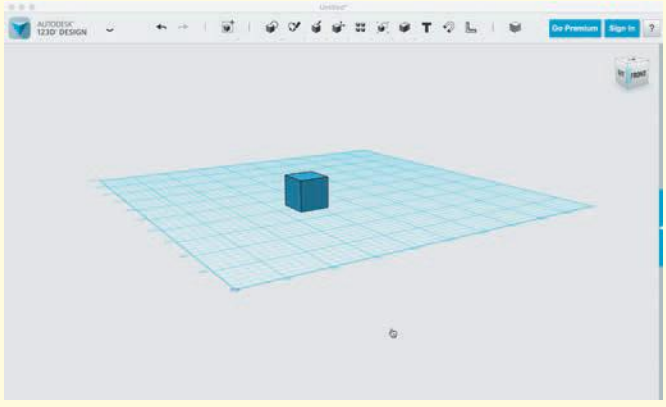
First you need to plan how you will create your 3D design. Your teacher will introduce your printer and suitable software for you and show you how to use it. If this is your first time, simple-to-use software is best. Here are three free apps you can use to design your model.

3DTin

Although 3DTin does not have many tools, it is a very easy application to learn. A total of six short built-in video tutorials thoroughly teach the application. 3D-print-friendly file formats (such as .obj or .stl) are built in for exporting your designs.

3DTin is a very simple educationally oriented application and is perfect for a number of our projects with simpler requirements.

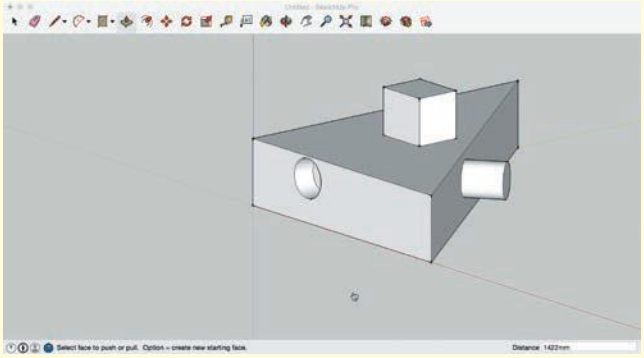
123D Design



123D Design is free. We suggest the stand-alone downloaded version, as you will not require an Internet connection to use it. Although this 3D application only allows exporting in .stl format, this is perfect for us!

If you also wish to use .obj format, use Meshlab to convert your file from .stl to .obj.

SketchUp Make



SketchUp Make (SketchUp Pro is the paid version) has a number of attributes that make it an easy-to-learn tool for beginners.

SketchUp's intuitive Push/Pull tool means construction of solids is instantaneous and the inferencing feature allows accurate positioning of midpoints. You draw any shape and pull it upwards to make a solid. It can be as easy as that!

The only downside to this excellent software is that the free version of SketchUp (SketchUp Make) does not export to a 3D-print-friendly file format (such as .obj or .stl). Fortunately, this problem is easily resolved by installing a plug-in to add an .stl export feature. Once this is done, you can forget about this limitation altogether!

Designing

1. Choose from these suggestions to design a model for printing on a 3D printer:
   - a house
   - a puzzle
   - a playing piece for a board game.
2. Of the software tools outlined, SketchUp (SU) offers convenient measurement and control. Create your model and export it as an .stl file. Your printer software usually converts .stl to gcode. This is known as 'slicing' and is really a set of x, y and z coordinates that instruct the print head where to travel while extruding the melted plastic filament. The steps to create a 3D print are:
   a. Design your 3D model using one of the applications above.
   b. Export it as .stl (or .obj) format or convert it to .stl.
   c. Open it in your 3D printer software (provided with your printer) and create your gcode.
   d. Prepare the printer and print.

Producing

1. Load the .stl file into your printer software and produce your gcode.
2. Determine the settings for the printer and print your model. Be prepared to make adjustments until the model prints correctly.

Evaluating

Ask:

- Was it successful?
- What do users think of it?
- What problems did you face?
- How did you solve them?
- What did you learn?
- What would you tell someone else trying this?
- What would you do differently?
- How could this design be improved?
- What software or hardware tools do you wish existed that would help with this project?

Additional content

Evaluation of digital media products

Your task is to analyse a range of digital media products.

1. Work through this chapter, carefully gathering the various criteria used to evaluate digital media. The list below provides suggestions of products you can analyse, as well as a set of basic criteria.
2. Draw up a table with products as column headings and criteria as row names.
   - Products: Adventure game, E-music, CGI movie, Bitmapped graphic, Vector graphic, Website, Digital home movie, DTP, 3D graphic, iPod, iPad.
   - Criteria: Digital media types, Purpose, Audience, Effectiveness, Digitisation process, Manipulation techniques, File formats, Compression techniques, File sizes, Storage, Delivery, Display, Speed, Suggested improvements, Structure (linear/non-linear), Cost, Software used, Hardware used, Platforms.
3. Select three criteria from the list and, for each one, select two actual products to compare and evaluate.
4. Evaluate each of the two products against those criteria.
5. For each criterion, add a single paragraph comparing the two products in terms of that criterion.
6. Circle where you judge that criterion to be a particularly important one (such as file size in the case of digital video).

OPTION 12 The Internet and website development

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- the Internet
- a historical perspective of the Internet
- intranets
- uses of the Internet
- email, research, chatting, messaging
- using search engines
- Internet software
- types of Internet protocols
- the World Wide Web
- controlling access to information on the Internet
- developing a website.

You will learn to:

- define and describe the Internet
- identify and discuss historical events for the Internet by developing a timeline
- describe key features of the Internet
- assess the Internet for communication in a variety of situations
- describe and use Internet software
- identify types of Internet protocols
- critically evaluate websites
- examine the features and strategies used in the design of a range of websites
- design, produce and evaluate a website project.

Key terms

Browser
computer software application that interprets the scripting language HTML

Cookie
small text file that stores temporary information about the user and is accessed by a website to uniquely identify that user

Email
electronic mail

File transfer protocol (FTP)
Internet protocol that allows the upload and download of files to and from other computers on a network

Firewall
hardware or software used to block unauthorised access, usually from the Internet into private networks

Hypertext markup language (HTML)
method of coding that indicates the way the content of a web page will be displayed

Hypertext transfer protocol (HTTP)
underlying protocol used by the World Wide Web that defines how messages are formatted and transmitted

Internet
collection of academic, government, business and individual networks linked around the world via many communication channels

Intranet
private network of information, usually accessible by staff of an organisation to display appropriate information

Packet
subdivision of a message that is separately transmitted and reassembled at the destination

Protocol
agreed set of rules for exchange of messages

Search engine
Internet-based searchable database where keywords or subjects of web pages are collected

Uniform resource locator (URL)
address that defines the route of a web page from a specific server

World Wide Web (WWW)
worldwide network of sites that can be searched and retrieved by the special protocol known as HTTP

Wind farming at sea

The Siemens Power Generation company is responsible for one of the world's largest offshore wind farms in Lillgrund, off Sweden's south coast – all controlled using the web.

Forty-eight turbines are placed offshore on piles sunk deep into the sea floor. Together, these will generate about 330 GW/h per year, enough to power about 60 000 homes.

Newer wind farms are now being designed using floating turbines, anchored to the sea floor.

To achieve maximum possible output, a wind turbine must be placed where the winds are strong enough. The wind velocity at Lillgrund in the Öresund Sound is ideal for wind power. However, one problem with offshore wind farms is that the deeper the water, the more expensive the farms are to build. At Lillgrund, the depth of water is between 4 and 10 metres.

A second problem is the harsh open-sea environment. Saltwater and severe weather conditions mean special precautions must be taken building offshore wind farms.

A third problem is caused by the difficulties in reaching and monitoring the turbines.

Siemens uses the WebWPS system to monitor the turbines, which provides remote control and data using a standard Internet browser. The browser delivers information such as electrical and mechanical data, operation and fault information, meteorological data and power grid data. Voltage and other power adjustments can be remotely controlled by the system.

The monitoring system continuously checks the main turbine components and gives early warning of any problems. The system uses a range of standard web technologies, including XML (extensible markup language), XSL (extensible stylesheet language) style sheets, Microsoft Internet Information Web Server and ASP. The web server is located on site and generates reports and stores historical data.

The SCADA system and the wind turbines are linked with an internal communications network using optical fibre cables. This network is split into loops, each consisting of eight to 10 turbines. The turbine terminals are connected via modem, routers and an ethernet network.

A detailed view of a turbine will record the following data:

- wind data – wind speed, active and reactive power, yaw angle and fault status
- electrical and mechanical data – three phases and current voltage, power, frequency, rotational speeds, temperatures of gear oil, generator
- statistical data – meteorological data such as wind speed and direction, air pressure and temperature.

The WebWPS SCADA system provides reports that can be exported to a Microsoft Excel spreadsheet, allowing quick analysis.



Wikipedia/Mariusz Pazdziora

Figure 12.1 Each of the 48 turbines in the wind farm off the coast of Sweden is remotely controlled using the Internet.



Siemens

Figure 12.2 A technician working on a turbine dramatically highlights its huge size.

QUESTIONS

1. Identify the data from a single turbine that would be transmitted to an operator's browser.
2. Outline two reasons for the choice of a spreadsheet such as Excel for displaying reports.

12.1 The Internet

Suppose all the information stored on computers everywhere were linked. Suppose I could program my computer to create a space in which everything could be linked to everything. These were the earliest questions Tim Berners-Lee, creator of the **World Wide Web (WWW)**, says he asked himself.

The power of information

The **Internet** is one of the most dramatic examples of our 'shrinking' world. Instant communication, information and entertainment are as close today as the touch of a button. The world has become a global community where each person can be as close as their mobile device to any other person on the planet.

With one click it is possible to book an overseas trip, check the weather before a plane flight, negotiate costs using the local currency, use a translation site to **email** proprietors of the guesthouse at which you are staying, and check out in advance the art gallery in London or the museum in Cairo you plan to visit by having a virtual tour. World news is available at all hours from home and favourite sporting events on the other side of the world can be viewed in real time. You can inspect a 360-degree street view of any major world city or town.

It is possible to virtually attend a graduation or be present at a friend's wedding, to travel almost anywhere in the world and to visit places of interest and feel that you are there.

Closer to home, your family history can be traced, you can download and purchase just about any music or book you desire, watch videos and share photos with family members anywhere in the world. If English is not your first language, you can have today's Australian newspapers translated for you in moments and delivered as a portable document format (PDF) file on your iPad.

Before leaving for the beach, you can use the Internet to check surf conditions, or you can shop online and order groceries delivered to the door.

You can use chat sites to collaborate on a project, share files or simply communicate with friends. Isolated students or those with a disability can study from home or hospital and access similar resources to those who are able to attend school.

You can download any one of tens of thousands of applications for your iPhone or iPad and subscribe to podcasts, interactive newspapers and magazines.

The creation of the Internet is considered by many to be the biggest social change since the Industrial Revolution, which began in the eighteenth century when the introduction of automation and production lines created huge social changes throughout Europe.

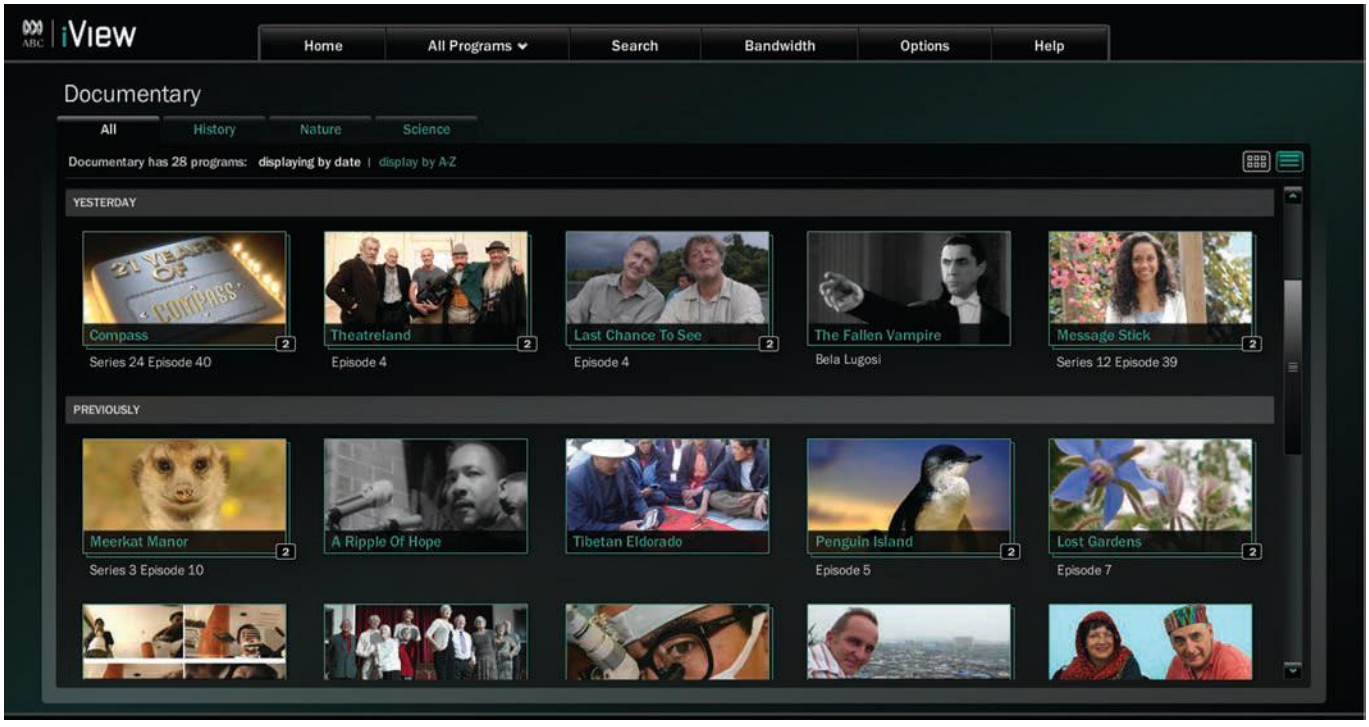
If you have access to the Internet, you have at your fingertips a stunning amount of information. At the time of the first edition of this text (2004), the Google **search engine** boasted it had indexed a mind-boggling three billion pages, by the second edition it was over 1 trillion (1 000 000 000 000) and at the time of this edition Google knew well over 30 trillion pages with unique **uniform resource locators (URLs)**, or addresses.

Of course, information is very different from knowledge and knowledge is very different from wisdom.

We can only guess how we will use this powerful information tool and what effects it will bring in the long term.



Figure 12.3 The PressReader app allows users to download the printed version of daily newspapers and magazines, using mobile devices such as an iPad, in the form of a PDF along with the ability to select articles for reading in text alone. Articles can also be read aloud using text-to-speech tools.



Australian Broadcasting Corporation

Figure 12.4 ABC iview offers free full-screen video, streamed on demand and at high resolution, for computers with a high-speed broadband connection or for mobile devices.

Describing the Internet

The Internet is not only one network. It consists of thousands of connected networks of varying sizes. Networks connect computers and allow them to share files and information.

The Internet is a loose collection of academic, government, business and individual networks linked around the world via many communication channels. The word is coined from the phrase 'interconnected networks'.

No one person or organisation runs the Internet. Instead, the Internet Society (ISOC), a private not-for-profit group, makes recommendations guiding its growth. Many organisations connect their networks into the Internet to make this worldwide network possible. The Internet Society decides the **protocols** or rules that make the Internet work, such as the transmission control protocol (TCP) and Internet protocol (IP).

When your home computer is linked to an Internet service provider, it becomes a part of this complex global communications network. From your own point of view, you will be unaware of the network boundaries you are crossing, the countries and computers through which you are travelling, or the microwaves, telephone lines, satellites and cables on which your data will travel.

ACTIVITIES

Identify

1 Write a description of the Internet to an elderly friend who has never used it.
2 What thoughts gave Tim Berners-Lee his idea for the Internet?
3 Where did the word 'Internet' come from?
4 With which major world movement has the Internet been compared?

Analyse

5 A friend has purchased a new computer and wants a broadband connection to the Internet. Outline the steps involved in establishing this connection.
6 Describe the purpose of an ISP.

Investigate

7 Use the Internet to find a current project being undertaken by ISOC.
8 Find out what connection the nineteenth-century book *Enquire Within Upon Everything* has with the Internet.

12.2 A historical perspective on the Internet

CORE ALERT Past, current and emerging technologies

In 1962, JCR Licklider of Massachusetts Institute of Technology discussed a 'Galactic Network' – a vision of computers interconnected globally, allowing people to access data and programs. In 1965, a computer in Massachusetts was connected to a computer in California using a dial-up telephone line.

Developing the Internet

Although data exchange was possible in the 1960s, the circuits of the telephone system were not reliable enough to successfully transmit a lengthy digital message without errors. Also, no other communication was possible over the same route.

A new way of sending large amounts of data to a destination was needed. Leonard Kleinrock published the first ideas on a concept called 'packet switching' in July 1961. He suggested message data should be split up into small **packets** (see figure 12.29).

These packets could then be transmitted along different routes that were not as busy (using routers) and rejoined at the other end in their correct order to reform the original message. In this way, any single link was not occupied for the whole time it took to deliver a long message.

Communicating using packets instead of circuits was one of the biggest advances in networking, but first, lots of different computers had to be able to talk to each other.

In 1969, the United States Defense Department's Advanced Research Projects Agency (ARPA) linked four computers and allowed hundreds of scientists to share research on a network known as ARPANET. Many other institutions linked up over the next 20 years.

New protocols

A protocol is an agreed set of rules for exchanging messages. In 1972, a new protocol allowed the sending of messages over the Internet and the first email (electronic mail) or direct person-to-person communication took place.

Transmission control protocol and Internet protocol (TCP/IP) were developed in 1974 by ARPA scientists, which allowed different networks to connect. Large mainframe computers owned by large corporations, governments and universities were the only computers at that time. Adjustments had to be made to allow for the newer, smaller microcomputers that were being developed. ARPANET remained the backbone of the system until 1982, when the protocols TCP/IP were widely adopted and the Internet as we know it was born.

By 1984, 1000 hosts were connected, with each host transmitting such a large volume of traffic that concerns arose that the new system would grind to a halt. Now private providers offered the public a chance to join this growing network. The organisations maintaining the links had to upgrade continually. This process has continued through the years to the point where home users now expect high-speed broadband access.

In the early 1980s, the domain name system (DNS) was developed to divide Internet addresses into logical groups, such as 'edu' for educational organisations, 'com' for commercial, 'gov' for government, and 'org' for non-profit organisations. Codes were also introduced for each country, such as 'au' (Australia) and 'nz' (New Zealand).

At first, all Internet communications were text only and the Internet just meant email, but with the introduction of graphical user interfaces on home computers there was a reason to invent agreed rules (protocols) to allow images and sounds to be exchanged as well. **Hypertext markup language (HTML)** code described how text and graphics were to be displayed correctly in these first graphical browsers.

Another protocol known as **hypertext transfer protocol (HTTP)** was developed to allow users to send and receive web page files across the Internet. It is HTTP that makes the Internet appear as if it is one large collection of pages, when in fact it is many (often linked) files stored on separate servers in different parts of the world.

INFOBIT

In 1910, Paul Otlet and Nobel Peace Prize winner Henri La Fontaine, opened their Mundaneum. Its aim was to collect all the world's knowledge on neatly organised index cards. The huge project eventually contained 12 million cards classified using a system invented by Otlet. The Belgian government donated 150 rooms in the Palais du Cinquantenaire for it. However, after being forced to move, it eventually closed. Very few people today have heard of the Mundaneum, but Otlet developed many of the ideas behind the modern Internet. What's left of the amazing Mundaneum is in a museum in Belgium.

Archie, the first search engine, was developed in 1990, and in 1992 the World Wide Web was first released to the public by Tim Berners-Lee and CERN.

By 2011, 22 per cent of the Earth's population browsed the Internet regularly and over 1.1 billion people had regular Internet access, not including cellular mobile users.

Mobile phones and the Internet

The first mobile phone with Internet connectivity was the Nokia 9000 Communicator, launched in Finland in 1996, but Internet access was difficult. Japan launched the first mobile Internet service in 1999.

In 2001, the BlackBerry® smartphone was launched in the United States. To make efficient use of the small screen and tiny keypad, most mobile device Internet services operated using a new protocol, WAP (wireless access protocol).

Developing countries soon reported that the majority of their users accessed the Internet from a mobile phone rather than a desktop or laptop computer. By 2008, more Internet access devices were mobile phones than personal computers. In many parts of the developing world, there are 10 mobile phone users to every personal computer user.

What is an intranet?

An **intranet** is a private network or group of networks that are permanently connected and use the protocols of the Internet and the World Wide Web.

An intranet is not the same as connected computers in a local area network (LAN) because it uses international standards, such as TCP/IP and HTTP, as its communication protocols.

Users attached to an intranet may have access to the Internet, but this is usually in a controlled way. An intranet can be protected from open access to the wider Internet.

The police department, for example, may access databases from the motor registry office. Together, these individual networks would form a private intranet.

A school-wide network is often a good example of an intranet. Computers throughout the school do have access to the Internet, but through a proxy server. It can be used to prevent access to certain web pages or to speed up access by storing frequently used pages. Each terminal has an address that obeys TCP/IP rules and there are often school-based web servers that can be accessed. Because Internet standards are used, computers throughout the school may use different operating systems and still access common files and servers. In some ways, intranets can be more complex than the Internet, as they may need to connect several local networks, each using different protocols.

The major difference between the Internet and an intranet is that the Internet is a public worldwide network and intranets are privately managed.



Wikipedia

Figure 12.5 The Nokia 9000, introduced in 1996



AP Photo/Paul Sakuma

Figure 12.6 The touchscreen BlackBerry Storm, introduced in 2008

INFOBIT

The Y2K (Year 2000) bug struck more than a decade late, or so thousands of screen-swiping iPhone owners felt when their alarm clocks failed to chirp in the new year for 2011. The device stayed mute for all who had relied on the built-in alarm to wake them after a late night out, in what was dubbed the 1/1/11 glitch. The alarm on the phone also failed to work properly for daylight saving in October 2010.

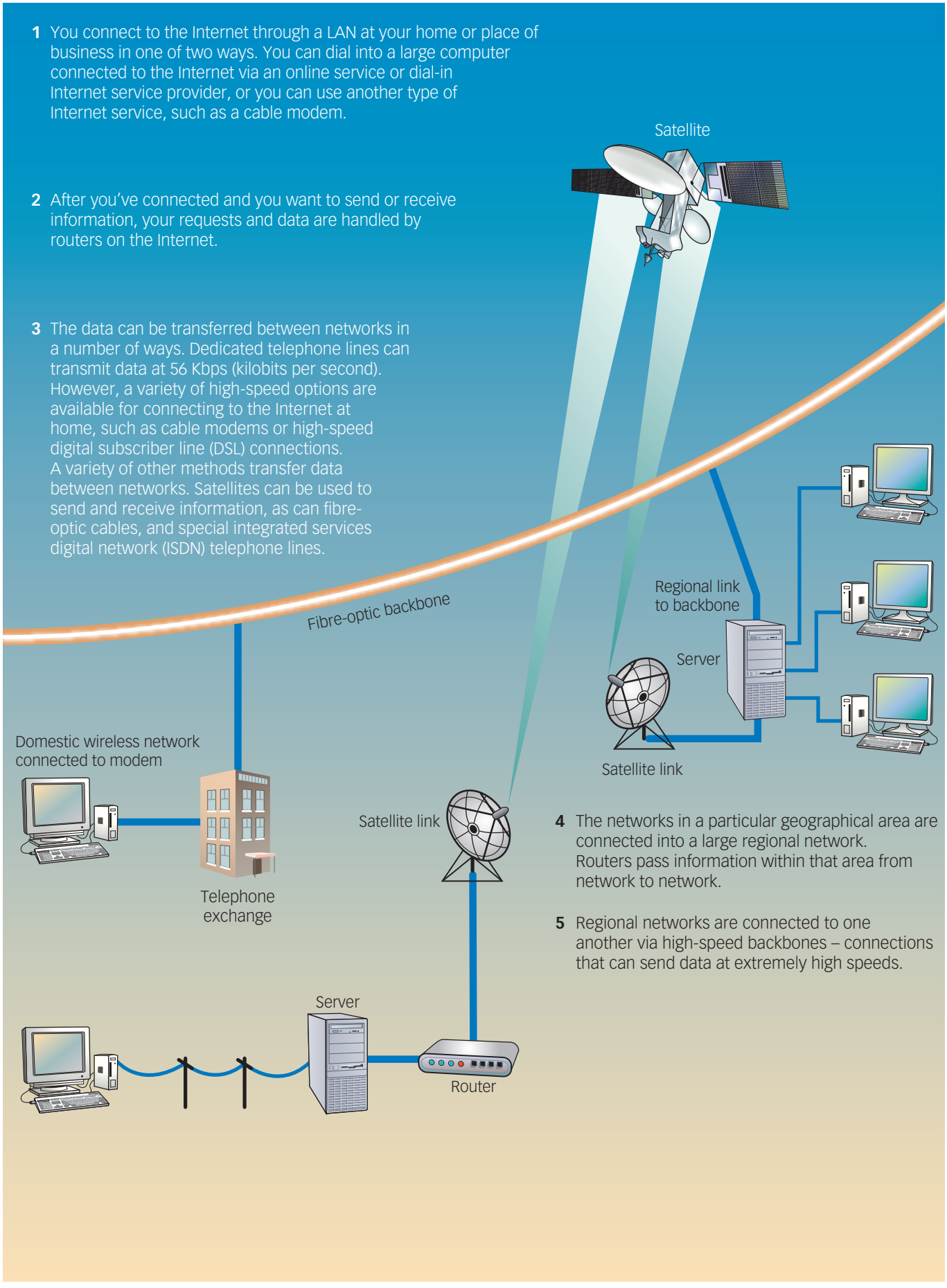
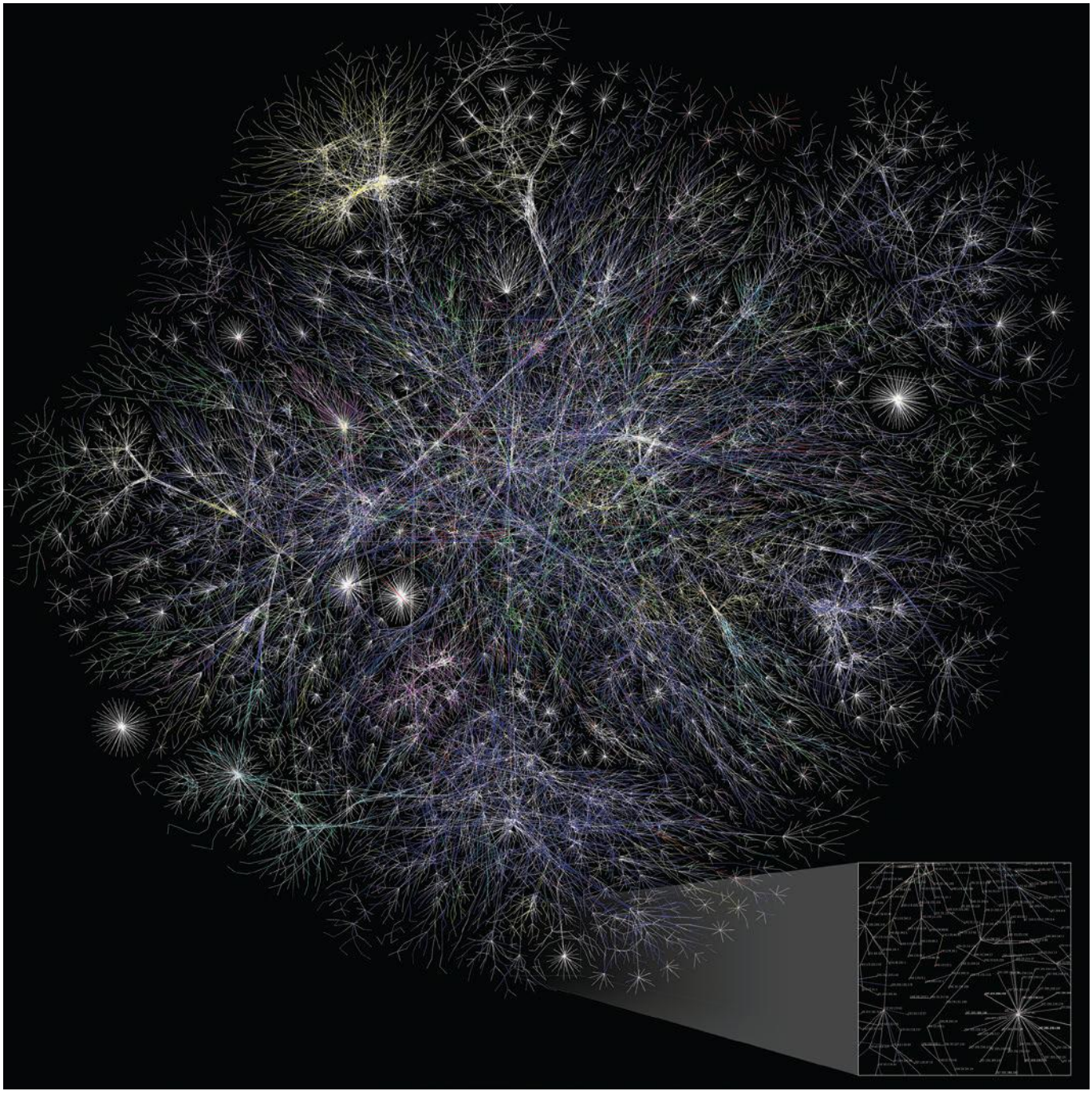


Figure 12.7 An overview of how the Internet is connected



OPTE project

Figure 12.8 A graphical representation of the connections that make up the Internet. Each spidery line represents a networked connection.

ACTIVITIES

Identify

1 What year was the World Wide Web established?
2 Identify five different activities that can be performed using the Internet.
3 What do the letters HTTP stand for?
4 Which company made the first Internet-capable mobile phone?
5 Name and describe the contributions of four of the people or organisations that were involved in the development of the Internet.

Analyse

6 In what ways do you imagine the Internet will affect our homes in the next 10 years?
7 Outline briefly the structure of the Internet.
8 Describe how packets work on the Internet.

Investigate

9 Investigate why dividing a message up into small packets is better than sending the whole message at once.

12.3 Features and uses of the Internet

One of the Internet's most powerful features is its cross-platform interoperability. The Internet does not care whether you are using a Windows PC, a Macintosh, a UNIX machine or any other. The Internet was designed as a true cross-platform network. These Internet technologies are popular in internal networks as well, as more than one platform can be used in a mixed situation to communicate and exchange data. The Internet will also connect to any network – another strength.

Connecting

It is possible to connect to the Internet in a number of different ways. Whichever method is used, the basic equipment includes a computer, some kind of data connection, software for access, an account with an Internet service provider and a modem or similar equipment for your computer to handle the signal being received.

In the early days of the Internet, traditional telephone connections required a modem and offered connection speeds of up to 56 kilobits per second. The main function of a modem is to convert digital signals to the analog signals required by a telephone line. This process is reversed at the receiving end. The modem gets its name from words describing these processes: modulation/demodulation ('mo-dem'). Modems can be internal or external to a computer and are required at both the sending and receiving ends of a communication channel.

Faster methods are described as broadband if connection speeds are greater than 2 megabits per second. One method of broadband connection uses optical fibre cable, the same means of delivery as cable TV, often in combination with DSL (digital subscriber line) and ISDN (integrated services digital network) connections using existing telephone lines to deliver data or wireless connections using mobile phone technology or even satellites.

ISDN lines provide a faster connection rate than a dial-up line and use 'multiplexing', which allows the standard telephone line to carry more than one signal at a time.

DSL divides a regular copper telephone line into separate channels for telephone and for data. Asymmetric digital subscriber line (ADSL) is a common form of DSL that assumes that more information will be downloaded than uploaded, so the download speed is made much faster. An ADSL service divides a telephone line into three channels: one for receiving data, one for sending data and one for using the telephone. This service is limited by your computer's distance from the ADSL modem at the telephone exchange, the quality of the telephone line and the number of users using the network at the same time. The Australian Government is building a National Broadband Network where optical fibre cable will be provided to most homes at speeds of over 100 megabits per second. From this point, it is converted by an optical network terminal (ONT) to electrical signals using copper wire or wireless to reach the user.

The main connection hardware used for each of the last three methods – ISDN, ADSL and cable – is a modem or router, acting as a connection device.

INFOBIT

The telephone wire, as we know it, has become too slow and too small to handle Internet traffic. It took 75 years for telephones to be used by 50 million customers, but it took only four years for the Internet to reach that many users.

TASK 1

Comparing Internet connection methods

In this task, you will set up a table to compare the transfer rates and current costs locally of:

- dial-up
- ISDN
- ADSL
- cable
- satellite.

Create a table like the one below in a word processing document. Use the table to compare and contrast the results, and decide which Internet connection method you would use. Give reasons for your answer.

Type of line	Transfer rate	Cost (select a limit)	Conditions (for example, availability)	Advantages/ disadvantages
Dial-up				
ISDN				
ADSL				
Cable				
Satellite				

World Wide Web

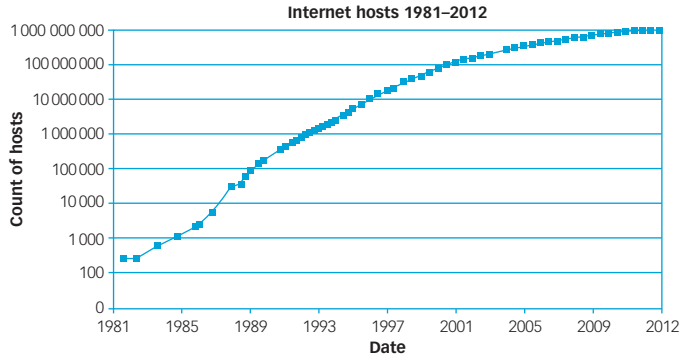
The World Wide Web (WWW) is the best known part of the Internet and is a network of sites that can be searched and retrieved by the special protocol known as hypertext transfer protocol.

Millions of websites have been created to allow people to find information, share ideas, express an opinion, provide online learning, entertain or just amuse. Newspapers and magazines are available from all over the world; allowing 'surfers' to find out the news at home in a language that they understand.

The web concept was designed in 1989 by Tim Berners-Lee and scientists at CERN, Geneva, who were interested in making it easier to retrieve research documentation.

Within a year they had developed a **browser**/editor program and named the new network the World Wide Web. The browser was improved so that hypertext links could be used in the search process.

Hyperlinks join web pages together to create a website, with a home page (a file usually called index.htm) being the first or opening page. In the case of the World Wide Web, hyperlinks join sites together across the world.



Adapted from http://commons.wikimedia.org/wiki/File:Internet_host_count_1988-2012_log_scale.png

Figure 12.9 This graph shows the dramatic increase in Internet use that began in the early 1990s.

PEOPLE

CORE ALERT People

Sir Tim Berners-Lee, creator of the World Wide Web



Getty Images/Carl Court

Figure 12.10 Sir Tim Berners-Lee

What is the difference between the Internet and the web?

Tim Berners-Lee gave the following answer:

The Internet ('Net') is a network of networks. Basically it is made from computers and cables. What Vint Cerf and Bob Khan did was to figure out how this could be used to send around little 'packets' of information … a packet is a bit like a postcard with a simple address on it. If you put the right address on a packet, and gave it to any computer which is connected as part of the Net, each computer would figure out which cable to send it down next so that it would get to its destination. That's what the Internet does. It delivers packets – anywhere in the world, normally well under a second.

Lots of different sorts of programs use the Internet: electronic mail, for example, was around long before the global hypertext system I invented and called the World Wide Web ('Web'). Now, videoconferencing and streamed audio channels are among other things which … encode information in different ways and use different languages between computers ('protocols') to provide a service.

The Web is an abstract (imaginary) space of information. On the Net, you find computers; on the Web, you find documents, sounds, videos … information. On the Net, the connections are cables between computers; on the Web, connections are hypertext links. The Web exists because of programs which communicate between computers on the Net. The Web could not exist without the Net. The Web made the Net useful because people are really interested in information (not to mention knowledge and wisdom!) and don't really want to have to know about computers and cables.

Source: http://www.w3.org/People/Berners-Lee/FAQ.html

QUESTIONS

1. Look up Tim Berners-Lee on the web and find out what contribution he made to the web.
2. When the web first began, did web pages contain images?

Email

Electronic mail, or email, is a popular feature of the Internet, allowing people to communicate across the world.

Email software acts like a simple word processor, allowing you to edit, check the spelling and save a draft version of your message and then send the final email.

Imagine a collection of connected electronic mail boxes all over the world that can send and receive mail wherever you are in the world. Although the message might travel right around the world, the whole process takes only seconds. It isn't surprising that ordinary mail is referred to as 'snail mail'. Some countries are doing away with snail mail altogether by opening and scanning handwritten mail, and transmitting it digitally and delivering these in a parcel each month. Others are delivering to local deposit boxes rather than homes.

An email server is like a web server that controls and stores email. The mail client on the local computer receives and sends the messages.

When the email message arrives at the recipient's mail server, the message transfers to the server and remains there until retrieved. The SMTP (simple mail transfer protocol) server handles outgoing mail.

Two main protocols exist for storage and retrieval of incoming email: post office protocol (POP) and Internet message access protocol (IMAP).

With POP, messages get delivered to one device and what you do on one device (either reply or send a new email) is not reflected across other devices you may own. POP is like a one-way street. The main advantage of IMAP over POP is that it solves this limitation. Multiple clients can connect at the one time. This feature is used by cloud services, to allow multiple devices belonging to the one user (phone, computer, tablet) to access mail and for changes to be reflected across all devices. IMAP is like a two-way street. Messages are deleted from the server when deleted from any of your devices. It also allows multiple folders to be used across devices. Most experts recommend IMAP for email, as it is more flexible.

To read an email that has been received over the Internet, an email software tool (called a client) of some kind is required. Email can either be accessed using stand-alone software such as Microsoft Outlook or Apple Mail or by using a webmail service – a website provided by your email provider's website or by using free services such as Gmail or Hotmail.

The mail client shows a list of all the messages in the user's mailbox. By looking at the email message header, users can see who sent the email, the subject of the email, and perhaps the time and date of the message and the size of the message.

When a user downloads this email, the email client on the receiver's computer takes over, asking the email server to:

- send a copy of the text file
- save the file to the local computer
- show all of the message headers in a list
- erase and reset the file.

Each account has a unique name so that when a message is sent, the email client gives the server the name of the receiver, the name of the sender and the body of the message. As other mail is sent to the same recipient, the server recognises the messages and attaches the new messages to the bottom of a text file, which lists them in the order in which they arrive.

An email address has three parts, as shown in figure 12.11: a mailbox name, an @ ('at') sign and a server address. In other words, it looks like this: imastudent@institution.edu.

The text file accumulates all the messages until the receiver logs in to read them.

Emails can be sent to thousands of people at the same time with just one click, in the form of a bulk mail-out.

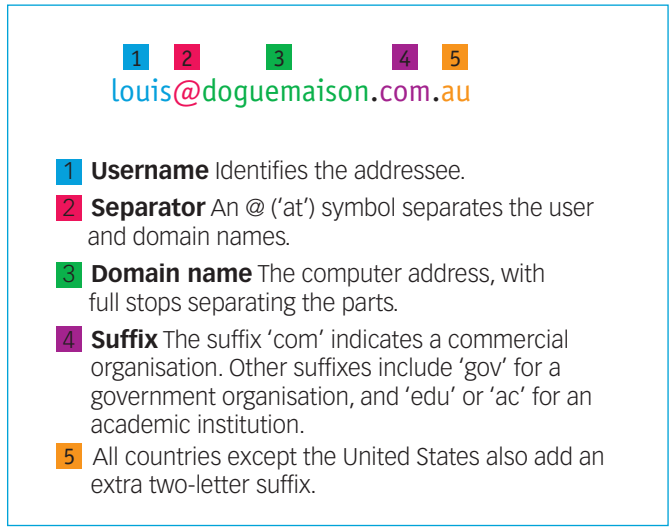


Figure 12.11 Parts of an email address

INFOBIT

When email first appeared, some questioned why anyone would pay a fee to a service provider to receive their mail. This shows how some people could not imagine the way in which email would begin a brand new form of communication rather than replace traditional 'snail mail'.

Parts of an email

The following information describes the elements of an email message.

- To: Type in the email address of the receiver or select the address from your address book.

- CC: Stands for carbon copy and allows you to send a message to more than one email address at the same time.
- BCC: Stands for blind carbon copy. Email addresses entered in this field are hidden from the receiver.
- Subject: Should indicate what the message is about.
- Reply: Creates a reply to the sender of the message.
- Reply to all: Creates replies to all of the recipients in the CC and BCC fields, as well as to the sender.
- Forward: Sends a copy of the message to another recipient.
- Attachments: Allows you to send a file (typical examples would be a word-processed document, image or PDF) along with your email. The attachment is sent using the **file transfer protocol (FTP)**, which is different from the email protocol.

Sending an email involves many separate protocols all working together.

SMTP controls how the ordinary text of an email message is sent and received, as well as how the message is organised, with a header (including subject, sender and receiver addresses) and body (containing the message).

Multipurpose Internet Mail Extensions (MIME) controls how attachments, such as computer programs, graphics or word-processed documents, are encoded as files in binary code.

POP and IMAP control how a mail server holds messages until they are downloaded and cleared.

The email you type stays on your computer until you hit 'send'. Then a copy of the email goes across the Internet to your service provider's email server. Here the server decides where the email is to go and sends it there.

The email remains on the recipient's ISP email server until the recipient goes online to check their email. The advantage of email is that it is instant, automatic and cheaper than a telephone call and the recipient does not have to be at their computer to receive it.

Some would argue that, far from making our lives simpler, email has introduced a whole new set of issues to our daily lives. To keep in touch we must now log in to our computers daily.

Spam

Electronic mail boxes can receive junk mail just like an ordinary street letterbox.

On the Internet, junk mail is called spam (figure 12.13). Mass marketers obtain email addresses, add them to lists and mass-mail unwanted ads and offers.

Dedicated mail software allows the user to write 'rules' that will prevent spam appearing in the user's inbox. For example, a rule may be created to trap any mail whose subject line contains the word 'bargain'.



Figure 12.12 A user can create personalised rules that will trap spam that fulfils certain criteria.

Email and viruses

An email virus is one that is usually contained in an attachment that is sent along with the email.

The attachment is usually an executable file, or a small program called a 'macro', normally used by applications such as word processors or spreadsheets.

A genuine macro is a helpful addition, allowing the automation of actions such as addressing a letter or drawing a graph from data in a spreadsheet. However, because macros are mini-programs, unwanted ones can be written that damage files on your computer. If activated, these macro viruses can attack the computer's system files, or destroy files on the hard drive, by copying itself over them.

The safest advice is not to open attachments unless you recognise the sender and it is clear they meant to send the attachment to you.



Alamy/D. Hurst

Figure 12.13 The term 'spam' comes from a British TV sketch comedy series, *Monty Python's Flying Circus*. In one sketch, every item on the menu was Spam® (a tinned spiced ham product) and so was unavoidable!

Privacy of email

Email is only as private as a postcard, as it is not even in a sealed envelope! An incorrect address will sometimes see the email delivered to the wrong person, or an ISP will return an automated message explaining that the message could not be delivered.

Most schools and employers have regulations that allow their emails to be read to ensure that unacceptable material is not included in an email or sent as an attachment.

INFOBIT

In the United States alone, over 10 trillion email messages are exchanged each year.

Email passwords

Password protection is very important for the security of your email. The password should be easily remembered, but not one that is obvious to everyone else. The 'remember password' checkbox in your mail software should be used with caution. If only one person always uses the computer, this can save time, but if you don't want your email to be available to everyone in the house, then the password needs to be protected.

Netiquette and emoticons

Traditional letter writing requires the writer to set the tone of their letter first. This takes time, and in the rapid-fire world of email, it is considered a luxury.

Over time, users of email have developed ground rules for its use. For example, writing a message in capitals is considered to be shouting, and the term 'flaming' is applied to messages that are angry and overly critical.

In the case of email, it is often difficult to tell whether the writer is making a joke, being serious or seeking the recipient's opinion. A shorthand method of overcoming this problem has been developed, using keyboard characters in clever combinations to form cartoon-like 'faces', known as emoticons. Some examples appear in figure 12.14. Other methods are adopted from texting and use abbreviations, such as LOL for 'laugh out loud'.

:-)	or	:)	Smile
;-)	or	;)	Wink
:-D	or	:D	Big smile
:-))	or	:))	Very happy
|-)			Cool
B-)	or	B)	Evil grin
:->	or	>:>	Another evil grin
;->	or	>;>	Evil grin with a wink
:-X	or	:X	I'm not telling
}-)			Devilish
:-^)	or	:^)	Tongue in cheek
:-(	or	:(	Sad
:-{	or	:{	Sad
Characters:			
~(_:(1)			Homer Simpson
888888888:-)			Marge Simpson
:[~			Vampire
8(:-)			Mickey Mouse

Figure 12.14 Some popular emoticons

Social networking

Social networking websites began as digital ways to connect with others who share common interests or simply make it easy for friends to link up. The most popular are Facebook, Twitter, LinkedIn, Instagram and Pinterest. At the time of writing, Facebook had over 1.23 billion individual users. Social media has made it easy for friends to keep in touch, for users to receive invitations to events and to feel part of a community when separated geographically.

Social networking sites have had a large impact on our lives. It has been said that the icon of the current generation is Facebook's Like button. A Facebook user can 'like' content such as status updates, comments, photos, links shared by friends, and advertisements. For some, personal identity becomes the number of likes they have acquired and one of their biggest decisions is the choice of Facebook profile picture. Advertisers take advantage of this and are eager to collect data on users when they click 'like' on their products, retweet or send an Instagram.

Despite all the benefits of services such as Facebook, it is important for users to be aware that profiles are being created about us that reveal very personal information about us we never knew we were sharing. These profiles are used by companies wishing to promote products to us, but could be used also to pose a threat to individual freedom or safety.

The term 'Web 2.0' has sometimes been used to describe social networking, but this term really refers to any sites featuring information sharing and collaboration.

Popular examples of this type of collaborative website, where any user can contribute to a common body of information, are YouTube and Vimeo (video sharing), Flickr (photo sharing) and wikis (from the Hawaiian word for 'quick') such as Wikipedia (information sharing).

Some have described one result of the growth of such tools as the democratisation of the web. Such sites allow regular Internet users the opportunity to bypass large media organisations and contact large numbers of people. Some are organised lobby groups, such as the political lobby site GetUp, others provide whistleblowers the opportunity to anonymously reveal information, and many sites act simply as an opportunity to share common interests. At election time, political parties are increasingly using social media.



Getty Images/Nicholas Kamm

Figure 12.15 Facebook is one of the largest and most popular social websites.



Figure 12.16 Many sites now have a 'share' button to allow users to link the site to the most popular social networking sites. This one is from YouTube. How many icons can you identify?

Blogs

Blogs (from the words 'web' and 'log') had begun to be widely used by 2004. Now there are hundreds of millions of individual blogs.

A blog is usually in the form of a personal website with text, images and videos and is often in the form of a personal diary or journal. Many blogs allow visitors to make comments and interact with the author of the blog.

Many bloggers express controversial views and report on current events. The positive and negative impact that blogging has had on traditional newspapers, radio and television continues to be discussed.

Twitter is a type of mini-blog service that enables its users to send and read messages known as tweets. Tweets, which may contain no more than 140 characters, are delivered to the author's subscribers.

Newsgroups

Newsgroups represent one of the oldest methods of communication on the Internet. They are a continuous public discussion on a particular topic, where the messages are not held on just one server but are replicated on hundreds of servers all around the world. Newsgroups that have been set up by schools or universities may require a password for participation. The system depends on many computers, known as Usenet (or NNTP) servers, sharing the job of storing discussions and spreading the load. Every imaginable topic is covered. Subscribers are notified when new messages have been posted to their newsgroups. A moderated newsgroup can be more valuable, as less serious, irrelevant or offensive contributions are removed.

Forums and message boards

Many websites provide message boards. These are public forums where messages can be posted and answered. Like other Internet services, they are accessible from all over the world. Forums are similar to newsgroups, except that information is kept on a single server maintained by the owner or originator of the discussion board.

Mailing lists

A mailing list (or listserv) is a collection of email names and addresses, recognised as a single group.

Some lists restrict either the number of participants or ensure that particular qualifications are met. For instance, a mailing list about health guidelines may be restricted to doctors. Like newsgroups, some mailing lists are moderated.

Chat rooms and forums

Online chat is a real-time exchange of text messages between a group of connected users. This creates a feeling of genuine conversation, unlike email. However, in chat rooms it is easy to lose track of what is being referred to, as many short messages appear rapidly. Before live video sessions on the Internet became available, people messaged in real time using their keyboards. There are many ways in which a group of people are able to have live chat conversations on the Internet – the most popular is through Internet relay chat (IRC), known also as chat rooms. It is important to recognise that you have no control over who you are exchanging text messages with in such a chat room. These people may be rude, aggressive and mindless, or perhaps not even be people at all, but small computer programs called 'bots' generating chatter. Chat sessions often have an operator who is responsible for monitoring the conversation and removing from the chat session any user who is disruptive. The risk of being deceived is high, so do not pretend to be someone other than who you are, have fun, and trust no one.

Unlike chat, a forum is not real-time. Users can use it at any time. They can initiate a new forum topic or reply to an existing one, and replies are threaded to show their relationship to previous messages, making conversations much easier to follow.

Conferencing or webinars

Conferencing software programs allow two or more users to 'meet' through a virtual conference. These are often known as webinars ('web seminars').

Users can transmit moving images and sound by attaching a webcam to their computer to capture video and audio content. They can type interactively to communicate between all participants. Tutorials are often conducted this way. ADSL lines, cable modems and other broadband services available today, which allow fast connection speeds, have encouraged such use of video as a means of communication. Many organisations save large amounts of money on travel costs by holding videoconferences instead of requiring employees to meet physically.

Learning management systems

A learning management system (LMS) is sometimes called a content management system and is a web-based technology or software application used to plan a learning sequence for education, such as a series of lessons. An LMS usually has two components: content and communication. Content might include lesson material, assignments, media, a record of marks and a calendar. Communication might be announcements, mail, discussions and chats.

Moodle, LAMS, Blackboard and Edmodo are popular examples used in many schools. See the case study on pages 235–6 for the story behind Moodle and LAMS.

Messaging

When using email there is often no way of knowing if the person you are communicating with is online at that time or how often they check their email.

Instant messaging (IM) saves time, as the recipient of the email does not have to click to reply and send, but rather reads a pop-up menu. Both responses are visible at the same time. Names and contacts can be added to a buddy list.

A chat room allows a group of people to be chatting, but IM is like a chat room for just two people. IM is not a secure method of communication, although there is some encryption. Confidential information should not be communicated in this way.

A common standard has not been agreed upon for IM services and so each service has its own protocol and usually cannot communicate to someone using another service. Some services use websites, others use special applications downloaded to the user's computer. Facebook, Skype and ICQ are examples of IM. Text messaging (SMS) and multimedia messaging service (MMS) are common examples of IM used with mobile phones.

As webcams have become commonplace input devices, 'video chat' has become a popular method of online live communication. Skype, AIM™ and Facetime (Apple) are popular applications supporting video chat.

VoIP

Services allowing telephone voice calls to be made over the Internet instead of using regular telephone exchanges are known as VoIP (voice over Internet protocol).

Skype is a popular example of a VoIP service. It uses an application that can be downloaded to a computer. If the call is to another Skype user, it is free. Skype also provides videoconferencing and instant messaging services.

E-commerce

Commercial transactions carried out over the Internet are known as e-commerce. Advances in technology have allowed a more efficient service to customers for activities such as shopping, share transactions and banking, and have provided access for many people who are unable to leave their home. Business transactions have changed in such a way that the challenge of time and distance has been almost eliminated and transactions can occur instantly and globally. The nature of work has changed, with some businesses no longer having a physical place of business, such as a shopfront, but only an online (Internet) presence.

Disadvantages of e-commerce include the impersonal nature of business transactions, and the opportunity for theft and misuse of credit card details over the Internet.

Advantages of e-commerce include: access is available 24 hours per day, seven days per week; products and prices can be updated immediately; products can be customised to individual tastes; and the greater customer base offered by the millions of participants on the Internet.

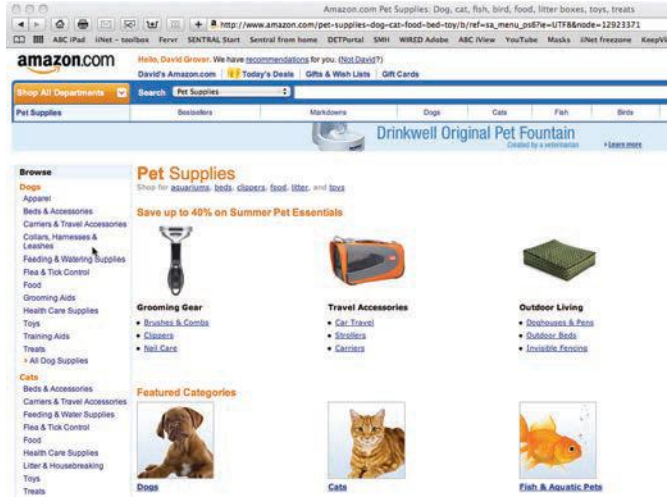


Figure 12.17 One of the most popular e-commerce sites is Amazon, where almost anything can be purchased online.

Businesses can gather customer information, analyse sales and react by making appropriate changes in marketing quickly. The middle person is removed as businesses deal directly with customers. Popular e-commerce activities are holiday and flight bookings.

Online shopping

Using the web, shoppers can browse virtual stores 24 hours a day, and comparisons can be made of the prices before decisions are made and the purchase occurs. Shopping is not restricted to Australia. Other countries can be visited and the access and choices are wider.

Internet banking

To open an Internet banking account, an application can be made online at the bank's website. Once the account is activated, money can be transferred between accounts, account balances can be obtained and bills can be paid with an option of using the BPAY® system.

CASE STUDY

CORE ALERT People

Two Australian digital learning tools

Moodle

Moodle (Modular Object-Oriented Dynamic Learning Environment) is a free software e-learning platform created in 2001 in Australia by Martin Dougiamas. Martin lived in the deserts of Western Australia, and was the only non-Aboriginal child in his settlement. His primary school education was by distance education where bundles of printed lessons were delivered by aeroplane every two weeks. He only saw his classmates at a sports carnival once a year. Martin said that this experience taught him the importance of students being able to interact with one another as well as with their teachers.

In his university days in the early 1990s, Martin saw the difficulties lecturers and students experienced using the Internet. He started using the learning tool WebCT for online learning. Martin saw it lacked features he believed were important for student interaction, but he was legally prevented from being able to add them because it was not open source. He decided to do a master's degree in Education and a PhD, and during this time he developed the first version of Moodle. There are now 50000 known installations with 1.37 million teachers and many millions of students.

What would Martin's primary school teachers have said if they had been told that he would one day develop Moodle, the most widely used learning management system in the world – and that distance education schools around the world would depend on it, including Sydney and Dubbo Distance Education High Schools?

Go to http://infosoftwaretech.nelsonnet.com.au to link to an interview with Martin.

Weblink

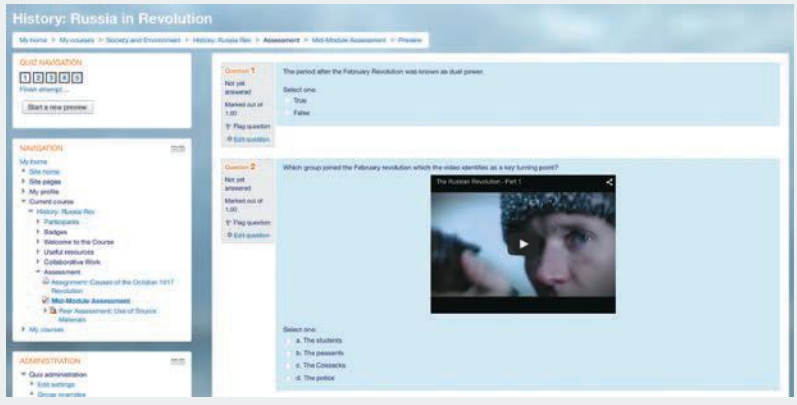


Moodle.com



Moodle.com

Figure 12.18 Martin Dougiamas, creator of Moodle



Moodle.com

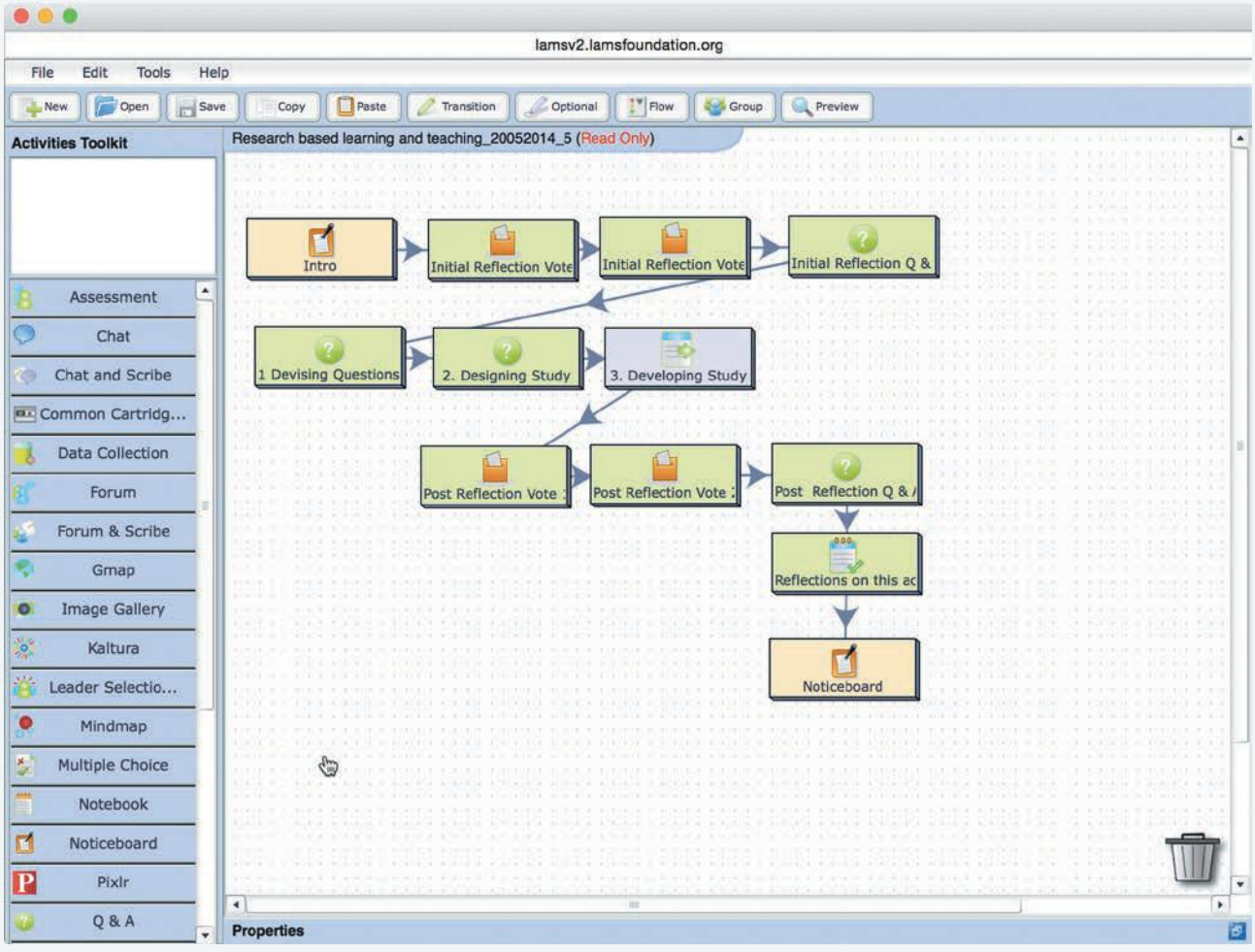
Figure 12.19 There are many types of modules available in Moodle. This figure shows a number of different types of quiz questions.

LAMS

LAMS (Learning Activity Management System) was also created in Australia, by James Dalziel at Macquarie University, and is now used by schools and universities around the world. LAMS is an online learning management system using drag-and-drop modules such as chats, forums and multiple-choice quizzes that can be connected to become an activity sequence (see figure 12.20). LAMS also keeps records of student progress.



LAMSFoundation



LAMSFoundation

Figure 12.20 The Learning Activity Management System (LAMS) offers teachers a wide variety of question types using drag-and-drop modules that connect to become a lesson sequence.

Online gaming

Many popular activities on the web involve playing games online. Early online adventure games, many of which are still popular, were known as MUDs (multi-user domains). With their origins in the early days of computers as text-based adventure scenarios, these online games often continued for years, involved many thousands of people and gained cult followings. With the arrival of fast broadband Internet, massively multiplayer online games (MMOG), involving thousands of players playing a game simultaneously, have developed from these early MUD games.

Whole websites are devoted to the most popular games and some people spend a great deal of time inhabiting imagined virtual worlds in which their adventures take place.

Both World of Warcraft and Final Fantasy are popular online multiplayer war games with origins in MUDs. Second Life and the ever-popular The Sims are examples of immersive virtual reality games.

Virtual offices

A virtual office is one that can conduct business from anywhere in the world using communication technology. A virtual office is usually set up in a home environment, but the business can be continued from a plane, in the airport or on a holiday.

Virtual assistants

The most well-known example of a virtual assistant is Apple's Siri, which is built into Apple's iOS. Natural language questions may be asked of Siri, such as 'How do I get home?' The location of home will be known and the current location and directions given. Siri can be asked 'Make an appointment for me to meet my wife for dinner next Tuesday evening' and she will manage that as well. Many users spend a great deal of time asking Siri to tell jokes!

Assistant is a third-party virtual assistant for the Android platform.

TASK 2

Timeline for the development of the Internet

With a partner, research the history of the Internet and display your collaboration as a PowerPoint or Prezi presentation to the class.

Here are the steps that you will follow:

1. Decide with your partner the tasks that each of you will complete.
2. Connect to the Internet and go to the Google search engine.
3. Type 'Internet + history' as your search request.
4. Remember that by clicking on the 'images' tab in Google on the opening search page, you should be able to find pictures to go with your presentation.
5. Read the information that you find and rewrite it in your own words using a word processor. In doing so, answer the following questions.
   - **a** What was the trigger for the Internet in the beginning?
   - **b** Identify the major inventions that led to the development of the Internet as we know it now.
   - **c** Identify the organisations involved with the development of the Internet.
   - **d** Identify the organisations now involved in maintaining the Internet.
   - **e** Identify the major popular browsers from the early days of the Internet until the present.
6. Have we reached the limit of Internet development? Discuss what you imagine the future will hold. For example, will snail mail (traditional post office mail) survive, or will only parcels be delivered in future? (Telegrams used to be delivered by boys on bicycles. Now there are no telegrams at all.)
7. You have now collected text and images and answered some background questions. Plan a storyboard to present this material in a logical order. Design each of your PowerPoint slides.
8. On the last slide of your presentation, create a bibliography of all of the sites you used to find the information and images.

ACTIVITIES

Identify

1. State the differences between a newsgroup and a mailing list.
2. Outline the difference between messaging and chat.
3. Provide three examples of e-commerce.
4. Give two reasons why emoticons were invented.
5. What do the letters MUD stand for?
6. What is one advantage of VoIP over regular phone calls?

Analyse

7. Outline the steps involved in joining a newsgroup.
8. You have been asked by a new computer user to find somewhere on the Internet to keep up with new developments. Why might a listserv be more helpful than a newsgroup?

Investigate

9. Select a newsgroup dealing with a topic that interests you, join it and write a short report on it.
10. Set up a chat from home with another member of the class where each person asks the other five questions from the information provided up to this point in this chapter. Submit the conversation to your teacher.

12.4 Accessing information using search engines

The World Wide Web could be considered the biggest book that has ever existed. It consists of billions of web pages linked to each other. It holds vast amounts of information, but this would be useless if there were no way to search the pages and organise them.

Types of search engines

Companies have developed special programs called search engines, which 'read' this vast number of pages and index them, although no search engine has ever indexed everything on the Internet. Keywords or subjects are collected and added to the search engine's database. Users can then search these for the information they are seeking. The top search engines respond to tens of millions of queries in a day.

One challenge in using a search engine is that a basic search for a word usually gives thousands or millions of 'hits' that have to be searched and sorted even further. Often there is too much information and surfers find it difficult to extract the specific facts required.

There are three main types of search engines:

- **Standard search engines** (such as Google and Bing). Here you type in a search word or phrase and links are provided to the matching pages along with short descriptions for each page. Google and Bing use different rules for ranking a web page's importance. Such ranking rules can decide whether you see it or not.
- **Meta search engines** (such as Dogpile). These engines submit your search to many search engines and return a number of links from each.
- **Natural-language-based search engines** (such as Ask and WolframAlpha). You type in a question in the normal way (for example, 'How many moons does Saturn have?') and these search engines analyse the question and provide links.

WolframAlpha, launched in 2009, is really not a search engine at all, but an answer engine that answers fact-based questions by working out the answer instead of listing web pages as a search engine like Google would.

For example, you can ask what day of the week you were born and it will answer correctly. Typing 'What is the life expectancy of a 15-year-old Australian male?' will produce a page of detailed data, including the answer of 79.16 years, and asking 'What was the weather in Sydney on New Year's Eve 2000?' will graph temperatures and rainfall for that day.

How search engines work

Each search engine works in different ways in an attempt to offer unique features.

Some use robot ('bot') programs called spiders or crawlers to track web pages, follow links, add the information to the search engine's database or use metatags. Billions of pages have been indexed by the top search engine (currently Google). The search engine then ranks each page in importance based on the number of pages that link to that page.

Within seconds, the search engine will provide a list of possible matches on the results page. Each of the pages listed is known as a 'hit'.

Refining the search can reduce the number of hits, or results. The search engine decides the importance of each hit.

WolframAlpha uses over 10 000 computers and advanced mathematical software to perform its powerful calculations. It still has a long way to go, but is an early example of an 'artificially intelligent' search engine.

Metatags are words the writer or developer of the web page has selected to describe the main contents of the page, which are used by search engine databases to index web pages. However, some people add metatags that fit popular topics but have nothing to do with the contents of the page. Spiders match metatags with the page's content and reject the metatags that do not match any of the words on the page.

How subject directories work

A subject directory is different from a search engine. A directory provides categorised lists of links grouped into subjects. Directories require the user to determine each of the categories to be used to complete the search.

Most search engines provide directory searches in addition to keyword searches.

INFOBIT

Searching for 'banana' using Google's search engine gives over 900 100 000 results at the time of writing. Bananana gives around 349 000. Bananananananananananananana gives 3140. Even 20 repetitions of 'na' still delivers results!

Searching newsgroups and images

Google has the ability to search Usenet groups to find relevant information that has been discussed or posted to a group discussion.

A Google search for 'spamdexing' on the web returned 150 000 hits, while searching through groups returned only 4250 results. Choose the search tool that best meets your needs.

Google also allows for the search of images relevant to a search specification by using keywords.

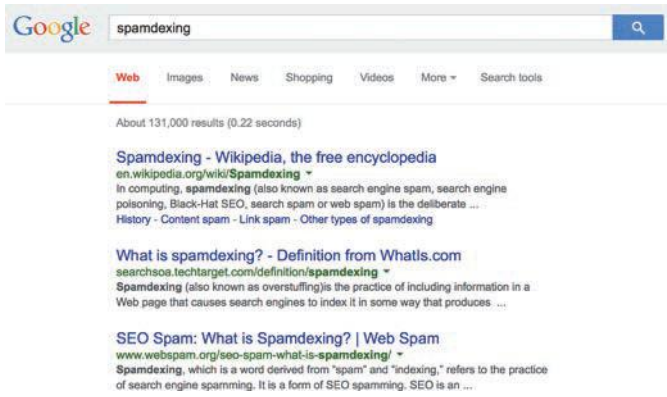


Figure 12.21 Google search for 'spamdexing'

Google

ISSUES

CORE ALERT Issues

Accessibility of websites

As Tim Berners-Lee puts it: 'The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect' (http://www.w3.org/Press/IPO-announce).

Accessibility refers to making a web page available to as many people as possible. One of the most important points to remember when developing a website is that the site must be accessible to as many people as possible. Policies and laws have been developed and passed to ensure this right.

A search on the Internet will find tools to assist you as a web developer to identify barriers within your website to people with disabilities. This issue will become more and more important as society begins to rely more heavily on the Internet for its main services and sources of information.

The World Wide Web Consortium (W3C®) Web Accessibility Initiative (WAI™), as well as governments in Australia and the United States, have created guidelines for standards that web pages should meet. Websites have been set up to encourage compliance with these guidelines.

Sites are available:

- to see how your site displays in text-only format
- to check spoken Internet and web access for users with visual impairments
- to create captions and audio descriptions for multimedia.

Try using one of these sites to check the websites you browsed in the task earlier in this chapter.

In Australia, the Australian Human Rights and Equal Opportunity Commission runs workshops on 'Designing for an accessible web' so that the power of the web can be harnessed by each of us.

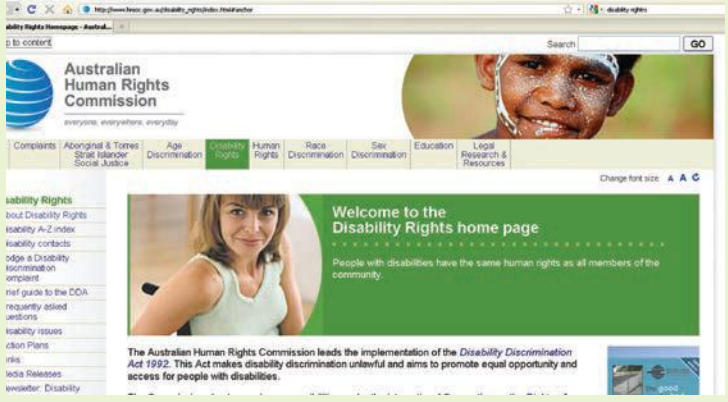


Figure 12.22 Disability rights on the web

INFOBIT

TouchGraph allows users to visualise the connections between many related websites.

QUESTIONS

1. Use an accessibility tester website to check the readability of some popular websites.
2. Select an example of a site that meets all tests and another that fails many tests.

Research

Research on the web requires efficient searching of the Internet and the ability to decide how reliable the results are.

To search for information, remember to:

- determine the keywords that will be used
- put the most important words first
- use double quotation marks whenever an exact sequence of words is to be found
- limit the number of hits by choosing English language only for hits
- type in lower case to find matches in both lower case and upper case
- use advanced searches to exclude sites with certain words.

Before using a search engine, read its online help because each search engine is slightly different. If the number of results is too big, refine the search and try the advanced features provided with most search engines.

A search for 'lion' could display over three million results. Refining the search by entering 'lion wild animal' reduces the number of hits. To reduce that even further, words such as 'toys', 'cards', 'pets', 'books' and so on need to be removed from the search specifications.

If you are the author or user of a site, you cannot be sure that a link to another website will remain 'live'. Further, it is not always possible on the web to find out the qualifications of an author or even if the content of a site is all their own work.

In comparison, encyclopaedias and similar trusted reference books are 'curated'; that is, they go through a number of careful checks before publication. Because they are costly to publish, only the most qualified and skilled writers are paid to work on them. In the case of the web, anyone can have a go – and that is both the web's weakness and its strength.

Another big difference between web pages and printed books is that the web has hyperlinks.

On a web page, an author may write: 'During the nineteenth century, the Industrial Revolution changed the way Britons lived and worked'.

The reader knows they can find out more by clicking on the underlined words. It is this interactivity that makes the web so powerful. Nothing like it has existed before.

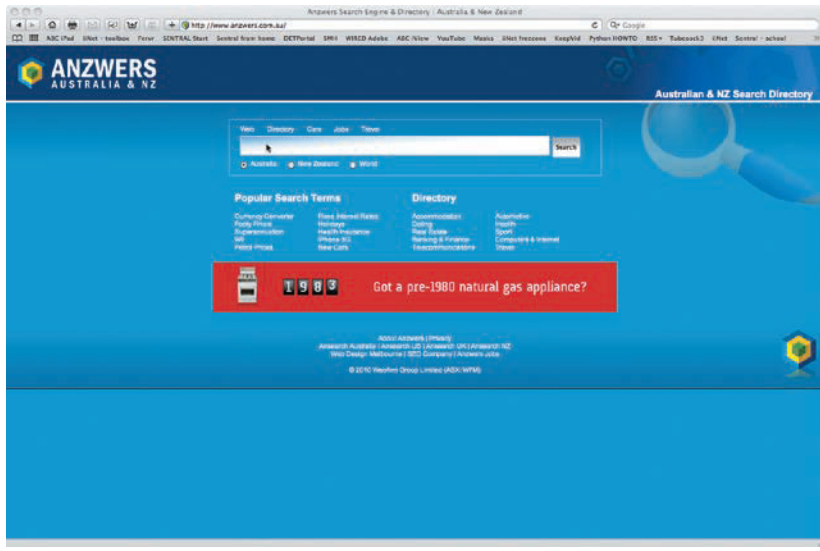


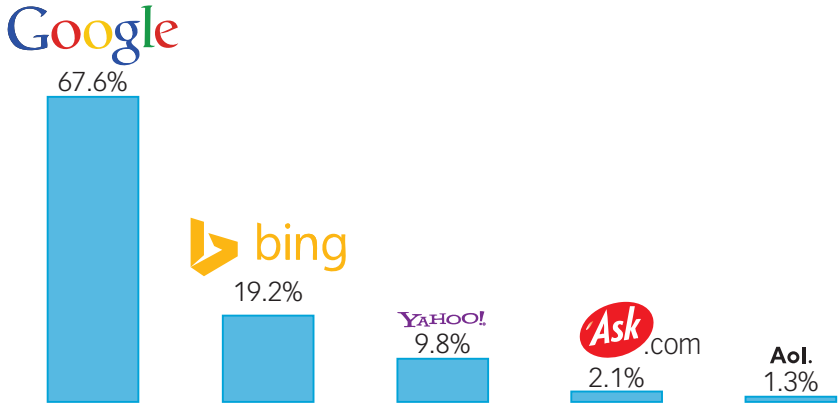
Figure 12.24 Answer engines are available on the web, such as Anzwers.

TASK 3

Exploring e-commerce

With a partner, investigate the purchase of three very different products over the Internet.

1. What is the most unusual product you can find for sale worldwide?
2. How will the payment be made?
3. Investigate the security and privacy policies for the sites chosen.
4. Is it possible to return goods? Who pays for the return costs?



Source: http://www.theseachmonitor.com/why-aol-ask-show-irrelevant-search-ads-fifty-percent-of-time/

Figure 12.23 Search engine market share in June 2014. Google remains the most popular search engine, followed a long way behind by Bing.

TASK 4

Exploring some exciting search techniques

You will use Google and Bing to explore Internet history.

Here are the steps you will follow:

1. Connect to the Internet and go to the Google search engine.
2. Type 'Internet timeline' and click search.
3. Select sites with images.
4. Choose a topic you are interested in and know something about and comment on the quality of the content using Google and Bing.
5. Create a table with two rows, one each for Google and Bing, and with two columns headed 'Strengths' and 'Weaknesses'. Use this table to summarise the two sets of search results.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

Answer engines

It is the existence of powerful search engines that has made the web so useful. However, finding answers to questions via search engines is a lot less predictable than the older habit of looking up an encyclopaedia. For this reason, 'answer engines' such as WolframAlpha were created. These are like online encyclopaedias that deliver only a few answers, but are detailed, usually accurate, and useful when you know what you are looking for.

However, there are other free services that have been constructed by communities. One of these is Wikipedia. If you are an expert in a field, you can submit an article others will check before it is added to the site. Wikipedia is available in over 70 languages. Because it is so open, sometimes material is not as reliable or authoritative as it should be, so it is wise to check before using it.

QUESTIONS

1. Why might a printed encyclopaedia be considered more reliable than Wikipedia? In what way might it be less reliable?
2. Use Wikipedia to research three topics from this chapter. Write a paragraph on each, reporting on how well each was treated.
3. Use a search engine to find out about the same three topics. Which method is faster? Which gave the most information? Which method was more accurate?

ACTIVITIES

Identify

1. Identify the different categories of search engines.
2. Identify the appropriate search tools you would use for each of the following searches about the British explorer Captain James Cook and find answers to each question.
   - **a** What was the name of James Cook's wife?
   - **b** What did James Cook look like?
   - **c** What connection did James Cook have with the planet Venus?
   - **d** What were the circumstances of James Cook's death and what was his age at the time?
   - **e** In his own words, what were James Cook's first impressions of Australia's Indigenous peoples?
   - **f** What are the big issues in current research on James Cook?
3. What is another name for an advanced search on the Internet?
4. Chat (IRC) is a tool used on the Internet for online keyboard conversations with other people. Name three other Internet tools used for communication.
5. What is accessibility?

Analyse

6. E-commerce has been more popular in the United States than in Australia. Can you suggest a reason for this?
7. Both email and Facebook allow a message to be made available to many people at once. Since this is true, what are the advantages of Facebook over direct email?
8. State two reasons for the popularity of emoticons.

Investigate

9. Examine a site using virtual assistants. What are the strengths and weaknesses of virtual assistants?
10. Do you believe that web search engines will charge for their services in the future? Justify your answer.

12.5 Internet software

CORE ALERT Software

The two main Internet software applications are the browser and email client.

The creation of the first browser enabled communication to break through the restrictions of plain text and web pages to display colourful, often animated, graphics.

Browsers

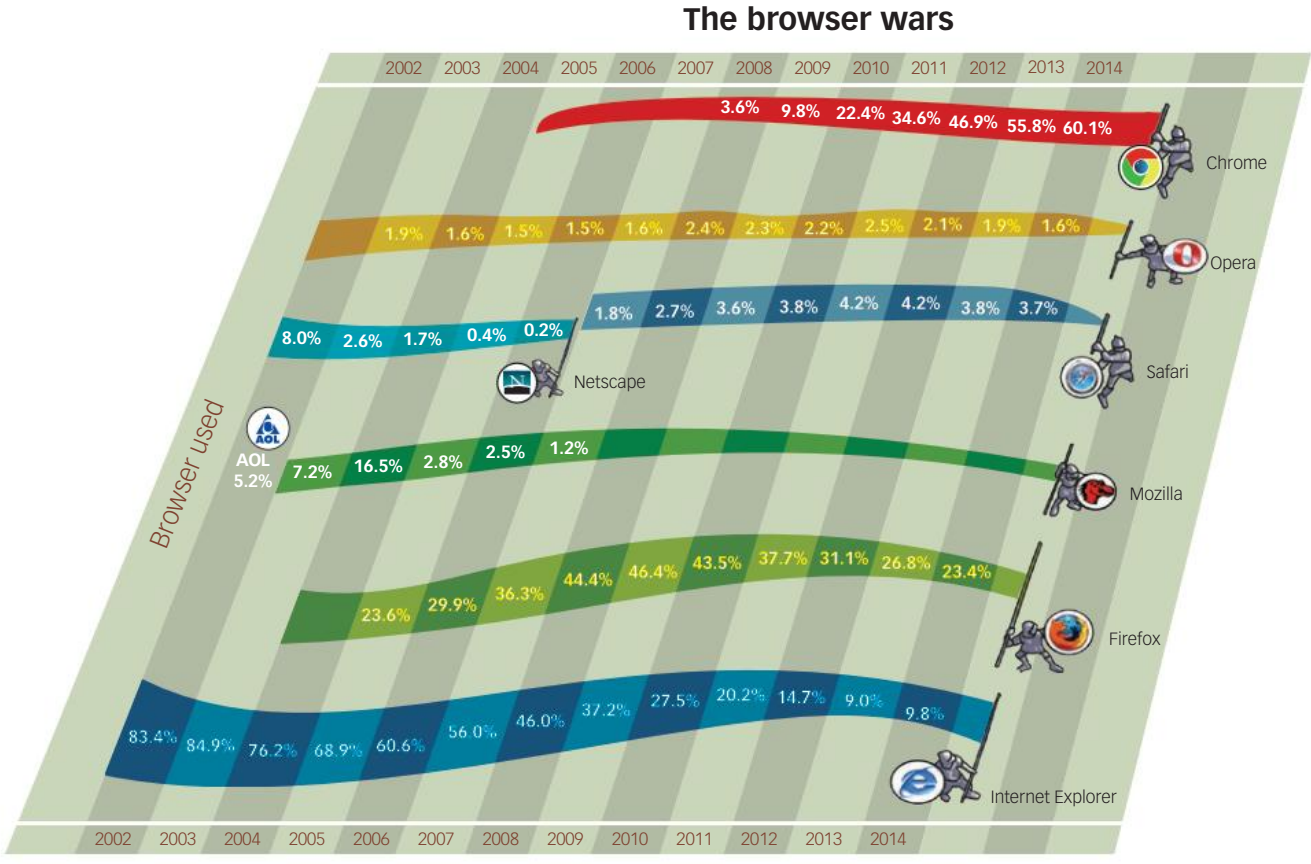
Marc Andreessen, who founded Netscape, created Mozilla™, the first web browser. A browser has one central function – to interpret the coding language HTML in order to display the text, graphics, movies and animations it contains, and to enable the interactivity of hypermedia. It places these elements within the browser window in their correct positions and often calls on helper applications or plug-ins to assist in the delivery of sound or animations the browser cannot recognise on its own.

Common browsers include Chrome, Explorer, Firefox, Safari and Opera.

As browsers have evolved, some have become complete sets of software that allow users not only to view web pages but also to create them, to enable videoconferencing and to double as email software. As the central communication tools of the Internet, they have become so sophisticated that it is sometimes difficult to tell if we are using the Internet or are looking at our own computer desktop. A further development involves operating systems themselves, which are trending towards full online integration with the web.

Before this becomes a reality, however, it is necessary for users to have a semi-permanent fast connection to the Internet. Broadband and wireless both meet this need.

Markup languages such as hypertext markup language (HTML) are not complex programming languages. They use paired tags (see figure 12.30) to describe how the content of a page should be displayed. It is common for HTML to be created using a text editor or word processor only, although special HTML software can assist greatly.



Source of statistics: http://www.w3schools.com/browsers/browsers_stats.asp

Figure 12.25 From these statistics, collected from W3Schools' log-files, you can observe the trends of browser usage. Today, Google Chrome, Firefox and Internet Explorer are the most popular browsers.

Web browsers can also be extended to use other features not available by using HTML, but using scripting languages such as JavaScript™, ActiveX® and XML (extensible markup language).

With the addition of plug-ins, browsers can be enhanced even further to read Adobe's PDF files, play movies, view Flash (SWF) animations, stream sound and video and much more.

We look at both browsers and the web in more detail later in this chapter.

To understand the way coding works in a web page, you need to understand each of the following sections.

Markup languages

It is possible to create a website using only HTML code. It is not the purpose of this text to teach HTML coding, although we will introduce you to the basic concepts involved. Your teacher may give you a more in-depth understanding than is covered here.

Here is an example of one line of HTML code:

```
<h3>My first web page</h3>
```

So what do '<' and '>' do? They are known as tags. For example, the <h3> tag means text in style h3, and the </h3> tag ends this style. You will be able to guess the meaning of most of the tags in the following task example.

Websites can be created by typing tags and coding entirely in HTML, although today there are programs that automatically create the correct tags when the author makes selections from a menu, in the same way as formatting in a word processor such as Microsoft Word.

Dynamic HTML (DHTML) is really a family of technologies working together to provide features unavailable in static HTML pages. For example, using DHTML it is possible to have an animation begin after a given number of seconds following the loading of a page, without the server needing to be contacted.

The web is changing rapidly. Web pages are being delivered to many types of devices apart from the computer and are being used for many purposes apart from straight text. For example, there are no HTML tags for footnotes and other specialist features required by lawyers, architects and the medical profession.

XML allows programmers to create their own definitions for tags for different purposes so that just one XML-coded page can be delivered to different devices in very different forms.

A computer browser would expect HTML, a mobile phone would expect WAP (wireless access protocol) and a hand-held device would expect a clipped web page. XML can take care of these separate needs.

Style sheet languages

HTML tags were used in the past to describe every detail of how each part of a web page looked. Cascading style sheets (CSS) now take care of these details by defining styles for different parts of a page.

CSS allows a web page designer to attach a style sheet that lists such things as font size, font colour and text alignment. This additional information is kept in a special area in the document and can be ignored if desired, or replaced by a user's own style sheet.

Visually impaired users can take advantage of this by enlarging font sizes and using special colours.

Plug-in technologies

A plug-in is an application built into a browser or added to a browser to enable it to interact with a special file type. The Flash plug-in allows Flash animations to be viewed in the browser, known as SWF files (pronounced 'swiff').

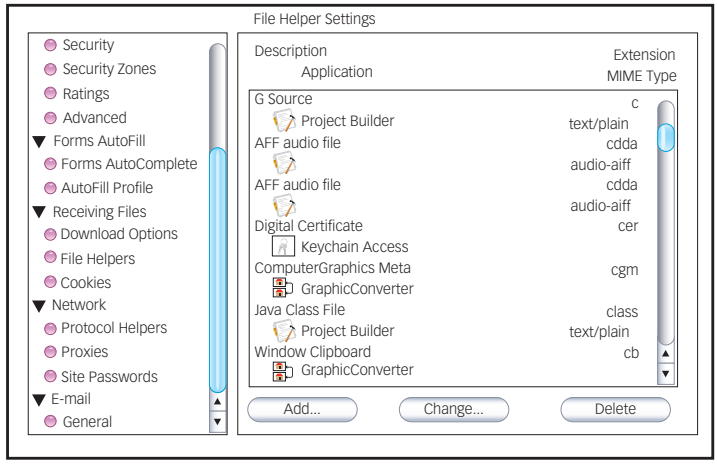


Figure 12.26 Plug-ins add functionality to browsers. This is a selection of browser plug-ins in a preferences panel.

Client-side scripting

Client-side scripts run on the user's computer. JavaScripts add functionality to HTML pages, such as changing an image in some way when the mouse rolls over as a cue to the user to click on the image.

Java applets, although different from JavaScript, are another form of client-side scripting that can be used to provide complex interactions with web pages.

Server-side scripting

Server-side scripts run on a server hosting the web pages. The need to extend the interactivity of web pages has led to the development of other languages such as PHP that allow dynamic web page features. The letters originally stood for Personal Home Page, and PHP is now widely used. Facebook, Wikipedia and Moodle all use PHP scripts to present their pages to the user.

Database technologies

Often a database needs to access data stored in databases. The SQL (pronounced 'see-kwel') language adds this feature and is another example of server-side technology.

HTML5

The development of HTML5 will mean less need for third-party technologies using plug-ins to play various file types, such as the Flash plug-in. Instead, the web page itself will handle these. HTML5 is designed to make it easy to use multimedia and graphical content as well as to work smoothly with mobile devices. Many features have been built especially for devices such as smartphones and tablets, which original HTML was never designed to support. HTML5 also adds video and audio support without the need for plug-ins, as well as vector graphics, drag and drop, a canvas element (for drawing bitmap graphics) and mathematical formulas.

Go to http://infosoftwaretech.nelsonnet.com.au to link to Andrew Hoyer's website. Scroll down, click on titles and try these. Start with cloth simulation and numbers to words.

Weblink

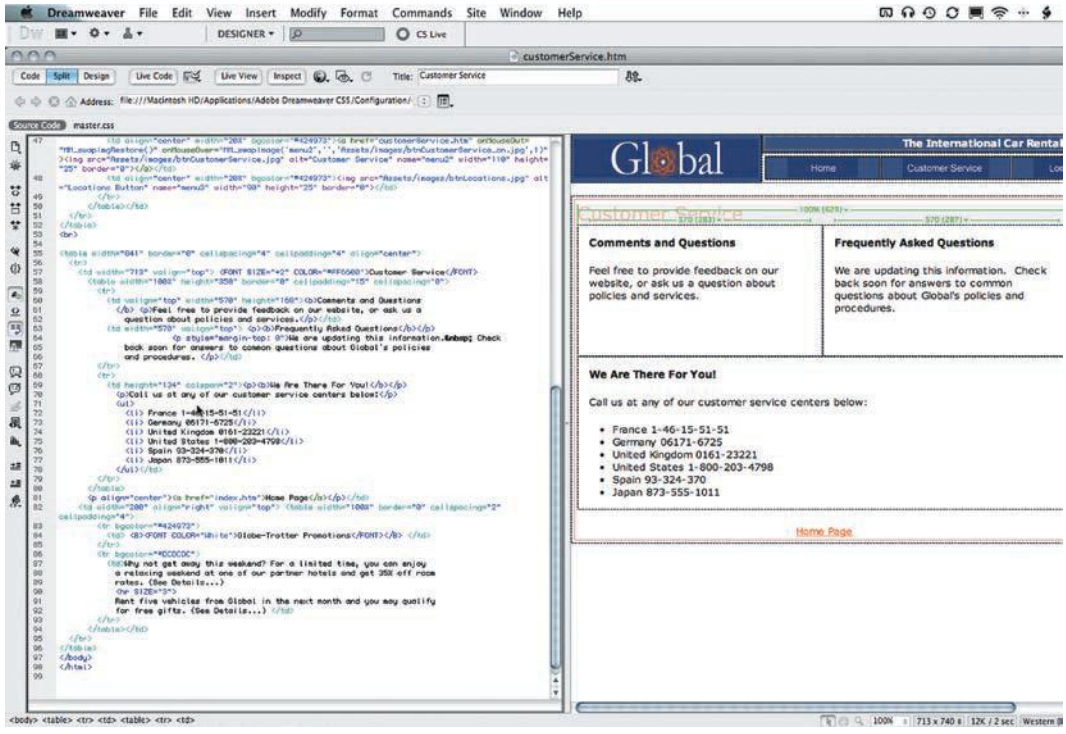


Figure 12.27 Adobe's Dreamweaver interface, showing the split design and code views

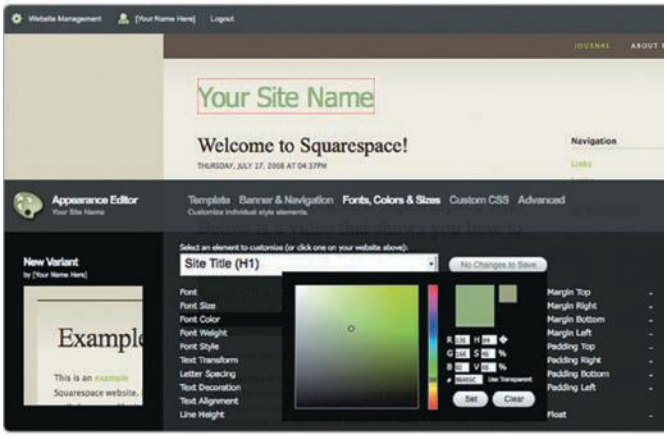


Figure 12.28 Squarespace is an example of a growing trend: an online website design environment rather than a desktop application that allows users to customise professionally designed templates in order to build a site and have it hosted.

Website design tools vs authoring software

Website design tools such as IM Creator and SquareSpace (see figure 12.28) allow users to create a professionally designed website and have it hosted, without any need to code. The designer is limited to the built-in tools, but for most websites, these tools provide all the features required.

Professional website authoring software, such as Dreamweaver, offer more control over a web design. They can be used simply; however, to take advantage of them the author needs to master HTML coding and other web-based coding languages.

The more advanced authoring applications assist the designer to manage their whole site, checking for inconsistencies in links and generating a diagram of the structure of the site.

TASK 5

HTML coding

1 Create a simple unlinked web page using a text editor and HTML coding. You will check this simple web page by opening it up using any browser, such as Explorer or Safari.

a Open your text editing application and type the following code exactly as it appears.

```
<html>
<head>
<title>My first web page</title> </head>
<body bgcolor="#FFFFFF"
link="#FF0000" vlink="#00FF00">
<h1 align="right">This is where you type text
for your page</h1>
<hr>
<center>
<h2>Headings can be in different sizes</h2>
</center>
<div align="right">Look at what this tag
does!</div>
<a href="http://www.boardofstudies.
nsw.edu.au/"> Clicking these words</a> will
take you to the Board of Studies website, if you are
online. This link should be red if you haven't visited the
BOS site and green if you have. Examine the HTML
code to see if you can tell why this is so.
</body>
</html>
```

b Save your file and call it 'index.html', as this is the commonly accepted name to use for the main page or home page of a website.

c Close your text editing application.

d Open a browser, such as Internet Explorer, Safari or Firefox. Go to File and select Open File …

e Locate your saved text file 'index.html' and open it.

f Find the words 'My first web page' and, if you are connected to the Internet, click the coloured words.

g Identify what each of the tags in the HTML code does.

2 One of the best ways to learn HTML coding and other web-based languages is the W3Schools website. Go to http://infosoftwaretech.nelsonnet.com.au to link to the website. Complete the integrated HTML tutorial.

Weblink

INFOBIT

Scientists set an Internet speed record by sending two movie-length DVDs of data across the Atlantic in less than a minute – more than 3500 times faster than broadband. This took place on Internet2®, being developed in the United States. Australia's Internet2 link, GrangeNet, was launched in 2002.

ACTIVITIES

Identify

1 What does a browser do?
2 What is the most popular browser at present?
3 What is a markup language?
4 What are tags?
5 What is the difference between an online web design tool and a stand-alone web authoring application?
6 Why do you think Dreamweaver allows you to view two panes at once, one showing the HTML code and the other showing the WYSIWYG (what you see is what you get) layout?
7 Write a one-sentence description of the languages discussed in this section.

Analyse

8 HTML is described as being a markup language using tags. Describe how these tags work and give an example of how they would create text that is a centred heading.
9 Load a fairly simple web page and find out how to view it in your browser as 'source' code (this is a choice available in the menu of most browsers). Print this code and identify at least five different paired tags by using a pen or highlighter to identify the text they surround.

Investigate

10 Find three websites using three different non-English languages. By using the web, find out how your computer represents these characters if they are not resident in your operating system.
11 Use Google's translation service to translate a web page into another language (paste its URL) and then copy and paste some of this to translate it back again into English. How accurate was it? (Go to http://infosoftwaretech.nelsonnet.com.au to link to the Google Translate website.)

Weblink

12.6 Types of Internet protocols

The Internet is not just one protocol. There are over 100 protocols, or agreed standards, which all work together to allow computers to communicate. There are three very common protocols you will use often: HTTP, SMTP and FTP. These are better known by the more familiar terms of web, email and file transfer respectively.

The World Wide Web Consortium sets the standards for web protocols so everyone agrees on how a sent message should look. Email messages need to be sent by different rules to a web page.

Transfer protocols

Although we have already encountered the transfer protocols in sections 12.2 and 12.3, we will summarise them here.

HTTP is the underlying protocol used by the World Wide Web. It defines how messages are formatted and transmitted, and what actions web servers and browsers should take in response to various commands. For example, when you enter a URL in your browser, it sends an HTTP command to the web server, directing it to fetch the requested web page.

SMTP controls the delivery of email. Most email systems use SMTP to send messages from one server to another. The messages can then be retrieved with an email client, using either POP or IMAP. SMTP is also used to send messages from a mail client to a mail server. This is why you need to specify both the POP or IMAP server as well as the SMTP server when you configure email on your computer.

FTP is an Internet protocol that allows the upload and download of files to and from other computers on a network. The files can be:

- programs to run on the local computer
- graphics
- sounds and music
- video
- text files.

Very often downloads are restricted to those who have authorised accounts and require a name and password. Other sites allow access to public domain software or freeware and shareware programs. To save space on FTP servers, large files are often compressed. To upload files that are necessary for a personal website, many web servers require the use of FTP programs to complete the task. When you add an attachment to an email, you are using FTP.

Communication protocols

You may have heard about TCP/IP, which every computer using the Internet needs, and imagine it to be one protocol. In fact, it consists of two entirely separate protocols.

The most basic is Internet protocol, which defines the address of a computer on the Internet. Each computer is issued a unique number, known as an IP address. This may be a permanent one issued by a network administrator (static addressing) or it may be dynamically issued by a remote server at the start of each session you have on the Internet.

This address is four numbers separated by full stops; for example, 128.254.241.147.

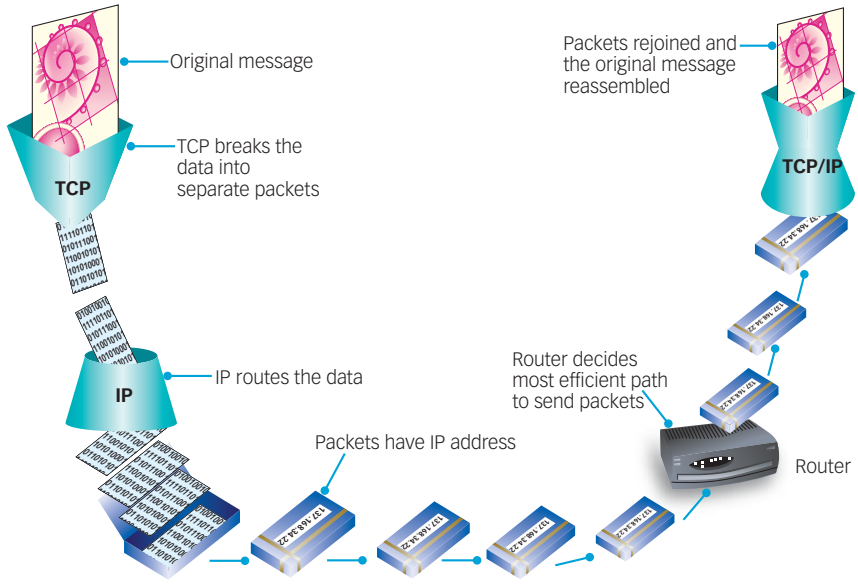


Figure 12.29 A message is divided into separate packets to send over the Internet, and is rejoined at the receiving end.

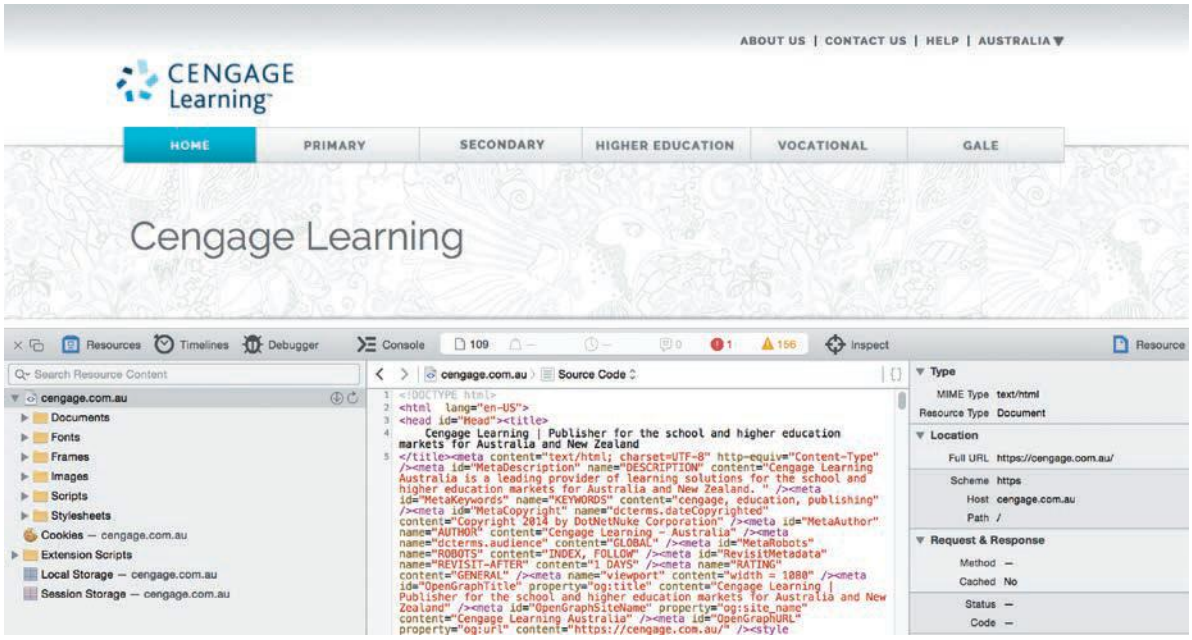


Figure 12.30 An example of a web page and part of the HTML code from which it was generated. Select 'View Source' on your browser to see the code for any web page.

The other Internet protocol is transmission control protocol, which defines how two computers on the Internet exchange data. When your browser shows status information such as 'contacting server' and 'receiving data', it is TCP that is at work.

What is a packet?

Every email you send travels as a series of packets and every web page that you receive comes to you as a series of packets.

Messages to and from your computer are chopped into smaller pieces called packets. Every packet contains fewer than 1500 characters, due to the limitations of hardware. These packets are sent around the world via the best available route so that the network is not clogged at any point and the packets are put together again at their destination, ready to be viewed (see figure 12.29). The packets do not travel together, but are regrouped at the end of their journey using the information in the packet.

This could be compared to thousands of cars in a city carpark leaving at the one time and by the same route in one very long line to get to a single address. The trip would be slow and the route congested. Instead, it would be better if all cars travelled many routes and joined up again at their destination.

INFOBIT

The world is running out of available IP addresses for use on the Internet. The current version is IPv6. IPv6 is managed by the Internet Engineering Task Force.

Networks that send data in packets are known as packet-switched networks. Each packet indicates the sender's IP address, and the IP address of the receiver, along with the total number of packets and the number of each packet.

If it is a web page being delivered, HTTP will be active only until your computer receives the page. The TCP/IP connection, however, will continue to be active until the user logs off the Internet.

ACTIVITIES

Identify

1 What is the function of a packet?
2 Describe the functions of each of the following: HTTP, SMTP and FTP.
3 What two protocols are defined by TCP/IP and what are their purposes?

Analyse

4 What is the function of the protocol HTTP?
5 Why would the transfer of computer file attachments require a separate protocol, such as FTP, rather than being sent as email?

Investigate

6 Find out the historical order in which each of the following Internet applications was invented: web pages, email, newsgroups, file transfer.
7 The IP address of a computer is four numbers separated by full stops; for example, 128.254.241.147. These numbers are now running out and a new system called classless inter-domain routing (CIDR) is being introduced. Use the web to find out how CIDR addresses work.

12.7 The World Wide Web

One thing that has made the growth of the World Wide Web so rapid is the fact that so many people have contributed to the total information it contains. One person may prepare a web page about the Industrial Revolution for their university lectures and another might provide a link to this site from their course notes in another country. In this way, the web continues to grow.

No one group could have achieved this result and no government controls its content, although some limit their citizens' access to areas of the web they believe are unsuitable.

Web pages

A web page is a hypertext document written using HTML code similar to the example studied earlier. It is located on the Internet using its uniform resource locator (URL), which is an address that defines the route to obtain the page from a specific server.

The main parts of the URL are the:

- transfer protocol – the transfer method used to access a particular resource on the web; for example, http://
- domain name – the address of the specific computer where the resource is located (the domain name can be replaced by a numerical IP address)
- file path – the full path to the file to be retrieved; it may be a simple filename (for example, gateway.html) or a directory path (for example, contactus/email.html).

The domain name and the file path are separated by a forward slash ('/').

The URL must be exact in order to find the resource. Web browsers have the ability to store the addresses of websites as bookmarks or favourites. Sites can also be saved and retrieved using web-based software such as that found at the Backflip website.

To obtain a URL, the following sequence occurs:

1. The browser sends the textual domain name to a DNS server to determine the numerical IP address for the host computer that will supply the web page.
2. The browser builds a request for the page that includes the port address of the server, a description of what is requested and a return address.
3. The computer that is running the browser transmits this message onto the Internet, which routes it to the server that will supply the web page.
4. The server processes the request, sometimes returning an existing page and sometimes building a new page.
5. The server sends information back to the user's computer via the Internet.
6. The browser displays the web page.

Hyperlinks

It was during the late 1960s that Ted Nelson first thought of the idea of words with attached explanations. Later, Tim Berners-Lee imagined that documents might be able to be linked electronically (hyperlinked) to help researchers.

Instead of an index that exists separately to the text, he imagined an index that was part of the text itself. Important words could act like buttons and when pressed would take the reader on a journey where they could read more.

A reader of Australian history could press the words 'Governor Macquarie', for example, and they would be taken to a page with more detail. They might become interested in his influence on the architecture of early towns such as Windsor. They might then click on 'Windsor' and read about the architect John Watts. HTML usually presents these links as blue underlined words, but they may also be images or icons. When a mouse is clicked over these areas, a request is launched for the linked item, which is then delivered for viewing.

INFOBIT

WWW, with nine syllables, is the only acronym that takes longer to say than the words for which it stands!

Site	Sydney Opera House
Overall design and layout	Logical, good use of colour, especially backgrounds
Internal links	Clear and consistent, navigation logical
External links	Yes (a few)
Frames	Yes
Digital media	Text, graphics (2D bitmapped and vector), audio, animation, movie
Plug-ins used	QuickTime®
Audience/purpose/ Is purpose fulfilled?	Adult and young people/what's on/ introduction to building
Content/Is it effective?	

Figure 12.31 Create a table like this one to help you evaluate websites.

TASK 6

Browsing the web

As preparation for designing your own website, you will browse a range of sites that meet very different needs.

You will examine:

- overall layout and graphical user interface (GUI) design
- internal links
- external links
- digital media types used (for example, graphics, movies, sound, virtual reality)
- plug-ins used.

You will also make decisions about the:

- audience
- purpose of the site and whether this is achieved
- content and the site's effectiveness overall.

1 Draw up a table using Microsoft Word or another word processor, with a separate heading for each item listed above in the task description.

2 Examine each of the following websites (do not restrict yourself to the home page only) and complete your table under the headings you have listed, using one or two words. We have completed one for the Sydney Opera House website as an example (see figure 12.31).

a Catch up on today's news at the *Sydney Morning Herald* website.

b Research something relevant to your education at the NSW Board of Studies website.

c Visit Adobe's Kuler colour selection website.

d Find out about politics in your own electorate at the NSW Parliament website.

e Visit ABC iview.

f Create your own newspaper using one of the many online websites.

g Type the following search keywords – sine, wave, tone, generator, lab – and see if you can find a website that will allow you to make music!

h Finally, experience amazing language translation at the Babel Fish website.

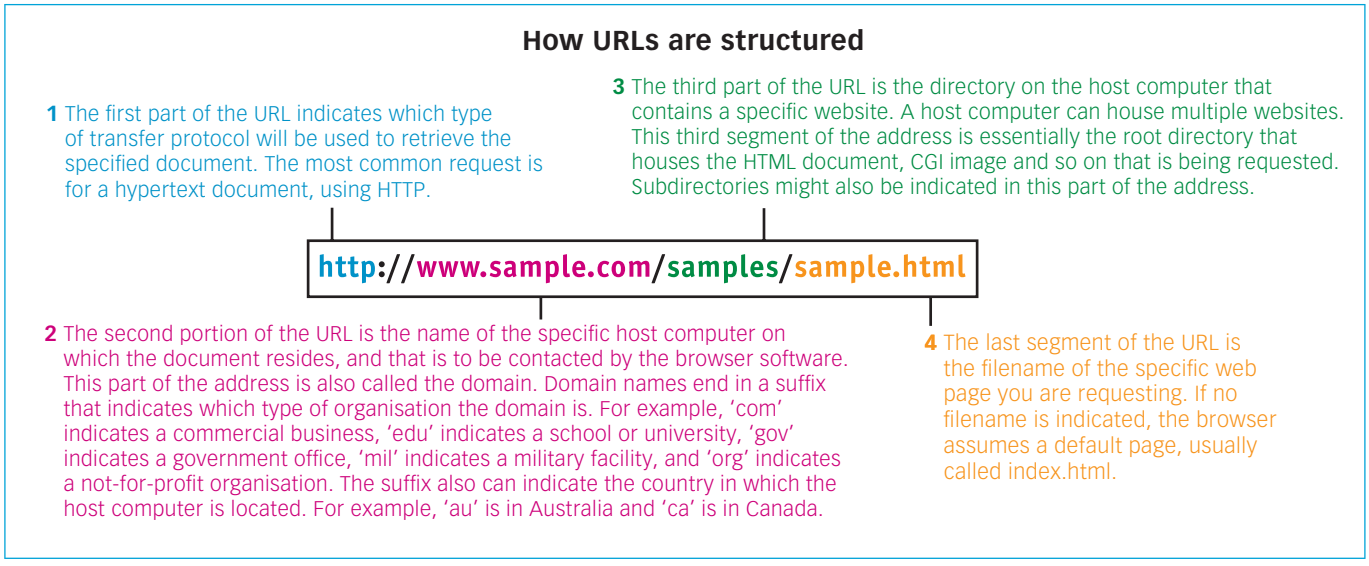


Figure 12.32 A URL dissected

ACTIVITIES

Identify

1 Identify four features that make a web page different from a printed book.

2 Identify four features that make the Internet different from a library.

3 Describe the parts of a URL.

Analyse

4 Outline the steps computers take in locating a particular web page using its URL.

Investigate

5 Interview a relative or friend who is over the age of 70. Ask them questions about the World Wide Web and the Internet. Ask if they have ever used the Internet. If not, ask why. If they have, ask what they use most often. The class can compare summaries.

6 Find out who or what manages the Internet.

12.8 Control of access to information

The Internet provides some wonderful tools that have given us easy access to vast amounts of information and fast communication. However, it has also introduced many challenges in the areas of security, privacy, copyright and accuracy.

Cookies

A **cookie** is just one or more pieces of information stored as text strings on a user's computer. It is used to keep track of data needed in the future. A web server sends a cookie and the browser stores it. The browser then returns the cookie to the server the next time the page is referenced. Usually the cookie is used to store a user ID; for example, ID=98743523.

Filling in a form for a purchase on the web may result in an ID being created. The next time you purchase from the same online store, the cookie may be returned to the server to customise the web page so it can welcome you by name. It is possible to find the cookie files on your local hard disk and see the text strings they contain.

Using a database to store a unique ID number in the cookie allows websites to accurately determine the number of visitors by counting those who return more than once and also which parts of a website are visited by which visitors. There are also providers that can gather so much information from multiple sites that they can create very accurate descriptions of our individual tastes, health, habits, job and political views.

The risk posed to privacy of linking data-rich profiles and personal information is great.

```
# RealMedia Preferred Transport File
# This is a generated file! Do not edit.
localhost        1   0   2   31   0
localhost        2   0   1   31   0
abc.net.au       2   2   0   0    1054684608   0   0
```

Figure 12.33 Example of a cookie

Security

Encryption

Encryption techniques prevent unauthorised access by changing data into a form that is unreadable without a 'key'. One area where this is very important is when you need to transmit your credit card number to make a purchase. The security of e-commerce on the Internet is vitally important to the continued success of online shopping and banking.

Proxy servers and firewalls

A proxy server is a computer used to block access to sites or cache (store) frequently used data. A proxy server may be implemented to control all communications so that the server carefully screens all messages. Proxy servers act as **firewalls**. These are a security device that is used by companies to prevent access by those outside the company, and may be either hardware or software.

A cable or ADSL connection allows a home computer to have a permanently open connection to the Internet, but allows greater access to your computer from outside. A hacker can leave a virus or other software code on the computer that can be activated at a later date.

A firewall monitors transmissions and can inform you if there are any unwanted intrusions.

Virus protection

Computer viruses can spread when you:

- launch an infected application
- use a disk that has infected files
- open an attachment that has been infected
- download from the Internet.

Some viruses are programmed specifically to damage the data on your computer by:

- corrupting programs
- deleting files
- erasing your entire hard disk
- sending an infected email to everyone in your address book.

If you wish to remove viruses from your computer, or if you suspect that some damage may have been done by a virus infection, then disinfectant or antivirus programs can be purchased that scan your hard drive looking for small fragments of code they recognise as part of a known virus. Once a virus has been identified, these programs can eliminate the virus and often repair the damaged files as well.

Virus protection should be installed on your computer to check downloads and incoming emails to protect your computer system. The software should be able to update itself or be regularly updated by the user to detect new viruses automatically.

Using the Internet safely

Cyberspace is part of real life and therefore some of the dangers that exist in our local environment also exist on the Internet.

Strangers that you would ignore on the street appear harmless on the Internet because their real persona is not visible. Chatting with strangers, instant messaging or emailing them online is therefore not a good idea.

Although messages may sound friendly and harmless, you can't see or hear the other person. This means you cannot tell if the person is who they say they are, which can be dangerous if the person is lying. To protect yourself, never give out your address, telephone number, password, or any other personal information. You should not use a screen name or nickname with your name in it; for example, it is better to use '1hello23' as a screen name than 'summer_kelly'. It is important for your safety to keep all personal information safe.

Meeting with a person on the Internet, or trading photos with someone you do not know, is not safe. If anyone suggests that you meet or exchange photos, you should not do so, but tell a responsible adult immediately. The photo they send may only be of the person that they have created for you!

Chatting to people all over the world or just down the street is a positive feature of the Internet, but care needs to be taken. If a problem occurs, check with an adult, who can decide what to do. Some solutions may include changing your email address or telling the police.

Another issue for parents and other responsible adults is the level of access they allow their children to the vast uncensored world of the Internet. As the Internet is largely uncontrolled, there is some pretty nasty material that many psychologists believe can be very harmful. Violent and explicit material can be controlled by ratings services as well as commercial software.

You have probably heard the phrase 'too much information!' That can certainly be true of the Internet.

There is a danger for some users who spend many hours online gaming that it will become a form of addiction and their relationships with family and friends will suffer.

Digital certificates

These are issued by organisations known as certificate authorities. The user requests a certificate with the user's name, a serial number and the issuing authority.

Certificates can then be used to verify that you are the person you claim to be in any transaction. Usually these certificates are stored on your computer.



CyberSmart

Figure 12.34 The CyberSmart website encourages cyber safety for students.

Truth and the Internet

The Internet abounds with information on a variety of topics from a number of sources, but not everything is true. The stories of the Californian Velcro® crop, with accompanying graphs and statistics, and spaghetti harvests are examples. The moral: you cannot believe everything you see on the Internet.

When you use the Internet for schoolwork or personal interest or for researching information, be careful. What you are reading may have no authority (or truth) at all. Users often put too much trust in unmoderated online encyclopaedias, such as Wikipedia. Always find out the credentials of the author(s).

As proof of this, check out the Museum of Hoaxes on the web.

Copyright

Those who create a web page usually own the text, graphics, photos, sound, videos and clip art used. Just because they are available on the Internet does not make them yours to use freely.

The Australian *Copyright Act 1968* (Cwlth) controls what copying is permitted. Educational institutions and government departments pay a fee to the Copyright Agency Limited (CAL) for making copies of material and these are distributed to authors and publishers.

Sites are often happy for information to be used by educational institutions for non-profit purposes, providing they are asked for permission.

Privacy

If someone working for an ISP wished to blackmail any person, they would have available more data in digital form than would ever have been available to them in earlier years via telephone taps and mail interception.

If you use the Internet regularly for your day-to-day affairs, and especially if you engage in research or e-commerce, the opportunity exists for your personal preferences, your financial circumstances, the names of family and friends and many other personal details of your life to be collected by others.

The *Privacy Act 1988* (Cwlth) and the NSW *Privacy and Personal Information Protection Act 1998* have been created to protect you against the unauthorised collection or misuse of your personal details.

INFOBIT

People in bushfire-prone areas can now use the Internet to view fire activity in their area. The images come from two NASA satellites orbiting the Earth. The website is available to the public and can support 80000 visits at the peak of the fire season.

APRIL FOOL'S DAY, 1957: THE SWISS SPAGHETTI HARVEST

On 1 April 1957, the British news show *Panorama* broadcast a segment about a bumper spaghetti harvest in southern Switzerland. The success of the crop was attributed to an unusually mild winter. The audience heard Richard Dimbleby, the show's anchor, discussing the details of the spaghetti crop as they watched a rural Swiss family pulling pasta off spaghetti trees and placing it into baskets.



BBC



BBC

'The spaghetti harvest here in Switzerland is not, of course, carried out on anything like the tremendous scale of the Italian industry,' Dimbleby informed the audience. 'Many of you, I'm sure,' he continued, 'will have seen pictures of the vast spaghetti plantations in the Po valley. For the Swiss, however, it tends to be more of a family affair.'

The narration then continued in a serious tone:

'Another reason why this may be a bumper year lies in the virtual disappearance of the spaghetti weevil, the tiny creature whose depredations have caused much concern in the past.'

The narrator anticipated some questions viewers might have. For instance, why, if spaghetti grows on trees, does it always come in uniform lengths? The answer was that 'this is the result of many years of patient endeavour by past breeders who succeeded in producing the perfect spaghetti.'

Source: http://www.museumofhoaxes.com/hoax/archive/permalink/the_swiss_spaghetti_harvest

Figure 12.35 The great 1957 spaghetti harvest. Find it on the web!

Equity

CORE ALERT Issues

Not everyone has equal access to the Internet and not everyone has the skills to use the sophisticated techniques needed to efficiently access that information.

Some people cannot afford an Internet connection or a computer. In rural areas and some countries, communications networks may be unreliable or non-existent. Other users may not be able to easily access information because they have a disability.

These are examples of equity issues: the principle that all people should as far as possible have equality of opportunity.

If such principles are not valued in society, then people with money or educational opportunity may be the only ones with access to information and thus to positions of influence and power.



Michael Leunig

Figure 12.36 Leunig's comment on social networking. What is your view?

ACTIVITIES

Identify

1 What precautions need to be taken when using the Internet?
2 What is a cookie?
3 What is a firewall? Does your school's network exist behind a firewall?
4 What is encryption?
5 What is a proxy server?
6 What is a digital certificate?
7 What is equity?

Analyse

8 Examine your school's website using the same headings you used in task 6 on page 249: content, overall design, links, use of frames, digital media used, coding and plug-ins used, audience and purpose.
9 Develop a 'stranger danger' strategy for users of the Internet between the ages of five and eight years.

Investigate

10 Investigate encryption and explain the differences between a public and private key in encryption.
11 You have asked your parents to make a purchase for you through an online store using their credit card. In 200 words, discuss the issues involved. Describe the positives and the negatives of such a purchase.
12 Investigate one issue of privacy concerned with the Internet that has been taken to court in Australia in the past five years. In less than 200 words, summarise the final court judgment.

12.9 Website development

CORE ALERT Projects: design, produce, evaluate

Before developing a website, it is important to know why it is being built. Clearly define the purpose of your website and determine the audience for whom the site is intended. These early decisions will affect most of the decisions you then make during the development of your website.

If you are working as a group, everyone must have the same vision and concept. It is worth spending time talking together to make sure this happens.

Design

The design should be determined by the impression you wish to create. Is the site aimed at a professional group? Is it to look fun or serious? Is it to be static or interactive?

The website should be designed on paper first by creating a storyboard that indicates clearly the content, the design and the navigation.

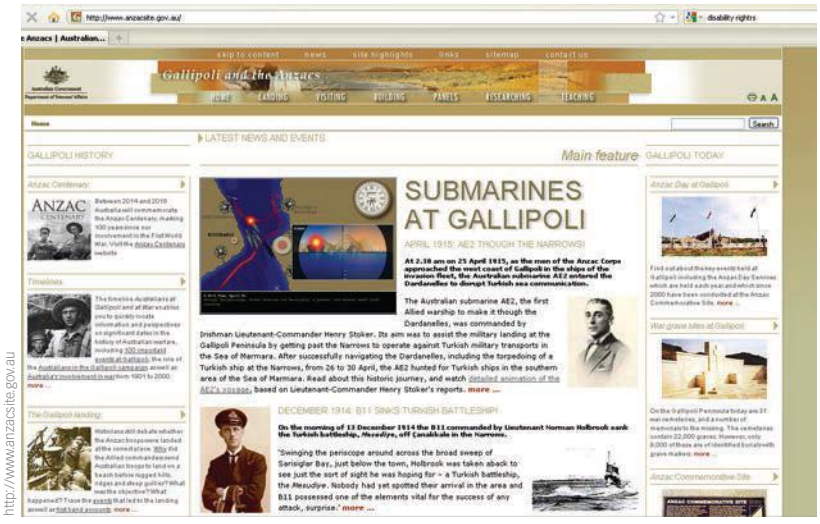
You should think about:

- text
- colours
- navigation
- theme (the same theme or different themes throughout)
- graphics, animation and music
- interactivity
- use of videos and sound
- use of graphics and photos.

Most important is the text that will appear on your website. The information should make the visitor want to return, the site should add value and should be clear as to the nature of the content included. The language you use should suit your target audiences, as should the number and type of images used.

In the design process, attention should be given to the following:

- the site should be accessible to everyone
- the download times must be acceptable on the slowest modems
- navigation should be easy, and should follow the same logical pattern on all pages in the site
- the site should be user-friendly
- animations and any other bells and whistles should be used with moderation
- your honesty and professionalism.



http://www.anzacsite.gov.au

Figure 12.37 The Gallipoli and the Anzacs website, an example of a well-designed and clear interface. Its stylish yet conservative appearance is appropriate for the subject. Browse the web and identify three other websites that are well-designed but use completely different styles.

Collecting content and building the website

Research the material for your website using standard search engines, books, magazines and interviews. Note any links to other sites you want to provide to your visitors.

Create and collect graphics and other media you will use.

Hyperlinks should connect the home page with other pages throughout the site. Links should be available on all of the pages within the site to enable the users to find their way back to the home page.

Images generally enhance a web page, but it is important to keep the overall download time for each page to a minimum by choosing the correct file format and checking on the size of the graphic. Long download times will frustrate users.

Photographs should be saved in JPEG (Joint Photographic Experts Group) format and other images as GIFs (graphics interchange format).

If you decide to include special files, it is wise to provide a link to users to allow them to download the required plug-ins.

The home page

A home page is often called the index page and the convention is to name it index.html. It is the first page a visitor meets on your website. The page is the introduction to the site and should explain clearly the contents of the site.

Most ISP server software is designed to automatically open the page having this filename first.

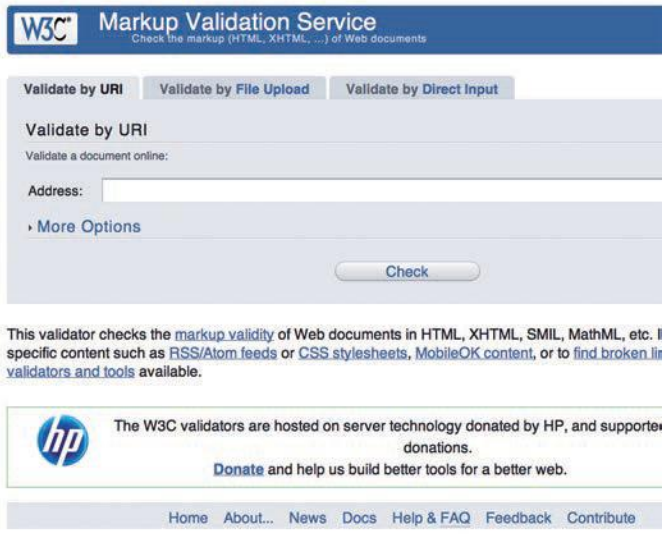
The page should be quick to load, so that the visitor does not decide to go somewhere else, and should act as a table of contents so they can be helped to find their way around the site.

Testing and validation

Websites need to be tested regularly during development. HTML describes how a page should look, but browsers sometimes interpret the instructions differently.

Validation involves making sure that the data is accurate and complete. Spelling and grammar can be checked using software, although many spellcheckers default to a US English dictionary, so care must be taken. The site should be checked manually by proofreading, checking grammar, spelling and punctuation, and for errors where the spelling is correct but the word is not used in the correct context. Manual proofreading also allows for the accuracy of the information to be checked.

The manual checking of websites must also include checking that all the links work, that the pictures load quickly, and that the information looks the same on a range of browsers and platforms.



W3C validation site, site-comments@w3.org

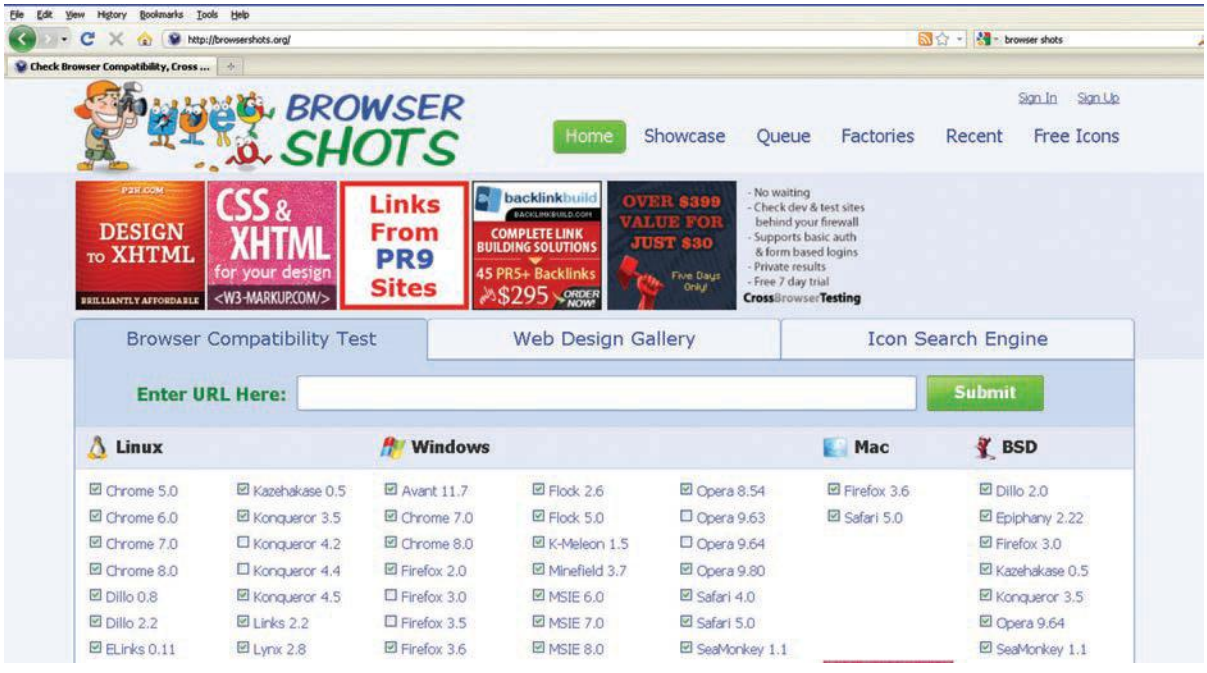
Figure 12.39 You can test any website using this W3C validation site to see how accurately it has been coded. Go to http://infosoftwaretech.nelsonnet.com.au to find the link.

Weblink

Maintaining a website

Websites should not just be uploaded and left alone. They need to be maintained regularly. Some sites need to be updated continuously during the day, as in the case of news and current events; others need only be done daily, weekly or even monthly. Maintaining may mean updating information and/or images by uploading and replacing existing files. Your website should have a 'last updated' date on the page to indicate how old the information is and sometimes it is appropriate to include a counter for the number of visits.

A site might even be totally redesigned as new features or plug-ins become available.



http://browsershots.org/

Figure 12.38 This website creates screenshots for any given website showing the way it will appear in many browsers.

Review questions

12.10 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: Internet overview website

Your task is to design and produce a website describing the Internet.

Overview

Use the following headings, each of which represents a single page on your site.

- What is the Internet?
- History of the Internet
- What is the Internet used for?
- Connecting to the Internet
- Email, newsgroups, chat, World Wide Web
- Browsers
- Internet protocols
- Security and privacy issues
- Imagining the future
- Frequently asked questions (FAQs)

You can use WYSIWYG web page design software, HTML hand-coding or a mixture of both to create the website.

Your teacher will instruct you about whether to use an individual or team approach.

Follow the stages for the process of website development outlined in section 12.9. Reread this earlier section and make notes of the main tasks in each stage.

Note: The following steps are written for a team. If you are working alone, interpret all these as referring to yourself.

Defining and analysing

1. Form a team of students to complete the project. Try to select team members who have the various abilities needed in design, research, software, organisation and so on.
2. Write out and agree on a statement describing clearly what you understand the project above is asking.
3. Suggest additions to the requirements, or perhaps parts that cannot be completed by your team.
4. Print your statement.
5. Have your teacher approve your final written statement by initialling it. This sheet will form the first part of your documentation for the project.

Designing

1. Have a team meeting to decide on the software you will use for your project. You may not have a choice here, as the available software may be limited.
2. Construct a careful storyboard for your site and print it out. Have each member colour-code the parts for which they will be responsible and write their names on the sections they will complete. The person creating the home page is to be assigned the task of creating all links to the group's home page.
3. Work out the number of days you will allow for each of the stages of the project so that you can complete it with time to spare. Do not forget to allow time for careful testing.
4. Design a template so that the separate pages will have a consistent layout.
5. Each person begins research to find the audio, graphic, video, animation and text content, and begins creating pages.
6. Create or acquire the required text, audio, graphics, video and animation. Agree on your collection of FAQs and write answers to them. Change these items into the formats required by your software.
7. Meet regularly to check progress.
8. Decide how the final project will be tested.

Producing

1. Create a single folder for all your work from this point on. Inside this, create a folder containing all images and other media for your HTML pages.
2. Select your software. Assemble the separate resources created in the last stage into a working product using your software. Test regularly using at least two different browsers.
3. Create and test all links, internal and external.
4. Finetune your site so it works smoothly.
5. Validate your site (see section 12.9).

Evaluating

1. Team members test the project on their own, on more than one browser, and recommend changes.
2. Other users test the project and comment on it. Their comments will mean changes – revisions and improvements.
3. Check content for accuracy (facts, spelling, grammar) and test all links.
4. The team completes documentation on all stages of the process. Include a record of the problems faced,

the solutions found to these and the tasks each team member accomplished.

5 Present your site to the class for final evaluation. Each student can evaluate these presentations by using a spreadsheet to add up the scores for each, and print a final summary by having the spreadsheet total the results. Evaluation should include:
   - overall content
   - overall appearance
   - navigation
   - text
   - graphics
   - audio
   - video and animation
   - use of plug-ins
   - accessibility
   - final proofing (spelling, grammar).

Project 2: Choose-your-own-adventure story

Create a story where the reader chooses the ending.

You are to design and create an interactive storybook for children that is to be viewed on a computer.

Overview

Threaded choose-your-own-adventure stories can be exciting to read. The author puts the reader 'in control' of the plot. One challenge, however, is that every time a choice is given, at least twice as much has to be written by the author!

Find some examples online of this type of story and gather some ideas before commencing this project.

Defining and analysing

1 Read the outline on pages 132–3.
2 Go to http://infosoftwaretech.nelsonnet.com.au. Follow the link to watch and play the Goldilocks game. It was created by a Year 12 student for their Multimedia course major project.
3 Record what you have learnt by this background research.

Designing

1 Create a story of your own.
2 Draw a storyboard that will become a navigational diagram for a website. It is likely to be hierarchical for this type of project.
3 Decide at least two unexpected branching decision points where the user can choose which of two directions they will take in the story by clicking hyperlinks on your web pages.
4 Have the teacher approve the storyboard. Ensure all links are shown clearly.
5 Choose the software you will use.
6 Type up the text using a word processor.
7 Acquire or create any graphics, videos or background designs.
8 If you have created a story using still images, consider adding some animated sequences.

Producing

1 Create all the pages of your website, including all text, images, animations and videos.
2 Create your interactivity by adding hyperlinks and anchors.
3 Create decision points where the reader will choose between two destinations. Each of these will take the story in a different direction.

Evaluating

Perform repeated testing with users and improve your story, repeating the project sequence.

Additional content

WebQuests

A WebQuest is basically an assignment that asks you to work with others in using the World Wide Web to study a specific topic.

The web can be used as a source for simple information retrieval, but this misses its power. In a WebQuest, you tackle questions that encourage more advanced thinking. A WebQuest forces you to transform information into something else, rather than just reporting it.

By breaking a task into meaningful 'chunks', a WebQuest helps you work through the kind of thinking that expert learners would use.

WebQuests usually contain the following parts:

1 A statement of your task, including background information.
2 Sources of information you need to research the task. These could include web pages, email addresses of people who can assist with your questions, searchable databases on the Internet, and books and other documents available to you. It is best not to set off adrift to browse the web aimlessly.
3 Your output. WebQuests can result in a number of different outcomes: a multimedia presentation, an essay, a story, a database, a conversation between two people, a play, a movie, a website or other such medium.

Usually a WebQuest will be a group activity and it will often involve some imagination, such as role-playing.

The following WebQuest is designed to relate to the content of this computing course, although your teacher may choose a different task.

WebQuest: Ethics and digital media

The growth of the World Wide Web has created legal issues that existing laws cannot always solve. Computer ethics seeks to find a balance between the positive and adverse effects of this new technology. This WebQuest provides you with the opportunity to form and express your opinion on ethics in digital media, especially when it comes to downloading copyrighted files from the Internet.

The question

What are the ethical arguments for and against the sharing of digital media?

Your task

Your task in this WebQuest is to form and argue a position on the ethical question of downloading copyrighted material from the Internet. Where do we draw the line between theft and sharing? Through the process of this WebQuest, you will understand how copyright laws, public domain, site licences and shareware work in conjunction with computer ethics.

Objectives

Your teacher will assign you to a team of three to six students. Each student will choose a WebQuest role to play.

- Your team will work together to create a presentation to the class describing the results of your research.
- Your presentation will compare ethical arguments from the point of view of each of the following:
  - film producer
  - artist (movie star)
  - film critic
  - lawyer
  - pirate.
- Each team member must complete both a self-assessment and a team assessment.

Process

This is a cooperative team project and, during the course of the project, you will be meeting with your team often.

Phase 1: Assigning specialised roles

In order to maximise productivity and minimise frustration, it is helpful to assign specialised roles for your team. To begin this WebQuest, hold a meeting of your group and assign each member specialised roles.

These roles are in addition to the normal team roles that each person plays. They should be assigned for each meeting or discussion session. It is very important that these roles be rotated among team members. Note that an assigned leader is not one of the specialised roles. Teams do need effective leadership, but they do not need a leader. It is best if the leaders develop as a result of the team process and change over time.

- Facilitator: It is the responsibility of the facilitator to schedule and manage the meeting.
- Recorder: It is the responsibility of the recorder to keep a record of the meeting.
- Spokesperson: It is the responsibility of the spokesperson to clearly represent team results to the teacher and the class and to act as the team's link with the teacher.

Phase 2: The big picture

Your team will gather to investigate the ethical issues surrounding the sharing of digital media, with the focus on the movie industry. Together, use the Internet to list answers to the basic question. Be creative, insightful and curious as you explore the web for answers.

Phase 3: Digging deeper

Each team member will now take on a role that will explore the ethics of digital media from different perspectives.

Be prepared to summarise what you've learnt to answer the WebQuest from your role's perspective.

WebQuest roles

Film producer: The student or students choosing the role of film producer will form a view about ethics in digital media. Are the current laws adequate to protect their intellectual property?

Artist (movie star): The student or students choosing the role of artist must argue the point that downloading movies from the Internet is wrong and that if people download their work illegally, they are being robbed of the right for payment for their work. The artist believes that all sites enabling the downloading of illegal material should be shut down immediately and their owners sued.

Film critic: The student or students choosing the role of film critic will support the view that everyone in the film industry already makes plenty of money, and that copying and sharing movies for personal use should not be illegal.

Lawyer: The student or students choosing the role of lawyer will look at the problem from the legal angle, answering the question 'What is legal and what is not?' They will listen to both sides of the issue and provide information to fellow team members on past copyright rulings and current issues and legal cases.

Pirate: The student or students choosing the role of pirate will determine what laws they are breaking by providing digital material online without permission. They may argue that if the existing laws are not enforced, why should they take them seriously?

Phase 4: Debate, discuss and reach consensus

Now you should have a team meeting. Each student will participate in a debate while playing their roles. Everyone should be prepared to state their feelings about video piracy, but also be flexible. This is a hotly contested subject in the real world, and will no doubt provoke spirited dialogue in the group.

At the end of your meeting, make a list of steps that must be taken to have your presentation ready by the due date.

Phase 5: The presentation

You may choose any medium to deliver your team presentation. It may be presented as a website, a PowerPoint presentation, a skit, an essay or a narrative story.

Your presentation must define the debate on ethics in digital media, including:

- current laws for protecting intellectual property
- proposed changes in current laws
- a plan for sharing and distributing media online
- a plan for prosecuting those who share and distribute media illegally
- a description of the impact of file sharing on the entertainment industry.

Be sure you include appropriate references to the resources you have used.

CASE STUDY

Create your own handwritten font

New applications that use the Internet continue to be developed. There are a number of websites that allow you to create a personal font in your own handwriting. Some sites, such as FontStruct, operate entirely within a website. Other applications, such as YourFonts, first require the user to print, fill out and then scan a template for their alphabet and any other symbols required. This file is then uploaded and the font is generated. YourFonts requires a payment before downloading a font file that can then be installed on your computer.



http://www.plothandwriting.com

Figure 12.40 Create your own handwritten font.



http://www.plothandwriting.com

Figure 12.41 The font is generated via the website server and a preview of it is sent for approval.

QUESTIONS

1. Identify three precautions a user should take to obtain the best possible results when filling in the template.
2. What creative ideas can you think of for special characters? (One could become your signature!)

OPTION 13 Networking systems

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- the advantages of communications networks
- the terminology used to describe networks
- a range of components used to create communications networks
- the daily business of maintaining a network
- network operating systems software
- factors affecting the design of networks.

You will learn to:

- discuss the issues of building networks
- distinguish between different types of networks
- make effective use of network resources and software
- compare a range of topologies and protocols
- assemble a small network using components and software techniques
- discuss effective network management strategies
- assess the nature of work done by an organisation.

Key terms

Bandwidth
maximum rate of transfer of data over a link to the Internet, usually in Kbps, Mbps or Gbps

Client
application that runs on a computer and works with a server to perform some operations

Distributed processing
getting information from data on different computers, and then combining it into one output

Encryption
running secret code to transform data so that it cannot be read without the correct key

Firewall
hardware or software used to block unauthorised access, usually from the Internet into private networks

Intranet
private network of information, usually accessible by staff of an organisation to display appropriate information

IP address
unique number that is assigned to a computer while it is connected to a network

Local area network (LAN)
network that connects computers and other components in a small area, such as a single building or a group of buildings

Network
two or more computers, and often other devices (such as printers, external hard drives and routers), that are linked together so that they can share hardware and transfer data to each other

Network administrator
person who configures and manages network settings

Port
network device, usually a physical socket, that can be used to connect a cable

Protocol
agreed set of rules for exchange of messages

Server
computer that runs a network operating system and is designed to communicate with client software to perform a range of tasks for the network users

Topology
way in which a network is laid out, which affects the way in which the computers are connected

Transmission
movement of data from one place to another

The National Broadband Network

In 2009, the Australian Government announced a new initiative called the National Broadband Network (NBN).

Faster broadband will affect all of us, from the way we work to the way we live, from the way we receive medical treatment to the way we receive our education. No longer will rural and remote communities feel the tyranny of distance; all Australians will have the opportunity to access quality business and social services from across the country and around the world.

We will have better access to education – media-rich resources, virtual classrooms and field trips, remote access to conferences and lectures, and extra assistance for special-needs groups such as the deaf and disabled. Improved health care means that patients will be able to access specialist services over the Internet, GPs will be able to collaborate in real time with specialists during patient consultation, and surgeons will be able to assist with intricate procedures from remote locations. Businesses and government departments will benefit from high-quality videoconferencing and live market information, communicating with their customers and suppliers to maintain services.

The NBN involves the laying of fibre-optic cabling to at least 90 per cent of Australian homes, schools and businesses, capable of delivering speeds of 100 megabits per second (Mbps). The remaining premises will be connected via a combination of next-generation high-speed wireless and satellite technologies delivering broadband speeds of 12 megabits per second or more.

Optical fibre is capable of transmitting information at a practically unlimited rate over long distances of tens of kilometres. The kind of optical fibre services that can be used in the NBN can assure speeds of 100 Mbps and higher to each home or business. Optical fibre networks are able to deliver a wide range of applications – telephone, Internet and television.

Wireless broadband uses radio frequencies to transmit information between radio towers and antennae, much like broadcast TV and radio. This means that wireless broadband is bound by the available bandwidth, which limits the total amount of information that can be transmitted to premises within the radio cell. All premises within the cell share this total capacity. As a consequence, the total capacity of a fibre network will most likely exceed that of a wireless network.

Satellite broadband is generally used where terrestrial broadband – optical fibre, copper wire DSL, wireless broadband access – is not available. Satellite broadband services offer coverage over large areas. A single satellite can provide coverage for all of Australia and external territories, including Antarctica. Satellite broadband requires a satellite transceiver, a small satellite dish, to be carefully installed at the premises and aligned at the satellite. Satellite broadband services use geostationary satellites. Information is sent to the satellite from a large, powerful Earth station transmitter, and the satellite then 'bounces' this information down to the user's satellite receiver. Broadband speeds over satellite can be 10 to over 100 Mbps, but the higher speeds require larger dishes and become costly. Typical broadband satellite speeds with modern equipment are up to 12 Mbps.

Considering how the Internet has changed our business and social lives over the last 10 years, it would be safe to assume that the next 10 years will also bring some big changes. This new digital infrastructure will provide scope for many future advances in technology.

QUESTIONS

1. How will our lives be changed by having faster access to the Internet?
2. What is meant by 'the tyranny of distance'?
3. In particular, how will education be improved?
4. How will health services be improved?
5. How will businesses use the new infrastructure?
6. What are the four different types of technology used to deliver broadband to homes and businesses?
7. Why do we need different technologies to deliver broadband?
8. Compare the advantages and disadvantages of each of these types of technology.
9. What is meant by 'bandwidth'?
10. In what ways do you think this digital infrastructure will change our lives in the future?



AAP Image/Dan Peled

Figure 13.1 Laying fibre-optic cable in the roll out of the NBN

13.1 Communications networks

Most people today are able to use a computer to communicate with other people, either at school, at work or socially. Computers and other communications devices need to send data and information to other specific devices around the world. The technology that allows this to happen quickly, accurately and securely is described in this chapter.

The role of a network

In figure 13.2, you can see a typical group of workers in an office-based business. You can see there are a variety of tasks to be performed. What role does the **network** play in this situation?

There are many examples of people using networks all around us in our everyday life. The Internet is the biggest one in current use, but there are many more that are not so obvious. Shoppers in a local shopping centre send and receive data across a network when they make a purchase. Data flows to and from the checkout terminal to the store's databases, and to their bank's database if they use electronic funds transfer at point of sale (EFTPOS) or an automatic teller machine (ATM). Similarly, when we interact with a GPS system or an electronic road toll, or use a mobile phone, data is collected and transmitted across a network and stored for processing on a **server**.

The cables and servers that play such a vital role in this process are often hidden from the user, usually for security reasons, but it does give the illusion that this **transmission** (transfer) of data is easy and without challenges. We can imagine a letter being transported across an office, a town or to the other side of the world. Many people and machines can read the address written on the envelope and pass it on to the next stage of its journey. So how does a packet of data – an email or another type of data – find its way from one place to another?

It is the cables in the communications network that provide the pathways of the journey, and devices such as routers will direct the data packet along the correct pathway. Other devices such as servers store the data if the recipient is not available to take delivery.

You will know that any hardware device will need to have some software installed on it to allow it to do its job, and network devices are no different. There are a variety of network operating systems that can manage different types of networks and a **network administrator** will use this software to keep the network running efficiently and securely. The data that is transmitted across networks may originate as emails or EFTPOS transactions, it may be electrical, optical or electromagnetic in nature, but ultimately it is binary in format and needs to travel to its intended destination safely.

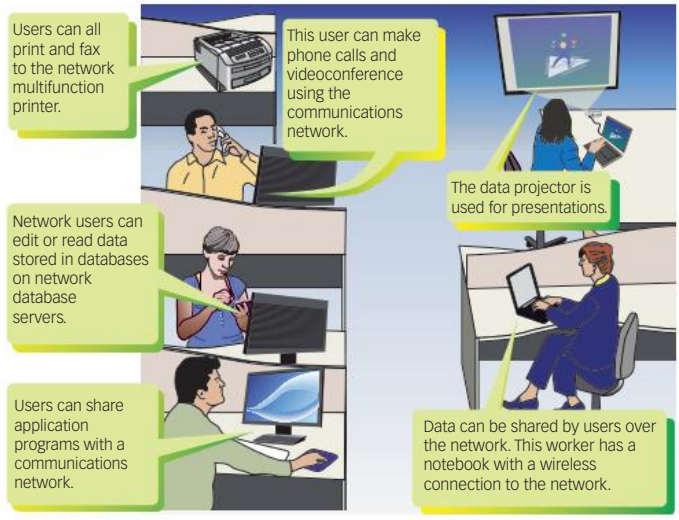


Figure 13.2 A communications network connects computers in an office and around the world.

Advantages and disadvantages

It is hard to imagine how we could survive modern-day living without being connected to a communications network. They bring enormous advantages, but unfortunately there are some disadvantages, mainly to do with security and access. Advantages include sharing peripheral devices such as printers, as well as sharing data, files and applications.

Sharing peripheral devices

CORE ALERT Hardware

The ability to share printers, faxes and scanners among network users enables a group of network users to reduce the total number of devices needed, so saving money and space. Printers selected for networks are often faster than the sort of printer attached to a single-user computer. There is also the advantage that if one printer is not working, a document can be sent to another printer on the network. Also, there may be different types of printers available and stationed in strategic places. High-volume printers will be needed for large documents, while A3 paper size capabilities may be required by some users.

Network printing or workgroup printing can be arranged in different ways. In a small home network, a printer may be connected to one of the computers and then set up as a shared printer. However, in larger networks, print-server

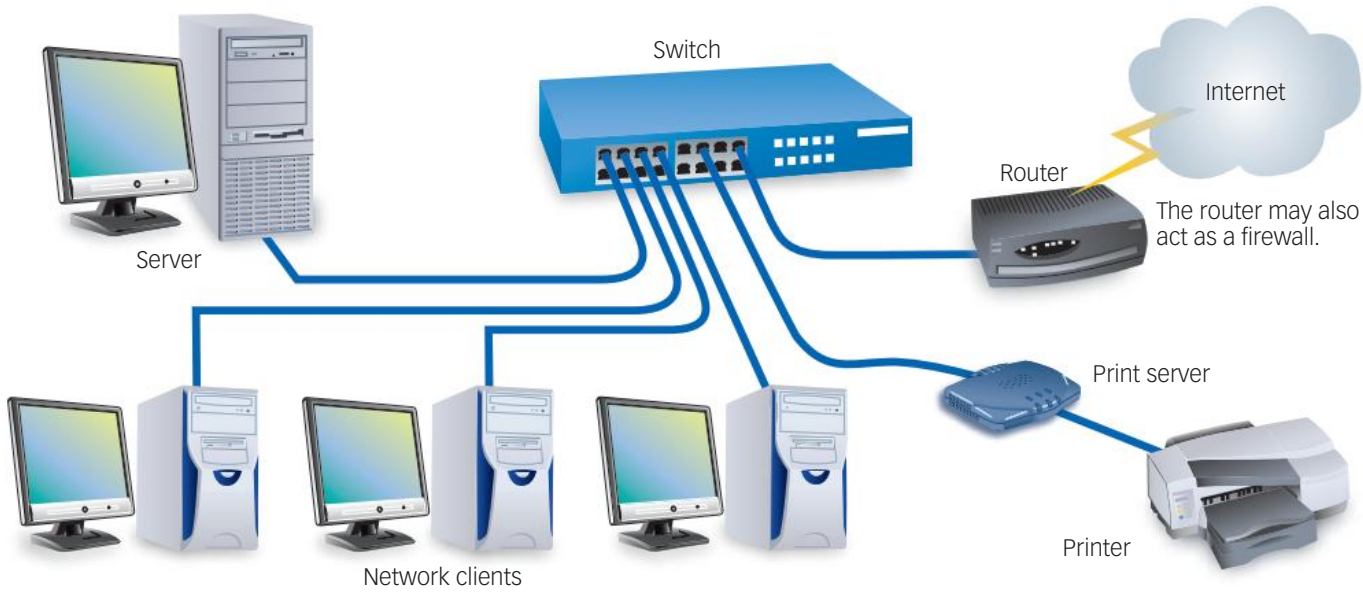


Figure 13.3 A typical network in a small business

software on a network server can direct print jobs to appropriate printers – these printers usually have their own network card installed or are connected to a network computer.

When a user activates the print command, their computer sends a print job to a network printer. The user will then usually walk over to the printer to collect the output.

One of the potential disadvantages of network printing is that on large networks, users may send a print job to the wrong network printer without realising it. Delays to workflow may occur as they try to find their printed material or consumables may be wasted as the same job is repeatedly sent to the wrong printer.

The network administrator is the person who should configure network printing settings. This task and some of the network administrator's other tasks are described later in this chapter.

Sharing Internet services

A single connection to the Internet can provide email, web and file access services to all network users. Being able to access this information from school, work and home at any time is clearly an advantage. The potential disadvantage is that one careless user may bring viruses into the network, thus creating havoc and destruction. To prevent this, most network systems use protective measures such as virus protection software and **firewalls**, which we will discuss later.

Sharing data and information

CORE ALERT Issues

As registered users of a communications network, people are able to retrieve their own files from the server while at work and often via the Internet through a secure portal. Fellow workers are able to make their files or directories available for specific people by setting network permissions. In addition, information that many people need to know is often posted on an **intranet**. There is an overwhelming volume of information that has been posted on the web for anyone to access. This information might be stored in structured databases or less formally on web pages.

While telephones and fax machines still have a part to play in communication between individuals, increased **bandwidth** on the Internet means that people can now work more collaboratively with their ideas and projects. Videoconferencing, group emails and wikis are useful for this, as well as less formal means such as blogs and social networking sites.

Some disadvantages of these emerging technologies are that data may not be secure, and may be unreliable or out of date. Invasion of privacy and identity theft also become concerns when personal data is available on an insecure site or server.

The increased storage requirements of digital media on networks are causing network designers to fit larger-capacity and faster hard disks, and to use faster network connections to support this increased 'need for speed'.



Figure 13.4 A variety of methods for sharing information

Sharing network applications

Another valuable use of a communications network is to store application software on a central server and have users access it when they need it. This can be done by downloading the application, such as a word processor or graphics program, to the user's computer or by allowing the user to have their document created and edited entirely on the server.

Both methods mean that the user always has the latest available version of the software. The second method may slow the network down, but it does save valuable storage space on the user's computer.

The term 'cloud computing' is used to represent the growing trend of accessing applications on the Internet to process documents or edit images. Many smartphone apps, such as those used for booking restaurants or finding journey directions, will have accessed a server to process the required data.

Distributed processing

Distributed processing relies on computers connected to a specific network. This is an advantage when a large and complex program such as weather forecasting needs to run. Different computers can process different parts of the program simultaneously and then collaborate when their task is complete.

It is also possible for everyday users to allow their home computers to become involved in large processing projects such as cancer research or earthquake prediction. If computers are standing idle for long periods of time (for example overnight), the Internet can be used to connect them to the appropriate network. Users just need to download the supplied application and leave their computers on. The software can then use the spare machine time to help solve some of the huge problems facing humanity.

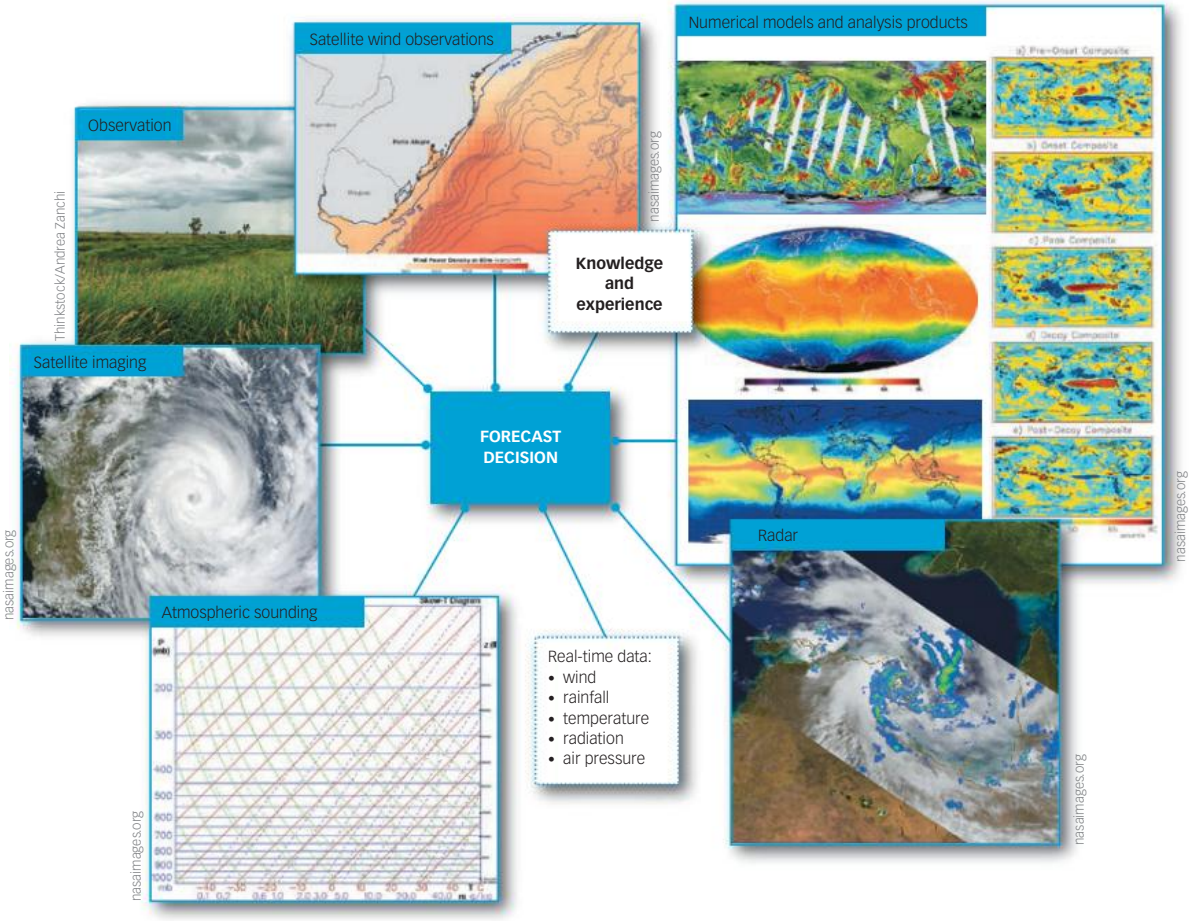


Figure 13.5 A weather forecast is produced after complex analysis on a network of computers around the country.

Security of information

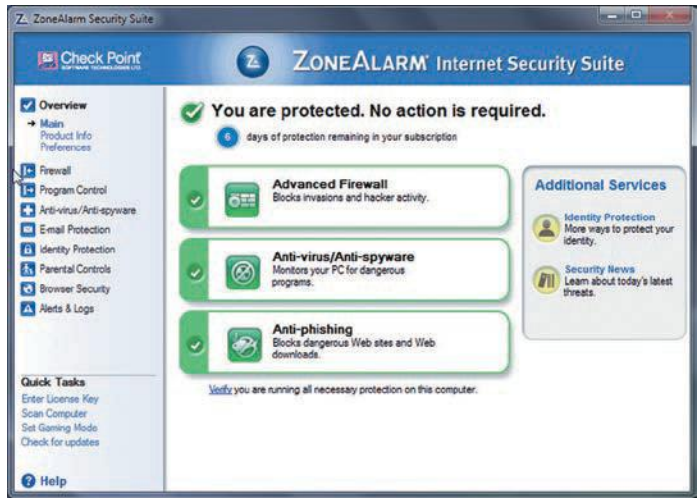
One of the greatest challenges for a network administrator is securing the network and the data it holds. Threats come from the Internet in the form of viruses and hackers, but also from inside the firewall in the form of workers causing careless or malicious incidents, or from fire, theft and mechanical breakdown.

There are many strategies that are used to protect valuable resources – namely making backups and setting security levels. These are discussed in section 13.8, but are worth mentioning here.

Making a backup essentially means making a copy of all data and applications, usually to another hard drive or magnetic tape. Depending on the importance of the data, backups occur every day or hour or as a mirror of the primary server's storage. Backups are invaluable when a worker has accidentally deleted an important document or there has been a serious system crash.

Users are encouraged to address their own security needs to a certain extent – keeping their own backup copy of important documents, setting permissions on sensitive or confidential information and keeping their passwords secure. If you are sending important information over the Internet, make sure the recipient is trustworthy. Data can be **encrypted** to make it more difficult for hackers to read your data.

Network administrators will install firewalls and virus protection software, and home users should do the same.



Check Point Software Technologies, http://www.checkpoint.com

Figure 13.6 A security package for your home network

TASK 1

Analysing a communications network

1 Identify a business such as a real estate agency or a supermarket that would use a computer network, and draw a diagram similar to figure 13.3 showing the possible resources the business would have on its network.

2 With reference to your diagram, describe the types of data and information that may be stored and transmitted on the network. You could modify the organisation structure diagram, using arrows to show the transfer of data.

3 Identify what data might be in the business's databases and how this data would be made secure.

ACTIVITIES

Identify

1 What is a network?
2 List three common examples of people using networks in everyday life.
3 How is sending an email similar to sending a letter? How is it different?
4 In a large organisation, who is responsible for keeping the network running efficiently and securely?
5 List the main advantages in using a network.
6 List the main disadvantages in having computers in a network.
7 What is distributed processing?
8 List the data that weather forecasters will need in order to produce a daily report.
9 What are the biggest threats to the security of a computer network?
10 List three things you should do to make your network data secure.

Analyse

11 List in order of importance (in your own opinion) the tasks for which you need to be connected to a communications network. Justify your answers.
12 What information is displayed on the intranet at your school? Do students see a different version from staff?

Investigate

13 Smartphones are used to send and receive phone calls, emails and web content. How do these devices connect with the Internet?
14 Retail stores and ATMs in shopping malls transmit data across their networks. Describe the nature of this data and the hardware needed to collect and store it.

13.2 Network protocols

A **protocol** is an agreed method of communication between two communicating devices. Most human beings understand that we have different rules depending on the method of communication we are using. Talking to friends will look and sound differently from when we are on a stage or on the telephone to an adult.

On a computer network, protocols are used to enable a conversation between computers to take place, such as sending and receiving data. Protocols may be open, which means they can be used by anyone, or proprietary, which means they were developed by a manufacturer to work only with the devices or software they make.

Open protocols

Open protocols are more popular, as they enable wider communication across a network and across the Internet. Figure 13.7 lists some commonly used open protocols.

HTTP	Hypertext transfer protocol	Transfers web pages
FTP	File transfer protocol	Transfers files (for example, to wikis)
SMTP	Simple message transfer protocol	Sends email messages
VoIP	Voice over Internet protocol	Sends voice messages
IP	Internet protocol	Adds and reads addresses on data packets
TCP	Transmission control protocol	Makes the connection between networked computers
	Ethernet	Transmits data along wireless and physical cables in frames

Figure 13.7 Some commonly used protocols

INFOBIT

Every uniform resource locator (URL) can be 'translated' into an IP address for a server on the Internet. The translation is done by domain name system (DNS) servers, which maintain the equivalent of large address books. People use URLs because they are easier to remember than IP addresses.

IP addresses

When a computer logs on to a network, it is given an **IP address**. The Internet protocol, usually part of the operating system, will allocate this.

The IP address for a computer is represented using four bytes of data. Each byte can represent decimal numbers between 0 and 255. For example, the IP address for http://www.google.com.au is 74.125.224.216.

Dynamic IP addresses are allocated to the network computer by a dynamic host configuration protocol (DHCP) server, which has the equivalent of a bag of IP numbers. When a machine logs on to the network, it is given an IP number only for the period of time it is logged on. It then surrenders that IP address when it logs off. This is a common method of assigning IP numbers to computers on a network.

Alternatively, computers (usually servers) can be given a permanent or static IP address. A static IP address is assigned to a computer by a network administrator. On some networks, the computers are given their IP address by a special network server.

Each computer visible on the Internet must have a unique IP address so that data downloaded from the Internet is delivered to the correct place.

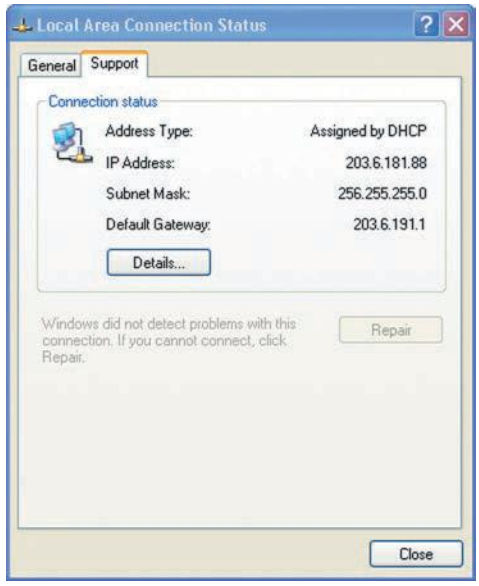


Figure 13.8 Every computer that is logged on to a network or the Internet needs an IP address.

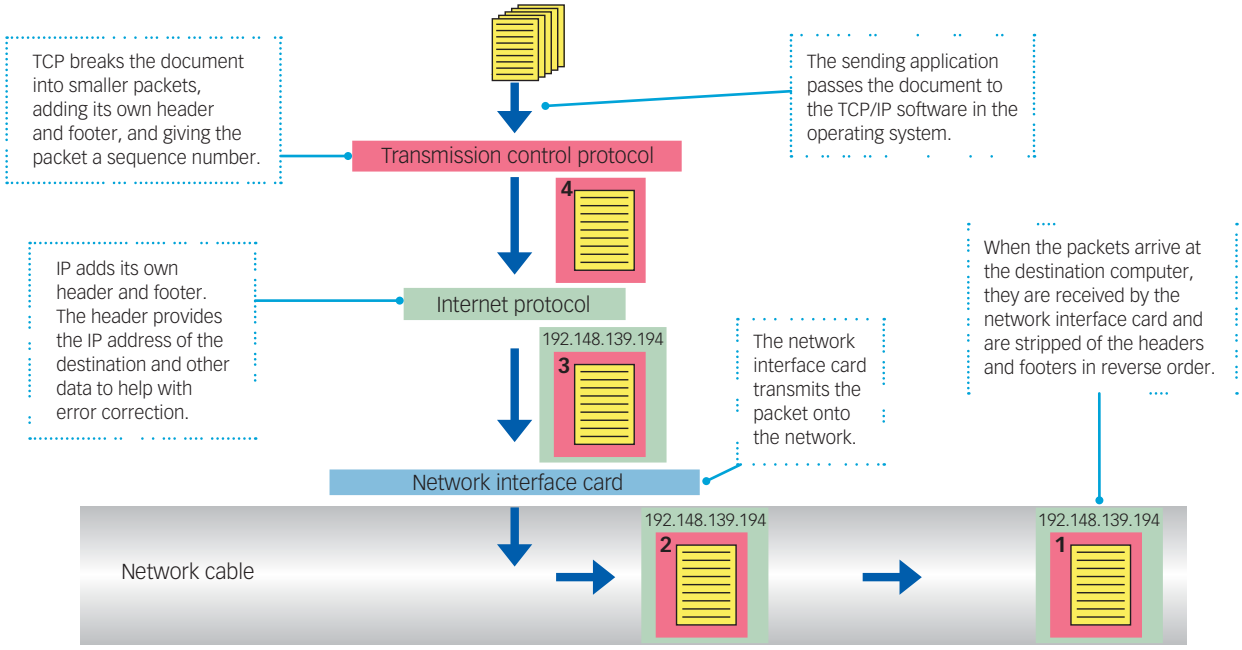


Figure 13.9 The TCP/IP protocol is now built into most operating systems. Data packets 1–4 follow each other through the protocol layers.

Transmitting data with TCP/IP

In figure 13.9, we can see how the transmission control protocol (TCP) and Internet protocol (IP) work together to send packets of data to another computer.

If we think of our data as if it were a text document, the TCP software breaks the document up into lots of paragraph-size parts called packets. TCP puts a unique serial number – starting with 1, then 2 and so on – in the header of each packet. This packet header also contains some other data to help with things like error detection, in case the data is damaged on its journey.

Other protocols

The following list describes other protocols.

- Bluetooth is a standard communications protocol for low-power devices within short range. A master Bluetooth device can communicate with up to seven devices in a wireless user group.
- AppleTalk® was developed by Apple to enable Apple and Macintosh computers to exchange data and share printers on a small network.
- NetBEUI was used to transfer data between computers on a small network. Both NetBEUI and AppleTalk have now been replaced, usually by TCP/IP.
- IPX/SPX was developed to support networking using the Novell® Netware® network operating system. If a network engineer decided to use the Novell networking software, the IPX/SPX protocols would be installed on all of the computers on the network to enable them to work together.

ACTIVITIES

Identify

1 What is a protocol?
2 Why are protocols needed on a computer network?
3 What is meant by an 'open protocol'?
4 What is an IP address?
5 How are dynamic IP addresses different from static ones?
6 Why do people use URLs rather than IP addresses to identify a website on the Internet?
7 Why are IP addresses important?
8 What are data packets?

Analyse

9 Why are there many different types of protocols?
10 Why do open protocols generally take longer to develop than proprietary protocols?

Investigate

11 Find out how to determine the IP address of your computer.
12 Find out what 'ping' means and how it originated.

13.3 Data transmission modes

We can describe three main approaches to communication between people and devices:

- simplex transmission
- half-duplex transmission
- full-duplex transmission.

Each transmission mode has developed over time to suit different technologies and uses of those technologies, as we will see in the examples discussed below.

Simplex transmission

Simplex transmission involves a flow of data in one direction only. An example of simplex transmission is broadcast radio. A radio station broadcasts a signal using a transmitter, and we are able to receive that signal with an aerial so that we can listen to music, news, sports and other things. We can't send signals back to the radio station on this communications link.

Within a computer, transmission of a video signal to a computer monitor is simplex – there is no means of 'reply' from the monitor. A webcast, which broadcasts audio or video data over the Internet, is another form of simplex transmission.

Half-duplex transmission

Half-duplex transmission is where a signal may be passed in two directions on a medium, but not at the same time. Conversations between people are usually half-duplex, as we take turns to speak and listen. Other examples include talkback radio and CB (citizen band) radio. Unlike simplex transmission, half-duplex communication allows a system to check if errors occurred in the data during transmission. The detection of an error in a computer system is made possible by including parity bits with the data, so that if any of the bytes of data are corrupted, the receiving computer will know, and can ask for the data to be resent. Some communications in computer systems are half-duplex, such as the flow of data to a printer.

Full-duplex transmission

Full-duplex transmission is used when devices need to be able to exchange data in both directions at the same time. This mode is the most versatile of all, and usually allows much faster transfer of data, with more rapid error detection and correction. On a telephone call, people can talk at the same time, although it is probably not a good idea! A network cable is also capable of having data moving in both directions at the same time. The network card can send and receive data simultaneously.

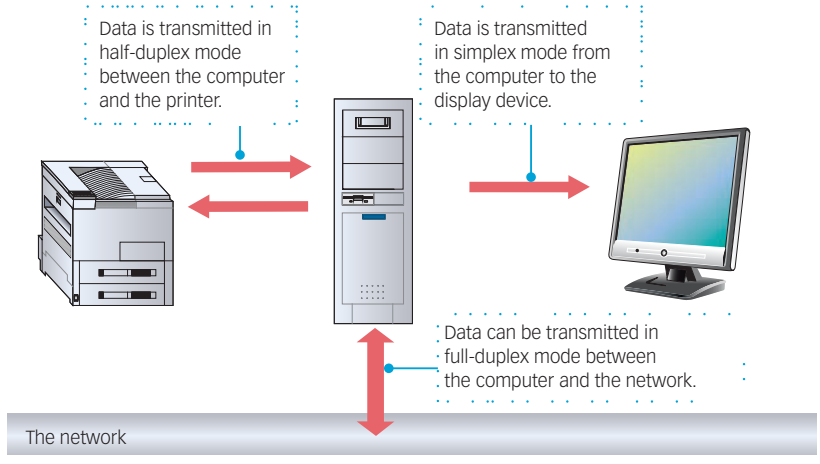


Figure 13.11 Transmission modes. In this diagram we see that communication of data between the computer and other devices and the network can be one-way (simplex) or two-way (half-duplex or full-duplex). The most versatile mode is full-duplex, but it is not needed for every application.

Checking for errors

Parity bits are often used to check that data has not been corrupted during transmission. A parity bit of 1 or 0 is added to the data byte, so that there is an odd number of ones in the packet. If the receiving computer counts an even number of ones, there has been an error.

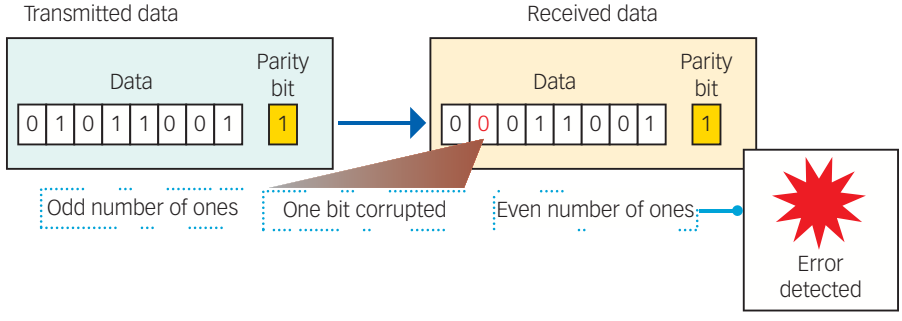


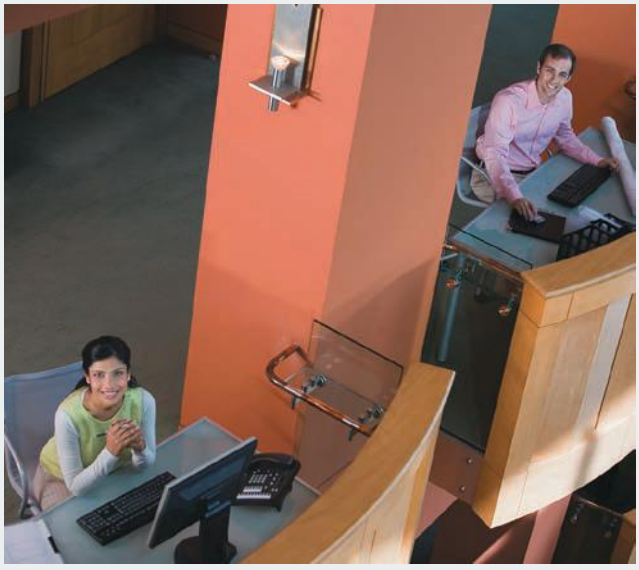
Figure 13.10 Adding a parity bit helps to check data for corruption.

CASE STUDY

Sharing business data

In a large retail business, sales personnel add new customers to a company database and register orders for these and existing customers. Using software that accesses the same database, the warehouse staff can see the list of orders to be dispatched. Also by using the same database, accounts receivable staff may follow up on invoices for orders that are overdue.

As products sell, the company's systems track products that are below the reorder mark, and alert the buyers to place orders for replacement stock for the warehouse. These orders are placed online using a business-to-business e-commerce website, giving the company confirmation that the products are available and an estimated delivery date.



Thinkstock/Jupiterimages

Figure 13.12 People working in different departments or locations need to share data and information.

Gathering and sharing data within a company has significant impact on marketing policies. Sales of certain items may be seasonal – such as flowers, swimwear and Christmas trees – but executive staff need to know whether the trends are increasing or decreasing year by year and adjust their decisions accordingly.

Some companies allow customers to check the progress of their own orders using the Internet. They can log on to the system, and find out if all the products they have ordered are available and whether they have been sent yet.

Similarly, while an item is being transported to the customer, its progress can be monitored by the use of smart bar codes and radio frequency identification (RFID) tags. All it takes is a quick scan of the tag and the data is stored in an online database for any authorised person to view.

QUESTIONS

1. How does enabling customers to find out information about their own orders contribute to the efficiency of this company?
2. What part do the people working in the packing department play in keeping the system up to date?
3. Describe how the data gathered by this network would be of value to the business management team.
4. Do you think that this order tracking system would be useful to online stores as well as shopping mall stores? Justify your answer.
5. Apart from the retail sector, describe other types of businesses that would benefit from this system of sharing business data.

ACTIVITIES

Identify

1. What is meant by the term 'transmission'?
2. List the three main modes of transmitting digital data.
3. Draw a table to compare the three main modes of transmitting digital data. Include the definition, an example from a computer system and how they compare with people in the real world.
4. What are parity bits and how do they help to detect errors in data transmission?
5. If the data has been corrupted in transmission, what needs to be done to put it right?
6. In which modes of transmission can error checking occur?
7. What is the advantage of full-duplex transmission?

Analyse

8. Which devices transmit and/or receive data in a typical communications network? In each case, describe what type of data this would be.
9. How do errors occur when data is transmitted from one device to another? How are they rectified?

Investigate

10. Apart from parity bits, what other methods are used to detect errors in data transmission? Apart from resending the data, is there any other way the data can be corrected?
11. If the full-duplex mode is so versatile, why is it not used for all forms of communication?
12. Is transmission of data across the Internet simplex, half-duplex or full-duplex? Justify your answer.

13.4 Data transmission rates

CORE ALERT Data handling

An important characteristic of any communications medium is the rate at which it can transmit data. Many people become frustrated when they have to wait more than a second or two for a file to download from a server or the Internet. The main factors that determine transmission rates are the devices such as network interface cards, modems and routers, along with the transmission medium being used – copper wire, optical fibre or wireless.

Three of the main terms used to describe transmission rates are bits per second (bps), baud and bandwidth.

Bits per second

The smallest symbol of digital data is the bit (binary digit), which has a value of either 0 or 1. Each bit is transmitted across a section of wire by a change in voltage or a change in characteristic of a light beam (for example, frequency or phase) in an optical fibre. Modern communications media allow very fast transfers of data, and are measured in megabits per second (Mbps) and gigabits per second (Gbps). This means that a 10 megabyte (MB) file, transmitted at 10 Mbps would take eight seconds to download. (Recall that there are eight bits in one byte.)

Baud

Baud rate is the number of signals (for example, voltage changes) that can be handled each second by the transmitting hardware. Originally, a transmission protocol or device used one signal or voltage change to send one bit of data, so a transmission rate of 300 bps meant that the device would need to have 300 voltage changes every second. However, this can be modified to two or more bits per signal change.

Eventually, descriptions of devices using baud rates became less relevant, as most computer users were more interested in how fast their data was being sent than how many signals were actually used to transmit the data. The number of bits per second that a network or medium can support is considered to be a better performance measure.

Bandwidth

We often express broadband connections to the Internet in terms of the bandwidth available.

This is a measure of the maximum possible data transfer. Bandwidth indicates the range of frequencies that data can be transmitted on. 'Broad' bandwidth, or broadband, indicates a wide range of frequencies, which in turn means the ability to transmit data at a faster rate.

Figure 13.13 compares the speeds of some of the common connection modes, although new technologies are constantly improving these rates. From day to day and place to place, actual speeds of transmission may vary based on factors such as line quality, distance from exchange (for ADSL/ADSL2+), hardware capabilities, server route and network congestion.

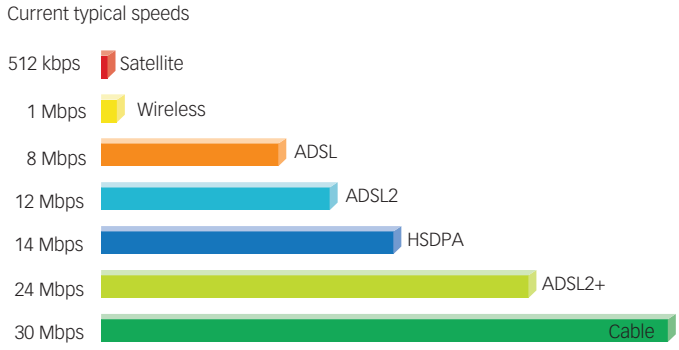


Figure 13.13 Comparing download speeds of some Internet connection modes. New technologies are constantly improving on these rates.

You can test your own connection speed for free by connecting to one of the websites designed for this purpose. The terms 'ping', 'jitter' and 'packet loss' are often used to measure the quality of an Internet connection.

A ping measurement tells you how long it takes a packet of data to travel from your computer to a server on the Internet and back. A result below 100 milliseconds should be expected from any decent broadband connection. Jitter is merely the difference in successive ping measurements and should be just a fraction of the actual ping value. So if one ping takes 0.10 seconds, and the next one takes 0.11 seconds, the jitter value is 0.01 seconds.

However, the quality of your broadband connection does not just rely on speed. Streaming media, voice, video communications and online gaming need to have the quality of the transmitted data preserved. Loss of data packets can mean much slower download and upload speeds, poor quality VoIP audio, pauses with streaming media such as video and what seems to be time warping in games.

INFOBIT

Julius Caesar is reported to have used encryption to communicate with his generals during his military campaigns. Early encryption methods systematically replaced the letters in a word with the letter following it in the alphabet, or with the letter an agreed number of places further on. For example, 'networks' becomes 'qhwzrunv' if a shift of three letters is used.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Software

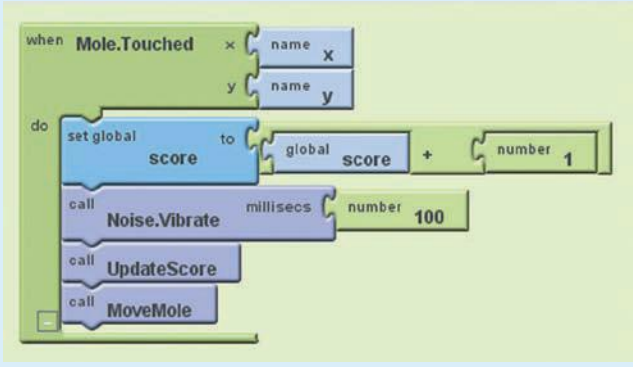
Create your own phone app

MIT App Inventor is a cloud-based tool, which means that you can build apps for your phone in your web browser.

It provides the fastest way to build apps for Android phones and tablets. Even with no prior experience, you can learn to build apps within hours.

Much like LEGO, App Inventor lets people drag 'blocks' of code around to create applications. The graphical blocks represent the different functions and capabilities of a smartphone.

You can find the tutorials, sample programs and ideas on the website. The program is an open-source web application and you will need a Google account to use the tools.



BBC

Figure 13.14 Programs can be built by clicking and dragging blocks.

The programming system was first provided by Google, and is now maintained by the Massachusetts Institute of Technology (MIT), who created a similar coding system known as Open Blocks. MIT scientist Mitch Resnick used this same idea to create the Scratch programming language, which also lets students put together programs by clicking and dragging on-screen blocks.

Numbers for total number of apps worldwide are hard to come by, but the Apple App Store and Google Play (for apps that work on Android devices) have quoted over a million each in 2014. Analyst estimates for downloads of apps in 2014 range from 56 to 82 billion. In 2017, there could be 200 billion downloads.

QUESTIONS

1. What is an Android phone?
2. What is the name of the programming language used to build the apps?
3. How easy is it to get a copy of this application and to use it?
4. Why have apps become so popular in recent years?
5. What other technologies were available for similar purposes before apps became popular?
6. What is the current market share between Android phones and Apple's phones?

ACTIVITIES

Identify

1. Why is it important to measure data transmission rates?
2. What are the main factors that determine transmission rates across a network?
3. What is the smallest symbol of digital data? What values can it have?
4. Name two ways in which bits can be transmitted across a cable.
5. What units do we normally use to measure transfer of data?
6. What is the difference between baud and bps?
7. What is 'bandwidth'?
8. What three terms do we use to measure the quality of an Internet connection? Describe what they mean.

Analyse

9. How long would it take to transfer a 1 GB file across a network operating at 100 Mbps?

Investigate

10. How fast is your Internet connection? Try downloading a large file, and observe any feedback on the screen. Alternatively, estimate the time it takes and calculate the rate yourself.
11. There are a range of free data download speed tests on the Internet. Search for one and measure the download rate on your computer. Try the test again at different times of day and on different computers. Document these results and compare them with the other members of your class.
12. A signalling technology called multiplexing has changed computer networks from a single-lane road to a multi-lane highway. What does the term 'multiplexing' mean in the context of data transmission?

13.5 Data transmission media

CORE ALERT Hardware

In the twenty-first century, most networked computers are connected using wire-based media, wireless infrastructure or a combination of both.

Wire-based media

For many years, we have been able to interconnect computers using a variety of wire-based media and their corresponding hardware and software technologies. The main type of wire used in local area networks these days is known as unshielded twisted pair (UTP) cables.

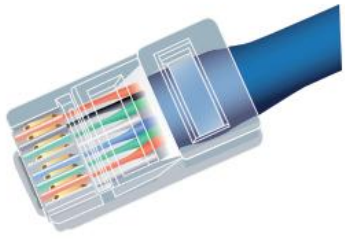
Unshielded twisted pair cables

UTP cables are often referred to as ethernet, Cat 5 or Cat 6 cables. They contain four pairs of wires, twisted around each other like a rope to reduce interference from external sources. This technology usually involves connecting each computer to a network device, such as a hub, switch or router. Disconnecting any one computer from the hub will not affect communications between the other computers.

If we only need to connect two computers, we could use just one crossover UTP cable especially designed for the purpose.

Most UTP cabling can support data transmissions of up to 100 Mbps, while others support as much as 1 Gbps (10 times faster).

An RJ45 connector for UTP cable. This is a standard type of connector for network cards.



UTP cables contain four twisted pairs of wires, each pair twisted around the others like a rope, to reduce interference with the signal on the wire. Each wire is colour-coded to make it easy to assemble the RJ45 connectors.

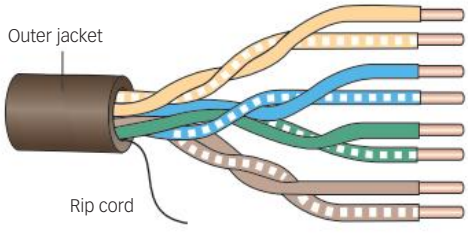


Figure 13.15 Unshielded twisted pairs. They are currently industry standard and connect easily to other network devices with the RJ45 connector.

Large networks in office buildings are often connected using UTP cable that is installed as part of the building's wiring. At each computer workstation, a wall outlet is fitted, with UTP cable running inside ducting to a cabling cabinet in the building. This type of network architecture is usually very reliable, but expensive to install.

The disadvantages of using built-in cabling for a communications network are that if a company moves to a different location, the wiring has to be left behind, and it can be expensive to make major changes to the wiring. However, it does offer the optimum balance between speed, cost, reliability and security.

Optical fibres

An optical fibre is made up of the core (which carries the light pulses), the cladding (which reflects the light pulses back into the core) and the buffer coating (which protects the core and cladding from moisture and damage). These fibres carry data encoded in light of different wavelengths or phases.

The advantage of optical fibre is that it can carry many different frequencies simultaneously, allowing a single fibre to carry very high rates of transmission, up to 10 million messages at any one time. Another advantage they have is that, unlike copper wires, they are less likely to suffer from electromagnetic interference from other electrical cables or severe weather storms.

Optical fibre is widely used in the telecommunications infrastructure over large distances both nationally and internationally. It is also used to deliver broadband Internet access to homes, schools and businesses.



Alamy/Hugh Threlfall

Figure 13.16 Optical fibres are about 5–10 microns in diameter. They are expensive and much more difficult to connect to a network, but provide great capacity and speed.

Wireless transmission

Many new networks are being developed that require little or no cabling. These are known as wireless networks, and they give more flexibility to the layout of workstations and reduce the costs of installing networks.

Users with notebook computers are able to work at any location that is in range of a wireless access point, without needing to connect a wire to a port in the wall ducting. Many offices and households now run mobile computing and even music systems via wireless connections. Many restaurants and conference centres offer customers free use of their network access points.

There are several technologies available for wireless networking, and they continue to develop in speed and sophistication.

Each computer on a wireless network has a wireless network adapter or card. These adapters use radio signals to communicate with the wired network via wireless access points.

Wireless modems are now used to provide 'anytime-anywhere' direct access to the Internet and are usually standard in mobile devices such as phones, laptops and tablets. For organisations with mobile workers, such as salespeople, wireless and mobile computing can significantly improve work efficiency and flexibility.

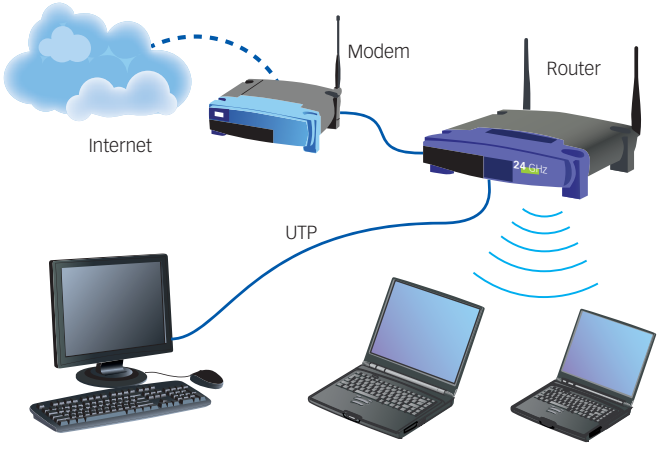


Figure 13.17 A wireless router in the home can provide access to the Internet for several computers.



Shutterstock.com

Figure 13.18 Satellites play an important role in transmission of data over large distances.

Smartphones can also function as a network modem, and can be useful for portable Internet connectivity when other options such as Wi-Fi hotspots fail. Some 4G networks can offer up to 10 Mbps for downloads.

Satellites and microwave towers play an important part in wireless networking over large distances. They are especially useful where the terrain is difficult, but speeds are much slower than cabled media.

An important consideration with wireless networks is security. Owners of wireless networks should turn on the security features provided, or they risk having intruders connecting to the network from outside the building. This is not as likely to happen with conventional wire-based networks.

ACTIVITIES

Identify

1 What is the main type of cable used in office and home networks?
2 Describe what UTP cable looks like.
3 What other hardware device is used to connect computers in a network?
4 What is the typical speed of transmission on a UTP cable?
5 What is the main advantage of using UTP cable compared to wireless? What is its disadvantage?
6 How does data travel along optical fibres?

Analyse

7 Prepare an argument for the situations when you would recommend either wired or wireless networks.
8 Draw up a table to compare advantages of wired networks against wireless.

Investigate

9 Investigate the existing network of optical fibre cables both internationally and in Australia. Where do the international cables come onto land in Australia?

13.6 Types of networks

We can classify networks according to their geographical or functional layout. Geographically, local area networks, wide area networks and virtual private networks are fairly distinct, while client–server networks function differently from peer-to-peer networks.

LAN, WAN and VPN

Local area networks

A **local area network (LAN)** is a group of computers and network devices that are connected, usually within the same building. They can range in size from a few computers in a single office to hundreds or even thousands of devices spread across several buildings. They function to link up computers and provide shared access to file servers, printers and other services.

LANs are usually privately owned, controlled and managed by a single person or organisation. They are expected to have a high data transfer rate and do not need any leased telecommunication lines. It is relatively cheap to set up a LAN or to extend it if you want to put an extra couple of devices on the network.

INFOBIT

An intranet is a private network designed to share an organisation's information with its workers. An extranet extends the intranet onto the Internet by providing passwords for access by other interested parties.

Wide area networks

An organisation that needs to connect computers in different geographical locations, such as Sydney and Melbourne, may transfer data between their LANs using public services such as telephone lines or the Internet. This is then called a wide area network (WAN). The Internet can be considered as the biggest WAN possible. To connect computers at different locations, an organisation will pay a telecommunications company for one or more different types of connection.

Virtual private networks

Before the Internet developed to today's capacity and security, large companies connected their WANs for distant city offices using dedicated telecommunications links that nobody else could use. These private networks were expensive, but they were quite secure. Virtual private networks (VPN) were then developed that are a way of using the Internet to connect LANs, but with a much higher degree of security. As well as needing secure passwords, the data is often encrypted, so intruders cannot read it. Large companies such as banks, retail chains and telcos (telecommunications companies) use VPNs.

A VPN can be provided by many ISPs by using combinations of specialised hardware, routers, software and security protocols. Once established, the VPN keeps the data secure, and keeps intruders out. It works rather like a hidden, private tunnel under a busy city. In fact, some of the protocols used in VPNs are called tunnelling protocols.

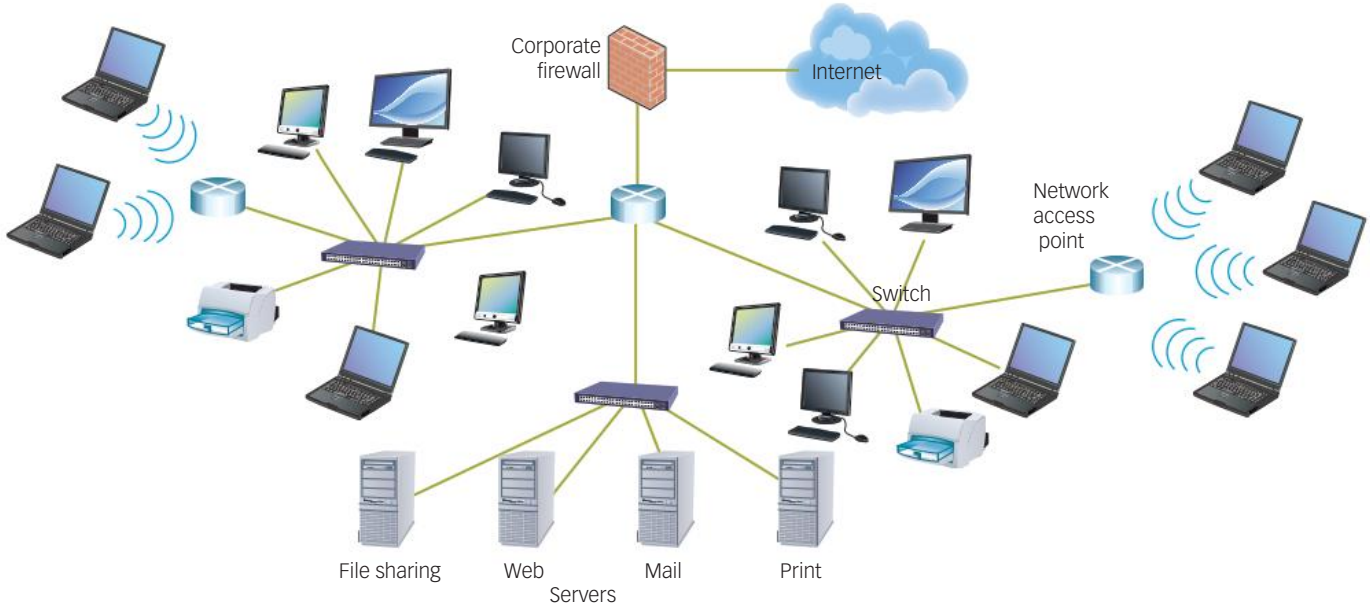


Figure 13.19 Large businesses will have a complex array of devices in their LANs.

Client–server and peer-to-peer networks

Networks can be classified into two main categories based on the processing and file-sharing strategies. Client–server networks have a deep focus on the role of their servers, whereas in peer-to-peer networks all of the computers function with equal roles.

Client–server networks

In this type of network, users work at workstations called **clients** and communicate with servers to complete a range of tasks, from file storage to mail access. Both server and client will have specialised software installed so that they can communicate with each other. In fact, you will be familiar with some of these applications already – email software and browsers. Both of these applications are designed to send and retrieve data to and from a server. The 'thinness' of a client is usually a measure of how much processing happens at the workstation, compared to the server.

The client–server model is used for larger networks in which we need to apply some levels of organisation and security. It is well suited to business, government and educational organisations. In this model, a network administrator will be responsible for setting up users and groups, along with security restrictions such as access limitations and password authentication.

Peer-to-peer networks

In peer-to-peer networks, all computers are workstations on the network. There are no specialised servers. Peer-to-peer networks are well suited to small network installations, such as in a home or small office, although more global networks exist.

The advantage of the peer-to-peer network is that it is relatively easy to set up, and the maintenance cost is relatively low. They do not need special network operating systems, which are quite costly and take some expertise to configure and maintain properly.

In an office network, as more and more users join the network, managing shared data and security issues may become more difficult. We may then need to consider upgrading to a client–server network.

Peer-to-peer software applications have become very popular for file-sharing across the Internet. Some sceptics say that they are mostly used to share illegal content and that they increase traffic on their networks. However, supporters of P2P (peer-to-peer) networking point out that it has legitimate uses.

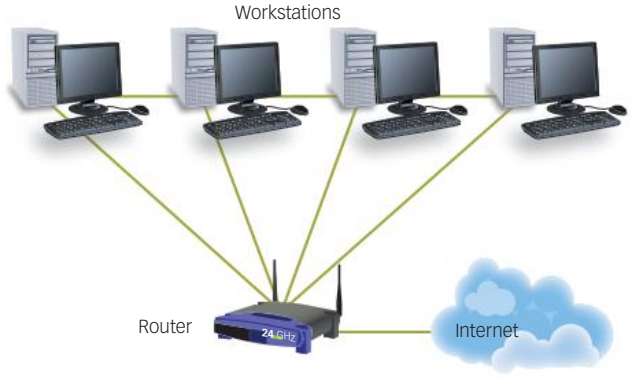


Figure 13.20 Peer-to-peer networks are easy to install but cannot support a heavy workload as traffic increases.

ACTIVITIES

Identify

1. What is a LAN?
2. What are the main differences between a LAN and a wide area network?
3. What type of network would the Internet be considered as?
4. What are the main disadvantages for a business organisation of using the Internet to transmit its data between locations?
5. What is the advantage of using a virtual private network?
6. What sort of organisations use VPNs?
7. What is the difference between a client and a server?
8. What is meant by the 'thinness' of a client?
9. How are peer-to-peer networks different from the client–server arrangement?
10. What is the advantage of a peer-to-peer network?

Analyse

11. Many organisations choose to use a VPN between offices in different towns. Describe what advantages a VPN provides.
12. Consider the network of computers at your home or school. Prepare a diagram showing the main hardware components.
13. Compare client–server networks with peer-to-peer networks.

Investigate

14. Retail stores and ATMs in shopping malls transmit data across their networks. Describe the nature of this network along with the data, and the hardware needed to collect and store it.

13.7 Components of networks

CORE ALERT Hardware

A communications network is assembled from a variety of components, each having a specialised responsibility. In this section, we consider the different types of components and the way they contribute to the functioning of a network – from servers to the connection devices that help to deliver data to and from these servers.

Servers

Servers are like ordinary computers in some ways – they need processors, storage, monitors and network connectivity. However, because they work so hard, these components are usually bigger and faster than their clients. The software that is installed on the server will determine what task it is responsible for, whether it be file sharing, web, mail or printing.

Depending on the requirements of the company, several tasks may be installed on just one machine or there may be separate machines for each task. For example, an ISP would have multiple web servers, while a large business organisation might have many database servers.

File-sharing servers

The main advantage of storing files on a file server is the ease with which the files can be located, preserved and protected. Some of this data will be stored in databases, while other data may be found in less structured file directories. The main risk of this centralised approach is that if this one machine stops working, many network users may be affected, so server hard drives are often mirrored or duplicated.



Shutterstock.com/dotshock

Figure 13.21 Many large businesses require multiple connected servers, such as mail services and search companies. Here we see a technician with a laptop managing a bank of servers.

When users are given access to a network, the network administrator will set permissions to determine which areas of the file server, or indeed the network, they will be allowed to access. They will also set a limit on the volume of data each user will be allowed to save onto the server.

Web servers

A web server sends web pages on request to a client's browser. This data will be in hypertext markup language (HTML) format, whether it has been stored on the server in that format or has been produced as a result of processing by the server. We often see web pages displayed in the browser with the extension .asp or .php. The content of these pages has been processed or organised on the server before being delivered to the client's browser in HTML format.

Every web server has an IP address and probably a domain name; for example, if you enter the URL http://www.abc.net.au/news/ into your browser, a request is sent to the server whose domain name is abc.net.au. The server then retrieves the requested page from the folder 'news' and sends it to your browser.

Any computer can be turned into a web server by installing server software and connecting to the Internet. There are many web server applications, including public domain software and commercial packages from Microsoft.

Mail servers

Email can be managed by an organisation in a number of ways. Some small businesses obtain email services from their ISP. Larger businesses and organisations may run their own mail server, on one or more server machines. Mail server software is used to manage email accounts for the users.

A commonly used product is Microsoft® Exchange Server. Network users are provided with a mailbox in the database on the mail server. The mailbox has an associated email address. Users gain access to their email messages using client software, such as Outlook. Alternatively, the user can retrieve their email over the Internet using their web browser. Most modern mobile phones are email-enabled, so that email messages can be delivered to users more conveniently.

INFOBIT

Internet companies such as Google and YouTube are reported to have more than one million servers and store several petabytes of data. However, security issues dictate that their actual capacity is kept secret.

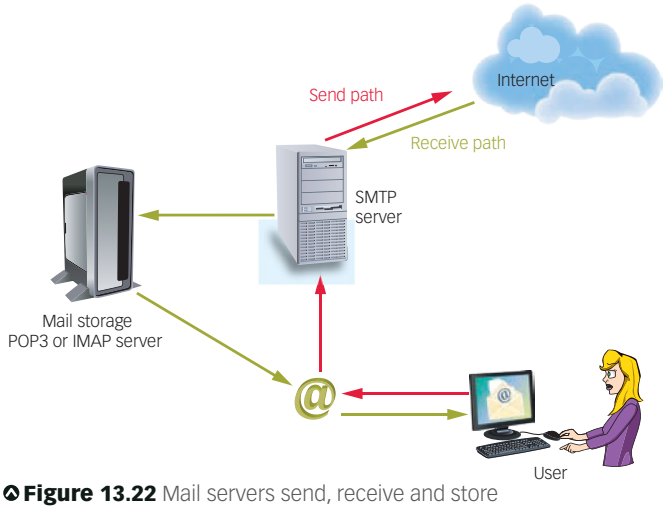


Figure 13.22 Mail servers send, receive and store email messages.

Proxy servers

A proxy server acts as an intermediary for requests from clients seeking resources from other servers. A client connects to the proxy server, requesting some service, such as a file or web page.

The proxy server evaluates the request according to its filtering rules; for example, it may filter traffic by IP address. If the request is allowed, the proxy provides the resource by connecting to the relevant server and requesting the service on behalf of the client.

A proxy server may optionally alter the client's request or the server's response, and sometimes it may serve the request without contacting the specified server. For example, in the case of a request for a web page, it may store recently accessed pages, and pass them on to the client without having to access the Internet again.

Print servers

A print server is simply a device that allows computer workstations to connect with one or more printers that are shared on a network. Each workstation has the ability to designate one of the printers on the network as its default printer, but may always choose to send a print job to any of the other printers recognised by the print server.

In small networks, one of the computers in the network group may be designated as the print server and the required software is loaded onto the hard disk of that computer.

The print-server software is configured to recognise all the printers on the network, as well as all the workstations that are allowed access to server functions. Each workstation can then be configured to connect with the server for printing capabilities, including granting or restricting rights to any one of the printers that are recognised by the print server.

Application servers

An application server is used to run a wide range of programs, such as word processing or spreadsheet applications, from one single location on the network. Everyone who needs to access those programs can then log on to the general application server. These servers are very powerful, as they need to support multiple users simultaneously.

One advantage of the centralised application server idea is that upgrades to the application for all users are guaranteed. There is no risk of old versions of the application accessing or manipulating data in an older, incompatible manner. Also, the licensing of the applications becomes much easier and often cheaper with this arrangement.

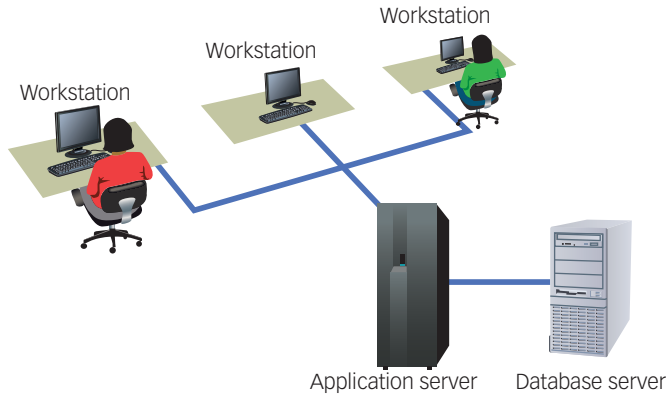


Figure 13.23 Network users are able to access applications stored on the server and use them simultaneously. These applications may then access the database server where all the company's information is held.

Database servers

A basic database system simply allows you to enter and search for information (a process often known as querying). The database might be stored on a simple desktop computer. However, it makes sense to have that data available to staff and customers for a variety of reasons and in a variety of formats. For instance, within one company some staff might have access to an order entry system, while other staff may need access to automatic reporting systems that provide sales summaries. Both access the data on the database server, but the ability to change and format it will vary between different departments.

Modern database servers can handle huge volumes of information and present it in a variety of formats. These may include automatically outputting web pages from stored data, allowing the placing of orders and other electronic commerce tasks. For many businesses, a database server in some form will lie at the heart of most daily activities.

Connection devices

Two essential components of communications networks are the servers and the users who connect to them. However, there is a range of hardware and software that provides the connection between these two components. They differ in how they do their task and where they will be placed on the network.

Hubs

A hub is a network connection device used to interconnect two or more network devices, such as computers and printers. A hub has a fixed number of **ports**, with each port being able to connect to one device via a cable. For example, an eight-port hub could connect a network of up to eight computers. A hub may also have an uplink port, which enables it to connect to other hubs.

In a standard hub, all of the ports can see all the data that arrives. The device is usually half-duplex – computers can only send or receive data at any one time; they cannot do both at once.



Figure 13.24 A hub is a small device that connects several network devices.

Switches

A switch is an advanced form of hub that allows full-duplex data transmission. Each port is isolated from the others, so data can travel directly to its destination without colliding with other data on the media. The switch can read the data packet to see the IP address of where it needs to go to and send it along on the appropriate channel. A switch can offer better performance on a network than a hub and usually has 24 ports plus an uplink port to connect to other parts of the network. Refer to figure 13.3 to see how a switch is used to connect clients and servers.

Routers

A router is usually a hardware device that can be configured and managed by software. Routers are used to connect networks, but are smarter than switches in that they can determine the best path for data packets to travel to get to their destination. Broadband connections to the Internet often use routers, as this enables a family or business to connect a small or large network to the Internet.

Many routers have in-built protection against Internet hackers, such as firewalls.

Gateways

A gateway on a network joins two different types of networks together; for example, a router acts as a gateway when it connects a LAN to the Internet. Large networks may choose to use a router or a server as a gateway. In some ways, this makes managing security simpler than having many pathways in and out of the network. Also, a gateway can do more than a router; it also performs protocol conversions from one network to another.

Repeaters

A network repeater is used to boost a data signal carried on a network. This is needed when the signal has to travel a long distance, as the signal may weaken over distance. This is known as attenuation and is caused by the cables physically absorbing the energy of the signal.

The repeater detects the incoming signal, amplifies it, and transmits it towards its destination.



Wireless network access point device

Alamy/Rafael Angel Irusta Machin



PC wireless network interface (adapter) card

Thinkstock/Alexandr Malyshev

Figure 13.25 A PC wireless card transmits to the wireless network access point using high-frequency radio waves. The access point device then passes on the data to a wired network using a UTP cable.

Network bridges

A bridge can be used on a network to divide it into smaller parts, but also to connect two similar networks.

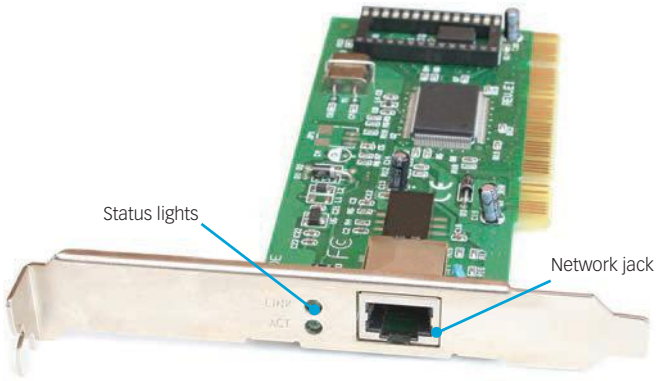
The bridge prevents the traffic in one segment from interfering with the traffic in another. The idea of segmenting (dividing) a network is rather like keeping different classes in a school in separate rooms. If they all tried to operate in one very large hall, the noise from one class would interfere with the others. A switch can be considered to be a type of bridge.

Network interface cards

Computer hardware and operating systems are now well suited to communicate with other computers on the network. Most new computer systems come with built-in networking components, and modern operating system software makes connecting networks relatively easy.

The network interface card (NIC) connects the computer to the network cable or uses wireless transmission to connect to the main network access point. The card behaves as a receiver and transmitter. Modern network interface cards designed for cable connection can transmit data at up to 10 Gbps. Modern wireless network cards transmit at up to 100 Mbps.

Modern NICs can 'sense' the rate at which other computers or devices are communicating, and adjust their transmission rate to match them.



Thinkstock/Helen Shorey

Figure 13.26 This network interface card attaches directly to a wired network.



Shutterstock.com/Kjetil Kolbjornsrud

Figure 13.27 Blade servers are now popular, as they can be replaced quickly with no effect on the rest of the network.

ACTIVITIES

Identify

1. Define a server.
2. In what ways are servers like ordinary computers? How are they different?
3. Draw up a table to identify the main types of server used on a network and their responsibilities.
4. What is the main disadvantage of storing files on a server?
5. What do we mean by 'mirroring' the hard drives on servers?
6. Draw up a table of connection devices and identify their main function.
7. What is the difference between a hub and a switch?
8. What is meant by 'attenuation' in a network? How is it caused and how is the problem solved?
9. How does the network interface card act as a receiver and transmitter?
10. What are the typical transmission rates of a cable NIC and a wireless NIC?

Analyse

11. What are the main advantages of having a print server on the network?
12. What is the difference between a switch and a router?
13. How are bridges and gateways similar in function? How are they different?

Investigate

14. How do web servers process .php and .asp pages?
15. Proxy servers can block IP addresses (both inward and outward data) as well as storing previously viewed web pages. Find out what other roles a proxy server can take on.
16. Mail servers may use both post office protocol (POP) and Internet message access protocol (IMAP). How are they different and why would the server use both?
17. How often are repeaters needed for UTP cables? What about optical fibre and wireless transmissions?
18. What are patch panels and how are they used in a computer network?

13.8 Security of information

CORE ALERT Data handling

Everyone who creates or uses data files should take responsibility for their security. This can mean the individual protecting their own files and passwords, as well as the network administrator securing a large network against serious malicious attack. Data files and applications should be protected against accidental loss and deliberate abuse.

Individual responsibility

Making copies of documents in a home or small business office should be a simple and regular procedure. Modern operating systems on personal computers can automatically back up your files to an external hard drive. Similarly, many external hard drives come with software that will back up your files regularly. Alternatively, a small network may have a file server to which all users can save their files, and this will be backed up regularly, or have mirrored hard drives to duplicate data. It is now common to use online storage sites for security and collaboration.

There may be times when we need to restrict access to confidential information by other users on the network. Most software will allow the creator of the document to set read and write permissions on each document, or to create folders on the network that can only be seen by selected users. Some documents can be encrypted to further enhance security from unauthorised intruders.

Of course, everyone is aware of the importance of passwords and their protection. Passwords on local computers or personal identification numbers (PINs) for access to EFTPOS and ATMs should always be kept secure and changed frequently.



Shutterstock.com/Billy Gadbury

Figure 13.28 In a high-security environment, employees may need to identify themselves using biometric devices such as thumbprint scanners before they can access the network.

Network administrator

Some of the most important responsibilities for network administrators include protecting the network and managing users, data storage and its backups.

Managing users

As a first step in protecting the network, administrators will issue usernames and passwords and set individual levels of access to different sections of the network. They will also be careful to remove users who have left the company. Users are often allocated to groups; for example, school students will need different access depending on their year level. Allocating permissions to groups will be a lot quicker than allocating them to individual students.

Managing data storage

Most organisations have large collections of data of different types, such as documents, databases and emails. Saving data and applications to servers makes it much simpler to access, secure and preserve. However, if the volume becomes too great, older or rarely accessed files can be archived into data warehouses or uploaded to off-site servers.

Many large networks use high-capacity hard disks for backup. The process is automated using software such as Microsoft SQL Server, which creates a copy of the data in compressed format.

Networks with more than one geographical site may use the network connectivity between those sites to back up their data. By configuring specialised backup software, the backup is usually set to occur when the network is relatively quiet; for example, overnight.

Some data needs to be backed up in real time – as the data is stored, a copy is made to another part of the system. Banking systems need this level of security of

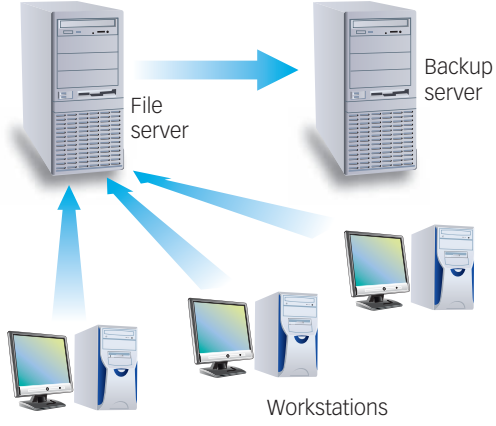


Figure 13.29 Backing up network data is essential.

data on financial transactions, as any lost data can be very expensive. Other forms of data may be backed up on a once-daily basis, and for many situations this is sufficient.

Securing the network

Many networks have a connection to the Internet so that users can use email and use the web for research. Unfortunately, this is a potential doorway for hackers, viruses and worms to enter the network, leaving a trail of destruction. To ensure these things don't happen, network administrators use a variety of tools and techniques, such as firewalls, antivirus programs, intrusion detection software and anti-spam software.

All these devices need to be upgraded regularly, as the threats that exist on the Internet keep changing. In addition, server rooms are often physically protected against intruders and fire risks.

ISSUES

CORE ALERT Issues

Generations of data protection

A generational backup is one of the simplest, most effective methods for backing up data.

The three-generation or grandfather-father-son method involves making a complete copy of the data to be backed up onto reliable media such as a network file server. The newest version of the data is always called the son. Assume this is created on a Monday, and backup is performed at the end of each day. On Tuesday, changes to the data in version 1 are made and so this becomes version 2 – the son. At the end of the day, version 2 is backed up and version 1 becomes the father. On Wednesday, a third version, version 3 (the son) is produced and backed up, and versions 1 and 2 move back another generation. When version 4 is generated, version 1 is discarded.

This continues in rotation so there are always three backups, each from a different point in time.

QUESTIONS

1. What is the advantage of having three generations of backup?
2. What are the disadvantages?
3. What happens to the 'grandfather' generations of the data?

Mon	Version 1 = Son				
Tues	Version 1 = Father	Version 2 = Son			
Wed	Version 1 = Grandfather	Version 2 = Father	Version 3 = Son		
Thurs		Version 2 = Grandfather	Version 3 = Father	Version 4 = Son	
Fri			Version 3 = Grandfather	Version 4 = Father	Version 5 = Son

Figure 13.30 A generational backup table

ACTIVITIES

Identify

1. What two steps should individuals take to keep their data safe?
2. Explain what is meant by 'backing up' in a computer environment.
3. Explain what is meant by setting 'permissions' on a document or directory folder.
4. List the four main tasks for which network administrators are responsible.
5. Why do network administrators allocate people to 'groups' on the network?
6. How does the network administrator make sure that there is more than enough storage space for all the data on the servers?
7. Identify the main ways that network administrators can secure a network.

Analyse

8. Think of a way that a network user could create a password that they can remember easily, but that they can change regularly.
9. Explain what is meant by firewall and anti-virus software.

Investigate

10. Research the data backup strategy used by a local small business. Prepare a short report commenting on the effectiveness of the strategy.
11. Find the names of three software applications that offer backup functionality. Describe what other functions they can perform in protecting data.
12. Explain what is meant by 'archiving data'. How is it different from backing up? Investigate strategies and policies that large companies might use for archiving data.

13.9 Network topology

During the evolution of computer network technology there have been a number of physical arrangements for connecting computers. This is referred to as the **topology** of the network, or the way in which the network is shaped or laid out. There are three main topologies – star, bus and ring. As networks and technologies have evolved, we also see combinations of these topologies, which we may describe as hybrid topologies.

Star topology

The star topology is probably the most popular and describes a network where a small number of computers are connected to a central point, such as a hub or a switch. The switch connects computers, servers and other network devices to enable and restrict the movement of data between them. A router can also act as the central device, which works like a switch but also allows access to the Internet.

Home networks or those in small businesses will use this topology, as it is easy to set up and add extra devices to the network. However, star topologies are often found in sections of large corporations or campuses as network switches are able to support very fast networks. Several data conversations can take place at once without interrupting each other.

The central switch can monitor traffic flow on the network. Any abnormal activity can indicate a faulty component, inappropriate use or that the network needs to be upgraded.

The main disadvantage of star topologies is that they use a large amount of cable. Also, if the central hub goes down, so does the whole network.

Bus topology

The bus topology became widely used with the use of coaxial cabling, where one length of coaxial cable would pass by and connect to each computer or device on the network in turn. This involves all of the computers sharing access to a common transmission medium – a bit like a rail line where passengers (data) can get on and off at certain 'stations'. The biggest advantage of this topology is that it uses much less cabling than the star topology. Unfortunately, the disadvantage is that collisions could occur on the common cable, and so systems had to be developed to avoid this. When wireless network devices connect to a network access point, they are using the same transmission medium and need to share the bandwidth. This is therefore classed as a bus topology. If too many users are using the network at the same time, the transmission speed is reduced.

Ring topology

Ring topology became widespread in IBM networks. Computers that are connected in a ring network work a bit like repeaters – they receive an incoming signal, and if the message is not addressed to the receiving computer, it retransmits the message to the next computer in the ring.

To manage the transmission of data, an electronic 'token' is passed from machine to machine in the ring. A computer can only transmit data when it receives a token.

A disadvantage is that this topology cannot be easily extended without interrupting the working of the network. Ring networks still exist, but the technology is not introduced in new networks.

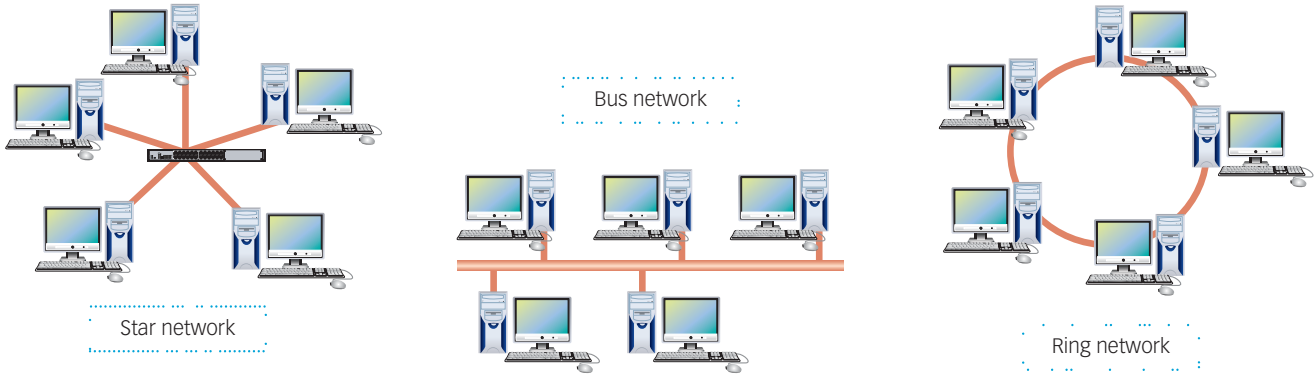


Figure 13.31 Three basic network topologies – star, bus and ring

Hybrid networks

It would be very expensive to reconstruct existing networks each time a new technology is released, so it is common for organisations to extend a network, adding new structures to it. Ultimately, the network takes on a hybrid form, often including star, bus and ring topologies.

Mesh topology

The idea of a mesh topology is that each computer has a connection to many other computers, so that if one link fails, data can be transmitted by another path. The Internet could be described as a mesh topology, as routers can send data packets along different pathways to reach a destination computer.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

Smart home networks

For some people, their dream home is a 'smart home' – a home with networked systems that manage the living environment. For some, the importance is security; for others, it is automated watering systems to keep the garden green. Some may want to check from their workplace that their pets are well, connecting to a webcam mounted in their home. Some members of the family may want the system to manage their entertainment systems, providing on-demand video and audio at any place in the home.

Whatever we imagine home automation to be, we can be certain a network will be involved. Some homes are being cabled as they are built and others are having network cables installed. Most often, houses are choosing wireless network options, connecting lighting, heating and home entertainment.

In the near future, perhaps there will be a 'servant' computer that hears our every command, no matter where we are in the home, and responds accordingly. This may be a passive device or a proactive robot that can move around the home. Whatever the future, it is most likely we will remain connected to our world with our smart mobile devices.



Shutterstock.com/Macrovector

Figure 13.32 Smart homes network their technology for organised living arrangements.

QUESTIONS

1. Look at the image in figure 13.32. Identify the systems being controlled with the tablet.
2. If you were installing smart home technology, what would be the most important things it could do for you?
3. What risks do you think are associated with having a smart home?
4. Investigate current options for installing smart networks to control devices in your home.

ACTIVITIES

Identify

1. What is meant by the term 'topology'?
2. What are the three basic topologies used in networks?
3. Draw up a table to compare the three topologies.
4. Which of the main topologies is currently the most popular? Why is this?
5. Which topology is the wireless section of a network considered to be?
6. What is the main disadvantage of this?
7. What is the main disadvantage of the ring topology?
8. What are hybrid topologies and how do they come about?
9. Why is the mesh topology not used in a small or medium-sized network?
10. Describe how the Internet can be considered to be a mesh topology.

Analyse

11. Why is the star topology the most popular?
12. Why is the ring topology no longer popular?

Investigate

13. When collisions occur on a bus network, how are they resolved? What part does CSMA/CD play in this?

13.10 Network operating systems

CORE ALERT Software

The network operating system (NOS) is the software that enables the network administrator to manage user accounts, control access and security, and generally keep the network running smoothly.

Managing users and groups

A network administrator creates usernames and passwords for all network users, so that they can be authenticated (checked) each time they use the network.

The network operating system also enables us to create groups of users and to allocate each user to one or more of these groups. This makes it much easier for the network administrator to control access to network resources. For example, in a high school, a network administrator would give each student a username, and add each one to the group for their year, such as 'Year10Students'. Each year group can be made a member of a higher group called 'AllStudents'.

Security permissions

Every resource on the network has an access control list (ACL) associated with it that records who has been given permission to use the resource, and the level of those permissions. The network administrator or the owner of a network object, such as a folder or server, can set the permissions on that object.

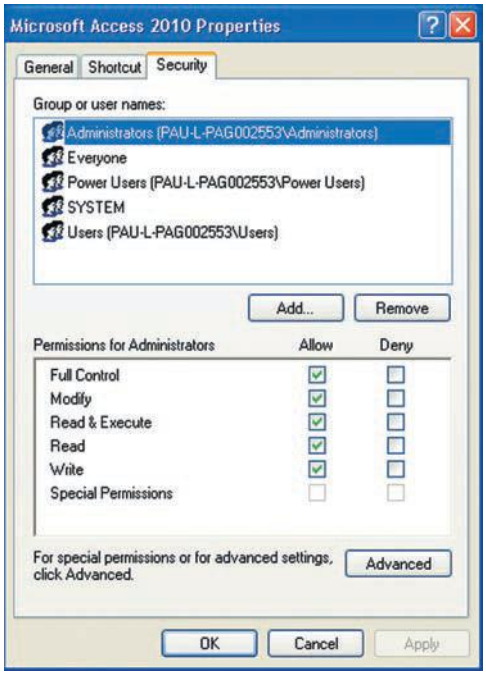


Figure 13.33 Administrators will set the user permissions of folders, files, printers and other network resources.

Every time we try to use a network resource, such as a network printer, a directory on a file server, or an application on a server, the network security system will check to see if we have the correct permissions on that resource.

On a school network, for example, an administrator creates a network folder called 'Year10'. The Year 10 coordinator will have write permissions on the folder and so can add documents to it. The group 'Year10Students' has read permissions on the folder, and so they can see what is inside it, but cannot add documents or make any changes to documents already in the folder.

User profiles

On many networks, people do not always use the same computer every day, as the resources are shared.

A network administrator may choose to configure the network so that a user can easily switch from computer to computer, but keep their environment the same. Features such as browser favourites or shortcuts on the desktop can be added to our profile, so that we see these features when we log on. If the administrator decides to use roaming profiles, you can see these features on any computer on the network. Each time a user logs on to the network at a computer, details about their profile are copied to the computer. When the user logs out again, any changes they have made to their environment are copied to their profile on a server. All this has to be managed by the NOS.

The disadvantages of using roaming user profiles is that they slow down the time taken to log on and increase the amount of traffic on the network.

Encryption and compression

Users often need to encrypt or compress their data before they store their files. This can be done in several software applications. However, sometimes it is necessary for the operating system to encrypt data before it is transferred over the network, so that unauthorised users are prevented from intercepting and reading it. Data can also be encrypted as it is stored on the server.

Compression of data on the servers is important to reduce the space that data files need. Unfortunately, this process is quite CPU-intensive and can slow the performance of the network temporarily. The network operating system can be set to perform these tasks at an appropriate time; for example, overnight when the network is not busy.

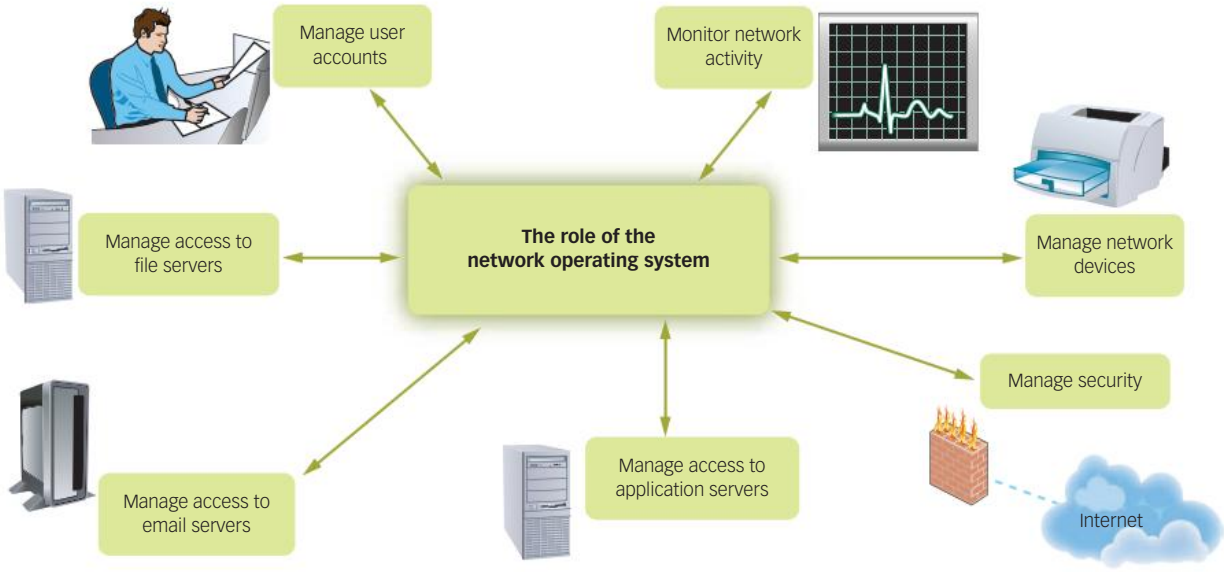


Figure 13.34 The network operating system has many tasks to perform to keep the network working well.

PEOPLE

CORE ALERT People

Network administrators

Katrina and Lauren jointly manage a large network of nearly 400 computers and several servers. They also support a large population of student and staff users in a NSW high school. Katrina and Lauren trained in network administration, and continue to learn new skills. Katrina gained a university degree in IT and specialised in Network Administration, whereas Lauren attended TAFE and gradually built up her skills in a practical way.

Both enjoy their work, finding strong job satisfaction in helping others to do their work effectively. No two days are the same, presenting them with continual opportunities to solve problems and to make their clients ever more productive.

They agree that although the job requires strong technical knowledge, it is a very people-oriented job, and that makes it so much more enjoyable. They find they need good communication skills, as many of their clients are not always very computer-literate.

QUESTIONS

1. In what ways are network administrators important to ensuring the success of a business?
2. Write a description of the personal qualities you think are needed in a network administrator.
3. What training opportunities are available for starting a career as a network administrator?
4. Ask a network administrator to complete a work analysis diary for a typical week, classifying their work in terms of user management, backing up data, maintaining security, installing software, upgrades or patches and so on. Write a brief report on your findings.

ACTIVITIES

Identify

1. What does the network administrator use the network operating system for?
2. Look at figure 13.34. Draw up a table to list and describe the different tasks that the network operating system must perform.
3. What is a user profile? How is it useful?
4. What does encryption mean?
5. Where does encryption usually take place?
6. Why is compression of data important?
7. What is the disadvantage of compressing large amounts of data?

Analyse

8. Which user groups would you be assigned to at your school?
9. Which parts of the network are you denied access to at school?
10. Give some examples of networks in which encryption would be important.

Investigate

11. What are the common network operating systems currently in use?
12. What other tasks do network operating systems perform, apart from the ones described in this section?

13.11 Choosing transmission media

There is no 'one-size-fits-all' solution to developing a network. Factors to consider would include how big the network will be, who will use it and for what purpose. Speed and security are advantages of wired networks, but for convenience wireless transmission is often used. Cost is always a factor, and this can increase dramatically if we want to use the latest technologies.

Cost of transmission media

Any network project will have some form of budget, and it is nearly always smaller than we would like.

If UTP cables are used, the costs involved would include:

- the length of cable – typically we run a length of cable from each wall outlet back to a switch
- installing wall outlets, positioned close to the workstations
- the labour involved – cabling must be done by licensed cablers
- fast network interface cards (NICs) for each computer.



Thinkstock/Adriana Spurio

Figure 13.35 Microwave dishes can transmit data over about 40 kilometres if they are within 'line of sight' of each other.

For wireless transmission, costs would include:

- wireless network adapters or NICs, which contain antennas and need no cable connection
- wireless access point(s), if connecting our network to an existing network or to the Internet.

If the network is to extend over several buildings, microwave dishes may be considered or the leasing of a virtual private network, which would be fairly expensive.

Transmission distance

The physical location of the computers that will use the network should be considered. If they are all close together, distance is not really an issue. UTP-cabled network guidelines suggest a maximum cable length of around 100 metres. Optical fibre may be needed if lengths are greater than this.

A problem with wireless transmission is that as distance increases, the bandwidth the link can support decreases. Maximum distance for NICs to access points is about 50 metres, but walls and obstacles can reduce this to around 20 metres.

In larger premises, such as a factory or warehouse, repeater units can be used to boost the signal. Alternatively, optical fibre and microwave dishes could be used for the longer distances.

Mobile broadband modems currently deliver at about 2 Mbps, but this can drop dramatically if the user is not in close range of a transmission tower, or if there is a lot of traffic on the network.

Security

If data is to be transmitted across the Internet, we don't have much choice in its pathway or the transmission media involved. However, there are some steps that could be taken to reduce the risk of unauthorised people collecting the data.

A virtual private network will have all of its data encrypted by default, and this offers a high level of security. Alternatively, some applications can offer encryption; for example, using the secure sockets layer in a browser or a public/private key method in distributing emails.

If you use a wireless connection, intruders have a much better chance of listening in to your transmission. Change the default network name and use the strongest security supported by your wireless devices.

Extensibility and sustainability

A network should be planned so that it can cope easily with being extended a reasonable amount. We can do this by including enough capacity for a specified increase; for example, 20 per cent. If we installed more outlets than needed in the first installation of a cable-based network, this might turn out to be cheaper than installing the extra outlets later, and would save a lot of disruption.

Extending a wireless network is relatively simple, although it may require additional wireless access points.

If our network includes a shared Internet link, we may find that adding more users affects the data throughput for each user. The evidence for this will be that the users will grumble more about slowness of Internet downloads!

Two possible solutions may be to negotiate a faster connection with the Internet service provider or add another link or account with the ISP.

ISSUES

CORE ALERT Issues

Listen who's talking!

Australia's security agency, ASIO, has asked the government to allow it to increase its powers to deal with new threats in the Internet age. ASIO wants a law that says that telcos and ISPs have to store 'metadata' generated by users of the Internet and mobile phones. Several state and federal police forces also support the idea. Welcome to the surveillance state of the future.

What does metadata mean? Basically it is everything relating to your calls, messaging and browsing history, but not the actual content itself. That means ASIO and the police would be able to find out which numbers you called, how long you spoke to them for, where the call was placed from and where it ended up, who you messaged and when, and websites you browsed and where from. Metadata does not include the content of calls (the actual talking part), the data you enter into websites or the content of messages.

National security bodies say that without this metadata, investigations into criminal wrongdoing and gang activity are being hampered and potential criminals have started using encryption technology to stop themselves from being tracked. With this system, police could have more chance of getting evidence to know where criminals and terrorists have been and when.

Opponents of the scheme say that every Australian would be treated like a criminal, costing them their privacy and a general presumption of innocence.

QUESTIONS

1. What does ASIO stand for? What is ASIO's main purpose?
2. What is 'metadata' in relation to mobile phone and Internet usage?
3. Why are some people opposed to this law? What is your opinion of the proposal?

ACTIVITIES

Identify

1. Why are there so many different designs of networks?
2. Refer to section 13.5. List the different types of transmission media that are used in communications networks.
3. What are the main factors that must be considered when choosing transmission media for a local area network?
4. List the main cost factors involved in setting up a network.
5. How far can a signal be transmitted in a UTP cable before it needs boosting?
6. What are the limitations for wireless transmission distances?
7. Why does using the Internet to transmit data involve risk?
8. What can network users do to make their data as secure as possible?

Analyse

9. How can network planners help to prevent networks becoming 'overcrowded'?
10. What is meant by extensibility and sustainability? Why are they important?

Investigate

11. Find out the current prices of some of the transmission media and other network hardware.
12. What are the maximum distances that optical fibre and microwave beams can transmit data before a booster is needed?

Review questions

13.12 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: Building a LAN

Overview

You are required to build a LAN for your classroom. Working in groups, you will need to allocate tasks to each member to achieve a solution that emulates the network in your classroom.



Microsoft

Figure 13.36 Network Properties from the Windows 8 operating system

Defining and analysing

1. Identify what equipment and software are available. Ask your teacher to provide a list, and whether you may get some from other sources such as other departments or the network staff.
2. You may need to search on the Internet for setting up the LAN for your particular operating system.
3. Ethical issues may arise in terms of how the hardware is acquired and what data may still be stored on it.

Designing

1. Each member of the group should have the opportunity to give their opinion on how the project will be developed.
2. Draw up a diagram to document the plan of action. Make sure everyone agrees on what they need to do and the deadlines.

Producing

1. Keep a diary of the group's progress. You may use an online collaborative site so that everyone can contribute.
2. Create a small client–server domain-based network. It should contain at least two clients and one server. Read again section 13.10. The following suggestions may also help with the basics, and you may need advice from a technician for the details.
   Create the server and user groups:
   a. Install or inspect the network operating system available; for example, Windows, Macintosh or Linux.
   b. Decide on a password for the network administrator.
   c. If possible, check that the server is running dynamic host configuration protocol (DHCP), as this will enable other computers to get their IP address automatically. Also, check the server is running a DNS server, as this is essential for a domain.
   d. Create some organisational units (OUs) within the domain. These are containers for computers and users that you may wish to group together. The OUs you create should be for each year level in the school.
3. Create a home page on the server and directories for all members of your group.
4. Create network shares and folders for the users.
   Test the network.
   Documentation:
   a. Draw a plan of the final network, identifying the characteristics of each piece of hardware and software.
   b. Develop a help manual for administrators and users.
   c. Describe carefully how you created and tested your network.

Evaluating

1. Ask some members of staff and fellow students to test your network. Provide a checklist for them.
2. Write a critique of your own and your group's performance at each stage.

Project 2: Documenting your school's network

Overview

Figure 13.19 shows a network map for a typical business. This group project will involve students creating a network map for their school's network, and also providing other relevant information. Tasks should be allocated and the final documentation will indicate the contribution made by each member of the team. There will be a group mark and an individual mark.

Defining and analysing

1. Form a group of 3–5 students.
2. Ask your school's network administrator to speak to the class to describe the system.
3. You may also ask about other aspects such as cost and history of the network.

Designing

1. Decide what information can be delivered and in what format.
2. As this is a group project, there will need to be a central document to record progress. Create an account in Google Documents or a similar facility online. Make sure everyone has access to this, including your teacher.
3. Identify and allocate tasks. Set deadlines for each. Create a Gantt chart to help with this.

Producing

Produce a detailed report that clearly describes the school's network, including a map of the network.

Your final documentation should answer some of the following questions:

1. The hardware:
   - What topology dominates?
   - What cable or wireless media are used?
   - Where are the servers and what function(s) do they perform?
   - Where are the switches, routers and hubs?
2. The software:
   - What network management system is used?
   - How are the users and groups defined?
   - What user security is used? What Internet proxy security is used?
   - What backup services are provided?
3. The users:
   - What services are provided to students, staff and administration?
   - Interview each group of users and find their opinion of the strengths and weaknesses of the system.

Evaluating

Each member of the group should write their own evaluation of:

1. the completed report – the format and content
2. how the group worked as a whole
3. how they contributed to the final project.

Additional content

Peer-to-peer networks

Earlier in the chapter, in section 13.6, we considered peer-to-peer networks in comparison with client–server networks.

In order for them to communicate with each other to share files and printers, the operating systems need the appropriate protocols to be installed. The use of common protocols such as TCP/IP has enabled computers running different operating systems to communicate with each other.

- Set up a peer-to-peer network involving one or more operating systems.
- Demonstrate that you are able to copy files, such as word processing documents, from one operating system to another.

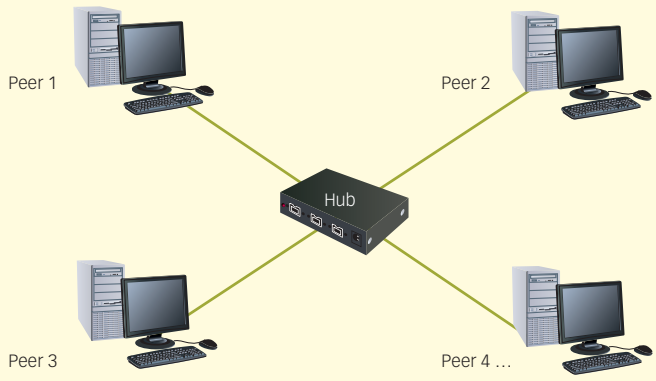


Figure 13.37 Setting up a peer-to-peer network using a simple hub

Extending the LAN

- Extend the client–server LAN you built in the previous project.
- Create a simple intranet by setting up a simple website on the server, and check that the other computers on the network can access the pages.

Industry links

Under the direction of your teacher, contact a networking company and ask about the possibility of your class visiting their premises or a company representative visiting your class.

OPTION

14 Robotics and automated systems

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- the history of robots and robotics
- different types of robots
- the purpose, use and function of robots
- automated control systems
- input, output and processing devices associated with automated control systems.

You will learn to:

- define and describe robots, robotics and automated control systems
- examine and discuss the purpose of robots and hardware devices associated with robots
- examine and discuss hardware devices associated with automated control systems
- investigate robotic and automated control systems.

Key terms

Actuators
output devices, such as motors and end effectors, that convert energy and signals to motion

Automated control system
group of elements that maintains a desired result by manipulating the value of another variable in the system

Controller
processes information from sensors and transmits appropriate commands to actuators in automated systems

Cyborgs
humans who use mechanical or electromechanical technology to restore or enhance their physical abilities

Degrees of freedom
measure of robotic motion; one degree of freedom is equal to one movement either back and forth (linear movement) or around in a circle (rotational)

End effector
mechanical device attached to the end of a robotic arm that carries out a particular task

Magnetic gripper
type of end effector used to pick up metallic objects

Motion sensor
automated control component that detects sudden changes of movement

Optical/light sensor
automated control component that detects changes in light or in colour

Robot
automatically guided machine that is able to perform tasks on its own

Robotics
science of the use and study of robots

Sensor
input device that accepts data from the environment

Solenoid
type of actuator that produces movement using a magnetic current

Temperature sensor
automated control component that measures temperature

IN ACTION

CORE ALERT Past, current and emerging technologies

Electric humans

The combination of artificial materials within the body has long fascinated humans and been the basis for captivating science fiction. From the 1970s *Six Million Dollar Man* to recent movies such as *Ironman 2*, we have been enthralled by the idea of the half-human, half-machine with superhuman abilities. Cyborgs are humans who use mechanical or electromechanical technology to restore or enhance their physical abilities. 'Cyborg' is actually a science-fiction shortening of 'cybernetic organism'. Research in robotics, digital technology, electronics and nanotechnology may, over the next half-century, alter the way we think about cybernetic technology.

The first generation of cyborgs is already walking among us. Millions of people around the world today have implanted medical devices, from pacemakers and artificial joints, to cochlear implants and artificial retinas, to brain chips and insulin pumps. Deep-brain implants that alleviate the disabling tremors of Parkinson's disease are also in use.

On the horizon are bionic eyes to let the blind see, and muscle implants that could allow paraplegics to stand and even walk. Artificial bones, blood, skin, eyes and even noses are now all being developed, and each could conceivably help people with a variety of medical conditions. Brain–machine interfaces are in the development phase and may eventually enable quadriplegic patients to control devices with their mind. Creating a reliable brain–machine interface is difficult, since we don't fully understand how the brain works.

In Australia, researchers are developing brain implants that can detect the onset of epileptic seizures and suppress them. They are also exploring new electrically conducting plastics that could stimulate and guide nerve fibres to repair spinal cords. Technologies developed here for pacemakers and cochlear implants can be transferred to many conditions where nerves have been damaged and need to be stimulated.

Despite the obvious benefits of cyborg and robotic technologies, they are presenting society with an ethical challenge. There is a concern they may be used by people without a genuine need. For example, retinal implants and wearable computers could be used to allow people to secretly record and transmit their vision. There is an ethical leap between using technology to help people overcome disabilities, and using it to 'improve' healthy humans.



Getty/LIFE Images Collection/Henry Groskinsky

Figure 14.1 Cyborgs may seem far-fetched, but the combination of human beings with mechanical technology is already assisting people with a variety of medical conditions.

QUESTIONS

1. Provide a definition of a **cyborg**.
2. Explain the following statement: 'The first generation of cyborgs is already walking among us.'
3. Identify the cybernetic technologies that are being developed and could help people with a variety of medical conditions.
4. Outline Australia's involvement with cybernetic technologies.
5. Describe the ethical challenge presented by cyborg and robotic technologies.

14.1 Robotics

Robotics is the science of the use and study of **robots**. The term 'robot' is usually applied to an automatically guided machine that is able to perform tasks on its own. Robots currently perform many functions, from making cars to defusing bombs. Children and adults play with toy robots, while vacuum-cleaning robots are sucking up dirt in a growing number of homes.

The use of robots

A robot can be programmed to perform tasks normally carried out by humans. These tasks are often repetitive, dangerous, very precise or even impossible for people to undertake. Robots have the advantage of never getting tired, being able to work with much higher accuracy than humans, and even being able to do things that humans cannot do, such as working in extreme temperatures. When robots perform boring, repetitive tasks in place of human workers, employees can spend more time performing creative, less tedious tasks.

Early and modern robots

The earliest robots were built specifically to perform simple tasks on an assembly line. These types of robots are still widely used in manufacturing. Modern robots usually have **sensors** to accept data from the environment and are increasingly found in the area of artificial intelligence. Intelligent robots are designed to imitate human behaviour and thought processes. Their inputs may include the senses of vision, touch, hearing and smell. An intelligent robot must be able to do two things:

- obtain information from its surroundings
- carry out physical tasks.

Modern robots possess three characteristics:

- programmability – they can be programmed to perform tasks like a computer
- mechanical capability – they can perform tasks in the environment like a machine
- flexibility – they can perform a variety of tasks by being reprogrammed or by responding to external conditions.

INFOBIT

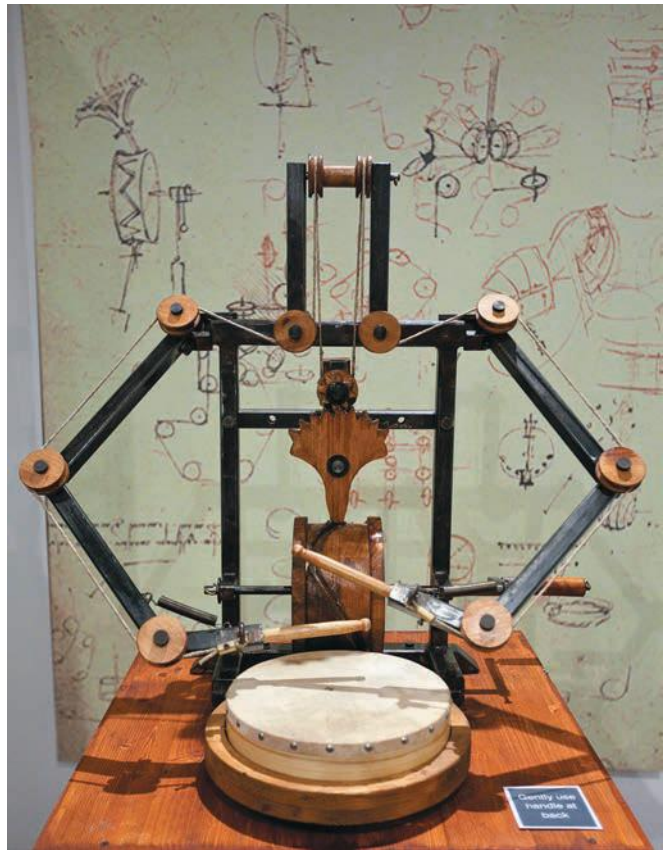
The word 'robot' comes from the Czech word *robota*, which means 'drudgery' or 'work'.

CORE ALERT Past, current and emerging technologies

The history of robots

Mechanical, computerised robots have been around for less than 50 years but the concept of robotic humans is not so new. The ancient Greeks spoke of 'mechanical helpers'. In the fifteenth century, Leonardo da Vinci, the famous Italian mathematician, artist and designer, drew plans for a mechanical knight (see figure 14.2). The knight was for entertainment and it was designed to keep a perfect beat once its handle had been wound.

During the 1920s, Karel Čapek wrote a play called *R.U.R. (Rossum's Universal Robots)*. In Čapek's play, the Rossum factory produced mechanical devices that were called *robota*, the Czech word for work. At first, these human-like machines were merely unintelligent slaves, but later, a scientist gave the creatures emotions. The robots eventually turned evil, killing the humans and taking over the world.



Newspix/Charles Brewer

Figure 14.2 Leonardo da Vinci's drumming robot, created by engineer Gabriele Niccolai from da Vinci's sketches

Following the early instances of robots in plays and science-fiction stories, robots started to appear in television shows, such as *Lost in Space*, and have since featured in many movies, including *2001: A Space Odyssey*, *Star Wars*, *Judge Dredd* and *Transformers*.

Asimov's Laws of Robotics

Isaac Asimov (1920–92) took a different view of robots from writers before him. He was the first to give robots characteristics that showed respect for humans. Asimov thought robots should be regarded as a very important technological innovation. In 1942, he wrote a story about robots, 'Runaround', which contained his Three Laws of Robotics. He later added a fourth law and called it the Zeroth Law. These laws are:

- Zeroth Law: A robot may not injure humanity or, through inaction, allow humanity to come to harm.
- First Law: A robot may not injure a human being or, through inaction, allow a human being to come to harm, unless this would violate the Zeroth Law.
- Second Law: A robot must obey orders given to it by human beings, except where such orders would conflict with the Zeroth Law or First Law.
- Third Law: A robot must protect its own existence, as long as such protection does not conflict with the Zeroth Law, First Law or Second Law.

The robot industry

The history of robots is quite new. While the ideas have been around for some time, the construction and use of robots did not really begin until the mid-1950s.

- In 1956, the first robot company was formed by George Devol and Joseph Engelberger.
- In 1959, computer-assisted manufacturing was first demonstrated at the Massachusetts Institute of Technology.
- In 1961, the first industrial robot, called UNIMATE, came online in a General Motors car factory.



Alamy/kolvenbach

Figure 14.3 In 1999, Sony built its first AIBO (robotic dog). The final version, released in 2006, could speak 1000 words, react to an owner's commands, take photographs and play music.



Alamy/Broccoli Photography

Figure 14.4 When robots first appeared in movies, they were often depicted as unfeeling villains with the potential to run amok and take over the world. More recently, robots have been portrayed as intelligent, social beings with a range of human-like emotions.

ACTIVITIES

Identify

1. Define the term 'robot'.
2. Define the term 'robotics'.
3. Identify the purpose of the earliest robots.
4. Identify the component of modern robots that enables them to accept data from the environment.
5. Name two characteristics of an intelligent robot.
6. Identify three main features of modern robots.
7. What was the name of the first industrial robot and in what year did it come online?

Analyse

8. Scientists have a very different view of robots from science-fiction readers and movie-goers. Explain these differences.
9. Discuss the relevance of Asimov's Laws of Robotics to the robotics industry today.

Investigate

10. Either write a short story involving Asimov's Laws of Robotics or summarise the plot of *I, Robot*, a movie starring Will Smith, loosely based on an Asimov story.

14.2 Types of robots

There are many different types of robots. One simple way to classify robots is according to whether they are stationary or mobile. Stationary robots are fixed in place, but their arms can reach out and manipulate parts and tools. These robotic arms have an **end effector** (see page 306) attached to carry out a task.

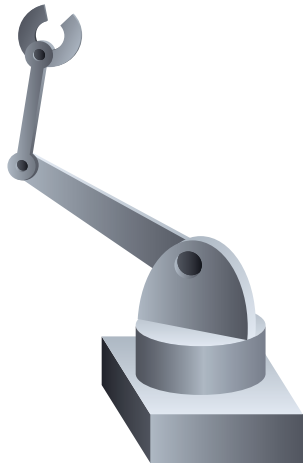


Figure 14.5 A robotic arm with an end effector attached

Stationary robots are often found in assembly lines, where they perform simple tasks, such as placing objects on a conveyor belt. Mobile robots, on the other hand, can move around in their environment and are not fixed to one physical location.

Industrial robots

Industrial robots have been around for more than 50 years, performing simple, repetitive tasks with superhuman speed and precision. They are now responsible for a remarkably wide variety of tasks, from assembling computers to popping frozen dinners into trays.

In the manufacturing industry, robots perform a variety of tasks, including:

- welding
- spray-painting
- assembly operations
- palletising and material handling
- dispensing operations
- laboratory applications.

Some robots used in manufacturing are designed to perform one particular task, while others are designed with interchangeable body parts, which make them more versatile. For example, a robot may act as a welder for one task, but by changing the end gripper, it may be turned into a spray painter. Significant improvements have been made in robotics technology in recent years. For example, to reprogram a new robot arm, an operator simply selects from among choices that the robot itself offers; a worker can teach a robot's eyes to recognise a new part in less than five minutes. Most robots used in manufacturing are stationary, but progress has been made in the development of more mobile robots.



Thinkstock/Andrzej Thiel

Figure 14.6 Robots in manufacturing

INFOBIT

Industrial accidents and the prevalence of some cancers have declined as a result of robots performing hazardous jobs in the workplace.

Mobile robots

Mobile robots usually move around on wheels, tracks or legs. Mobile robots began to appear in the 1980s in the area of nuclear science. In 1979, a nuclear accident at Three Mile Island in the United States caused a leak of radioactive material. The accident was a major concern because of the amount of radioactive substances released into the environment. This incident led to the development and use of special robots, called teleoperators, to handle the radioactive material. Today, mobile robots are used in areas such as security control, bomb disposal, planet exploration, transporting hazardous materials, and disaster rescue and recovery.



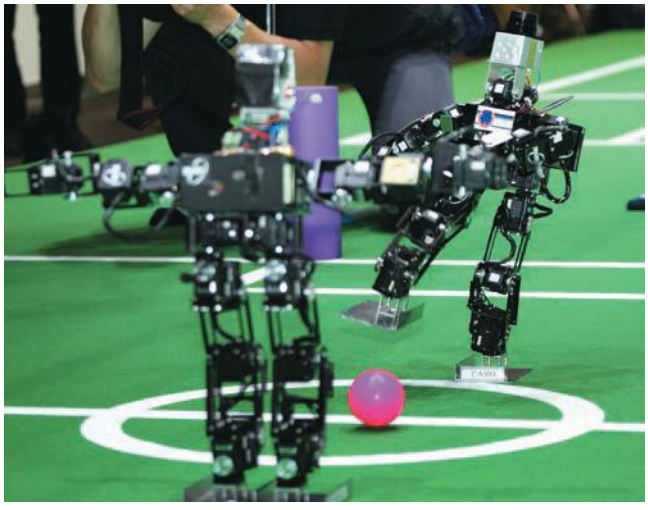
Hydronalix

Figure 14.7 This mobile robot is used to rescue distressed swimmers. Its sonar device scans for the underwater movements of swimmers in trouble and an in-built speaker allows a lifeguard on shore to calm and instruct the person being rescued.

Educational robots

Robots, or robotic kits, are used extensively in education. Robotic equipment in the classroom is used to teach and learn about programming and computer control. One example is the Mindstorms EV3 kit developed by LEGO. The kits usually consist of building blocks, sensors and motors, which are assembled into models. Among other functions, a model can be programmed to walk and to carry out a variety of tasks or missions. The upcoming practical activities will provide you and your classmates with the opportunity to collaboratively embark on a series of robotic challenges.

Another educational example is the programming of robots to play soccer in the RoboCup competition. Teams from all over the world enter the competition. The robots operate completely autonomously – there is no external control by humans.



Getty Images/Yoshikazu Tsuno

Figure 14.8 In the RoboCup Humanoid League, autonomous robots with human-like senses play soccer against each other. RoboCup is an annual international robotics competition that promotes robotics and artificial intelligence (AI) research. There are many other stages of the competition, such as RoboCupRescue, RoboCup@Home and RoboCupJunior.

INFOBIT

Interactive 'social robots' called Petimos have been designed to help protect children when they make friends on social networks. Petimos' primary function is to guard against cyber bullies and adults masquerading as children.

Domestic robots

Robotic toys include remote-control cars, remote-control boats, barking dogs and crying dolls. Other domestic robots perform boring and repetitive household chores, such as vacuuming.



http://www.wired.com/reviews

Figure 14.9 Many modern toys are considered robotic because they are programmed devices. They may react to light, sound and touch, using special sensors for input.



http://www.robosoft.com/eng/contact.php

Figure 14.10 Kompai is a domestic robot that can record grocery lists via voice commands, call an emergency number for medical assistance and remind elderly people to take their medication.

The changing nature of work

Spill something in a nuclear reactor core and you can't just send in the janitor to clean it up. (Well you can, but just once.) What you can do – repeatedly – is send in remotely operated robots designed by Matt Cole. At 33, Cole is chief engineer of Colorado-based SA Technology, which earns more than $20 million a year making 'bots' for nuclear facilities.

For a kid who taught himself to weld, mill and lathe before he was old enough to vote, Cole believes it is a dream gig.

'We do the worst, the hottest, the weirdest jobs,' he says.

Like what? For starters, his creations mop up areas that are so radioactive they've been dubbed infinity rooms – a Geiger counter needle goes past 11!

Each task requires its own unique bot. For example, if a piece of nickel lodges in a pipe at a reactor plant and turns into the extremely radioactive and dangerous isotope cobalt-60, Cole and his team of engineers construct an agile bot that can extend a telescopic arm, spray liquid nitrogen to cool the pipe, and cut away the radioactive segment. Other bots are designed to plunge into giant waste tanks and hose down radioactive materials such as caesium-137. SA Technology bots are at every major nuclear weapons facility in the United States, as well as most nuclear power plants. As more and more Cold War-era weapons facilities are being decommissioned, business has never been better.



Gamma-Rapho

Figure 14.12 In order to reduce the safety risks to humans, robots can venture into radiation-exposed areas.



Joshua Zaffos, 'Alphageek: Matt Cole Builds Robo Rooters that Scour Out Reactors', *Wired* magazine, June 2010, http://www.wired.com. Photo by Leon Chew.

Figure 14.11 Matt Cole's robots perform tasks that are too dangerous for humans.

INFOBIT

During the 2011 nuclear crisis in Japan, many people were surprised that robots were not deployed to repair the crippled reactors. Despite being a technological powerhouse and a world leader in robotics, Japan essentially relied on a small team of engineers, firefighters and helicopter pilots to perform the task of cooling the reactors.

QUESTIONS

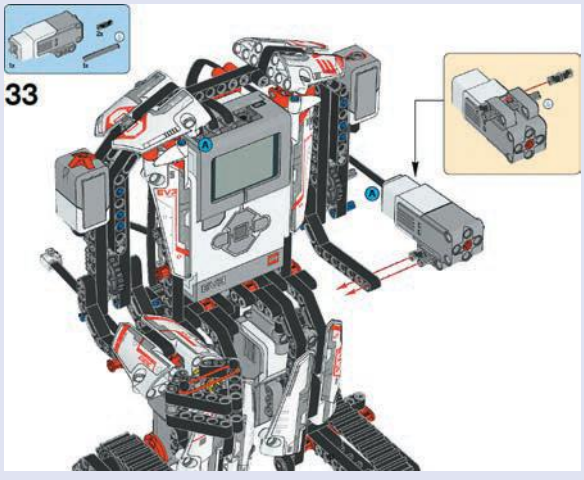
1. Describe the tasks carried out by Matt Cole's robots.
2. If robots such as those created by Matt Cole did not exist, how would we deal with toxic accidents and the decommissioning of nuclear weapons?
3. Automation and the development of robots for dangerous tasks, such as those described in the article, are viewed by most people as beneficial to society. However, many workers in less dangerous jobs have been made redundant by robots. Do you think the development of new robotic technologies, and their implementation, is inevitable? What, if anything, should we as a society do for those people who lose their jobs?

TASK 1

LEGO Mindstorms EV3

Using a LEGO Mindstorms EV3 kit, or equivalent, you will familiarise yourself with the robotics kit and programming environment required for this chapter. Most robotics kits supply tutorials with the accompanying program.

1. Examine the building blocks contained in your robotics kit. Identify special components such as the light sensor, touch sensor, sound sensor, motors and lights.
2. Create a poster of all the components in your robotics kit, with pictures and labels. Hang the poster in your classroom or laboratory to use as a quick reference guide during this topic. Note the way the pieces are measured. For example, with LEGO, the building blocks are measured according to the number of bumps on each piece.
3. Open the software you will use to operate the robotic equipment. For LEGO, this may be Mindstorms EV3.
4. Work through the available tutorials to familiarise yourself with the program. Pay particular attention to the icons and buttons in the program.
5. Identify the output ports and the input ports. What names are they given in the program? What components are plugged into the output ports? What components are plugged into the input ports?
6. Use one of the Mindstorms EV3 tutorials to build a model.
7. Copy the program in the tutorial to make your model functional.
8. Run the program and observe the model in action.
9. Write another program for the model and run it.



LEGO Mindstorms EV3 tutorial

Figure 14.13 A typical assembly instruction from the LEGO Mindstorms EV3 tutorial

ACTIVITIES

Identify

1. Identify the main difference between a robotic arm and a mobile robot.
2. Why are robots used in industry?
3. List four tasks performed by robots in manufacturing.

Analyse

4. Find one example of a robot used in manufacturing. For your example, answer the following questions.
   - **a** What is manufactured?
   - **b** What tasks does the robot perform?
   - **c** Is the robot a stationary arm or a mobile robot?
5. Find an example of a robot used for security control. Describe the function of the robot in the system.

Investigate

6. Develop and conduct a survey on the use of robots in industry and in the home. Develop a chart to illustrate the findings and present them to the class. A sample of questions for domestic robots might include the following.
   - **a** What would you want a domestic robot to do?
     - Housework
     - Gardening
     - Cooking
     - Security
     - Entertainment
     - Other
   - **b** How much would you be prepared to pay for a domestic robot?
     - Less than $100
     - Between $100 and $500
     - Between $500 and $2000
     - Over $2000
   - **c** Questions relating to industrial robots include the following.
     - How aware are you of robots being used in industry to manufacture goods?
     - Why do you think robots are used in industry?
     - What advantages do robot workers have over human workers?
7. Visit the RoboCupJunior Australia website and read about the RoboCupJunior competition.
   - **a** Locate two Australian schools that have entered the competition and read about their project.
   - **b** Find out where and when the next RoboCupJunior competition is going to be held.
   - **c** With your teacher, discuss the possibility of entering the competition.

14.3 The purpose of robots

The most common use of robots has been in manufacturing, where robotic equipment often replaces human workers on production lines. Robots are preferred because they:

- can operate equipment more precisely than humans
- can work 24 hours a day, 7 days a week, without getting tired or losing concentration
- may be cheaper to use over a long period
- can work in environments that may be too dirty or dangerous for humans
- may be able to do work that is impossible for humans to perform.

Dirty tasks

In manufacturing, many jobs in factories are messy or dirty. Dirty tasks may include welding, grinding, moulding and casting. When robots are used to perform these tasks, it enables human workers to partake in more meaningful and creative pursuits.

Repetitive tasks

Robots are reliable workers. They do not have emotions and therefore do not feel worthless when performing menial tasks. For most people, repetitive tasks performed in industry are considered very dull or boring. For example, a robot's only task may be to pick up an object from a conveyer belt and place it in a box. The robot can perform this task all day, every day, without getting bored.

Dangerous tasks

In manufacturing, robots often perform tasks that are very dangerous for people. Using robots for tasks involving extreme temperatures, for example, reduces the risk of workplace accidents. Apart from dangerous tasks in manufacturing, robots are also being used to carry out other important but dangerous activities such as clearing landmines, helping in rescue missions and mopping up toxic leaks. Police robots are used to defuse and remove explosive devices. Some robots are so tough that they can survive multiple blasts.

INFOBIT

The first known case of robot 'homicide' occurred in 1981, when a robotic arm crushed a Japanese factory worker.



Getty Images/Javier Pierini

Figure 14.14 Purpose-built robots include prosthetic arms that can handle heavy or delicate tasks.

Impossible tasks

Working deep under water, exploring live volcanoes at short distance or travelling to faraway planets are impossible tasks for humans. Robots are often called on to perform underwater salvage missions to find sunken ships or planes. The *Titanic*, which sank in 1913, sat on the ocean floor at a depth of 3811 metres for more than 70 years before being located. At this depth, the ship was too deep to be explored by human divers. In 1985, a team of researchers, with the aid of a robot named Jason Junior (JJ), were able to locate the wreck of the *Titanic* (see page 321).

Underwater robots were also called on following the explosion and fire on the Deepwater Horizon drilling rig in 2010. Operating one and a half kilometres under the ocean's surface, they played a vital role in the fight to stop oil gushing into the Gulf of Mexico. In 2014, robot submarines were used to search for a missing Malaysia Airlines plane (MH370).

PEOPLE

CORE ALERT People

Animatronics engineer Grant Imahara

Grant Imahara is an animatronics engineer who has worked on such movies as *The Lost World: Jurassic Park*, *Star Wars Episode 1: The Phantom Menace*, *Terminator 3: Rise of the Machines* and *The Matrix Reloaded*.

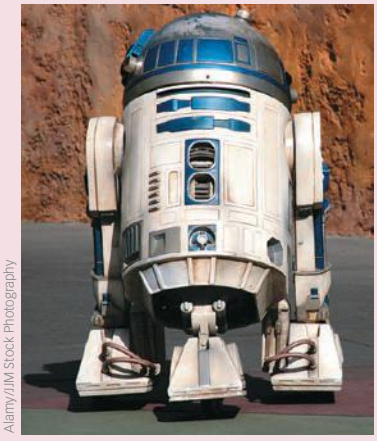
Grant was one of those kids who would disassemble remote controls and take all the wheels off toy cars. His life changed at the age of four when he received his first LEGO set. It introduced him to robots and provided a foundation for his interest in engineering. After graduating from college, he was asked to work for Lucasfilm, where he worked in the special effects model shop.

He made spaceships and miniature cities as well as robots. He was part of the R2-D2 development team for episodes one, two and three of *Star Wars*. Then the *MythBusters* opportunity came along and now he gets paid to blow things up. Grant has also written a book on building robots called *Kickin' Bot* and his combat robot, Deadblow, was featured on *BattleBots*.



Getty Images/Jason LaVeris

Figure 14.15 Grant Imahara is an animatronics and robotics expert who is best known for his work on the American television show *MythBusters*.



Alamy/JJM Stock Photography

Figure 14.16 In *Star Wars Episode I: The Phantom Menace*, *Star Wars Episode II: Attack of the Clones* and *Star Wars Episode III: Revenge of the Sith*, R2-D2's movements were controlled by Grant Imahara.

QUESTIONS

1. Identify the event that changed Grant Imahara's life.
2. Research and provide a job description of an animatronics engineer.
3. Research and explain the relationship between animatronics and robotics.

ACTIVITIES

Identify

1. Identify the industry where robots are most commonly used.
2. Outline the reasons why robots are used in manufacturing.
3. List four areas of robotic use today, apart from the manufacturing industry.
4. List the reasons why robots are considered to be more reliable workers than humans.
5. Name two dangerous tasks performed by police robots.

Analyse

6. Imagine you could have a robot that would do any task you requested – a companion to do all the work you find tedious or tiring. How do you think this might affect you as a person?
7. Describe the types of jobs that would not be suitable for robots.

Investigate

8. Apart from the *Titanic* discovery, describe another situation where underwater robots have been used to locate or explore shipwrecks.
9. Underwater robots proved invaluable following the 2010 Deepwater Horizon oil spill (also referred to as the Gulf of Mexico oil spill). Research this environmental disaster, paying particular attention to:
   - the reasons why robots were used to contain the oil leak
   - the difficulties encountered during the clean-up
   - the tasks performed by the robots.
10. Investigate the ways in which robots are used to help people with disabilities.

14.4 The use of robots

Robots are used in many areas of our modern life to perform a wide range of tasks. In manufacturing, robots are used in assembly production lines. They are also used in all types of exploration, both in space and here on Earth, in medical science to perform operations, in agriculture, and to maintain and repair machinery.

Exploration

For centuries, explorers and scientists have been gathering data about Earth and our solar system through missions and voyages, often at great risk to themselves. Today, robots have enabled research and data-gathering to take place without directly involving humans.



Questacon

Figure 14.17 RoboQ is an adaptive robot that receives input from sensors to make physical movements or produce vocal responses. It is the main attraction of a hands-on Questacon exhibition in Canberra that highlights the important work robots perform in modern society.

INFOBIT

Unlike hardware robots that we can see and touch, web robots are programs that traverse the web automatically collecting and analysing data. They are also known as web wanderers, bots, crawlers or spiders.

Robots in the Antarctic

Compared to a century ago, the Antarctic is relatively accessible to scientists who wish to study its climate, ecosystems and glaciers. However, there are still places too dangerous, too remote or simply too expensive for humans and standard research equipment.

Robots in the Antarctic are involved in a range of research activities, including flying low over vast ice sheets and mapping the hidden realms below ice-covered lakes and seas. The types of robots include pilotless aircraft capable of flying preprogrammed routes or automated submarines that venture far below ice shelves at depths considered unsafe for humans.

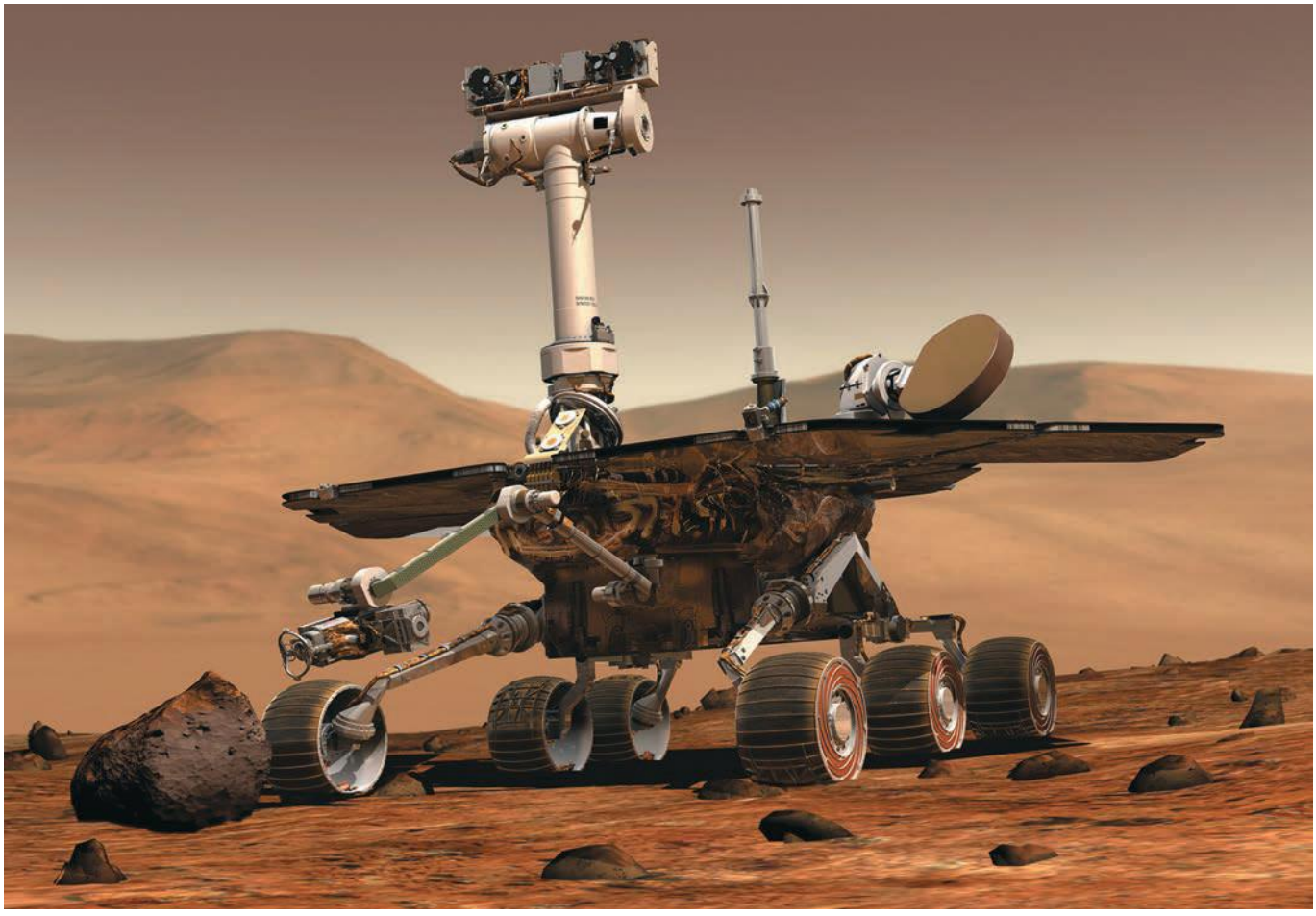


US National Science Foundation/Josh Landis

Figure 14.18 Nomad (pictured) was the first robot to explore an extreme polar environment. It is equipped with a sophisticated laser rangefinder and sensors, which are used to detect obstacles and make the robot cognisant of potentially dangerous terrain.

Space missions

Much of the research work performed by scientists and geologists in space has only been possible through the use of robots. Robots are suited to space exploration because they can perform tasks less expensively and more quickly. They operate for long durations, often 'sleep' for extended periods before their mission begins or while waiting for suitable exploration conditions. NASA's twin robot geologists, the Mars Exploration Rovers, for example, have been exploring Mars since 2004 (see figure 14.19). They periodically enter a low-power hibernation mode as the daily sunshine on Mars declines and their solar panels struggle to provide sufficient energy to their batteries. When the weather conditions become more favourable, the robots 'awaken' and recommence exploration. Moving from place to place, the rovers perform on-site geological investigations. Each rover could be considered the mechanical equivalent of a geologist walking the surface of Mars. Their robotic arms are capable of movement in much the same way as a human arm with an



NASA Images

Figure 14.19 The Mars Exploration Rovers have been performing on-site scientific investigations of the 'red planet' since 2004.

elbow and wrist, and can place instruments directly up against rock and soil targets of interest. In the mechanical 'fist' of the arm is a microscopic camera that serves the same purpose as a geologist's hand-held magnifying lens.

Underwater exploration

Exploration also takes place under water where temperatures are at the other extreme to that of volcanoes and pressure may be strong enough to crush the human body. The design of the latest underwater robots is closely based on the anatomy of crabs – known for their ability to walk both on land and under water. With the help of such amphibious robots, scientists have been able to study marine plant and animal life, as well as ocean currents and underwater ecologies.

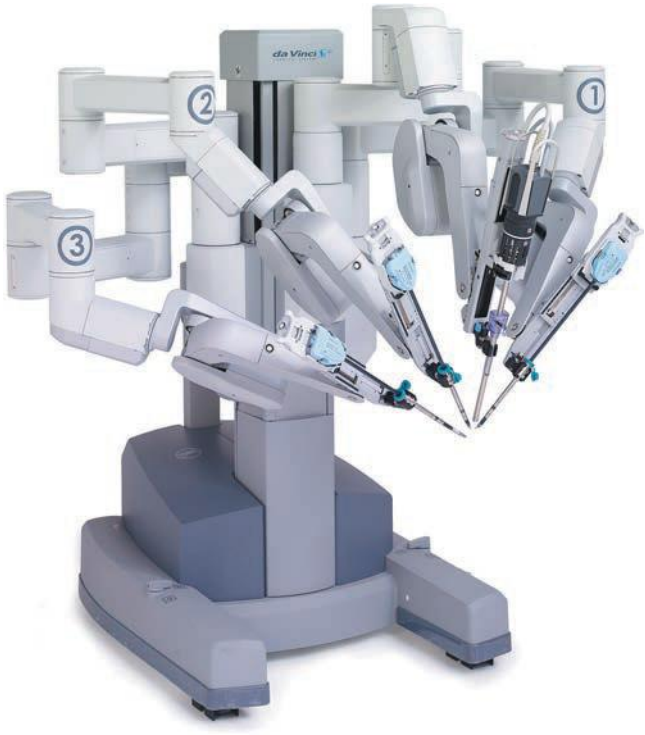
INFOBIT

Underwater robots are often large and when they crash into things such as delicate coral they can cause a lot of damage. Robotic engineers in the United States are developing small, agile, fish-like underwater robots that will explore sunken ships and monitor coral reefs. They may also be used to move through urban industrial pipes to track down illegal pollution spills.



Getty Images/The LIFE Picture Collection/Bill Ingalls

Figure 14.20 Live volcanoes are extremely dangerous places for people to be near. Robots such as Dante II are able to travel into live volcanoes to collect gas, water and rock samples for scientific research.



PictureMedia/WENN.com

Figure 14.21 Dr Roboto is a remotely operated surgeon featuring four arms.

Medical science

Extensive research has been carried out into the use of robots in medical science. Researchers believe robotic technologies can improve existing procedures and provide new approaches to current problems.

One example is the use of robots to perform surgery through very small incisions, greatly reducing the risk to patients (see figure 14.21).

Assembly

Robots and computer-controlled systems have made a significant impact in the manufacturing industry, particularly in assembly lines. In the modern world, much of what is produced is done so on an assembly line. High-speed assembly lines produce cars, furniture, soft drinks, computers, razor blades, toasters and numerous other items. These goods are produced in massive quantities, and all have to be of the same quality.

In 1961, the first industrial robot was introduced to the assembly line at General Motors' vehicle manufacturing plant. The system allowed the company to manufacture cars quickly and at a low cost. The robot, called UNIMATE, was developed by the father of robotics, Joseph F Engelberger. The task of the huge robotic arm was to sequence and stack hot pieces of die-cast metal by following step-by-step instructions. It greatly improved the speed and accuracy of vehicle manufacturing. But this new technology resulted in changes to the nature of work in the car industry. Many jobs were replaced by robots. Workers who did retain their positions were required to retrain, since the remaining jobs required more technical skills.

Maintenance and repair

Robots are well suited to performing maintenance and repair work, such as on roads. Road surfaces tend to show signs of wear after long periods of heavy use or under extreme weather conditions. They can develop long cracks, which can make driving hazardous, and therefore need to be repaired constantly. It has also been found that by taking preventative maintenance measures, the durability of a road is significantly enhanced.

Assisting people with disabilities

The world's most sophisticated robots are now designed to support our surging population of elderly and disabled citizens. There is a range of household robots that can understand instructions and help with household chores. They can perform almost anything, such as taking a bottle from the fridge, using tongs to lift bread from the toaster onto a plate and carrying a tray of food from the kitchen to the dining table.

INFOBIT

Swimming robots are micro or nano robots that can swim when injected into the body. Their applications include removing parasites and breaking kidney stones.



Popular Science: A Bonnier Corporation Company

Figure 14.22 This wheelchair contains two robotic arms programmed to help users perform everyday tasks such as cooking, dressing and shopping.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

Robots in space

NASA researchers envision futuristic robots that act like people and work more efficiently with astronauts. The idea of building human-like robots capable of using their hands to do intricate work is not new to space travel. The original Robonaut was conceived in the 1990s.

Robonaut 2 (R2), developed by NASA and General Motors, can lift and hold four times the weight of any previous robotic assistant. R2 is stronger, has more movements and is more technologically advanced than the original Robonaut, according to NASA. The flexibility of R2 allows it to use the same tools as astronauts, removing the need for specialised robot components.

The robot has two highly flexible arms and hands on a torso that will be bolted onto a fixed spot in NASA's space station's Destiny laboratory. Astronauts can replace an arm, a hand, or a limb as needed and will be able to attach other parts for future stages in its life. The greatest benefit of R2 may eventually be in performing jobs too difficult or dangerous for humans.

The NASA team hopes to eventually teach R2 to do all kinds of things on the space station. For example, R2 might perform delicate tasks such as setting up science experiments for the crew, or it might just as easily run a vacuum cleaner.

R2 is also destined for car assembly plants. It can lift approximately five kilograms with each arm, about four times that of other humanoid robots. Its nimble hands, fingers, and opposable thumbs also enable it to perform more specialised or intricate jobs.



NASA Images

Figure 14.23 Robonaut is a human-like machine that, when fully developed, is expected to perform tasks and seek help only when it encounters problems it cannot solve on its own.

QUESTIONS

1. Robonaut 2 is classified as a humanoid. Research and write a definition of the term 'humanoid'.
2. Outline the characteristics of Robonaut 2 that allow it to perform more dexterous tasks than its predecessor.
3. Describe the features of Robonaut 2 that could be considered human-like.

ACTIVITIES

Identify

1. List three different areas of exploration in which robotic technologies are used.
2. Why are robots suited to space exploration?
3. How long have NASA's twin robot geologists been exploring Mars?
4. Identify the type of creature that has been the inspiration for underwater exploration robot design.
5. Who is considered to be 'the father' of robotics?

Analyse

6. How are robots used to help people with disabilities?
7. 'Scientists would be better off spending valuable funds on developing robots to help the disabled, rather than on exploring live volcanoes.' Do you agree or disagree with this statement? Justify your answer.
8. Discuss the ethical issues that arise from the introduction of computer-controlled systems to replace human labour.

Investigate

9. Research some of the changes to the nature of work that began with the introduction of the first automated assembly line.
10. How have advances in robotic and computer technology enabled surgeons to perform operations remotely on patients who may not even be in the same country?

14.5 The function of robots

Like other computer systems, robotic systems are composed of hardware and software. Movement is an important function of many robots and it is the hardware and software that facilitate this process.

Movement

Robotic motion is described in terms of **degrees of freedom**. One degree of freedom is equal to one movement either back and forth (linear movement), or around in a circle (rotational). To understand how this works, consider the human arm. The human arm has six degrees of freedom, allowing the following movements:

- shoulder – up and down (one degree)
- shoulder – forwards and backwards (one degree)
- elbow – up and down (one degree)
- wrist – rotate (one degree)
- wrist – up and down (one degree)
- wrist – left and right (one degree).

Additionally, the operation of thumbs and fingers gives several more degrees of freedom.

In a robotic system, usually one robotic joint corresponds to one degree of freedom, but this depends on how the hardware is connected. Most jointed robots have six degrees of freedom that are similar to the human arm; an articulated arm type, for example, usually has six degrees of freedom. Six degrees of freedom is usually sufficient to conduct most simple tasks.

So, in a robot with an articulated arm, the following movements are possible:

- arm – up and down (one degree)
- arm – lengthen and shorten (one degree)
- body – rotate (one degree)
- wrist – up and down (one degree)
- wrist – rotate (one degree)
- wrist – left and right (one degree).

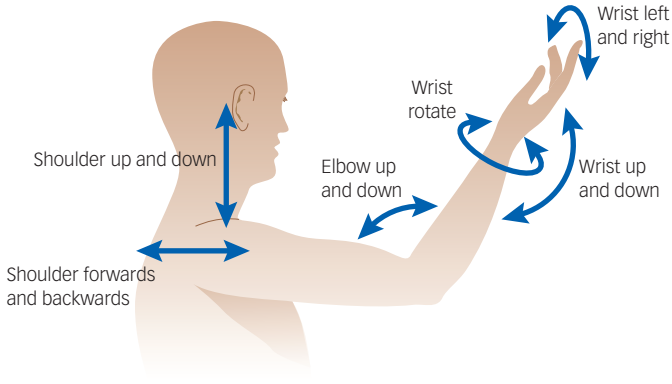


Figure 14.24 Degrees of freedom in the human arm

Robots move in three ways: pick-and-place, point-to-point and contouring.

- Pick-and-place: This movement has only two positions per axis and suits loading and assembly functions in mass-production situations.
- Point-to-point: This movement is controlled from one point location in space to another. Each point is programmed into the robot's control memory and then played back during the work cycle. This type of movement is suited to tasks such as spot welding.
- Contouring: This movement allows the robot to follow a path that forms the shape of a smooth curve. The robot's gripper carries out a programmable path movement and performs variable functions on this path. Applications include spray-painting, continuous welding and grasping objects moving along a conveyor.

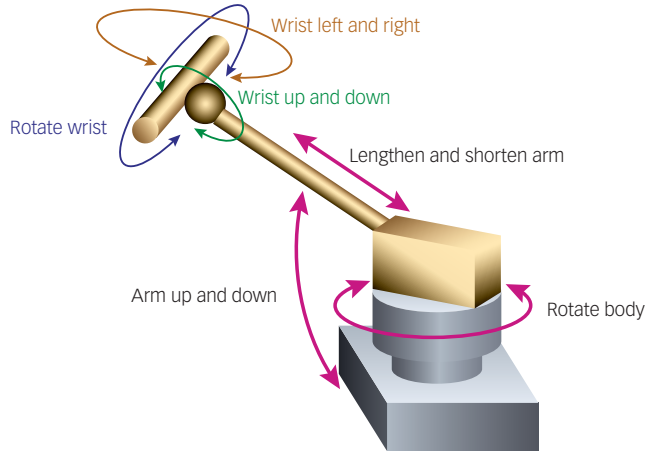


Figure 14.25 Degrees of freedom in a robotic arm

Hardware

The hardware used to control robotic systems can also be likened to human body parts. The human body is considered to be made up of five main physical components: a body, muscle system, sensory system, power source and brain system. The physical components of a robot resemble that of a human (see figure 14.26.)

Robot sensors receive signals from the environment and pass them to the **controller**. In humans, our eyes act as sensors, collecting signals from our environment and passing these signals to our brain. The robot controller processes signals from sensors into output signals that enable movement or some other event to take place. Our brain processes signals received from our eyes and sends

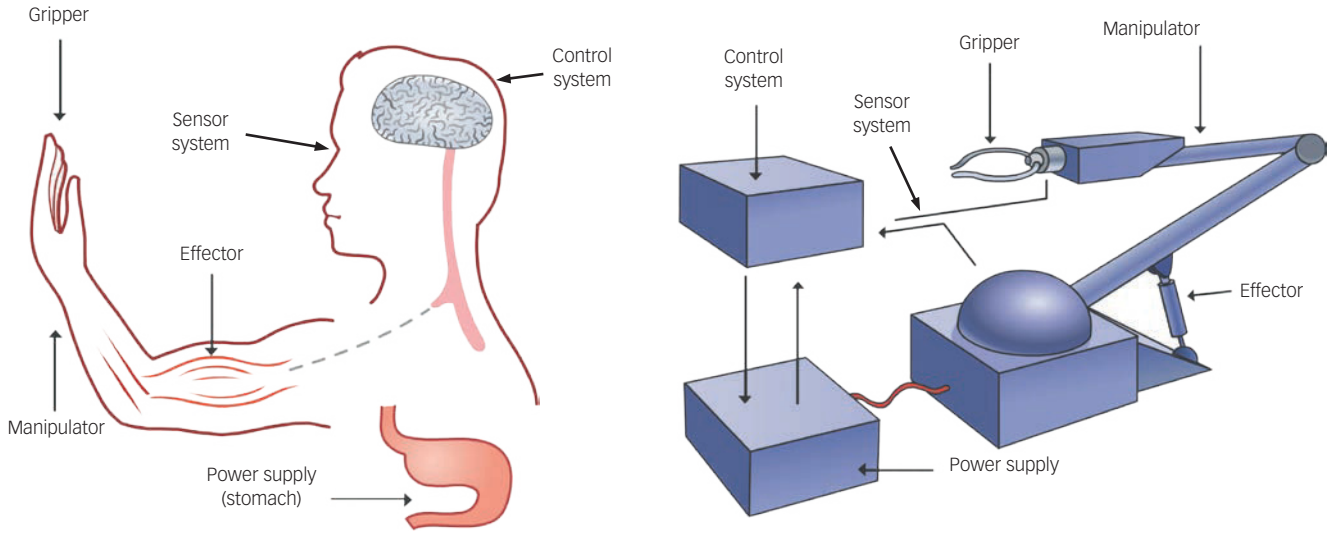


Figure 14.26 The human body and computer-controlled systems have similar components.

messages to drive particular body parts. For example, when we see a step in front of us, the brain sends a message to lift the leg to climb the step.

In a robot, these output signals are sent to **actuators** to tell them to carry out some action, such as switching a motor on or off, opening or closing a valve, moving an arm to a specified point or avoiding bumping into an object. Actuators are output devices, such as motors and end effectors, which convert energy and signals to motion.

End effectors are particular types of actuators or output devices for robots and are connected to the end of a robot arm. Different types of end effectors exist, and all perform a physical task. End effectors may be tools, vacuum grippers or **magnetic grippers**; all of which possess a specific set of commands (see figure 14.28).

A robotic arm is usually fitted with one type of end effector at a time. If the end effector on the arm needs to be changed, the robot would need a new set of commands or program instructions to operate it. For example, it is not possible to replace a gripper with a screwdriver head and expect the robot to perform the same task. It would be necessary to change the programming of the robot controller and use a different set of end effector motors to drive it.

Components of the human body system	Components of a robotic system	Functions of the robotic components
Body structure	Physical structure; for example, gears, screwdrivers and levers (hardware)	Provides movable body parts
Muscle system to move the body structure	Actuators (motors); for example, electric motors, solenoids, pneumatic or hydraulic cylinders	Converts energy and signals to actions to move the body parts
Sensory system that receives information about the body and the surrounding environment; for example, sight, touch	Sensor system, either direct contact (for example, touch sensors, strain gauges or pressure sensors) or non-contact (for example, infrared, light, sound, radar, sonar, laser beam or visual)	Receives information about the robot's environment
Power source to activate the muscles and sensors	A power supply; for example, mains electricity or batteries	Provides the necessary power to activate the actuators and sensors
Brain and nervous system that processes sensory information and tells the muscles what to do	Controller (brain); for example, microprocessor(s) and software, or wired into the hardware	Processes information from the sensors and sends appropriate commands to the actuators

Figure 14.27 The physical components of a human body compared to the components of a robotic system

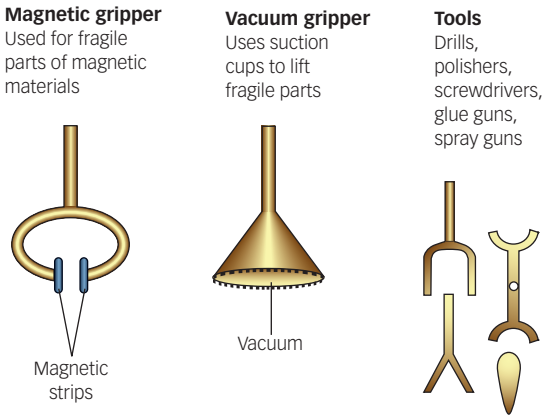


Figure 14.28 Types of end effectors

Software programs

CORE ALERT Software

All robotic systems use software to instruct the hardware on how to perform tasks. As a rule, industrial robots perform quite specific tasks. The software that drives the hardware is often a specialised control language. Other robots are designed to perform more general tasks, such as the LEGO robots constructed for home and educational use. These general-purpose robots are instructed by more general-purpose programming languages.

Programming languages may use different techniques to control robots in performing tasks. They fall into two categories: online programming and offline programming. Online programming involves 'teaching' the robot the path it must take. This is done by manually moving the robot arm through the required motions. The path is recorded and a program is generated. Offline programming requires programming code to control the robot's motions before the robot is put to action.



Thinkstock/Denis Tabler

Figure 14.29 A magnetic gripper in action

PEOPLE

CORE ALERT People

Robot developer Hugo Elias

When Hugo Elias was eight, rather than make him set the table for dinner, his dad would teach him how to wire a circuit with a knife and fork. By the time he was 14, Hugo had joined the local robot club, which met every Wednesday evening to tinker with robots and discuss the group's grand visions for the future. The group went on to become the Shadow Robot Company, which now makes everything from a pigeon-feeding robot to a robotic hand claimed to be as dexterous as a human one.

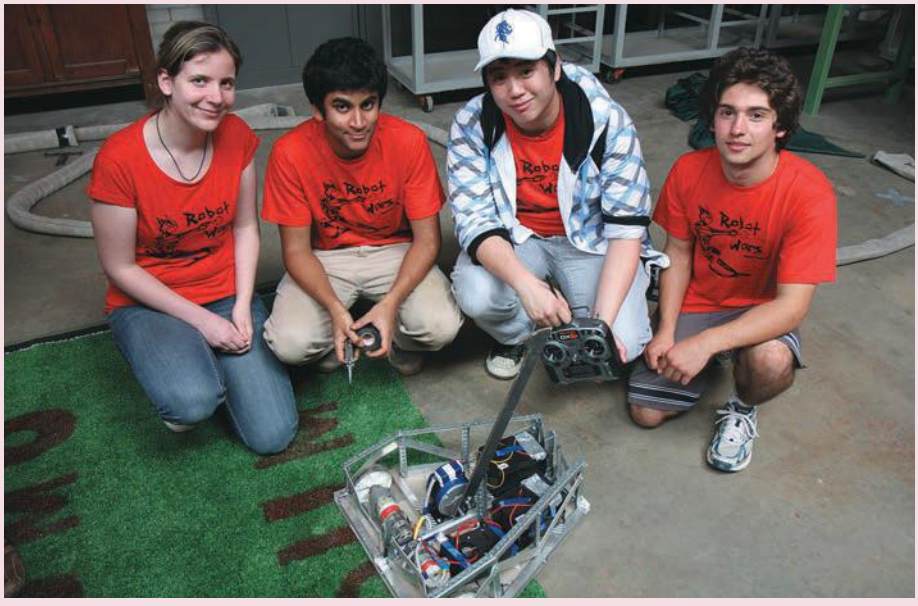
For Hugo, a typical day includes designing mechanical parts on a computer-aided design program, testing prototypes, writing software, wiring electronics and researching new ideas. He has a degree but believes this is one job where your academic qualifications are less important than practical experience.

'My degree didn't qualify me to do my job. Practically everything can be self-taught or learned on the job,' he says.

The best piece of advice Hugo can give budding robot developers is to build a portfolio of projects. 'I'm interested in seeing what projects people have worked on in their own time – competitions, and projects they have done for themselves,' he says.

For Hugo, building his portfolio meant taking part in competitions such as Robot Wars. Although each project takes a long time to complete, and can be set back by small mistakes, Hugo still regards his career as 'play' rather than work. 'If I won the lottery, I would still be doing this,' he says.

© 2010 Reed Business Information - UK. All rights reserved. Distributed by Tribune Content Agency



Flickr/Getty/Froge

Figure 14.30 According to Hugo Elias, taking part in competitions such as Robot Wars is one of the best ways to launch your career as a robot developer.

QUESTIONS

1. Identify the tasks carried out by Hugo Elias in a typical day.
2. To be an effective robot developer, Hugo Elias states that 'academic qualifications are less important than practical experience'. Why do you think he holds this belief?
3. Investigate the Robot Wars competition mentioned in the article. Explain the purpose of the competition and describe the robots used by participants.

ACTIVITIES

Identify

1. Explain the term 'degrees of freedom' as it applies to robotics.
2. Identify the number of degrees of freedom possessed by an articulated arm.
3. List three types of end effectors.
4. Name two ways that robots may be programmed.
5. List the main components of a robotic system and describe the function of each.

Analyse

6. How many degrees of freedom are in a human elbow joint? Describe these movements and draw a diagram to illustrate them.
7. Describe the difference between pick-and-place movements and point-to-point movements.

Investigate

8. Research one type of end effector used by robots. In your research include:
   - **a** the name of the end effector
   - **b** a picture or diagram
   - **c** an explanation of the task it performs
   - **d** a poster or digital presentation on the findings of your research.
9. Use the online simulator at the BBC's Robot World Techlab to build and program a robot.

14.6 Automated control

In our everyday lives, we use devices that are operated by manual control; that is, they need to be operated by humans. Examples include cars, sewing machines, vacuum cleaners and electric drills. Automated systems, on the other hand, are designed to operate under automatic control. Automatic control means they will operate independently or without human intervention. These devices are given appropriate instructions through special programs. Robots can be classified as computer systems that use automated control.

Automated control systems

These systems accept data, process this data and produce data signals or actions to change the operations of another system. The purpose of an **automated control system** is to maintain a desired result. It achieves this result by manipulating one or more variables of another system. A good example of this is an airconditioning unit that uses a thermostat to maintain a constant programmed air temperature. This involves:

- input – the airconditioner reads the room temperature using a **temperature sensor**
- process – this reading is compared to the set temperature entered by the user
- output – signals are sent to turn the thermostat on to adjust the temperature.

Components of automated control systems

Signal conditioners are used to ensure data signals can be understood and measured by a data acquisition device. Often, control systems need to convert analog data to digital data (and vice versa). During this process, the signals may suffer from interference – sometimes referred to as noise. Signal conditioners help remove any unwanted interference and may be used on both input and output data signals.

Components	Functions
Sensors	Input devices that detect conditions in the environment then send the results as signals to the controller
Signal conditioners	Devices that help keep the signals passed to and from the controller 'clean'; that is, reduce the amount of interference in the signals
Controllers	Devices that process the input signals from the sensors to produce the output signals required to drive the actuators
Actuators	Output devices that perform the physical actions that have an effect on the environment

Figure 14.32 The components of an automated control system

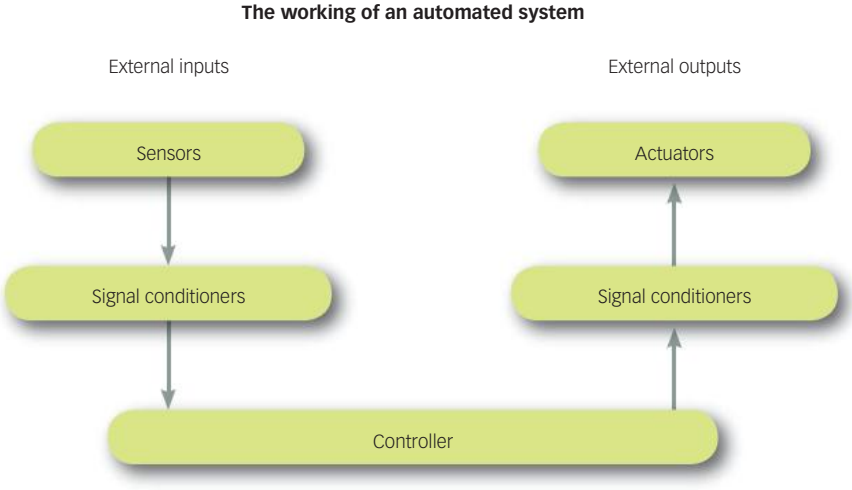


Figure 14.31 A diagrammatic representation of an automated control system

Historical perspectives

CORE ALERT Past, current and emerging technologies

The history of control systems is categorised according to developments in technology. There are four main periods:

- mechanical and hydraulic
- direct digital
- minicomputer
- microcomputer.

Mechanical and hydraulic

The mechanical and hydraulic period began during the Industrial Revolution of the eighteenth and nineteenth centuries. The development of control systems at this stage was based on mechanical devices, with inventors having little understanding of how machines could be automatically controlled. Developments in control systems during this period were slow and not usually planned. However, a number of machines, such as looms and lathes, were designed to be self-regulating.

Direct digital

In 1959, the first digital computer was used to control an automated system. Computers were installed to monitor the control system from a central location using analog controllers. The development of control systems during this stage was still limited by slow and unreliable computers.

During the direct digital period there was a growing need for:

- more organised methods of controlling systems, which could be achieved by viewing the whole system as dynamic
- a set of good mathematical models to program computers correctly, which involved developing a better way of controlling computer hardware.

Transistors were developed during this period and built into computers.

Minicomputer

In 1965, the first minicomputer was introduced by Digital Equipment Corporation (DEC). During this period, improvements in computing technology had a direct effect on process control.

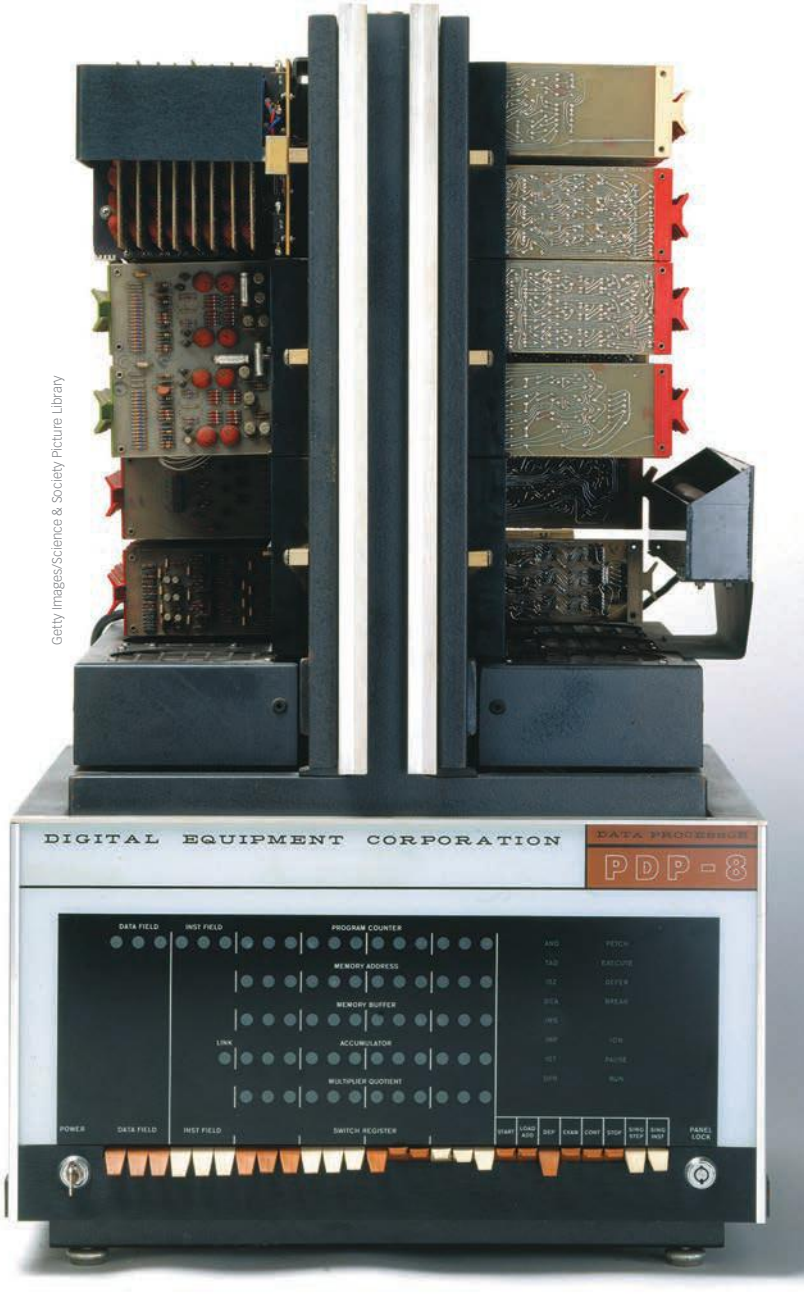
Computers became extremely reliable and were able to process large amounts of data more quickly. The number of computers used in automated control grew considerably.

Microcomputer

In 1972, the microcomputer appeared and made significant changes to the way computers were used. Programmable controllers were developed and replaced the older styles, which used hard-wired relay logic. This meant that process controllers could be built for control systems.

INFOBIT

The IBM ASCC (Automatic Sequence Controlled Calculator) was the first large-scale automatic digital computer built in the United States. Built in 1965, it contained over 800 kilometres of wires and weighed more than 3000 kilograms. Mathematical problems were entered into this massive machine using 1440 dials.



Getty Images/Science & Society Picture Library

Figure 14.33 Digital Equipment Corporation introduced this minicomputer, used in automated control, in 1965.

Types of automated control

In the manufacturing industry, a common method of categorising automated control systems is according to the type of operation they perform and the type of products they produce. The three main types of automated control systems are continuous, batch and discrete. The features of each are outlined in figure 14.34.

Control systems	Features
Continuous	Designed and built to perform one manufacturing task, 24 hours a day, 7 days a week, with some time required for system maintenance. Not flexible; for example, a new model of car may require a new assembly plant to be built.
Batch	Produces large quantities of a particular product, but can be quickly altered to produce new or alternative products. The control system is capable of being quickly reprogrammed.
Discrete	Entire system is involved in producing a single item. Produces items only in small quantities; for example, CAD/CAM. Least suited to large-scale production. Expensive.

Figure 14.34 Features and examples of different types of control systems

Household control

Computer control systems are a common feature in many households already. These include automated:

- security systems
- climate control systems
- sprinkler systems
- audiovisual sound systems.

TASK 2

Automated systems

Write a program to control a LEGO model. The program is to control a set of traffic lights to manage vehicles at an intersection. In a later task, you will develop the model further.

1. On paper, design a set of vehicle traffic lights. Draw the lights and list the components, such as green light, amber light and red light.
2. Write down the rules required to operate the model. For example, the light will be green for 10 seconds. Next the amber light should go on for 2 seconds, and the red light will turn on for 10 seconds.
3. Build the traffic light with your LEGO kit. Connect the traffic light to the computer or interface if necessary. Write the program by converting your set of written instructions to appropriate computer instructions.
4. Run the program and document the results. Now modify the program to control a T-intersection. Remember, when the lights are green one way, they must be displaying red for the other direction. The lights must not change to red without first showing amber.

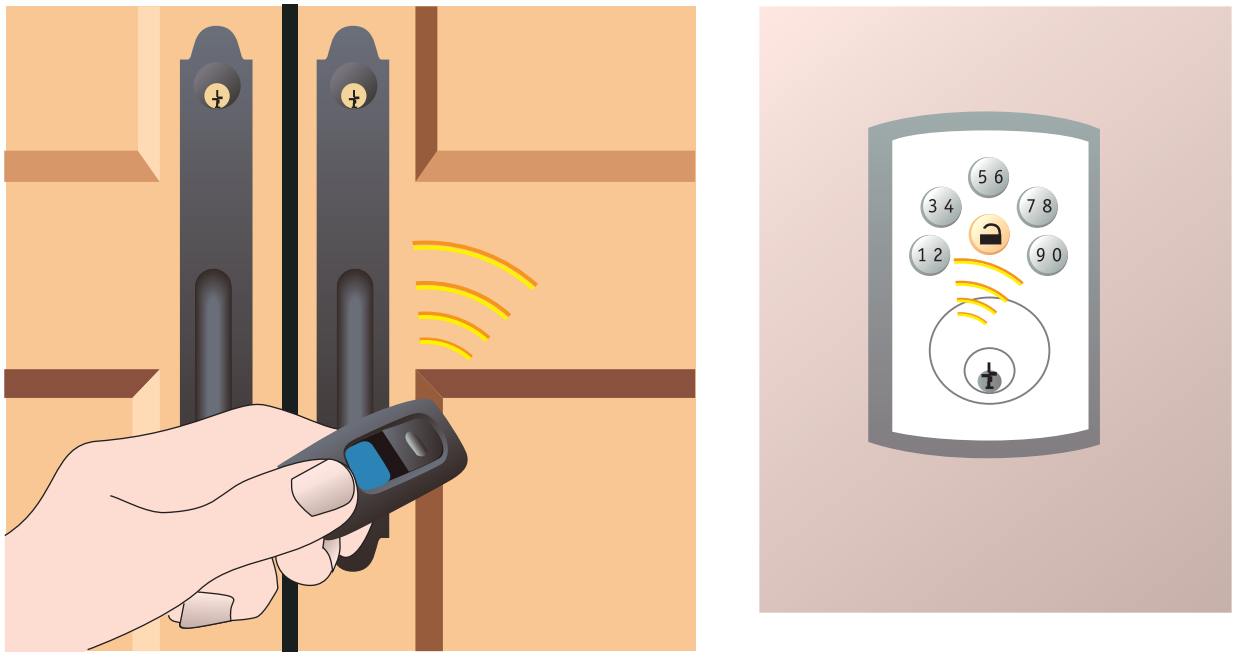


Figure 14.35 Automated security locks are just one example of a variety of control systems that can be found in the home.

ISSUES

CORE ALERT Issues

Scientists worry machines may outsmart humans

A robot that can open doors and find electrical outlets to recharge itself. Computer viruses that no one can stop. Predator drones, which, though still controlled remotely by humans, come close to a machine that can kill autonomously. Impressed and alarmed by advances in artificial intelligence, a group of computer scientists is debating whether there should be limits on research that might lead to loss of human control over automated systems that carry a growing share of society's workload, from waging war to chatting with customers on the phone.

Their concern is that further advances could create profound social disruptions and even have dangerous consequences. As examples, the scientists pointed to a number of technologies as diverse as experimental medical systems that interact with patients to simulate empathy, and computer viruses that defy extermination and could thus be said to have reached a 'cockroach' stage of machine intelligence.

While the computer scientists agreed that we are a long way from Hal, the computer that took over the spaceship in Stanley Kubrick's famous movie *2001: A Space Odyssey*, they said there was real concern that technological progress would transform the workforce by destroying a widening range of jobs, as well as force people to learn to live with machines that increasingly copy human behaviours.

The researchers largely dismissed the possibility of highly centralised super intelligences and the idea that intelligence might spring spontaneously from the Internet. But they agreed that robots that can kill autonomously are either already here or will be soon. Such scenarios raise important questions about military personnel being sheltered from the consequences of their actions.

What could a criminal do with a speech synthesis system that could mimic the human species? What happens if artificial intelligence technology is used to mine personal information from smartphones?



Corbis/DoD

Figure 14.36 Predator drones, such as this one in Afghanistan, still need a human hand to work – at least for now.

QUESTIONS

1. Identify the concerns researchers have raised in relation to advances in artificial intelligence.
2. According to the article, what are the legitimate concerns related to technological progress and the workforce?
3. Discuss the threat that artificial intelligence systems such as self-driving cars, software-based personal assistants and robots pose to human jobs.
4. Do you think automated systems are benefiting humans and improving society in general, or are they perhaps moving us towards a technological catastrophe?

ACTIVITIES

Identify

1. Outline the difference between manual devices and automated systems.
2. Using an example, outline the purpose of an automated control system.
3. Describe three types of automated control systems.
4. Identify four periods in the development of process control.
5. Describe the types of automated control systems that were developed in the first four periods of automated control.

Analyse

6. Identify the advantages and disadvantages of each type of automated control system.

Investigate

7. Find one example (different from those mentioned in the text) of each type of control system – batch, continuous and discrete – and, for each example, discuss why you think this type of system is used.
8. Research one control system and write a report. Include the category of control system, list the inputs and outputs, describe the main processes, and explain the role of the computers in the system.
9. Research the origins of automation and create a timeline that showcases the major developments.
10. Investigate and present a report on how modern homes are being equipped with a variety of technological tools that automate tasks.

14.7 Sensing devices

As mentioned earlier, sensors obtain information from the environment. The type of sensor used will depend on the type of data required by the system. Sensors may be classified as active or passive.

Active and passive sensors

Active sensors require physical interaction between the sensor and another device. These sensors use sound waves rather than light or visual data. For example, active sensors may be used to track people in a building or they may be used to trace the location of ships at sea.

Passive sensors require a change in the environment in order to operate. Most security systems use sensors called passive infrared detectors (PIRs) to detect intruders and turn on an alarm. PIRs are electronic devices that detect body heat when intruders enter or move around a protected area.

Type of sensor	Function
Temperature settings	Measure current temperature and may include control units, such as those used to control temperature in airconditioning units
Motion and pressure sensors	Detect sudden changes of movement
Optical/light sensors	Detect changes in light or changes in colour
Chemical sensors	Detect the presence and quantity of various chemicals

Figure 14.37 Various forms of sensors are used to measure different types of data.

INFOBIT

The latest touchless thermometers are able to detect body temperature from a distance. A person simply stands in front of a small mirror on the device and the temperature sensor displays a reading within seconds.

TASK 3

Build a traffic light with sensors

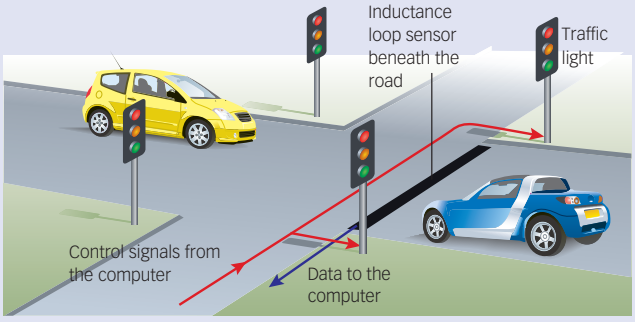


Figure 14.38 A traffic light system uses an inductance loop that is controlled by computer.

In this task, you are required to use your robotic equipment to simulate a pedestrian traffic light. You may base your work on the vehicle traffic lights completed in task 2 if you wish, or start from scratch. In small groups, work through the following steps:

1. Draw a sketch of a pedestrian traffic light, identifying the red, amber and green lights and a push button (sensor).
2. Select the required components from your robotics kit.
3. Note which of the components are input devices (sensors) and which are output devices (actuators).
4. Build the model of a pedestrian traffic light, including a touch sensor.
5. Write a program for the model that obeys the following rules:
   - The light is green unless the sensor is activated.
   - The touch sensor is to be activated when a pedestrian pushes the button.
   - When the sensor is activated, the light is to turn amber for a set time, then red.
   - The light should remain red long enough for someone to cross the road, and then turn green again.
6. Convert your written phrases into a programming code using the appropriate language.
7. Run the program and observe the results.
8. Did the program run as expected? If not, make the necessary changes and run it again.
9. In your group, discuss how the system could be made safer for pedestrians by including a walk/don't walk light.
10. Challenge: Implement your pedestrian safety ideas into the model.

Traffic lights

Traffic lights use a range of sensors to control traffic and help keep people safe on the roads. Commonly, traffic light systems use an inductance loop placed in the road. As a car goes over the loop, a small current is induced. This is fed to the processor controlling the system. The system then recognises that a car is present. Some traffic lights do not use sensors. At busy intersections, for example, traffic lights may simply operate on timers in order to ensure that traffic moves as smoothly and safely as possible.

Navigation systems in cars

Satellite navigation systems, or satnavs, provide drivers with directions as well as information on traffic and estimated time of arrival. Satnavs use global positioning to help drivers determine where they are at any one time.

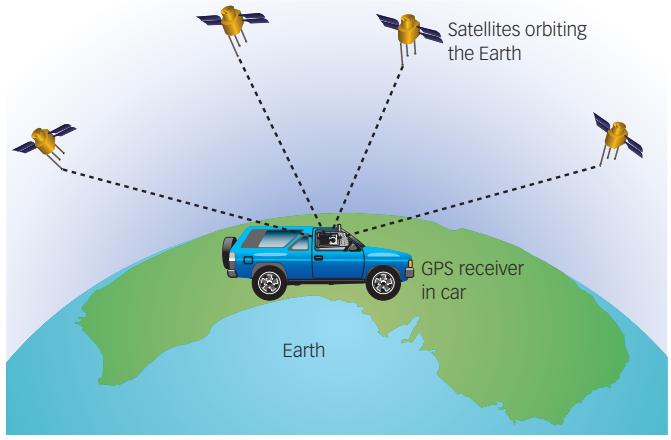


Figure 14.39 Global positioning systems rely on a process of triangulation whereby the location of a transmitter can be determined by measuring either the distance or the direction of the received signal from three or more different points.

ISSUES

CORE ALERT Issues

Location-based services

Location-based services (LBS) are software applications that provide users of mobile devices – particularly GPS-enabled smartphones – with personalised services based on their current location. There are apps, for example, that notify friends of your location in real time or allow users to locate the nearest automatic teller machine. Other services allow businesses to direct advertising at people; for example, transmitting digital coupons based on users' proximity to particular shops.

Unlocking the GPS functionality of mobile phones has opened up a whole new world of convenience, but it has also increased concerns about privacy and raised questions about the measures that LBS providers are implementing to protect users' information. Not surprisingly, concerns have been raised about the threats to privacy posed by LBS technology.



Thinkstock

Figure 14.40 Trends in social media and the prevalence of smartphones with in-built satellite positioning have encouraged an increasing number of people to broadcast their whereabouts via location-based services.

Locational privacy refers to the ability of an individual to move in public space with the expectation that their location will not be systematically and secretly recorded for later use. Location-based services have the potential to strip away locational privacy, making it possible for individuals and organisations to harvest data on the movements of LBS subscribers.

Users must provide their consent before a service provider can determine positioning data from their mobile phone. However, once consent is given, information may be quietly collected by organisations – particularly advertisers – who may assemble profiles on users without their knowledge. Privacy activists say consumers may be surprised to learn companies monitor LBS users' activity and profit from their data.

QUESTIONS

1. Identify two advantages of location-based services.
2. Provide a definition for the term 'data harvesting'.
3. Outline the privacy concerns associated with location-based services.

INFOBIT

Most late-model cars contain an astonishing array of sensors to allow engines and electronic systems to run at peak efficiency.



Thinkstock/Hans Wijnveen

Figure 14.41 Engine control units accept inputs from a range of sensors and display a variety of information about a vehicle's performance.



Thinkstock/John Keith

Figure 14.42 Motion detectors are often connected to security alarms.

Security alarms

There are many types of security alarms used in homes and commercial buildings. You may have one in your home. A common design is an alarm that uses a **motion sensor** detector to pick up unexpected movements in its path. These types of systems have two main components:

- a source of light, such as a laser beam
- an **optical/light sensor**.

In a home security system, the light beam is aimed at the light sensor, across a passageway. When somebody walks between the light source and the sensor, the path of the beam is momentarily blocked. The sensor registers a drop in light levels and sends a signal to the control box. This activates a timer and allows the homeowner to enter a security code. If the light source is disturbed by an intruder and the security code is not entered, the alarm sounds.

Automatic doors

Automatic doors use a sensor to open doors at the required time. The sensor is often placed at the head of the door. It is passive and may be an ultrasonic device or a passive infrared detector. When the presence of a person is detected, a message is sent to the controller to open the door.



Thinkstock/Maciej Noskowski

Figure 14.43 Automatic doors use optical or motion detection sensors to activate their motorised opening and closing mechanisms.

INFOBIT

Developments in chemical sensors now enable doctors to visit patients and perform an immediate blood test. The hand-held sensors allow physicians to get an immediate on-site chemical analysis, without having to wait days or weeks for laboratory reports.

Nanosensors

The development of nano-enabled sensors is in the early stages, but the technology is expected to be a strong force in the treatment of a range of illnesses from the common cold to cancer. The present era of nanotechnology has reached a stage where scientists are able to develop tiny programmable machines that can work inside a patient's body. Nanotechnology may enable engineers to construct sophisticated nanorobots that can navigate the human body, transport important molecules, manipulate microscopic objects and communicate with physicians by way of miniature sensors, motors, manipulators, power generators and molecular-scale computers.

TASK 4

Build a car with sensors

In this task, you are going to use your robotic equipment to simulate a car turning a corner on a road. The vehicle is to follow a set path on the road, which goes around a 90º corner.

1 On a large sheet of white cardboard, draw the path the car is to follow. Draw the path using a thick black felt marker so that it is about 2 cm in width, as shown in figure 14.44.



Figure 14.44 The path of a car

2 Sketch the car, identifying the wheels, axles, motors and sensor.

3 Choose the correct components from the LEGO or other kit needed to build the model. Hint 1: The car will need two motors to perform a turn.

4 Build the model of the vehicle with a touch sensor and light sensor. You may need to refer to the resource material in your kits to help you with this construction.

5 Write a program that will enable the car to follow the path.

6 Convert the phrases into the appropriate programming language. Hint 2: Use the light sensor to determine when the car strays from the path. Hint 3: To make a small turn, the car should use one motor for a short time.

7 Run the program and observe the results.

8 Did the program run as expected? If not, document what did happen and make the necessary changes to the program and run it again. This step may need to be repeated several times until successful.

9 Modify the program so the car follows the same path in the opposite direction.

10 Modify the activity again by extending the path so it resembles a rectangular shape. Make a decision as to whether or not you will need to adjust the program so that the car remains on the path while it completes a full 'lap' of the path.

ACTIVITIES

Identify

1 Identify three types of sensors.
2 Identify two types of sensing devices.
3 Outline the purpose of chemical sensors.

Analyse

4 Explain the difference between active and passive sensors.
5 Explain the purpose of a sensor.
6 Explain the function of an inductance loop in a traffic light system.
7 How are alarms activated in home security systems that contain light sensors?

Investigate

8 Toll roads with electronic payment sensors can be found in several Australian cities. Explain the purpose of a toll road system and draw a diagram to represent the system, showing its main components.
9 Fibre-optic sensor systems are now widely used and are becoming the first choice for a range of applications. Investigate the benefits of fibre-optic sensors and identify the areas where they are in operation.
10 Countdown timers are being trialled on pedestrian traffic lights in some parts of New South Wales. Explain how these systems operate and discuss whether or not you believe they will improve pedestrian safety.

14.8 Actuators and controlling devices

Actuators and controlling devices are the unsung heroes of automated control systems. In simple terms, they represent the muscles and brains of automated systems.

Actuators

Actuators convert commands to actions; that is, they perform the physical work of a control system. Figure 14.45 lists the types of actuators available.

Type of actuator	Function
Solenoids	Used to move an arm through a small movement
Electric motors	Provide smooth, continuous rotational motion in a clockwise and anticlockwise direction
Stepper motors	Provide precise movement to a specified location
Relays	Act as a switch to control mechanical movement
Pumps	Used to force liquid or gas into piston chambers to cause mechanical movement

Figure 14.45 The types of actuators and their functions

Solenoids

A **solenoid** consists of a magnetised iron rod surrounded by a tightly bound coil of wire. When an electric current passes through the wire, a strong magnetic force is produced that is strong enough to move the rod. When the current is switched on, the force moves the rod in one direction. When the current is switched off, the rod moves in the opposite direction. A push movement may be used to connect the starter motor of a system, such as a car starter motor. A pull movement may be used to open a valve, such as in an automatic watering system.

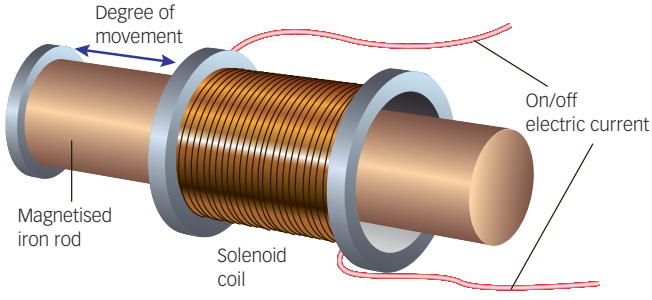


Figure 14.46 A solenoid uses magnetic currents to move a rod.

Electric motors

Electric motors provide smooth, continuous rotational motion in a clockwise and anticlockwise direction. Motors are the most commonly used type of actuators in a control system. They can produce a wide range of movements using gears and levers.



Shutterstock.com/chenws

Figure 14.47 Electronic motors are often used in LEGO models.

Stepper motors

Stepper motors provide precise movement to a specified location. The rotational movement may be controlled to an accurate number of degrees. Stepper motors are useful in automated systems when very precise movements are required.



Shutterstock.com/monkey business images

Figure 14.48 Stepper motors control the precise movements required by 3D printers.

Relays

Relays are also called switches. They consist of a solenoid connected to a mechanical switch. Relays are often used with a small electric current to turn on a large electric current. For example, a 5-volt signal from a computer could be used to turn on a 240-volt power supply to an electric motor. Relays often serve as a safety mechanism for systems using large currents.

Pumps

Pumps can be hydraulic (oil) or pneumatic (air). The forces created by a pump make the pistons move, causing a mechanical action. Pumps are often used in robotic arms and can achieve very rapid and precise movements.

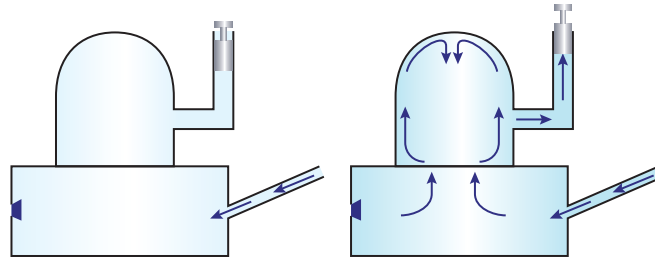


Figure 14.49 A pump pushes gas into a chamber until it is so full that it forces pistons to move.

Controlling devices

The controlling devices in automated control systems are responsible for coordinating a range of processes. The controller usually consists of a microcomputer and a memory unit.

Microprocessors

Often the controller of an automatic control system is the microprocessor of a computer. Like other systems, the microprocessor is set up to accept data from input devices, process it and send data to output devices. In a controlled system, the microprocessor receives its input from sensors and, once processed, sends the appropriate signals to the actuators.

Use of feedback to the controller

There are several methods of classifying automated control systems. An open-loop control system does not use feedback. The system has some form of input, process and output, but the input does not rely on the system itself. An example of an open-loop system is an oven, where the cook chooses the oven temperature and settings to initiate the cooking cycle. While the food is being cooked, there is no check made on the state of the food. In the manufacturing industry, open-loop automation usually involves devices that pick up and place objects.



Figure 14.50 An example of how an open-loop system, such as an oven, works

A closed-loop system uses feedback. The input of the system depends in some way on the output of the system. An example is a temperature control system, or thermostat, used to control an airconditioning unit in a building.

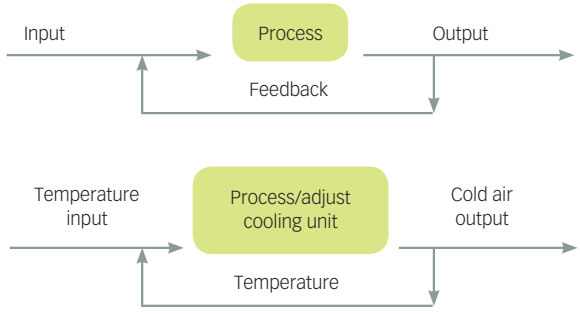


Figure 14.51 An example of how a closed-loop system, such as a thermostat, works

ACTIVITIES

Identify

1. Provide a definition of an actuator.
2. What is a controlling device in a control system?
3. What is the difference between a closed-loop system and an open-loop system?

Analyse

4. Describe the functions performed by actuators.
5. List the actuators in your robotic kit.
6. Think of a system that does not use feedback. Draw the system as a simple block diagram.
7. Draw a block diagram of a closed-loop system and build it with your robotic kit.
8. Compare and contrast how the models of open-loop and closed-loop systems function.

Investigate

9. Build an open-loop system with your robotic kit.
10. Design and build a model with your robotic kit using the motor actuator. The model should include a sensor to control the movement of the motor. An example is a car that travels in one direction until it touches a wall, then reverses.

Review questions

14.9 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

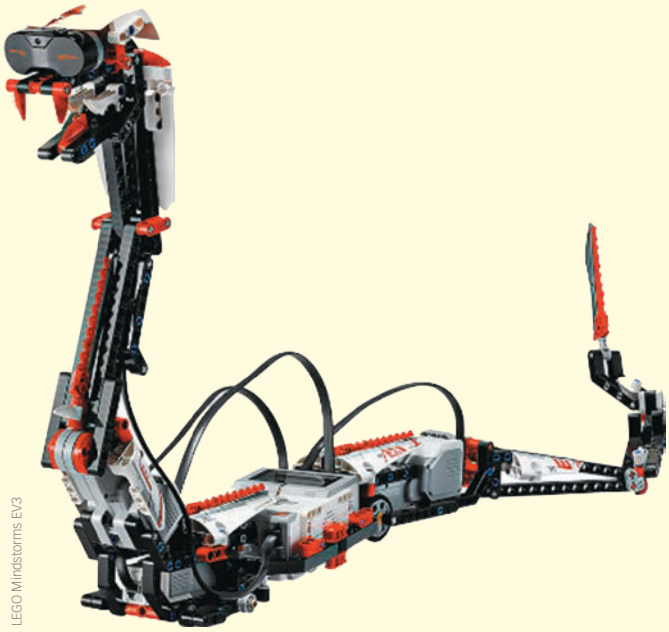
Project 1: Build a robot

In the following project, you will design and build a robot. To complete this project successfully, it is recommended that you work in teams of three or four people. Check out online resources for LEGO robots.

Robotics scenario

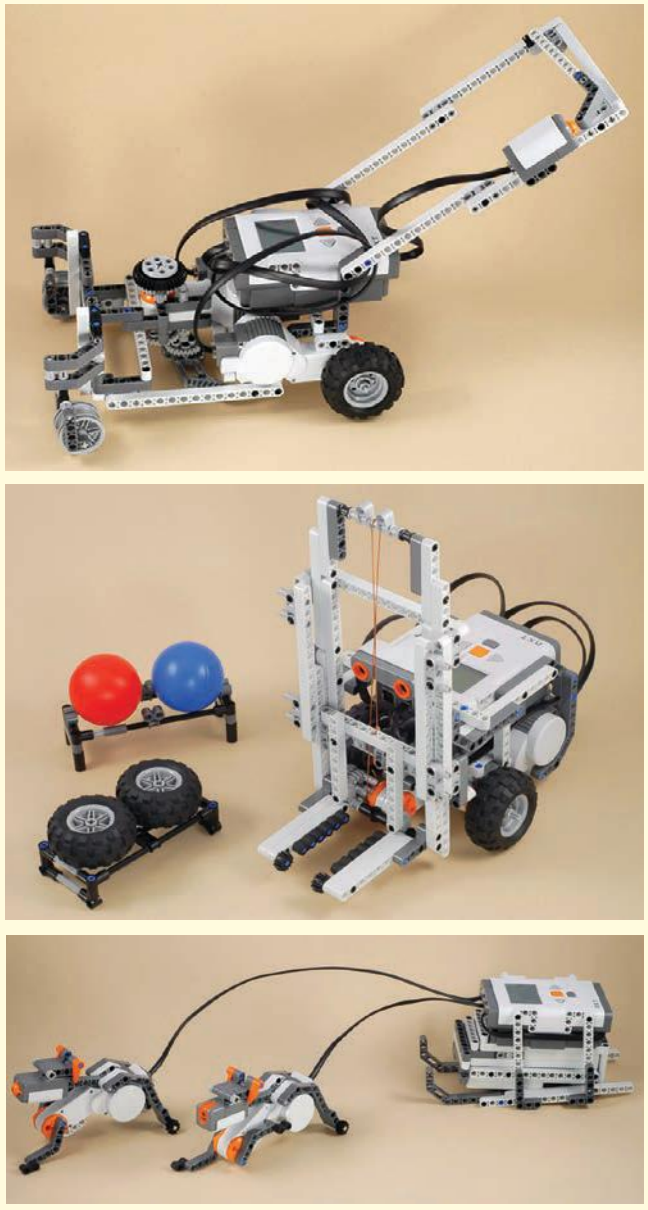
Use your robotics kit to construct and program one of the models suggested in the kit. Examples of LEGO models include:

- Mindstorms EV3 starter robots
- voice-controlled car
- bumper car
- ball hunter
- forklift
- robot arm
- crazy lawn mower
- door alarm
- Segway with rider
- disco dancer.



LEGO Mindstorms EV3

Figure 14.52 R3PTAR, an example of a LEGO Mindstorms EV3 starter robot



http://www.nxtprograms.com/. Copyright LEGO

Figure 14.53 Crazy lawnmower, forklift and Huskies pulling a sleigh

The project should include:

- a block diagram of how the system functions
- a description of what the model will do (if you have completed chapter 15: Software development and programming, this may be in the form of a flowchart)
- the working model, with a brief explanation from each group about what it does
- a working, saved program for the model
- a presentation and demonstration of the project to the class.

You will need to follow the stages outlined in chapter 1: Projects: design, produce, evaluate to complete the project.

Defining and analysing

1. Form groups of three or four students.
2. Discuss what the project model will do. This will form the criteria for the project. For ideas, look at real-world applications of robots and automated systems.
3. Document your discussion, using a word processor. Include the names of your group members.
4. Submit it to your teacher for approval.
5. If appropriate, break down the system into small components and list them.
6. Assign team members to the following roles:
   - building the model components
   - programming the model components
   - documenting the progress of the project (in a written format as well as taking pictures, drawing diagrams and other relevant documentation).
7. Establish a timeline for completing all parts of the project and include it in the documentation. Allow time for testing and modification.
8. Determine the building blocks necessary for the model. This is likely to include the contents of your robotic kit, along with any additional hardware or components.
9. Determine the software required for the project. In most cases, this will be the software accompanying the robotic equipment.

Designing

1. Create a block diagram of the system.
2. List the rules and/or steps required for the programming components of the project.

Producing

1. Build the model components.
2. Write the robotic programs according to the language specifications and save them.

Evaluating

1. All team members contribute to the documentation, including a description of their part in the project.
2. Each group takes a video of the working model and uses it with the documentation to create a digital presentation of the completed project.
3. Test the model components using the programming code you have written.
4. Make any necessary modifications.
5. Did the model perform as outlined in the planning stage?

Project 2: RoboOlympics

You are to design, build and program a robot in order to complete three separate challenges. You may progress to the next challenge only after completing each one to the satisfaction of your teacher, who signs off on each one. These may be completed in any order, but it is a competition and points will be awarded for the best results among individual class teams.

Here are some suggested RoboOlympic challenges, but your class may like to invent their own.

- Reach the top of an inclined slope.
- Race against other robots.
- Two robots play tug of war or push each other out of a circle.
- Robot must follow a curved line on a large, flat surface.
- Robot must escape a maze.
- Robot must sense and lift an object.
- Robot must move a ball into a goal.

You are to design, build, modify and program a robot to achieve the best possible result in three challenges.

Your robot can be redesigned and reprogrammed separately for each event.

The robot may have three tries for each event.

You are to document your progress in a logbook updated throughout the project and either the events' judges or your teacher will award points for each result. The best overall team score wins the RoboOlympics!

Defining and analysing

1. Pairs of students devise and set up separate events. Use the list above as idea starters. Establish the rules for your event.
2. Student pairs take turns to introduce their event to the class.
3. Form a group of 3–5 people. Decide roles (designers, builders, programmers, journal writers, testers).
4. Decide which challenges you will take on and the order in which you will tackle the challenges.
5. Discuss possible solutions for each challenge.
6. Build your robot.
7. Write a program for your robot for your first challenge.
8. Update your logbook.

Designing

1. Modify your robot and program to achieve efficiency.
2. Update your logbook.

Producing

1. Build your robot and create your program.
2. Upload it to your robot.
3. Take one of the challenges. You have a maximum of three attempts at each challenge.

Evaluating

1. Perform repeated testing and refine your designs and repeat the last challenge if desired.
2. Repeat this project design cycle for your next challenge.
3. Update your logbook.

15 OPTION Software development and programming

Syllabus outcomes: 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.5.1, 5.5.2, 5.5.3

Chapter outcomes

You will learn about:

- some of the ways in which people can develop software
- factors that need to be considered by the programmer when developing programs
- user interface design principles
- the methods of setting out your design for a program
- a programming language, and how to write and store programs
- how programs work with data.

You will learn to:

- design programs
- write program code with an appropriate set of tools
- work carefully, testing your programs to make sure that they work properly
- set out your program code so that others can read it and understand it easily
- use problem-solving techniques.

Key terms

Algorithm
series of steps in a procedure that will solve a problem in a finite time

Array
data structure containing items all of the same data type that are individually identified by an index

Assignment statement
statement used in program code to assign a value to a variable

Compiler
converts the entire code to machine language at the one time, ready for later use

Control structure
instructions in a programming language that decide the order of execution of programming code

Debugging
elimination of logic errors from computer code

Flag
variable (usually Boolean) used to indicate that a process in a section of code has been executed

Flowchart
diagram representing an algorithm and consisting of an accepted set of symbols

Interpreter
converts lines of code to machine language at the time of execution

Object code
machine language binary computer code following translation from the programmer's source code

Pseudocode
English-like language used to represent an algorithm

Run-time error
error occurring at execution time of a program

Software
programs operating in a computer system

Source code
program code before translation into binary code

Syntax
grammar or rules of a programming language

Variable
named area of memory 'reserved' by a program to hold the data a program is working with

9780170365987

IN ACTION

Finding the *Titanic*: An early programming adventure

In the perpetual darkness more than two miles below the surface of the North Atlantic, a submersible sled slowly traced the alpine contours of the ocean bottom in the summer of 1985.

Named the *Argo*, after the ship in which the legendary Greek hero Jason sought the Golden Fleece, the 4.5-metre-long craft looked like a section of scaffolding flung on its side and stuffed with equipment. Far above, in front of a video screen in the control room of the US Navy research vessel *Knorr*, members of a joint French–American scientific expedition intently watched the images transmitted by the submersible as it was towed above a desolate landscape of canyons and mudslides. After 16 days of patient search, a scattering of metallic debris appeared on the screen, followed by the unmistakable outline of a ship's boiler. An excited yell arose from the scientists.

The ocean liner *Titanic*, which sank 73 years earlier with more than 1500 of its 2200 passengers on board, had finally been found. This quest for the remains of the *Titanic* in the crushing depths of the sea was a remarkable application of computer programming.

Argo's collection of sonar, lights and cameras was controlled by an array of computers, each programmed in a different computer language. The computer on the unmanned *Argo* itself was programmed in FORTH, a tiny but versatile language originally designed to regulate movement of telescopes and also used to control devices and processes ranging from heart monitors to special-effects video cameras. The computer on the *Knorr* was programmed in C, a powerful but rather cryptic language capable of precisely describing computer operations. The telemetry system at either end of the finger-thick coaxial cable connecting the vessels, which allowed their computers to talk to each other, was programmed in a third, extremely basic language known as assembly language.

Programming languages are the cleverly arranged sequences of words, letters, numerals and abbreviations used by people to communicate with their computers. Without them, computers and their equipment would be useless hardware. Computer languages tend to be much more precise than human languages. They do not have multiple meanings or a sense of humour.

Today there are thousands of computer languages (see a few in figure 15.11). They allow their users to solve complex mathematical problems, crunch business statistics, create musical scores and draw computer graphics. No language is perfect for every situation. Usually the language is known to the programmer, it can be used on the available computer and it is suited to the problem to be solved.

The three languages used on the *Titanic* expedition are a good example. For the computers aboard the surface ship *Knorr*, C was the preferred language because it provided more direct control of the computerised hardware. FORTH was the only high-level language that could be used on the submersible *Argo*'s computer. And the precise timing required of the signals passed by cable between the two vessels was best achieved by strict assembly language.

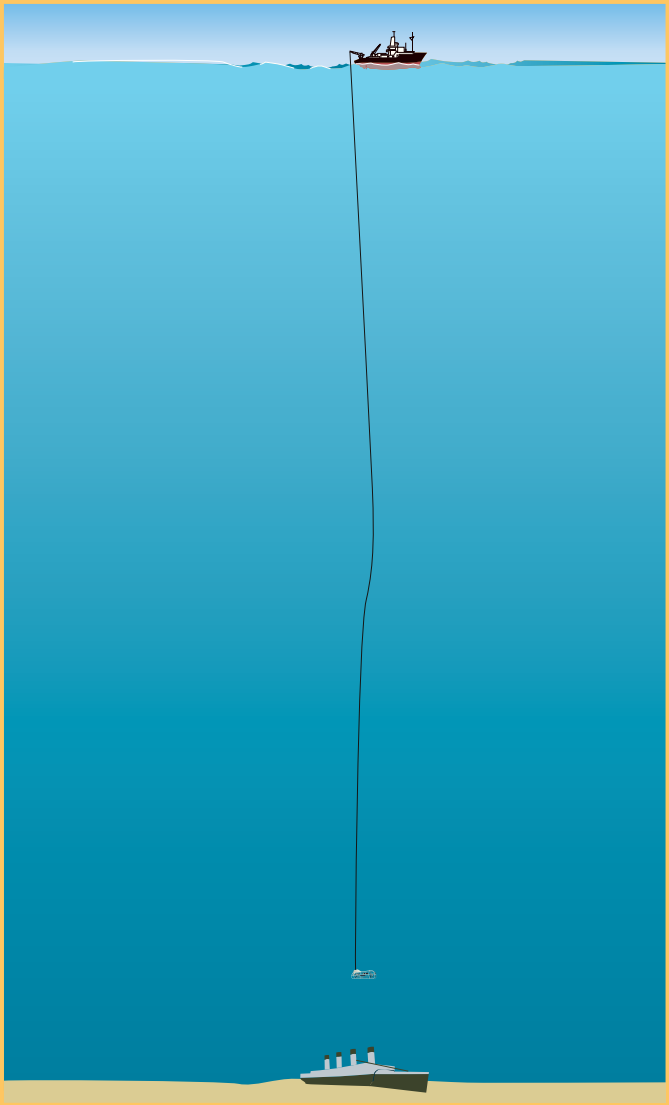


Figure 15.1 The *Argo*, with its ability to send real-time video images to the *Knorr*, was the key to finding the *Titanic*. This illustration shows the relative depth of the *Titanic*, resting on the seabed.

QUESTIONS

1. List the three computer languages used to find the *Titanic*.
2. Describe a major strength of each of these languages.
3. What are the main similarities and differences between human languages and computer languages?

15.1 What does a computer program look like?

If you were asked to make a cup of tea for a stranger, you would probably do something similar to the following:

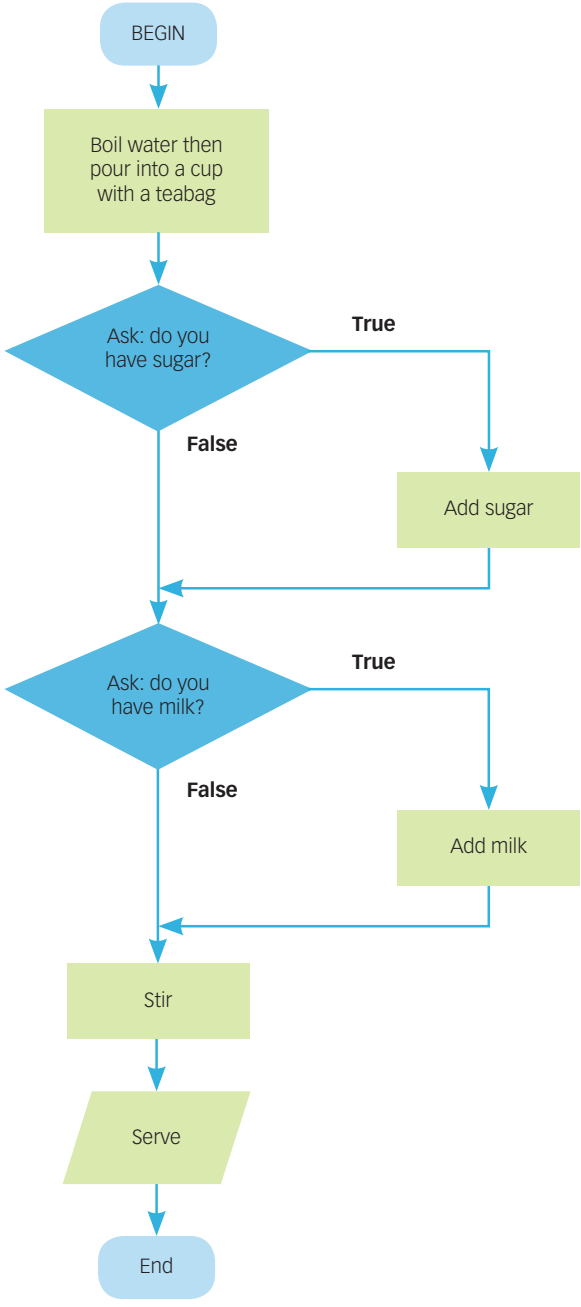


Figure 15.2 Making a cup of tea

The order in which you perform the actions is important. It would not be a good idea to put the milk in the water before the tea bag, or to boil the water after all the other steps!

Flowcharts

Figure 15.2 is called a **flowchart**. It is often used by computer programmers to help them think through the order in which steps in their code need to be arranged.

Flowcharts use five basic symbols, shown in figure 15.3.

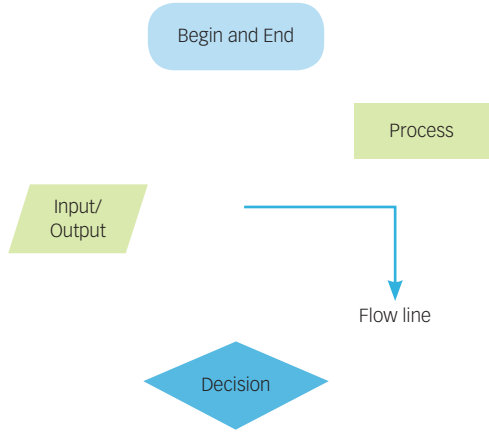


Figure 15.3 Flowcharts use these standardised symbols.

Flowcharts always **BEGIN** and **END** with the rounded shapes.

Any **action** that needs to be performed is drawn in a rectangle.

Any **information** (**input or output**) needed from a user of the program or any information given by the computer back to the user is drawn in a parallelogram.

Finally, any **decision** needing to be made is drawn in a diamond.

Decisions always have one **flow line** in to them and two flow lines out: one for **True** and one for **False**.

Try this …

Imagine a number guessing game being played against a computer. The computer has secretly chosen a number (under 100) and you have to guess it as quickly as you can.

How would you program a computer to play this number game?

A good first step would be to draw a diagram to show the logical order of moves. The flowchart might look like figure 15.5.

Carefully check through your program, by pretending **secretnum** (the secret number) is equal to 30.

Check what happens if your guess is 1, 29, 31 or 100.

Notice how this flowchart also keeps track of how many guesses you are having.

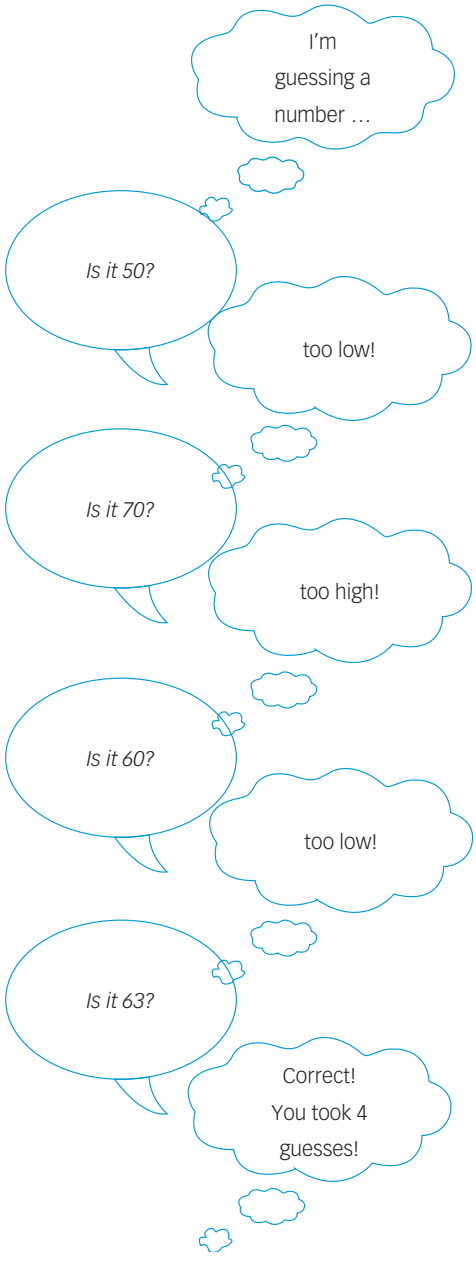


Figure 15.4 Number guessing game

Pseudocode

As well as flowcharts, programmers have invented another simple way of thinking about their programs before beginning to code them.

It is known as **pseudocode**, which means 'not quite real code'. Pseudocode is very much like plain English. Pseudocode is written in almost the same form as program code, but without using a real programming language. Using pseudocode we can describe the logic to be used in a program, and a programmer can translate this into a working program using one of many programming languages.

Notice the lines of text in the pseudocode are indented from the left margin to make the code easier to follow.

Try to understand both the flowchart and the pseudocode by tracing them both with your fingers at the same time.

Pseudocode uses standard keywords (in capitals) and indenting to make it easier to follow.

Our number guessing game would look like this in pseudocode (again setting the secret number to be equal to 30):

```
BEGIN high low guessing game version 1
   set secret to 30
   get guess
   WHILE guess is not equal to secret
      IF guess > secret THEN
         print "too high"
      ELSE
         print "too low"
      ENDIF
      get next guess
   ENDWHILE
   print "Correct!"
END
```

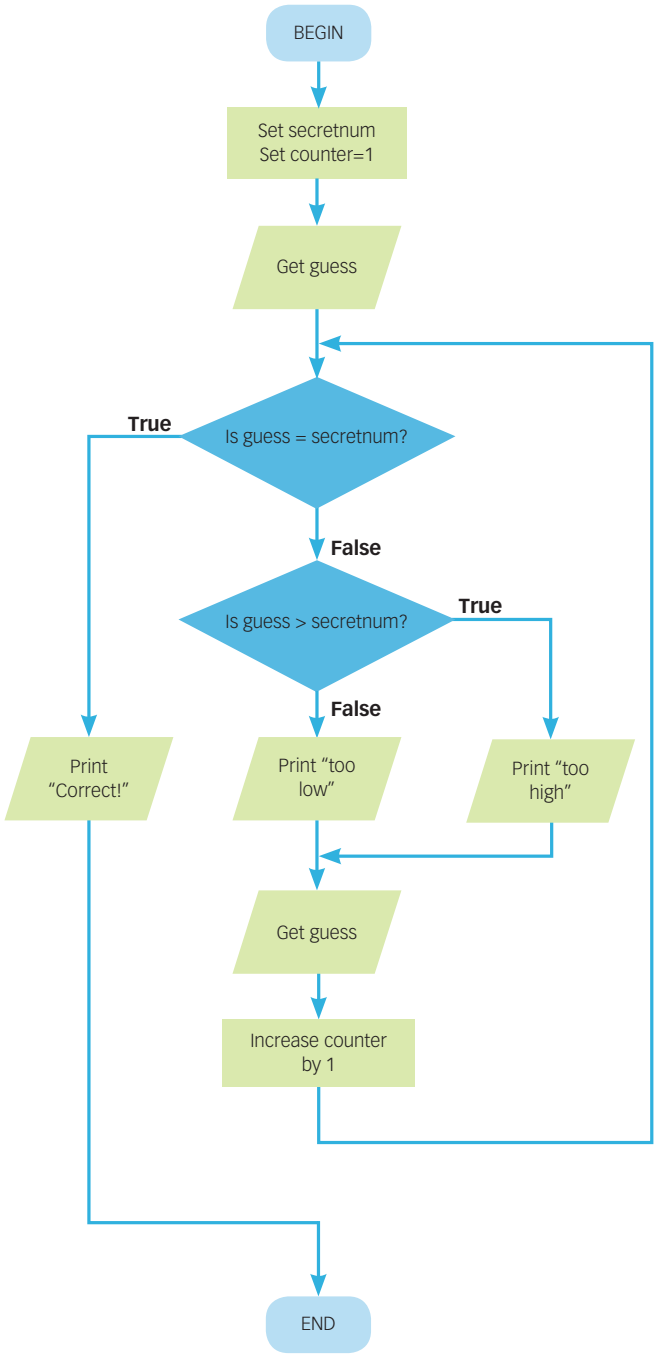


Figure 15.5 Number guessing game flowchart

Many people imagine that even the simplest computer programming languages are very difficult to understand. This is not true.

Scratch is a great way to learn programming, as you build programs using jigsaw shapes you can only join in correct ways. Try tracing through the following program, noting how it matches both the pseudocode and the flowchart above.

Download Scratch or use the online version to build the game yourself. You can find all the shapes in Scratch's *Scripts* panel by noting the colour of each. You will need to create the two **variables**, *secret* and *guess* in Scratch's *Data* tab. Click the green flag to run your program code.

Using the free introductory programming language Scratch, our number guessing program is shown below.

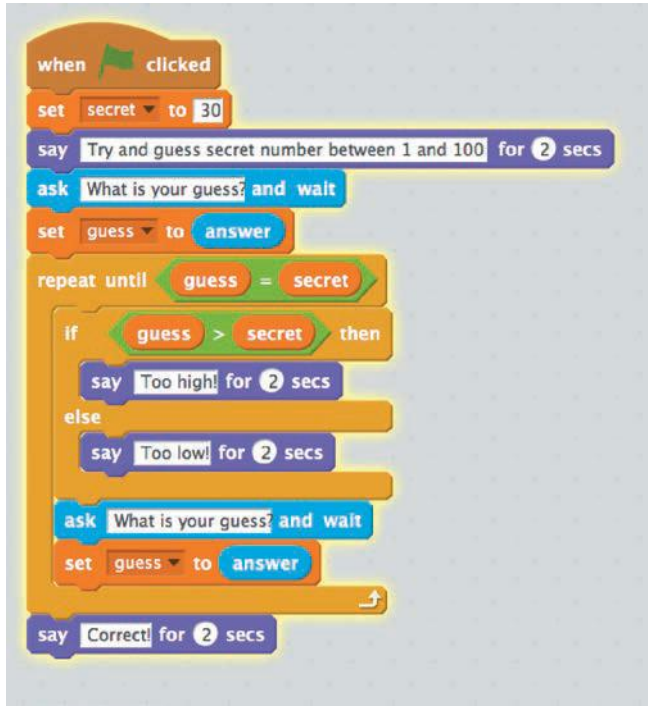




Figure 15.6 Number guessing game using Scratch

Scratch is a highly visual language. If you were to translate the flowchart or pseudocode into code using the well-known language Python (version 3), it would look as shown in figure 15.7.

In red are comments to help you understand what is happening in each line. They are not part of the code. In Python, comments are indicated by the symbol #.

Can you see how the flowchart had the same steps as this code and in the same order?

Notice how the indented **while** block asks if the guess is *not* equal to the secret number? This indented block will keep repeating until the guess *is* equal to the secret number. When that happens, the program escapes to the last line and prints "Correct!"

Your teacher might ask you to type this code using a Python **interpreter** and then run it. You will be adding to this code and improving it through the chapter as you learn more.

There are excellent resources for learning programming online. Go to http://infosoftwaretech.nelsonnet.com.au and follow the links to code.org and Blockly Games.


```
secret=30                                  # set secret number to 30
guess = input ( "Your guess?: " )          # ask user for input
guess = int ( guess )                      # change guess into integer
while guess != secret:                     # != means "does not equal"
   if guess-secret > 0:                    # same as "is guess > secret?"
     print ( "Too high" )
   else:                                   # arrives here only if guess < secret
     print ( "Too low" )
   guess = input ( "Your guess?: " )       # next guess requested
   guess = int ( guess )                   # change guess into integer, repeat while loop
print ( "Correct!" )                       # print "Correct!" only when guess is correct.
```

Figure 15.7 Python (version 3) code for high low game version 1

PEOPLE

CORE ALERT People

Software developers

Florence is a good example of the modern generation of software developers. She has a degree qualification in software development, as well as a master's degree in finance. Personnel with dual qualifications like Florence are able to provide:

- business skills to understand what a business is doing and where improvements can be made
- technical software development skills to envisage how these improvements can be made.

People like Florence have a real capacity to add value to a business – typically bringing a broader vision for the benefits of technological change and growth in a company than those who are 'just business people' or 'just technologists'.

Florence works for a large website software development company that specialises in integrating mobile telephony and SMS with web and other applications, and in mobile computing applications – the leading edge in development these days.

QUESTIONS

1. Several universities offer combined degrees with computer science as one component. Find out what combinations are offered at three universities.
2. In your own words, suggest to what extent software developers have to be 'inventors' of the future.

15.2 Basic programming ideas

Computers do not understand ordinary spoken languages such as English. Their language, called machine language, is represented using only two symbols, '0' and '1'. In fact, the first computer programs were written using only zeros and ones. There were no keyboards and instructions were input by flipping switches.

All the applications we use, such as Word, Photoshop and all operating system **software**, such as Windows and OS X, must first be translated into this machine language before a computer can use it.

Have you wondered why we do not use natural spoken languages for programming?

Natural languages

Computers are not yet able to interpret natural English reliably. Recognising human speech (which they can do quite well) is much easier than turning speech into computer instructions. The meanings of natural languages can be unclear. The newspaper headline 'Giant waves down funnel!', for example, can have over 10 meanings (see if you can work out at least eight!), so it would be easy to choose an incorrect one (see figure 15.8).

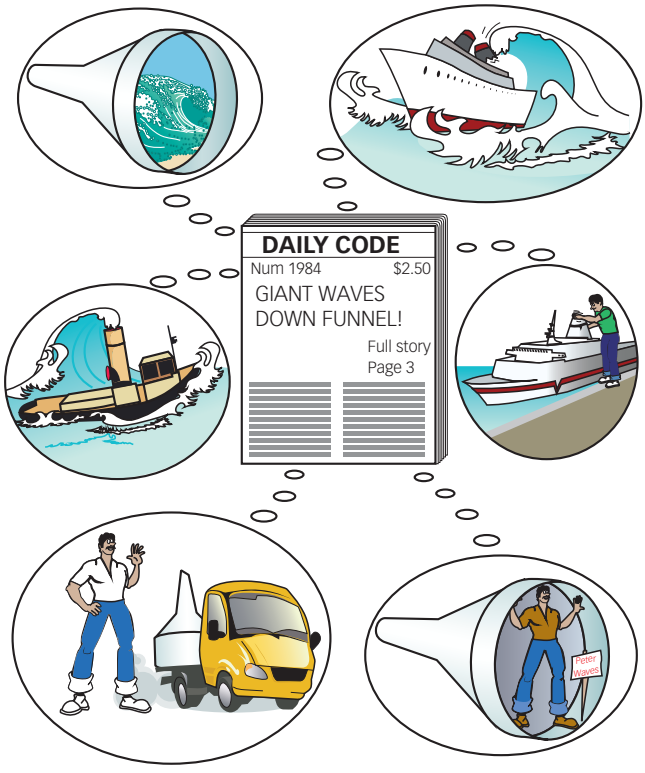


Figure 15.8 English language can be interpreted in many different ways.

English is also full of idioms and metaphors: 'I have been working like a dog', 'she's one sandwich short of a picnic' or 'he's as thick as two planks' may be quite challenging for a computer to understand!

Complex machine means complex programs

The computer is the most complex machine that human beings have ever built. The programs it runs can be even more complex. However, like all complex things they can be understood by breaking them into simpler parts.

A computer program is a set of instructions run by a computer, just as a storybook is made up of a collection of sentences. These instructions are like the turn-by-turn instructions you might be given for directions: turn right at the intersection, walk two blocks, keep walking until the first set of traffic lights. The computer follows each instruction you give it.

As incredible as it may seem, it can be argued that the key process a computer performs is just addition – although very, very fast!

Think of some basic mathematical operations:

- Subtraction is just adding the negative value of a number.
- Multiplication is adding the same number a number of times.
- Division is repeatedly subtracting (which we said was just negative adding) a number until zero is reached.
- Raising some number to a power is multiplying (a form of adding) that number by itself many times.

The first computers were programmed very simply, just like a cookbook. Ingredients (input) were put into the computer, the method steps for the recipe were written out in order (processing) and finally the product emerged (output).

These early languages, such as the first versions of BASIC (Beginner's All-purpose Symbolic Instruction Code), were lines of instructions one after another, and each line was numbered. Often there were many jumps to another part of the program code and back again. This was messy, hard to follow and became known as 'spaghetti' code, and sometimes in Australia as 'kangaroo' code.

Example of older "spaghetti" code

```
10  INPUT "What is your name: ", U$
20  PRINT "Hello "; U$
30  INPUT "How many stars do you want: " N
40  S$ = ""
50  I = 1
55  IF I > N THEN GOTO 80
60  S$ = S$ + "*"
65  I=I+1
70  GOTO 55
80  PRINT S$
90  INPUT "Do you want more stars? ", A$
100 IF LEN(A$) = 0 THEN GOTO 90
110 A$ = LEFTS(A$, 1)
120 IF A$ = "Y" OR A$ = "y" THEN GOTO 30
130 PRINT "Goodbye "; U$
140 END
```

The same code now structured in Python

```
UserName=raw_input("What is your name: ")
print "Hello ", UserName
Answer="Y"
Numstars=1
while Answer == "Y":
    NumStars=int(raw_input("How many stars do you want: "))
    print NumStars * "*"
    Answer="":
    whileAnswer=="":
        Answer=raw_input( "Do you want more stars? ")
        Answer=Answer[:1].upper()
print "Goodbye ", Username
```

Figure 15.9 An example of line-numbered old-style 'spaghetti' code compared to the same program written in a structured language, such as Python. This Python program simply prints stars on a line.

The big picture: Inputs, processing and outputs

We understand that all programs do some form of processing of instructions. They receive input, process it and produce output.

Inputs

Programs can receive inputs from several sources, including:

- a person using an input device (keyboard, mouse, microphone)
- another program or the operating system
- files and databases.

A program will often have to ask the computer user for some input. The user might be asked to choose from a list of alternatives, click a button or type in some text, before the program will do anything else.

Processing

Programming languages have evolved over time and use different methods. Programs very often go to work immediately, processing input to produce output. For example, the number 3 is provided as input to a program that squares numbers, and the output 9 is produced immediately. Once given input, these programs run from start to finish without interruption and produce output.

Other programs wait for input from the user, perform the necessary processing and respond by providing a form of output.

Inputs in desktop operating systems such as Windows or Mac OS, or a touchscreen tablet based one, take the form of *events*. Programs that respond to events such as mouse clicks are described as event-driven.

Outputs

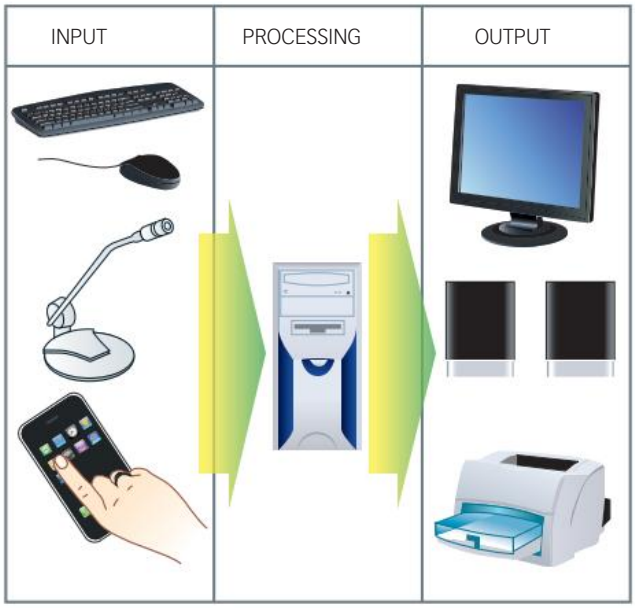
Programs can provide output using a range of devices or destinations, including:

- the computer display
- audio speakers
- a printer
- databases and files
- other processes.

Which language is best?

Programming languages come into and go out of fashion. Programmers have favourites and many arguments take place over which language is best to use for a given task. Figure 15.35 shows a timeline of the development of many of the more popular languages.

In the 1980s, languages began to use modules as basic building blocks. This allowed sections of code to be reused in other programs instead of having to be rewritten each time. In the 1990s, languages such as Java began to be used for server-side programming. These were not new languages, but were built on the work of the past, and especially on the C language. Students often ask which languages are the most popular. This changes regularly, but it is important to know that learning any one of them makes learning another much easier. Recently, the 10 most popular programming languages were judged to be (in descending order): C, Java, PHP, JavaScript, C++, Python, Shell, Ruby, Objective-C and C#.



Recipe: Honeycomb confectionary

INPUT	PROCESSING	OUTPUT
1 cup sugar 4 tbsp golden syrup 3 tsp bicarb of soda	• Mix sugar and golden syrup in a large saucepan. • Simmer 7 mins. • Remove from heat and quickly add soda and mix in: it will foam up. • Pour into greased tin. • Leave to set. • Cut into squares.	Honeycomb

Figure 15.10 Computer programs can be compared to recipes in a cookbook. The ingredients are the input, the method is the processing and the dish that is produced is the output.

This chapter will introduce you to the important ideas in computer programming, and it will introduce a few languages, but it will not teach you to code in a computer language. You will need to learn this with your teacher in class. We have chosen three computing languages, along with pseudocode, to illustrate the examples in this chapter:

- Visual Basic, because it is widely known, easily learnt and uses graphical user interface (GUI) components, although it compiles (creates a working program) only for a Windows-based computer.
- Python, because it is open-source and free, has a version for all platforms, and is an increasingly popular choice for teaching programming and it is used in some excellent school competitions. Large organisations that use Python include YouTube, NASA, Google and CERN.
- Pascal, because it is very close to pseudocode (see section 15.1) and has a long and proud history as a teaching language.

Seeing the same example in a number of languages will help you understand the basic concept better.

What does a program look like in different languages?

Figure 15.11 shows the same program written in a number of languages. This program outputs the greeting 'Hello world!', which has become a traditional first programming exercise given to beginners in any programming language. If you want to see more than 200 examples, follow the link at http://infosoftwaretech.nelsonnet.com to the Scriptol website.

Weblink



Figure 15.11 The same program written in six computer languages. In each case, the program outputs the greeting 'Hello world!'

Parts of a program

A motor car uses fuel as input, an engine for processing and wheels for output, but the engine is made up of many smaller parts, each with a name and a purpose.

Our number guessing program is made up of parts too. These include **controls**, **variables**, **operators**, **assignment statements**, **functions** and **strings**. We will introduce each of these now and then explore them more completely.

Control structures

All computer programs are built using just three basic building blocks, called controls or **control structures**. This is similar to the way thousands of different structures can be built using just a few different shapes of LEGO bricks.

These are:

- sequence
- selection
- repetition.

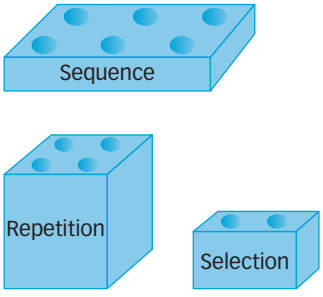


Figure 15.12 In the same way as three LEGO brick shapes can be used to create thousands of different structures, so too the three building blocks of computer programming (sequence, selection and repetition) can be used to create thousands of different programs.

A Dutch computer scientist, Edsger Wybe Dijkstra, disliked the way code logic would jump from line to line as spaghetti code and popularised what became known as structured programming. He argued any computer program could be written using only these three control structures.

The first control structure in our number guessing program shown in Figure 15.13 is **sequence**. The first three lines of our program form a sequence. This is the simplest type of control structure and the only one the earliest computing programs used.

The second control is the IF … ELSE **selection**. It checks if *guess* is larger or smaller than *secret* and delivers the appropriate message.

The third control in our program is the WHILE pre-test loop, an example of **repetition**. The word WHILE is followed by a test, acting as a gatekeeper by comparing the values of *guess* and *secret*. It only allows this section of the program to progress if these values are *not* equal.

Controls are shown in orange.

sequence

```
secret=30
guess  = input ( "Your guess?: " )
guess  = int( guess )

while  guess  != secret:
    if  guess-secret > 0:
        print ( "Too high" )
    else:
        print ( "Too low" )
    guess  = input ( "Your guess?: " )
    guess  = int( guess )

print ( "Correct!" )
```

while pre-test loop

if … then … else selection

Figure 15.13 Our number guessing code written in Python, showing the three types of control structures: sequence, selection and repetition (looping)

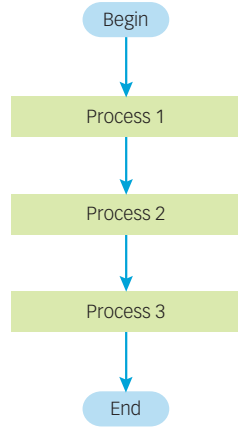
Structured programming

Sequence

The simplest control structure is sequence: lines of code follow in order one after the other. Most programs have lines written this way. Figure 15.14 shows the sequence structure in both flowchart and pseudocode format.

SEQUENCE

FLOWCHART



PSEUDOCODE

```
BEGIN
  Process 1
  Process 2
  Process 3
END
```

Figure 15.14 The sequence control structure in both flowchart and pseudocode

Selection

Most programs rarely follow a simple sequence from beginning to end. Instead, they come to a branch where a decision has to be made. This means that the program reaches a point where it has to decide what to do next. In order to make the decision, the program uses a question or tests a condition. This is called the selection control structure. The outcome of the test condition decides the next action.

Program languages generally use two main branching structures; one allows a choice from two options, known

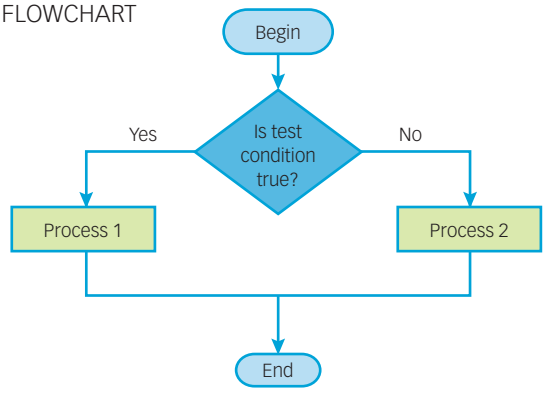
as **binary selection**, and another is used when we have many choices, and is known as multiple selection or **multi-way selection**.

Binary selection

In a flowchart, we represent binary selection using a diamond-shaped box, as shown in figure 15.15. Inside the diamond, we ask a question that can be answered only with a 'Yes' or 'No' or, if you prefer, you could answer 'True' or 'False'.

BINARY SELECTION

FLOWCHART



PSEUDOCODE

```
IF <test conditions> = True THEN
  do Process 1
ELSE
  do Process 2
END IF
```

Figure 15.15 The binary selection control structure in both flowchart and pseudocode

In pseudocode and program code, we ask this question using what we call a test condition evaluated by the computer as either True or False. The following is one example in actual code.

Python uses two equals signs in the comparison, to indicate that it is not an assignment (see section 15.4) but a test condition. In the following example, `PasswordEntered` is not being given (assigned) the value `CurrentPassword`; instead, we are testing whether `PasswordEntered` already equals `CurrentPassword` and the correct message is then printed.

Python

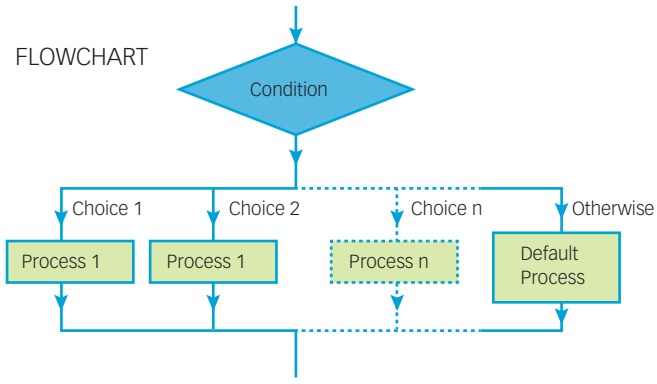
```
if PasswordEntered == CurrentPassword:
   print("Password is correct")
else:
   print("Password incorrect")
```

Multi-way branching

In many programming situations, a user may have many choices but may only choose one. In these situations, we may use the CASEWHERE (also known as SELECT CASE) structure for multi-way (multiple) branching.

MULTI-WAY BRANCHING

FLOWCHART



PSEUDOCODE

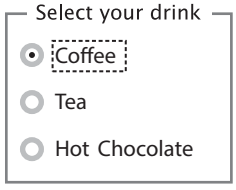
```
CASEWHERE expression evaluates to
       choice 1 : process 1
       choice 2 : process 2
       choice n : process n
       otherwise: Default process
ENDCASE
```

Figure 15.16 The multi-way branching control structure in both flowchart and pseudocode

Here, we consider the choices available for a software-driven hot drink machine (see figure 15.17). We have a choice of three drinks, but we may only choose one. The actions taken by the software after making the choice vary depending on the drink.

Only one of the actions will be performed and the drink machine will fill the cup with the drink selected by the user. In pseudocode we write:

```
CASEWHERE Drinkselected is
   Coffee:          pour coffee
   Tea:             pour tea
   Hot chocolate:   pour hot chocolate
   OTHERWISE:       do nothing
ENDCASE
```




```
SELECT CASE DrinkSelected Is
 Case Coffee: pour coffee
 Case Tea: pour tea
 Case Hot Chocolate: pour hot
 chocolate
 CASE ELSE: do nothing
END SELECT
```

Figure 15.17 The interface for a drink machine's multi-way selection could appear like this. Radio buttons allow only one choice to be made.

Repetition

Repetition, or looping, is the most important of all the control structures as it allows a computer to repeat actions effortlessly many times. We also call these control structures loops or iteration, and most languages support at least two different types.

The repetition structure does not have a special flowchart symbol. We use the diamond-shaped decision

box and a rectangular process box to show the movement through a loop.

Like branching, loops include a test condition. The test is used to decide whether the loop should keep going or terminate (stop repeating).

The type of loop we decide to use depends on how we want it to behave. Two important categories of loops are:

- pre-test loops
- post-test loops.

Pre-test loop

A pre-test loop performs a test before starting on the loop. This type of loop might not execute the loop statements at all, depending on the outcome of the test condition. If we run a finger around the logic flow lines in figure 15.18, we can see that the loop tests the condition, only executing the loop code if the condition evaluates to True, then tests the condition again, and repeats this cycle until the test condition evaluates to False.

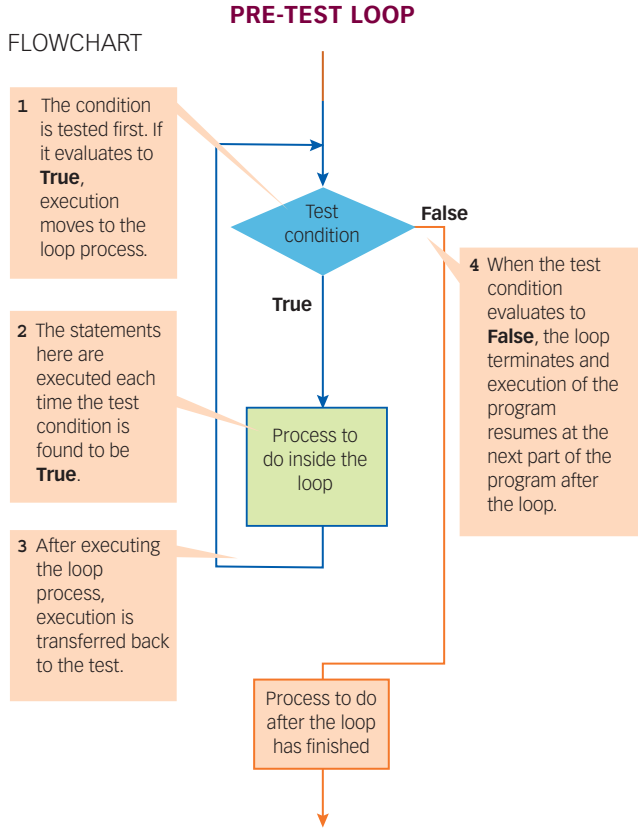


Figure 15.18 The logic of a pre-test loop is explained here, in flowchart and pseudocode form. In the pre-tested loop, a condition is tested first. If this evaluates to True, the process(es) inside the loop are executed. Execution is then transferred back in a loop to the test condition, with the loop being repeatedly entered each time until the test condition evaluates to False, when execution of the loop ceases.

For example:

```
Visual Basic
Do While <Expression>
   <Code to execute>
Loop

Python
while <expression>:
   <code to execute>
```

Note: Unlike most other languages, the Scratch programming language uses repeat as a pre-test control.

Post-test loop

A post-test loop performs the test condition after each execution of the loop, and keeps repeating while the condition evaluates to False. This type of loop must always perform the loop action at least once – the very first time – and possibly many times, until the loop test condition evaluates to True, which causes the loop to terminate. If we run a finger around the logic flow lines in figure 15.19, we can see that the loop first performs the process and only then tests the condition, here repeating the loop code again if the condition evaluates to False, or exiting when the test condition evaluates to True.

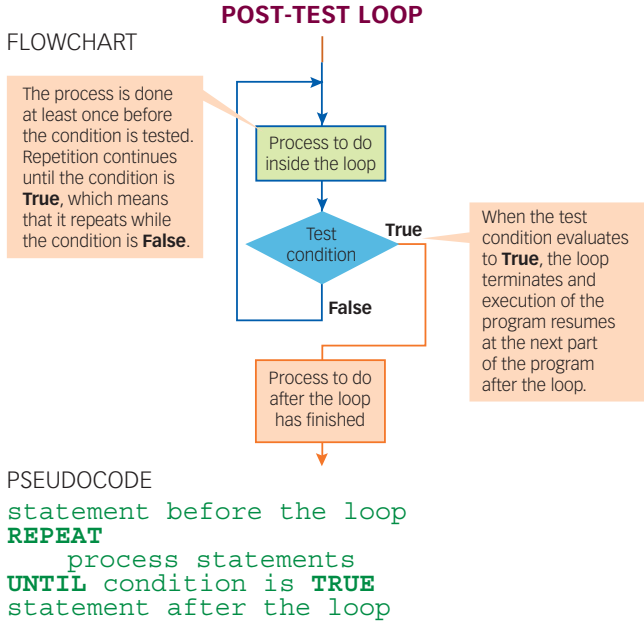


Figure 15.19 The logic of a post-test loop is explained here, in flowchart and pseudocode form. In the post-tested loop, process(es) are always completed first. Execution is then transferred to a test condition within the loop. If this evaluates to False, the loop is again entered and the process(es) inside are executed until the test condition evaluates to True, when execution of the loop ceases.

Many languages support both pre-test and post-test loops; however, Python has no post-test structure.

Both types are terminated by the test condition, whether it is at the start (pre-test) or end (post-test) of the loop. We therefore have to make sure a process happens, usually inside the loop, to ensure that the loop will eventually terminate. We refer to these loop types as event-controlled, as some event (such as running out of chips) will cause the loop to terminate.

Of course, both pre-test and post-test loops can have True and False reversed.

FOR … NEXT loops

There is a special type of loop that we might use when we want to perform an action a known number of times. This is called the FOR … NEXT loop, and most programming languages provide this loop type.

The FOR … NEXT loop includes a built-in counter, which is used by the loop to perform the required number of repetitions.

In pseudocode:

```
FOR Counter = StartValue to EndValue
   do something
ENDFOR
```

For example:

```
Visual Basic
For Counter = 1 To 10
   display value of counter
Next
```

This range function in Python loops 10 times only, not 11.

```
Python
for x in range(1, 11):
   print(x)
```

Variables

We have considered the idea of programs receiving inputs, performing some processing and providing outputs. We need some type of 'container' that will hold these values while the computer works with them.

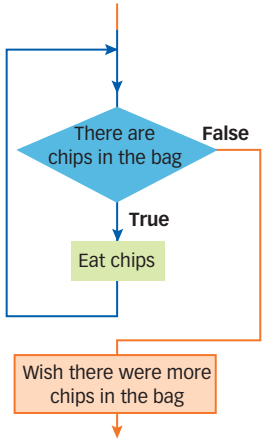
Variables are containers used to hold data. An important property of variables is that their values can be changed by the program. They are just containers and not the values themselves. Variables exist in special areas of memory and each variable is given a name (an identifier) so that the program can refer to it.

In the following program, *guess* is a variable (see figure 15.21).

When we write a program using variables, we should tell the computer what type of data each container is holding, as the computer only 'sees' a string of zeros and ones (binary). For example, in our program *guess* is an integer (a whole number).

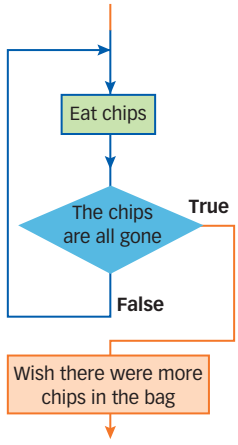
As far as the computer is concerned, these zeros and ones could be an integer, a colour, a sound, a decimal or the letter 'M'!

(a) Pre-test loop




```
WHILE There are chips in the bag
  Eat chips
END WHILE
Wish there were more chips in the bag...
```

(b) Post-test loop




```
REPEAT
  Eat chips
UNTIL The chips are all gone
Wish there were more chips in the bag...
```

Figure 15.20 Compare the idea of eating all the chips in a bag using the two different approaches to repetition. If the chip bag was empty to start with, the post-test example will instruct you to do something that is not possible (eat chips). While this is not a disaster in real life, in a program it could cause an error. The error would not happen with the pre-test loop.

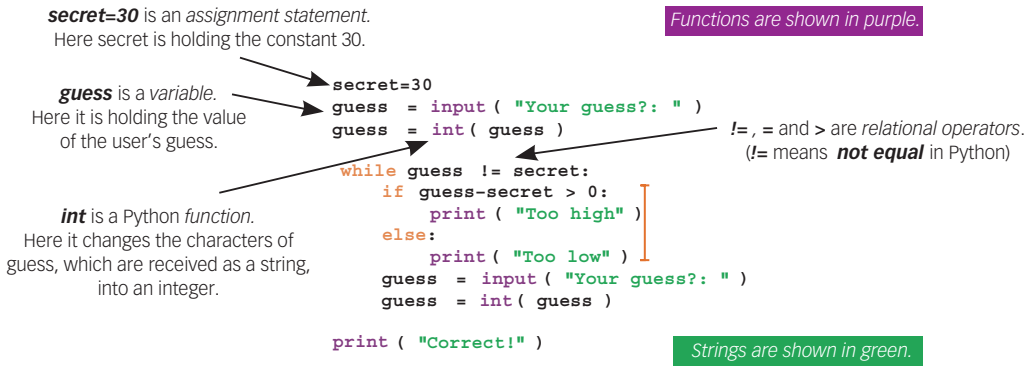


Figure 15.21 Our number guesser code showing variables, constants, assignment statements and functions

Declaring variables

We declare our variables before using them in order to let the computer know what data type each holds. This sets aside the correct space in the memory of the computer in preparation for holding the variables' values.

The Python language, however, does not require variables to be declared first, but assumes a data type from the value it was given first. If a variable called MachineName is given the value 10, Python will assume MachineName is storing integers and not characters.

A program declaration statement in a programming language such as Visual Basic might look like this:

```
Dim FirstName As String
```

The Dim keyword indicates that the program line should reserve some space for a variable and to expect that it will be in the form of a string of characters. Dim originally came from the word 'dimension', reminding us that space is being set aside in the memory of the computer. The next word, FirstName, is a variable name made up by the programmer. Joining nouns that describe what the variable does is a useful and common practice.

These declaration statements are placed at the very beginning of programs.

Initialising variables

Most programmers also initialise variables before they are used in a program; otherwise, the program may try to perform an operation for a value that does not exist. Initialisation involves setting the initial (starting) value for a variable. In order to do this, we use an assignment statement.

We usually place the initialisation statements immediately after the declaration statements in the program.

In our number guessing program, we initialised *secret* to 30 by using the assignment statement **secret=30**.

ACTIVITIES

Identify

1 Identify three parts of a computer program.
2 Identify three control structures that can be used in all programs.
3 What are the names of the two selection control structures?
4 What are the names of the two repetition control structures?
5 Draw a simple flowchart to show pre-test repetition.
6 Draw a simple flowchart to show post-test repetition.
7 Define the term 'variable'.
8 What two things should be done with a variable before it is used in a program?

Analyse

9 Explain why it is important for a variable to be declared in a program.
10 Explain why natural languages cannot yet be used to program a computer.

Investigate

11 Compare three computer language versions of 'Hello world!' code. What are the differences and what are the similarities?
12 Research and describe the differences between an event-driven and a sequential programming language.

15.3 Data types

Each programming language supports a range of data types, and has rules about what we can do with each data type.

Most of the data that programs work with can be classified into one of the following categories:

- character data – the building blocks of text
- string data – hold strings of characters, rather like strings of pearls
- integers or whole numbers
- real numbers – used for decimals
- Boolean data – used to represent true or false
- date and time data
- binary data – hold large objects such as movies, sound or graphics.

There are also more complex software objects that are used to represent things such as documents, spreadsheet workbooks or collections of data from databases.

Let us consider some of the simpler data types.

Characters

The building blocks of words (strings) of text are characters; for example, letters of the alphabet or the numerals 0 to 9. Many of our programs will need to perform operations on individual characters contained in a string. Character data types exist in different forms in different programming languages.

Most languages contain the char data type, which is designed specifically to hold a single character. For example:

Visual Basic

```
Dim FirstLetter As Char
```

Strings

Characters are represented by a character code – either ASCII or the more extensive Unicode. Strings are sequences of characters. Computer programs frequently deal with character strings to hold data such as names, addresses or telephone numbers.

String variables are created to hold string data. The maximum size of the string that can be held in a string variable depends on the language being used. One of Python's strengths is its handling of strings.

Our number guesser code shows all strings in green (see figure 15.21).

Integers

Integers are whole numbers, either positive, negative or zero. The number of bytes used to represent an integer determines the maximum size of the integer possible. Modern languages can support more than one size for integer data.

Integers represented by one byte can hold 2^8, or 256 different numbers. Two-byte integers hold 2^{16}, or 65 536 integers, four-byte variables can hold 2^{32}, or 4 294 967 296 different numbers, and so on. Eight-byte variables can represent 18 446 744 073 709 600 000 different integers!

Real numbers

Real numbers, also called floating point numbers, are what we usually call decimals, and may be either positive or negative. Usually there are two or more data types supporting real numbers. These are:

- single – meaning single precision, which usually has at least six significant digits after the decimal point
- double – meaning double precision, which usually has at least 10 significant digits after the decimal point.

In Visual Basic .NET there is also a data type called decimal, which uses 16 bytes and stores enormous numbers. We might want to use this data type if we are calculating how many paper clips it would take to stretch across the universe or the number of molecules in a litre of water!

We may declare real number variables like this:

Visual Basic

```
Dim WorldRecordTime As Single
Dim DistanceToTheSun As Double
```

Boolean

The Boolean data type, named after mathematician George Boole, is used to represent data that is either *true* or *false*. It is the simplest data type of them all. We might declare a Boolean variable like this:

Visual Basic

```
Dim GameOver As Boolean
```

and we might initialise the variable like this:

```
GameOver = False
```

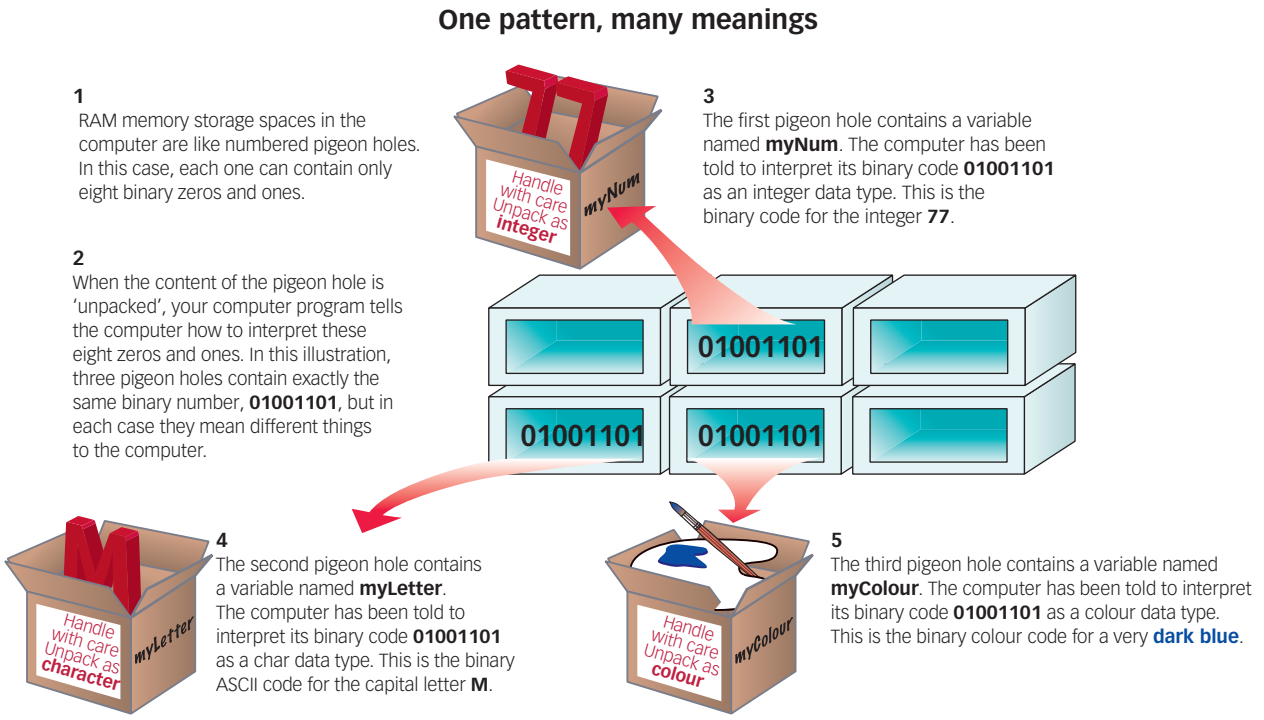


Figure 15.22 Exactly the same pattern of zeros and ones, in this case 01001101, can represent very different types of data. Here it can mean either the integer 77, the colour dark blue or the letter M. The computer program needs other information to tell it in which of these ways it should interpret the binary code. As explained, this is known as declaring a variable.

Date and time

Many programming languages have special data types to support the modelling of dates and times. On many computer systems, date and time data are stored as real numbers. The date component is the integer component of the number and represents the whole number of days since some point in history. The time component is usually represented by the fraction component of the number, and represents the fraction of a 24-hour period. For example, 6 a.m. would be represented as 0.250 000, as a quarter of the day has elapsed by that time.

INFOBIT

The Y2K date crisis

In the years and months leading up to the year 2000 (Y2K), analysts started to find that some software systems were showing faults in calculations that involved the year 2000. They realised that this was due to many computer systems storing the year portion of dates in two digits – 00 – and these dates were being interpreted as the year 1900 rather than 2000. As the clock ticked over for the millennium's New Year, fireworks exploded, crowds cheered, almost nothing failed and the world had spent billions of dollars in disaster prevention.

ACTIVITIES

Identify

1 List the data types and variable names you might use in your programming language to hold the following data:
- **a** first name
- **b** birth date
- **c** URL for a web page
- **d** recommended retail price
- **e** bank balance
- **f** the number of printers in the network
- **g** the sale price for a house.

Analyse

2 Think about different ways of representing dates. Invent two ways of representing dates in a computer's memory.

Investigate

3 Search the web for examples of how different programming languages store integers and real numbers. Provide two language examples for:
- **a** integer
- **b** long integer
- **c** single-precision real numbers
- **d** double-precision real numbers.

15.4 Operators and assignment statements

Now that you understand the different types of data used in programming languages, you need to learn how to use them to perform calculations.

Operators

Programming languages enable us to perform a variety of operations on data using three types of operators – arithmetic, relational and logical operators.

Arithmetic operators

In computing code, the four arithmetic operations are usually written as:

addition	+
subtraction	–
multiplication	*
division	/

Relational operators

The relational operators most commonly used are:

equality	=
less than	<
greater than	>
greater than or equal to	>=
less than or equal to	<=
not equal to	!= or <> or /=

Our number guesser code uses != to indicate 'not equal to' (see figure 15.21).

Logical operators

When we combine test conditions in programs, we often use logical operators such as AND, OR and NOT.

The AND operator (sometimes written &&) is used when two or more separate conditions must all be true in order to execute a particular section of code. For example, a program to enter students into a swimming competition may need to check their age and gender.

For example, a statement like this:

```
(SwimmerAge = EventAgeGrouping) AND
   (SwimmerGender = EventGenderGroup)
```

will only be true if *both* statements in brackets are true: the swimmer must be the right age and gender before being permitted to enter the event.

The OR operator (sometimes written ||) is used when any one of two or more conditions will cause the whole expression to prove true.

For example, a statement like this:

```
(DiscountVoucher) OR
   (CustomerMonthlyBorrowings > 5)
```

will be true if you have a discount voucher *or* if you have borrowed more than five books in the last month.

The NOT operator (sometimes written !) creates opposites of expressions and so can be used to exclude one or more values.

For example, a statement like this:

```
NOT DiscountVoucher >= 5
```

would be logically identical to:

```
DiscountVoucher <5
```

Concatenation

This strange-looking word becomes very important when we work with data stored in string and character variables. Concatenation joins strings of letters together. For example, if we want to compose a small message to a sporting competitor congratulating them on their result, we might concatenate a string with their name like this:

```
Message = "Congratulations to " & Winner
```

This would result in output like this:

```
Congratulations to Sally Pearson
```

We usually concatenate strings using either the ampersand symbol (&) or the addition symbol (+), depending on the programming language we are using.

Assignment statements

When data is received by a program procedure, it will usually belong to a variable. From that point, the variable contains the value it has been assigned. At any time it suits us, the variable's value may be changed by the program code.

Assignment statements are used in program code to assign a value to a variable. In the following example, a variable called Area is being assigned a value calculated on the right-hand side of the equals sign.

Visual Basic and Python

```
Area = Length * Width
```

Be careful not to confuse assignment with equality. Always think about assignment as taking the value calculated on the right and placing it into the variable on the left.

Study the following practical examples of assignment statements.

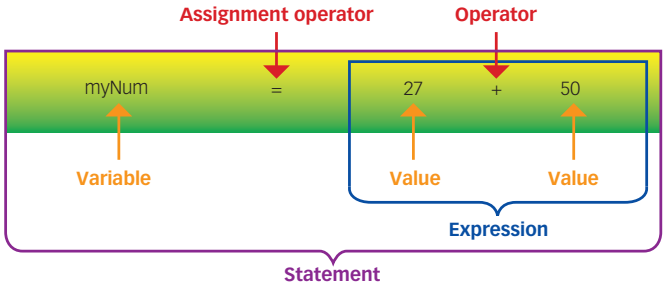


Figure 15.23 An assignment statement. Here our statement begins with a variable that is made equal to an expression. The expression is the sum of two integer values. This sum is written to myNum using an operator.

Example 1: Assigning specific value to a variable

```
Visual Basic and Python
Score = 50
```

Example 2: Incrementing a variable

We often need to increase a numeric counter variable, usually to keep count of how many times an action has happened. We describe this as incrementing the variable. The code to do this might be:

```
Visual Basic and Python
Counter = Counter + 1
```

This can also be written in shorthand as:

```
Counter += 1
```

The program will execute this line, which adds one to the value in Counter, using the following steps:

- read the value from Counter
- add one to this value
- assign the new value back into Counter.

If Counter had the value 5 just before this line of code, it would have the value of 6 immediately after the statement has executed.

Some languages also use Counter++ to increment the counter by 1.

Example 3: Subtraction

Coding can also be used to perform subtraction.

```
Visual Basic and Python
BankBalance = BankBalance - AmountWithdrawn
```

Example 4: Multiple calculations

The following program code works out the volume of a room in a building.

```
Visual Basic and Python
RoomVolume = Width * Length * Height
```

Note that when there are multiple calculations in one line of code, the order of operations is the same as we have learnt in mathematics. Calculations are performed in this order:

- bracketed operations and order (raised to a power), from left to right
- multiplication or division, in order, from left to right
- addition or subtraction, in order, from left to right.

ISSUES

CORE ALERT Issues

Different languages

When we develop software, we tend to fall into the trap of thinking all other users speak the same spoken language as ourselves. Most software developers now write software so that the language of the menu commands and help files is selected at installation, and installed with the appropriate national language.

The commands on the screen menus and in the help files need to be clearly understood by the user in order to use the software.



Figure 15.24 A Chinese simplified version of the Preferences panel on an Apple laptop, showing how some specialised English terms are not translated

QUESTIONS

1. How many different languages are spoken by the peoples of the world?
2. What are the five top-ranking languages, in terms of the number of people who speak them?
3. What international equity issues are involved in this issue of software and languages?
4. The English language uses words composed of combinations of letters from a 26-letter alphabet. The QWERTY keyboard is well suited to this. Find out how modern computers and software can be made to work with languages using a different alphabet.

15.5 Functions

Each programming language has its own set of built-in functions we may use when programming. We need to know what functions are available and how they work. We can also write some of our own functions as we need them, as we see later in section 15.7.

Functions are usually written with parentheses – for example, MyFunctionName() – to indicate they may receive some input. In computing, as in mathematics, functions produce a single value of some type; however, this rule is not as strictly obeyed in computing. In the examples that follow, we consider how existing functions may be used in program statements.

Our number guesser code shows some functions, such as **input**, **int** and **print** in purple (see figure 15.21).

Functions that round numbers

The following examples show functions that round numbers.

Consider the following calculation:

```
AverageAge = Int(SumOfAges /
   NumberOfPeople)
```

Let us assume the variable SumOfAges contains a value assigned earlier in the program – the total of all of the ages for a group of people. The variable NumberOfPeople contains the number of people in the group. When this division takes place, it is unlikely to result in an integer, but instead a value like 27.67.

In Visual Basic, the Int() function – or in Pascal or Python, the Trunc function – chops off the decimal fraction part of the number and returns only the integer part. Thus, if the result from the division is 27.6, the output will be truncated to 27.

Input functions

There are a variety of functions available whose purpose is to receive data input. We consider here input functions that are given a string of text as input. For example:

```
Visual Basic
BirthDate = InputBox("Please enter
   your birthday in form dd/mm/yyyy")
```

When this statement is executed, the user sees a pop-up input box like figure 15.25.

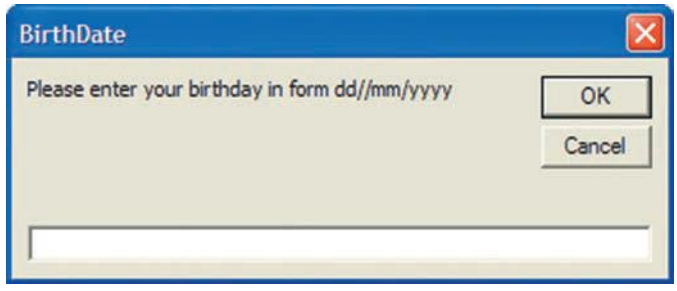


Figure 15.25 A pop-up dialogue box asks for a user's input.

The program execution is suspended until the user types in their birth date and clicks the OK button. The value typed in is assigned to the variable BirthDate. In Python, this is:

```
Python
BirthDate=input("Please enter your
   birthday in form dd/mm/yyyy")
```

Output functions

Programming languages also have functions that we can use to provide output to the program user, such as print or write.

We might display the output in a text field, or we might use a Msgbox() function to provide pop-up messages to the user. For example:

```
Visual Basic
MsgBox("Your birthdate is", BirthDate)

Python
Print("Your birthdate is " + BirthDate)
```

Mathematical functions

Most languages have a variety of mathematical functions for such things as:

- trigonometry (such as sine, cosine and tangent)
- random number generation
- logarithmic calculations
- squares and square roots
- rounding numbers
- finding statistical values (such as mean and average).

Function	Output	
Len( )	This function returns an integer value that is the number of characters in the string of text. For a string like 'Program', the value will be 7.	For example, Result = Len(Program) will assign the int value 7 to the variable 'Result'.
Left( )	This function returns a specified number of characters from the left side of the string. If you ask for three characters, and the string contains the value 'Program', the value returned will be 'Pro'.	For example, Result = Left(3) will assign the value 'Pro' to the variable 'Result'.
Right( )	This function returns a specified number of characters from the right side of the string. Asking for three characters from the string value 'Program' will return a value of 'ram'.	For example, Result = Right(3) will assign the value 'ram' to the variable 'Result'.

Figure 15.26 Three functions designed to work with string data (text), giving examples of their output

String-handling functions

There are many other functions that are designed specially to work with string data (text). Figure 15.26 shows some examples of these common to many languages.

Other functions

The functions we have considered so far are only a few of the very large number of functions we can possibly use. Programming languages have references in help files so that we can explore and find functions to use in our programs. Use the Internet to find out what other functions exist for the languages we have introduced in this chapter.

Constants

As well as variables, programs may also use constants to represent fixed numbers and strings. Like variables, constants can be created in the program, use a reserved area of memory and are given a name. A constant cannot be changed once its value has been set in the program. In our Scratch number guessing program, we assigned the value 30 to the constant *secret*. This was an example of using a constant.

ACTIVITIES

For these activities, you may wish to use the programming language you are learning.

Identify

1. Give examples of the symbol used for 'not equal to' in various languages.
2. Give three examples of arithmetic operators.
3. Give three examples of relational operators.
4. Give three examples of logical operators.
5. What is concatenation?
6. Use pseudocode to give an example of an assignment statement.
7. What is the purpose of a counter?
8. What is the purpose of a function?
9. Give an example of an input function.
10. Give an example of an output function.

Analyse

11. Work out what the following line of code might do:
    SalePrice = RRP – (RRP * DiscountRate)
12. Work out what the following line of code might do:
    TimeTaken = TimeFinished – TimeStarted

Investigate

13. Find out about five useful functions used in your programming language, and prepare a short table summarising how these functions can be used.

15.6 Algorithms

One student has responded this way when asked about programming:

'I tell someone that coding is a type of art. There are no bounds to your creativity and you can create anything you want and it can be easy or hard.' Another said: 'You should try coding! It's really fun, but I'm not promising that it will be easy. It's really useful and teaches you patience.'

One of the exciting things about programming is that we are presented with interesting problems to solve. If you give several different people the same problem to solve, you may find that they all solve it in different ways. It is important to learn that there are often many solutions for a problem. The first one that we think of may be the best, but we should always try to creatively think of other ways, and then reflect on which is best, and why it is best.

Describing a problem

A key part of any problem solving is being able to understand the problem, and then to separate the problem or task into a number of smaller subtasks.

Discussing problems and solutions with others is always a good idea, as we hear different ideas on the same situation. It is important to listen and welcome these and not just think of our own approach.

An **algorithm** is a method for solving a problem in a finite number of steps. But how do we communicate our algorithms to others?

The two most commonly used methods of describing algorithms are flowcharts and pseudocode, which we have studied already.

Flowcharts

We have seen already how flowcharts are a visual or graphical representation of the flow of logic in a problem solution. We now add another symbol for a subprogram to the standard symbols we introduced earlier.

The algorithm described in a flowchart begins and ends with a terminator symbol, with the word 'Begin' or 'End' in it, as shown in figure 15.27. As we see in the examples that follow, the symbols are connected using flow lines, with arrows to show in which direction we trace through the program.

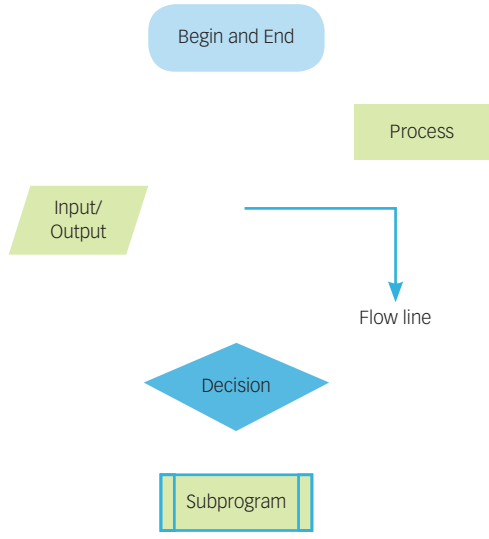


Figure 15.27 Here we see the common symbols used in flowcharting to which we have now added the symbol for subprograms.

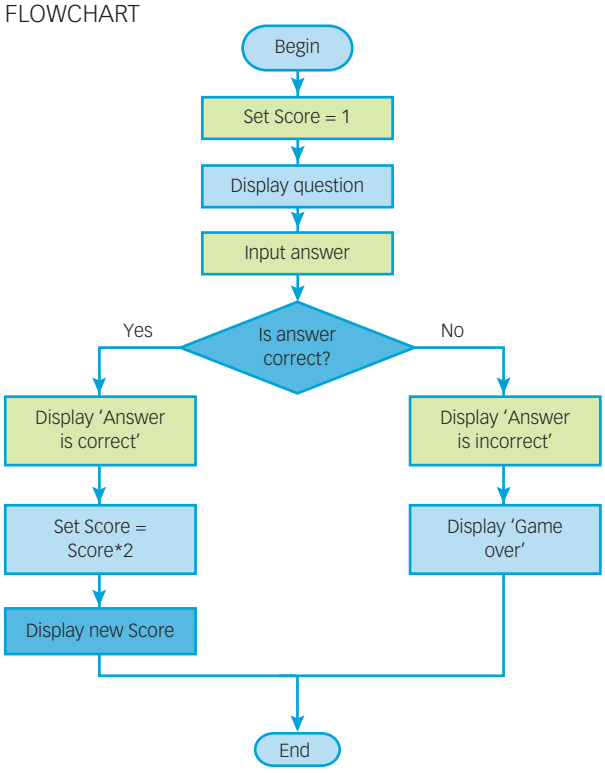
Longer programs should be broken into smaller units or *subprograms*. These are represented in a flowchart by a new symbol: a rectangle with double lines. Subprograms can be expanded using a separate flowchart on another sheet. Flowcharts should not extend beyond a single sheet of paper or screen, but should be broken into parts.

In a project at the end of this chapter, we will work on a quiz game called 'Double or Quit' for a television show. The program doubles the player's score each time they answer a question correctly. On the left of figure 15.28, we see only a part of this program that asks a question, receives an answer, decides if the answer given is correct, then provides appropriate output to the player.

INFOBIT

Computer programs are the most detailed structures ever created by human beings and programming is one of the fastest growing occupations. Comparisons between programs can be quite surprising but not always accurate. If code is not written efficiently, it can be many times larger than is necessary, as well as slowing down its operation. Windows 8 has over 80 million lines of code; the Large Hadron Collider has 50 million lines of code; Firefox has around 10 million; Photoshop around 6 million; the Hubble Space telescope 2 million; the Age of Empires game just over 1 million.

FLOWCHART



PSEUDOCODE

```
BEGIN
   Set Score to 1
   Prompt with Question
   Get Answer from player
   IF the Answer from player is correct THEN
      output "Answer is correct" to the screen
      output "Your score has doubled" to the screen
      Score = Score * 2
      output Score to screen
   ELSE
      output "Answer is incorrect" to the screen
   END IF
END
```

Figure 15.28 Flowchart for part of a simple quiz game program, together with the pseudocode expression of the same algorithm. This pseudocode algorithm uses the IF … THEN … ELSE … ENDIF structure.

TASK 1

Input to output

Write a program in your chosen language, according to these requirements:

1 The program should ask for the user's personal details, including first name, family name, birth date, favourite singer, favourite movie actor, then display details on the screen like this:

First name:

Family name:

Birth date:

Favourite singer:

Favourite movie actor:

2 Modify the program to display the same data in a sentence-like format, such as: You are <first name> <family name> and you were born on <birth date>. Your favourite singer is <favourite singer> and your favourite movie actor is <favourite movie actor>.

TASK 2

Using programming functions

Use pseudocode or the programming language you are familiar with to do the following:

1 Find out about the string functions available in your language. Write separate programs that perform the following actions.

a Asks the user to enter a word, then tells them how many characters the word contains. (You should use a function that finds the length of a string.)

b Requires the user to enter their name in lower-case letters, then displays the same name in upper-case letters.

c Asks the user for a word and then strips off the first and last letter and prints the result.

2 Write a program function to calculate the area of a circle (area = πr^2). Now include it in a program that asks the user for the radius of a circle in millimetres, and outputs the area of the circle. And have it loop so the user can run it without restarting it each time.

TASK 3

Programming with Scratch

1 Go to http://infosoftwaretech.nelsonnet.com.au to link to the Scratch website and download and install it. (It's free.)

2 Find an existing Scratch starter project online and examine its algorithm. (You can find the direct link at http://infosoftwaretech.nelsonnet.com.au.)

3 Modify this program yourself. The Scratch website suggests features to add.

4 Modify your Scratch program in some way.

TASK 4

Improving our number guessing program

Compare the following pseudocode with version 1 on page 323. Identify three new features that have been added. Your task is to add these features to your existing code.

```
BEGIN high low guessing game version 2
   set playAgain to true
   print "I'm thinking of a number
      between 1 and 100"
   WHILE playAgain is true
      generate secret as random
         number between 1 and 100
      print "What is your guess?"
      get guess
      set counter to 1
      WHILE guess is not equal to
         secret
         IF guess > secret THEN
            print "too high"
         ELSE
            print "too low"
         ENDIF
         print "What is your guess?"
         get guess
         increase counter by 1
      ENDWHILE
      print "Correct!"
      print "You took " + counter +
         " guesses."
      print "Would you like to play
         again?"
      get playAgain
   ENDWHILE
   print "Thanks for playing!"
END
```

1 A variable *counter* has been added that counts the number of guesses the user makes when the correct number is guessed. Also, a print statement has been added to the end to tell users how many guesses they had.

2 The program now uses a *function* to generate a new random secret number each time.

Python uses a special module called **random** to produce random values of various types.

The random function for integer values looks like this: randint(a,b) and it produces a random integer so that $a \leq n \leq b$. Note that this includes the end values. For example, randint(1,5) will produce any one of the values {1,2,3,4,5}.

As this function is part of an outside library of modules that must be imported into your program, you need to add import random as the first line of your code, and use random.randint(a,b) when you want to refer to the function itself.

The reason for writing the function in this way, known as dot notation, is that it shows randint(a,b) belongs to the random module.

Notice that the guessing game asks the user for a number **between** 1 and 100, but not equal to them – think carefully about the values you need to choose for a and b.

3 The program now asks the user if they wish to play again. This makes it possible to play more than one game without needing to restart the program. See if you can code this feature in your chosen language.

4 Carefully test your program and iron out any problems by inputting simple numbers then some 'incorrect' ones; for example, decimals, negatives, characters.

Here is what this improved program looks like in Scratch. Trace through the logic by first deciding on a secret number.

Try building it in Scratch yourself.

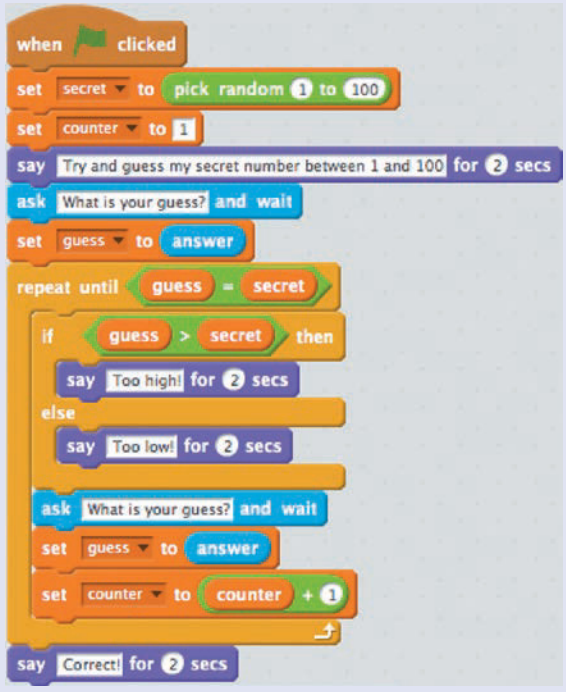


Figure 15.29 The improved number game program in Scratch

TASK 5

Describe an algorithm

1 Create an algorithm description using a flowchart or pseudocode for any one of the following:
   - **a** playing the memory card game
   - **b** using a toaster to prepare toast
   - **c** recording a television program
   - **d** playing a selected track from a CD on a CD player
   - **e** generating the squares of all integers from 1 to 100
   - **f** (harder) generating the first 20 Fibonacci numbers. (Look this up online if you do not know what Fibonacci numbers are.)

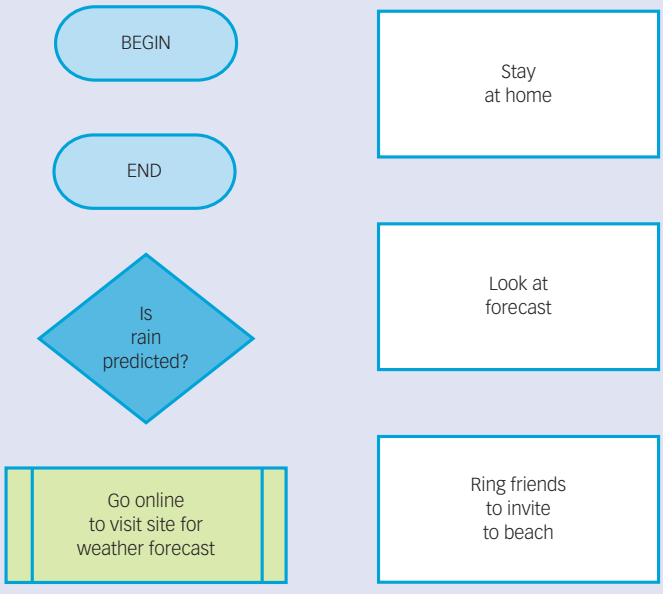
2 Represent the algorithms you selected in flowchart form and in pseudocode, using computer-based tools such as Word, PowerPoint or Illustrator.

3 Present the algorithm for peer review and feedback. Ask the reviewer to suggest an added feature. Each algorithm should include a written description of how you developed the algorithm and should mention any assumptions you had to make during the work.

4 Make modifications to the algorithm, if needed, after feedback is received.

TASK 6

Developing a flowchart



1 Copy the flowchart symbols, arrange them in a logical sequence and draw correct flow lines between them to construct a logical flowchart.

2 Label relevant flow lines emerging from decision boxes as 'Yes' or 'No'.

3 Check your answer with another student.

4 Use the drawing tools in MS Word to create a digital version of your final answer.

ACTIVITIES

Identify

1 Define the term 'algorithm'.

2 What are two ways to represent an algorithm?

3 Draw and describe each of the symbols used in flowcharting.

Analyse

4 What are the differences between pseudocode and ordinary English?

Investigate

5 Write an algorithm expressed in flowchart form for finding the largest of four integers.

CASE STUDY

CORE ALERT Projects: design, produce, evaluate

Introductory programming project

Further improving our number guessing game

The number guessing game is often given as a first programming exercise, because it involves all the topics you have learnt so far: variables, user input, output, counters, loops, arithmetic and logical operators and functions. It is a great way to learn about coding.

Your task is to change the game so that instead of printing 'high' or 'low', it uses the words HOT, WARM, COLD and FREEZING.

Read each stage carefully and use the diagrams below to assist you in making these improvements.

Planning

The player (user) has to guess a secret number chosen by the computer. The computer will respond each time with the appropriate word. We use a special function in Python to generate our secret number:

```
secret = random.randint(1,100)
```

Defining and analysing

Absolute value function

We will need a way to test how close the player's guess is to the secret number.

We can use (guess – secret) to measure this gap, but it will be a negative answer whenever guess is less than secret.

Python has a module called abs() that gives us absolute values or the value of the number without the positive or negative. It is exactly what we need! It looks like this:

abs(x) returns the absolute value of a number

We will decide first the ranges for each 'temperature':

Hot	within 5 of the secret number
Warm	within 20 of the secret number
Cold	within 40 of the secret number
Freezing	greater than 40 away from the secret number
Correct!	exactly equal to the secret number.

Flowchart

We first draw up a flowchart of the logic we will use (see figure 15.30). Can you explain why the tests have been placed in this order?

Designing possible solutions

Next we develop a complete pseudocode for the program. The act of coding is made much simpler when the logic has already been carefully thought out.

An IPO table summarises the input, processing and output for our game, shown in figure 15.31.

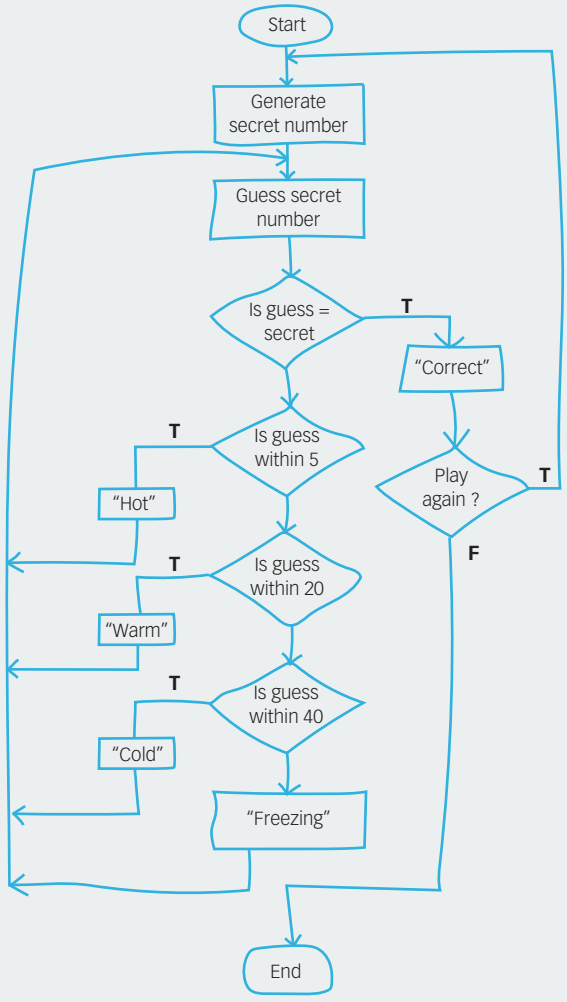


Figure 15.30

Input
• Our guesses
Processes
• Generate a secret random number • Compare secret number and guess • Count the number of guesses the player makes • Ask if the player wants to play again
Output
• Display the appropriate message: 'Freezing', 'Cold', 'Warm', 'Hot' or 'Correct!' • Display the number of turns

Figure 15.31

Choice of language

We will use Python for our example here, but this code can be adapted easily to other languages.

Producing a solution

We need to give different messages depending on the guess. We can use a CASEWHERE statement in Python and reduce our typing.

```
BEGIN high low guessing game version 3
   set playAgain to true
   print "I'm thinking of a number
      between 1 and 100"
   WHILE playAgain is true
      generate secret as a random
         number between 1 and 100
      set counter to 1
      print "What is your guess?"
      get guess
      WHILE guess is not equal to
         secret
         CASEWHERE abs(guess-secret)
            <= 5: print "HOT"
            <= 20: print "WARM"
            <= 40: print "COLD"
            OTHERWISE: print
               "FREEZING"
         ENDCASE
         print "What is your guess?"
         get guess
         increase counter by 1
      ENDWHILE
      print "Correct!"
      print "You took " + counter +
         " guesses."
      print "Would you like to play
         again?"
      get playAgain response
   ENDWHILE
   print "Thanks for playing!"
END
```

Repeating

How do we create a repeating loop that stops?

We use a while loop entered only if *secret* and *guess* are not equal. We keep track of the number of guesses by using a variable called *counter*.

The player is not asked the value of guess until they are inside the while loop. We therefore set up a dummy value for *guess* of, say, –1 before we ask the player. We also initialise values for *counter* and *secret*.

```
counter = 0
guess =-1
secret = random.randint(1,100)
while  guess <> secret:
  guess = raw_input ("Your guess?: ")
  guess = int(guess)
  counter = counter + 1
  if guess == secret:
     print ('Correct! You took ' + str(counter)+ ' guesses.')
  elif abs(guess-secret)<=5:
     print ('Hot')
  elif abs(guess-secret)<=20:
     print ('Warm')
  elif abs(guess-secret)<=40:
     print ('Cold')
  elif abs(guess-secret)>40:
     print ('Freezing')
```

Need to set initial values for:
- counter
- guess
- secret

Play again?

We want the player to be able to play our game again without quitting and restarting it. To do this, we will wrap it in a second while loop, which will be entered whenever a variable called *playAgain* is not equal to 'no'.

Players can only quit if they answer 'no'.

We now have a problem. The first time the game is played there is no value for *playAgain*, so the while loop will not be entered. We must initialise it to anything except 'no'. We will make it equal 'yes'.

Need player to be able to play again? Wrap whole code in another while loop that repeats whenever playAgain equals anything other than 'No'.

```
while playAgain<>"no":
   counter = 0
   guess =-1
   secret = random.randint(1,100)
   while  guess <> secret:
      guess = raw_input ("Your guess?: ")
      guess = int(guess)
      counter = counter + 1
      if guess == secret:
         print ('Correct! You took ' + str(counter)+ ' guesses.')
      elif abs(guess-secret)<=5:
         print ('Hot')
      elif abs(guess-secret)<=20:
         print ('Warm')
      elif abs(guess-secret)<=40:
         print ('Cold')
      elif abs(guess-secret)>40:
         print ('Freezing')
   playAgain=raw_input("Would you like to play again? ")
```

Problem: first time while loop is reached there is no value for playAgain. Error produced. Will need to initialise playAgain to 'Yes'.

Evaluation

Play the game a number of times and test all aspects of it.

```
import random
playAgain="yes"
print('Hullo! guess my number between 1 and 100.')
while playAgain<>"no":
   counter = 0
   guess =-1
   secret = random.randint(1,100)
   while  guess <> secret:
      guess = raw_input ("Your guess?: ")
      guess = int(guess)
      counter = counter + 1
      if guess == secret:
         print ('Correct! You took ' + str(counter)+ ' guesses.')
      elif abs(guess-secret)<=5:
         print ('Hot')
      elif abs(guess-secret)<=20:
         print ('Warm')
      elif abs(guess-secret)<=40:
         print ('Cold')
      elif abs(guess-secret)>40:
         print ('Freezing')
   playAgain =raw_input("Would you like to play again? ")
print ("OK. Bye!")
```

Final code is tested. Users play game and suggest improvements.

Some questions

What happens if the player types in a number outside the range 1 to 100?

What happens if the player types in a word instead of a number?

15.7 Desk checking and subprograms

Programmers use desk checking to check the logic of a program. The process involves simulating the action of a program with pen and paper. The programmer will:

- set out a table or chart showing all the variables used by the program
- work through each statement of the program in the order it should execute, modifying the values in the desk check chart as they go
- perform the desk check in such a way that all possible choices by a user will be considered.

Using desk checking

Desk checking can often reveal errors in programs, but is not guaranteed to find them all.

It is only one of the techniques we use in programming to try to verify that the program code will properly implement the algorithm.

If the desk check is conducted by someone other than the programmer who wrote the code, it is even more useful, because the program author will often make incorrect assumptions about how a user will respond to the program.

CASE STUDY

Desk checking and correcting algorithms – simple example

Examine the following algorithm:

```
#An algorithm to count the
   number of letters in a
   word that has length 4
   letters
Set word to user's input
Set letter_count to 0
Set current_position to 0
   #Note that the first
   position here is labelled
   0, not 1
WHILE current position is
   less than length of word
   Increase letter_count by 1
   Increase current_position
      by 1
END WHILE
Print letter_count
```

We perform a desk check on this algorithm using the word 'desk' as the input. Step through the above algorithm carefully and confirm the following table has been completed correctly.

Example 1

Word (user's input)	Current_ position	Letter_ count	Expected printed output	Comment
desk	0	0	4	Initially
desk	1	1	4	After finishing first loop in while statement
desk	2	2	4	After finishing second loop in while statement
desk	3	3	4	After finishing third loop in while statement
desk	4	4	4	Loop exits as current position is no longer less than 4. '4' is printed as final output. Desk check shows algorithm is correct.

QUESTION

Try coding this algorithm using your favourite coding language.

Using subprograms

Subprograms are used in programming languages and are called by a variety of names such as function, procedure or subroutine.

Subprograms are smaller self-contained programs that form part of a larger program and that perform a particular task. They may be reused many times in a large program and are often stored in libraries of subprograms.

It may help to think of the real-life analogy of cooking to explain why we use subprograms in programming.

Think of a few tasks a chef might perform during food preparation and turn them into subprograms. The chef might follow instructions like the following:

- dice (two onions, finely)
- peel (500 g carrots)
- heat (300 mL milk in saucepan, do not boil)
- peel (1 kg potatoes).

The subprograms are named as dice, peel and heat, and each involves certain tools and skills that can be reapplied to different ingredients. These would be better explained in a separate part of the cookbook rather than written out in detail each time they are needed.

A sandwich maker has access to a list of different types of sandwiches, each of which has an ingredient list. For example, if a customer asks for a cheese and tomato sandwich, the ingredients are obviously sliced cheese and tomato. If they ask for a salad sandwich, this might have a fixed list of ingredients, such as lettuce, tomato and beetroot.

When the sandwich maker interacts with the customer, they ask them for their preferences – things like 'What type of bread?', 'Margarine, butter or plain bread?' and 'Salt and pepper?' The answers to questions like this are stored in a set of variables that, in the example shown, are grouped together as SandwichPreferences (see figure 15.33 on page 348).

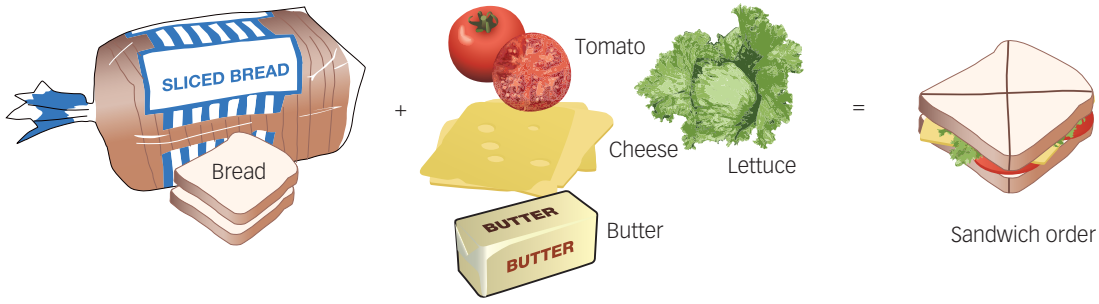


Figure 15.32 The sandwich-making program accepts choices from a customer, stores them in variables, checks availability and makes the sandwich.

TASK 7

Writing subprograms

1. Write flowcharts for each of the three subprograms for the MakeSandwich program shown in figure 15.33.
   - **a** GetSandwichPreferences
   - **b** PrepareBreadSlices
   - **c** IngredientsAvailable
2. In GetSandwichPreferences, the subprogram should ask the user a series of questions, storing the answers given into variables.
3. The IngredientsAvailable subprogram should check to see if all of the ingredients needed for a specific sandwich are available. To do this, you should assume the ingredients are in a list that can be checked one by one.
4. You may wish to extend the PrepareBreadSlices subprogram in case it needs to be able to use toasted bread.

TASK 8

Analyse existing programs

Download some of the sample programs from NelsonNet, and complete the following tasks on each program.

1. Identify in plain English what the program does.
2. Describe all the variables used in the program, stating what each is used for.
3. Describe in pseudocode and as a flowchart the algorithm the program uses.
4. Suggest improvements that could be made to the program that might:
   - **a** make it work more efficiently
   - **b** make it easier to use.

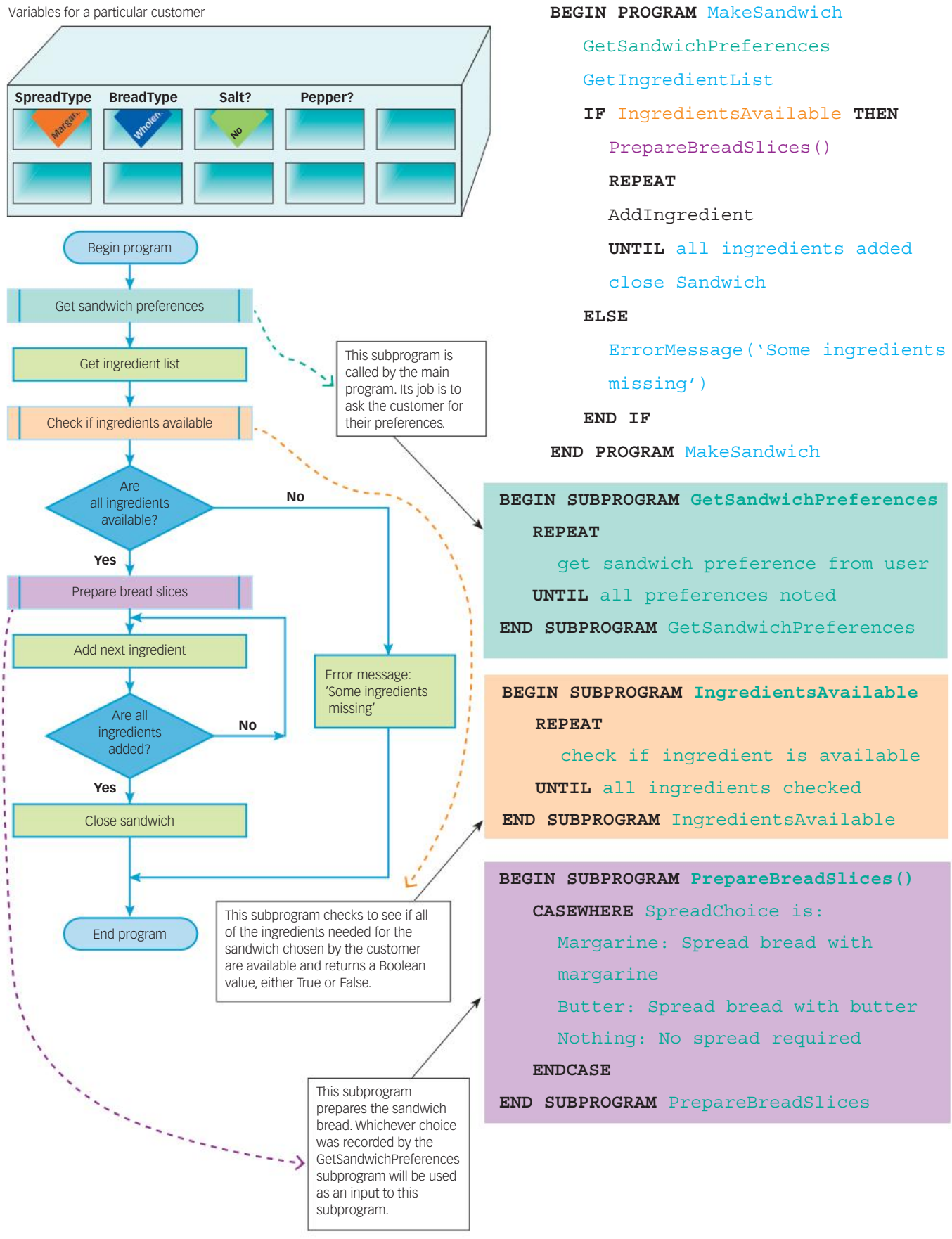


Figure 15.33 Pseudocode listing for a program to make a sandwich. The three subprograms for the MakeSandwich program are shown in pseudocode. We can see how the same program can be described in flowchart format, where the coloured subprogram sections match colours in the pseudocode.

CASE STUDY

Desk checking and correcting algorithms – harder example

Examine the following algorithm:

```
  #An algorithm to count the number
         of vowels in a word

Set word to user's input
Set vowel_count to 0
  #Note that the first position is
         labelled 0, not 1
Set current_position to 0
Set vowels to 'aeiou'
WHILE current position is less than length of word
   IF letter at current position is in vowels THEN
         Increase vowel_count by 1
         Increase current_position by 1
   ENDIF
END WHILE
Print vowel_count
```

When a desk check is performed on this algorithm using the word 'iou' as the input, the algorithm performs correctly. Step through the above algorithm carefully and confirm the following table has been completed correctly.

Example 1

Word (user's input)	Vowels	Current_ position	Vowel_ count (final output)	Expected printed output	Check
iou	aeiou	0	1	–	–
iou	aeiou	1	2	–	–
iou	aeiou	2	3	3	CORRECT!

When a desk check is performed on this algorithm using the word 'algorithm' as the input, the algorithm performs incorrectly. Step through the algorithm carefully and confirm the following table has been completed correctly.

Example 2

Word (user's input)	Vowels	Current_ position	Vowel_ count (final output)	Expected printed output	Check
algorithm	aeiou	0	1	–	–
algorithm	aeiou	1	1	–	–
algorithm	aeiou	1	1	–	–
algorithm	aeiou	1	1	–	–
algorithm	aeiou	1	1	–	–
algorithm	aeiou	1	1	–	–
algorithm	aeiou	1	1	–	–
algorithm	aeiou	1	1	–	–
Continued …					
algorithm	aeiou	1	1	3	INCORRECT!

QUESTIONS

1. Can you explain why the algorithm works correctly for the first example, and incorrectly for the second example?
2. The algorithm can be fixed by changing just one line. Which line must be changed and what change is required?
3. Write out or type the corrected algorithm and copy and complete a table by stepping through the algorithm once again, this time using 'vowelcount' as the input word.
4. Have all possibilities now been tested? Can we now be sure the algorithm is perfectly correct?
5. Code this algorithm in your favourite programming language and test it by running it.

ACTIVITIES

Identify

1. What is the purpose of desk checking?
2. Describe the steps involved in performing a desk check on a program.
3. What are the main reasons for using subprograms?

Analyse

4. Functions are different from ordinary subprograms in that they return a value. Explain why some subprograms do not need to return a value.

Investigate

5. Find out about the syntax for subprograms in the language you are using.
6. Find out why the GOTO statement is regarded as bad practice in programming.

15.8 GUI layout

As we discovered in chapter 3: Software, modern computer operating systems present a graphical user interface (GUI) to the user, where the main elements of common desktop computers are windows, icons, menus and pointers. When we use a modern graphical programming language, we can take advantage of the range of software objects available to create programs with a graphical user interface. Another example of a GUI is a smartphone touchscreen.

A very important factor contributing to the success of good software is the design and layout of the interface presented to the user.

Graphical tools

Using graphics tools can be quite effective in designing forms and reports for software. Many programming languages have built-in graphical tools so that the screen and form designs can be quickly turned into programs.

GUI objects

In chapter 3: Software, we discovered the range of different GUI objects made available in operating systems. When we design and develop a program using these objects in a programming language, the graphical tools enable us to drag these objects onto forms and position them according to our design.

We are then able to write program code to make the software behave as designed. For example, we may drag a button onto a form, and create program code that runs when the user clicks the button.

Some of the more common objects we might use in graphical programming are shown in figure 15.34.

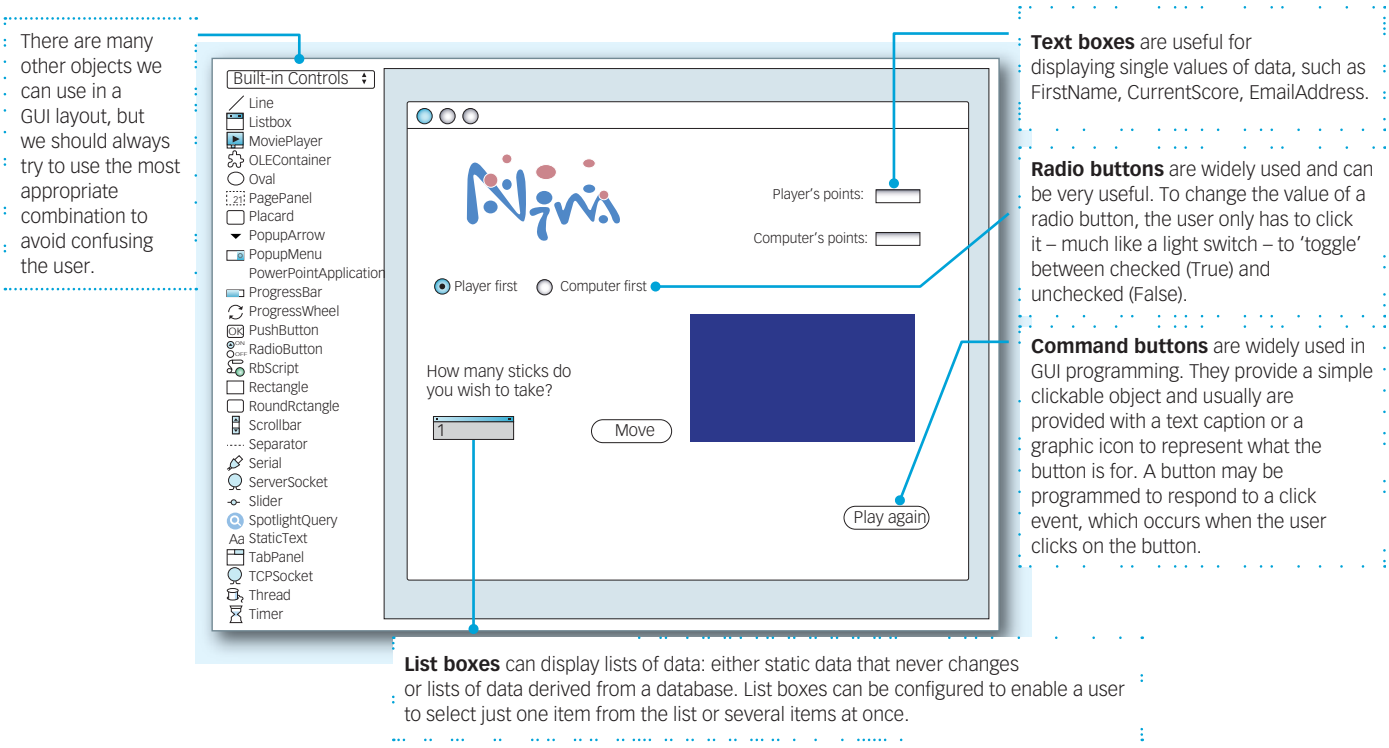


Figure 15.34 Graphical user interface showing various types of GUI objects

TASK 9

Decisions, decisions

1 Create a GUI layout for a confectionary dispensing machine accepting cash, card or smartphone orders. The choices should include prices. Write pseudocode and flowchart for the program that will dispense the items and charge the user.

2 Create a GUI layout for a home airconditioning system. The program should ask for the desired temperature level, and turn on either cooling or heating to achieve that temperature level.

3 Create a GUI layout for a small portable music player. It should offer choices to play a chosen music clip, or to play all clips.

PAST, CURRENT AND EMERGING TECHNOLOGIES

CORE ALERT Past, current and emerging technologies

The challenge of diminishing displays

The following text appeared in the first edition of this book. How accurate were our predictions? The iPod Touch, the iPhone, the iPad and other similar products had not yet been created. Read the extract and answer the questions that follow.

Australians have a reputation for being fast adopters of technology – we adopted mobile phones much faster than other nations. As mobile phones progressively merge with pocket PCs and personal digital assistants, it seems inevitable that eventually a large part of the population will be connected to the Internet wherever they roam! The devices being developed and promoted become increasingly powerful, with more and more capabilities. One thing they all share is a relatively small output display, compared to a typical desktop computer or notebook LCD screen.

Software developers and programmers have been used to the quite large resolutions available on desktop computers – the desktop metaphor is delivered quite easily. On the much smaller resolutions and screen sizes of the mobile device, we have to find ways to deliver a mobile user interface that:

- *can fit in the space available*
- *appears easy to use; that is, is 'intuitive'*
- *works with the limited input devices available*
- *works consistently over a range of different types of applications.*

Perhaps you will be one of the pioneers in this field.

QUESTIONS

1 What ways have been developed to solve the problems we proposed back in 2004?

2 Describe the applications you have used, or seen others use, on a mobile device.

3 What sorts of applications could be of positive use for the very young, the elderly and school students?

ACTIVITIES

Identify

1 Identify two types of GUI.

2 Identify four elements in a WIMP GUI.

Analyse

3 Why might WIMP be unsuitable as the user interface for a touchscreen phone using fingers as a pointer?

Investigate

4 List the GUI elements used on a standard smartphone application.

15.9 Programming languages

Figure 15.35 shows a few of the popular programming languages of the 2300-plus that have been invented.

The following programming languages are among the most popular at present (as measured by statistics gained from websites, forums, books, jobs and blogs):

- C
- C++ (pronounced 'see-plus-plus')
- Java
- PHP
- Python
- JavaScript for web pages.

There are also many specialist scripting languages built into commercial applications; for example, Flash uses ActionScript and FileMaker Pro uses ScriptMaker. Most of these can be used to cover the programming theory in this course.

Examples of programming languages

CORE ALERT Past, current and emerging technologies

CORE ALERT Software

Different languages have different strengths and weaknesses.

Fortran was once one of the most widely used languages in science and engineering.

COBOL is a business language and was behind the Y2K problem when many computers failed to recognise the change of date at the start of the new millennium. It was the first data processing language to resemble English and is still used by many banks.

Logo was invented by Seymour Papert to help children learn programming by using graphics and simple instructions.

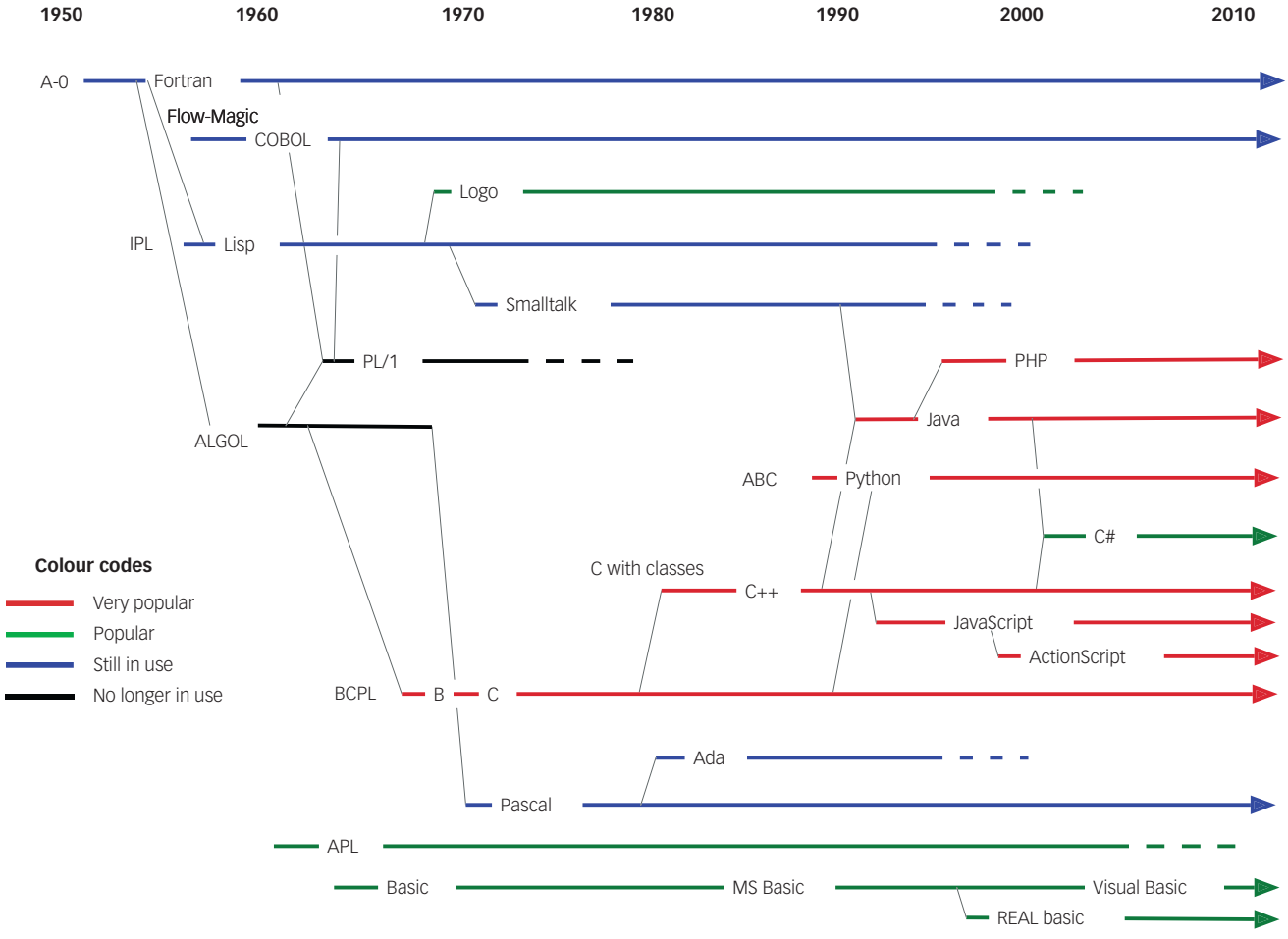


Figure 15.35 The development of computer languages began in the 1950s, with the most popular ones today shown in red.

ALGOL was designed by an international committee to be the world's first universal computer language.

Pascal was designed by Niklaus Wirth and was widely used as a teaching language. It was designed to simplify ALGOL.

BASIC was designed as a Beginner's All-Purpose Symbolic Instruction Code, which is where it got its name!

C evolved from languages called A and B. Along with C++, it is one of the most used languages today.

JavaScript is widely used in programming web pages and Java (not really related) is used to write mini-applications, called applets, running inside web pages.

Types of languages

Languages can be grouped according to the methods they use. The two main groupings are:

- imperative – languages that describe how things are to be done using sequences of actions
- declarative – languages that describe what needs to be done and not how to do it.

Subcategories of these languages include functional, logic, procedural, object-oriented and event-driven.

Most programming languages in the past were based on procedures. A procedure, or function, is a set of specific instructions. The data is separate from the procedures, and it became very difficult to trace the way the data changed as it travelled between many functions.

Another approach, known as structured programming, is based on breaking a complex problem down into a set of smaller tasks. However, programmers were constantly reinventing the same functions each time they needed them. By reusing standard modules, a lot of wasted time and effort was avoided.

Object-oriented programming treats the procedures that act on the data as a single self-contained 'object' with its own rules and characteristics.

Choosing a programming language

It takes time to learn a programming language, which is why users will defend strongly the languages they know.

Should you choose to study the most *widely used* language? Java runs on many platforms and is widely used, whereas Mathematica speeds up complex operations in mathematics but has a much smaller base of users. Both languages are therefore needed.

Should you choose the *easiest* to learn? This may get you started, but you may end up investing time in a language without the future power you need.

Fortunately, whichever you choose there will be an overlap with other languages and your efforts will not have been wasted. Once you learn one language, it is much easier to learn another.

Perhaps one day far into the future there will be only one natural language all-purpose programming language, which will make choosing a lot easier!

Source code to object code

Programmers usually write code in the form of lines of text, using the grammar (**syntax**) of a programming language. The text is usually written using a text editor provided as part of the programming language's integrated development environment (IDE). The program, written in text, is referred to as **source code**.

Computers cannot execute the programs in this form, and programming language tools have to translate the program code into 'machine language' or **object code**. It is represented using only zeros and ones. At this point the code is executable, and the computer can run it.

Some languages are designed to be translated. These languages are described as compiled languages, such as C++. The entire program is converted into the computer's machine language of zeros and ones, using a **compiler**, and run immediately or filed to be run later. The first compiler, called A-0, was created by Grace Hopper in the 1950s, and she was the first to use the term 'compiler'.

Other languages are translated by an interpreter at the time the program is executed and are called interpreted languages, such as Python and JavaScript. For this to be possible, the interpreter must be present on the computer system when the program runs.

Compiled programs usually run faster than interpreted ones; however, an interpreter is useful in **debugging** large programs, as it takes time to recompile a large program in order to test it every time code is changed.

Some software packages have built-in programming languages to enable us to customise them. For example, Microsoft Office applications come with an interpreter for Visual Basic for Applications.

ACTIVITIES

Identify

1 What is source code?
2 What is object code?
3 What was the world's first universal computer language?

Analyse

4 What should be considered when choosing a computer language for a project?

Investigate

5 Use the Internet to find at least three computer languages not included in figure 15.35.

15.10 Data structures

The variables we have considered so far are quite simple, as each variable holds one item of data. These are described as simple or scalar variables. Programmers often need more complex data structures that hold more than one item of data in a unit or container. The most commonly used complex data structure is the **array**.

Arrays

Many of the programs we write need to work with lists of data of the same type, such as lists of names or addresses or class marks in a test. This is why programming languages provide us with arrays.

Arrays can be thought of as lists or tables of variables of the same data type; for example, an array of string variables or an array of integer variables.

Arrays are held in memory, just like single-value variables, so that processing the data in an array is very fast. And just as for the variables we used previously, arrays should be declared by the program, as this declaration tells the language compiler or interpreter how much memory the array will need. In some situations, a programmer is not sure how big the array will be before running the program; for example, names in a school class. This is why most languages allow us to change the size of the array while the program is running.

Arrays are identified with a variable name, which should indicate what type of data the array holds. Each language has its own rules for this. Example declarations for an array that will hold a list of six student names are:

Visual Basic

```
Dim StudentNames(6) As String
```

Pascal

```
VAR
StudentNames: array[1..6] of string;
```

Python does not have an array type. Instead it uses lists, which are more flexible – considered both a strength and a weakness.

Python

```
myList=[1,2,3,4,5,6]
```

A simple list like the one described above is called a one-dimensional array. It has only one column of data.

In the program code, we need to have a way to make reference to individual elements of the array. We use an index number to do this. The index number for a one-dimensional array tells us the row the element takes up in the array. In the list of StudentNames in the array shown in figure 15.36, we can see that the name 'Tabone' is contained in array element 4.

In most programming languages, arrays are indexed starting at element 0. In our examples in this section, arrays will start at element 1 in order to avoid confusion.

1	Wirth
2	Martin
3	Lin
4	Tabone
5	Fenton
6	Liang

Figure 15.36 A one-dimensional array of string variables

Listing all the values in an array

We can use a WHILE or REPEAT loop to display all of the names in the array shown in figure 15.36.

We could also use the FOR … NEXT loop, as follows:

```
ArraySize = 6
FOR Counter = 1 to ArraySize
   display Counter
   display StudentName(Counter)
NEXT
```

In the FOR … NEXT loop, the counter is initialised and told when to stop in the FOR … line, so we don't need to have a separate statement to increment the counter, as we did in the WHILE loop.

Searching for a value in an array

We may want to search the array to see if it contains a particular name. An algorithm to do this is presented below in pseudocode form. In this case, the example stops when it finds the value it is looking for.

```
Set FoundItem = False
Move to the first array element
REPEAT
Read the array element
IF the array element value = search
   value THEN
   FoundItem = True
ELSE
   Move to the next array element
ENDIF
UNTIL (FoundItem = True) OR (at end
   of array)
```

Note that in the example, the loop will terminate when the item is found, or when the search reaches the end of the array.

Records

Many programs require us to deal with data about people or things like products in a shop. To describe the properties of each person or object, we might need to use a collection of variables of different data types.

A record structure is a complex data type acting as a container for a number of different simple data types.

In Visual Basic, this is called a Type or a Structure, depending on the version of the language. In the Pascal language, it is called a Record. In C++, it is called a Struct. In Python, we would use a Class structure.

Creating a record type declaration suitable for holding the data about a competitor in a quiz is like this:

Visual Basic

```
Structure Competitor
   Dim FirstName, FamilyName As String
   Dim ScoreAchieved As Integer
End Structure
```

Pascal

```
TYPE
   Competitor = Record
      FirstName, FamilyName: String;
      ScoreAchieved: Integer;
      end;
```

The record structure is the most detailed data type we have introduced so far. It allows for many different types of data to be included as parts of the one container. However, record definitions are used for many different purposes even in the one program, so these will need to be defined each time. Once one record is defined, it can be used any number of times as a kind of 'pattern' to create new records of that same design.

In either language, these statements do not create a new variable, but only define a new type of record. To use it, we need to add declarations like these:

Visual Basic

```
Dim Competitor1, Competitor2 As
   Competitor
```

Pascal

```
VAR
Competitor1, Competitor2: Competitor;
```

During the execution of our project quiz program, we can use the data stored in the records for things like displaying the competitor's name on the screen and keeping track of their score. At the end of a round, the data in the record may then be copied into a data file.

Files

A file is a much more flexible data structure than a record. In computing, a file is any collection of data grouped under a single name. Files can be organised in many different ways and there are various ways the separate items can be separated from one another. For example, in a spreadsheet file the columns are often separated by commas and the rows are separated by the new line character. This file structure is recognised by most databases to allow the exchange of data between these two types of applications.

Files can be thought of as permanent containers for data. This is very useful for keeping the data ready for the next time we wish to use it.

The simplest type of file is the text file, which can be thought of as a long string of characters. Sometimes we write lines of text into a text file, indicating the break between one line and the next with a newline character.

We often need to write data into files. If we need to have data stored in a highly organised way, the best storage location is a database. If we only need to store text to log events or actions, we might use a simple text file for simplicity.

The simplest type of write action we can do to a text file is to *append* text, which is like the way we write notes in a diary – we just add text where we left off last time. We might use an algorithm like this:

```
BEGIN
   Open file for appending
   Write line of text to file
   Close file
END
```

ACTIVITIES

Identify

1 What is the difference between an array and a record?
2 How do you declare an array in Visual Basic and Pascal?

Analyse

3 Give examples of the use of an array and a record structure in a program.

Investigate

4 Find out about the rules for using arrays in the language you are using.
5 How do you declare an array with two dimensions?

15.11 Testing program code and detecting errors

The purpose of program testing is to try to verify that the program operates as it should. In the process of testing, we may find errors and correct them when they are found.

If we work carefully, testing is made much easier, as many potential errors will already have been eliminated.

Unit testing

Software developers test new software at different stages of the process of development. Most software is composed of many distinct components. Within each component, we may isolate one or more units of code. Units can often be isolated as distinct subprograms, procedures or functions.

Unit testing is usually done by the programmer first, but may also be tested later by a software tester – someone with specific skills in program testing. To do this, the programmer will run the program unit using a set of test data. The programmer should already know what the program does with each of the sets of data. The programmer compares the actual program output with the expected output. If the two sets of data don't match, the programmer then attempts to find the cause for the difference, which may be due to program errors. This is very much like what we did in desk checking, but here the programmer tests the program with real data.

The tester should ensure that the program is properly tested at the boundaries for the calculations being performed. Let us consider an example of a program that decides the grade to be granted to a student in a course, depending on the mark achieved. The grading rules for the course are:

- 0–49: Keep trying!
- 50–69: Pass
- 70–84: Credit
- 85–100: Distinction

The boundary values are 0, 49, 50, 69 and so on. The function called DecideGrade is used to evaluate a mark and award the appropriate grade.

In code, the procedure is called with code like this:

```
StudentGrade = DecideGrade(StudentMark).
```

The value of StudentMark that is passed to the parameter or argument of a function should be an integer value between or including 0 and 100. The function DecideGrade should return values like 'Keep trying!', 'Pass', 'Credit' or 'Distinction' and assign such a value into the variable StudentGrade.

The programmer should have ensured that the program rejects marks outside the acceptable limits. Here marks that are less than 0 or greater than 100 are outside the acceptable range. The program should also reject any input that is not a number.

The programmer will write code that carefully tests the program for a range of values, including values outside the boundaries, such as –1 or 101. The program tester will also check what happens when a student gets 0, 100, 49 or 50, for example, to ensure that the decision boundaries are responding correctly.

The program should also be tested to see what it does if you pass it a real number such as 49.9999. If the rules are to accept integers only, then a value of 49.9999 should be rejected.

Programmers are very cautious and they provide error-handling code to deal with situations when the wrong data is passed to the program.

Error detection

When we design a program, we want it to work perfectly – even brilliantly! We certainly don't want any errors in the program. Despite our best efforts, errors may be introduced into the program code. We will probably find some of them before we think the job is finished, but perhaps not all of them.

There are different types of errors made in programming. Understanding what they are and how they are introduced is helpful, as we all like to avoid making errors.

The main types of errors are:

- syntax errors
- logical errors
- run-time errors.

INFOBIT

Error-handling code is included to deal with potential errors during program execution. Error-handling may simply cause the program to terminate or quit with an error message or it may deal with the error, taking a different path of program execution.

Syntax errors

Syntax errors are like grammatical errors or spelling errors we make when writing an essay or assignment. The errors have to do with our use of the language. In programming, we must obey the rules of the language or the program will not work. Modern programming languages provide syntax checkers, which even check the line of code you are writing as you write it, and if you make a syntax error, the development tool will warn you in some way. The warning may be that the code changes colour to red or a message may pop up on the screen.

This is the most common type of error you will make when beginning to learn a computer language because you are only beginning to learn the rules of the language. You may omit a comma or put a space accidentally in the wrong place or leave out a closing parenthesis. For example, the following code written in Python:

```
for x in range(1, 11)
   print(x)
```

will produce this message:

```
SyntaxError: invalid syntax
```

because one of Python's rules states that the test condition for loops must end with a colon. Even the indent on the line for the print (x) is an important feature of the syntax.

The corrected code would be:

```
for x in range(1, 11):
   print(x)
```

Syntax errors are very easy to miss, aren't they?

Describe what the output will be here.

INFOBIT

A Commonwealth Bank customer found one day that more than $230 million had been deposited into his account! Someone had entered the account number into the field for the deposit amount, but the system didn't alert anyone about it. The bank apologised and corrected the mistake.

Logical errors

Logical errors in a program can be caused by:

- a failure by the programmer to understand the problem
- an incorrect algorithm.

Logical errors can be of many different forms, but they include:

- using the wrong mathematical formula, such as multiplying two numbers when you meant to divide – this type of error is hard to find, as the code will usually execute without complaint but the output data will be incorrect
- putting statements in the wrong order
- leaving out an essential step.

Imagine a banking program that added withdrawn amounts to the balance each time you withdrew some money from your account, instead of subtracting it. Each time you withdrew cash, your balance would get bigger. In your dreams only, of course! This would be an example of a very serious logical error made by a programmer.

Run-time errors

Some errors will only show up when the program is executing. A common cause for **run-time errors** is that the program attempts to perform an illegal operation. This might be as simple as:

- dividing a number by zero
- trying to open a file that no longer exists or has been renamed
- attempting to work with a software object using the wrong name or path
- performing a calculation that results in a very large number and then trying to assign it to a variable that is too small to hold it
- expecting to receive data of a specific type but receiving data of a type that does not match.

Good programmers will try to avoid run-time errors using a range of strategies, including:

- careful desk checking
- peer review of the program code by someone who did not write it
- carefully testing the program code against a range of data, including data that is deliberately wrong.

ACTIVITIES

Identify

1 Identify three types of programming errors.
2 At what point in the development of a program does a programmer discover a run-time error?

Analyse

3 How can syntax errors be avoided?
4 How can logical errors be avoided?

Investigate

5 Find out the meaning of the term 'computer bug' and research when this term was first used and by whom.

15.12 Correcting errors and program documentation

Sometimes, despite our best efforts, a program does not work as it should, even after a program's algorithm has been desk checked and all syntax and run-time errors eliminated from the code. Programs are often very complex and so special debugging tools have been developed to locate remaining hard-to-find errors.

It is important you document how a program was designed and what changes have been made to it over time. There are many examples of valuable code that had to be abandoned because it was not properly documented.

Debugging tools

Most programmers use a special collection of tools to program, called an integrated development environment (IDE). This usually includes specialised debugging tools to help the programmers find certain types of errors. Most syntax errors are very easily found by the IDE debugger.

Debuggers allow us to do things like 'watch' the lines of code while they execute, stepping through the program line by line, and enabling us to see what happens to the value of each variable.

There are three main tools usually provided:

- Breakpoints: These are markers that signal that the execution of the code is to halt at that line of code. The programmer can then examine the values of the variables at that intermediate point in the code's execution.
- Program stepping: The program can be made to halt (using a breakpoint) and then the code can be executed one line at a time ('step by step'). The programmer can see if the lines of code and modules execute in the correct order and variable values change correctly.
- Variable tracking: Debuggers usually provide this tool. Each variable is listed and its value can be inspected at any point in the execution of the code. These values can also be compared to those predicted in desk checking.

Stubs

A stub is simply a temporary short piece of code, a 'filler', used to fill the place of code that has not yet been written or that is not yet working. It works by returning a dummy value used by the rest of the program to allow other parts of the program to work and be tested.

Flags

A **flag** is an even shorter piece of code: usually a single Boolean value, a 1 or a 0. It is like a flag used in a race: if it is down, the race has started! A flag allows programmers to see if a section of code has been executed, as it will change from one value to the other. The programmer examines the flag's final value. If it has changed, the code in that section must have been executed.

Debugging output statements

A debugging output statement is a print statement temporarily inserted in a section of code. These can be used to print a message that the code has been executed (like a flag) and to print out the current values of variables.

Program documentation

When we write programs, it is very important that we properly document our work. Our program design will always include a clear statement of the purpose of the program and the algorithm that the program uses.

There are two main categories of documentation for programs:

- **internal documentation** – within the program code. There are two main methods of internal documentation: using comments in the program code and using self-documenting variable names.
- **external documentation** – such as help manuals.

Using comments in program code

Programming languages enable us to leave *comments* within the program.

The comments in the source code of the program are for the benefit of the programmer and any other person who may have to work on the program. Experienced programmers organise their comments very neatly, so that they don't make it hard to read the program instructions.

Comments are encoded by using the appropriate symbol, followed by text. In the Visual Basic family of languages, the comment symbol is an apostrophe ('). In Pascal, comments are shown inside curly braces.

Visual Basic

```
'this part of the program calculates
   the score
```

Pascal

```
{this part of the program calculates
   the score}
```

Python

```
# this part of the program calculates
   the score.
```

In most modern programming editors, the comments are shown in a different colour, to make it easy to distinguish between comments and the code that will be executed.

When a program is compiled by the IDE, or interpreted by the language interpreter, the comments are ignored ready for it to run.

Tip: During testing, most programmers need to see what happens when a line or several lines of code are removed. They often turn them into comments by inserting the comment symbol. These are removed later, whereupon the comment becomes actual code again, and will be included in program execution.

Comments are used for things like:

- identifying the author of the program and the date it was last modified
- explaining what sections of code are doing
- marking out parts of code that have been modified
- 'commenting out' code that the programmer may wish to suppress during testing.

Variable naming methods

Meaningful selection of variable names is a very useful method of internal documentation, as they make code easier to understand. The variable name can be made of multiple words that are concatenated (joined together), such as:

```
StreetAddress
```

External documentation

Outside our programs, we make use of other forms of documentation for different purposes and for different people. For the users of the program, we usually prepare a user manual – a guide on how to use the software we have developed.

We may also prepare a help file so that users can look up what they need to know using the Help menu on the menu bar of the software.

ACTIVITIES

Identify

1 Identify three tools commonly found in an IDE's debugger.
2 What is the difference between a stub and a flag?
3 Name two internal forms and one external form of documentation used by programmers.

Analyse

4 What is the difference between using a debugger and using stubs, flags and debugging output statements to find errors?
5 What is one important feature of intrinsic documentation and why is it important?

Investigate

6 Find out about the debugging tools available in the programming language you are using, and describe how they are used.
7 Find out about the documentation tools available in the programming language you are using, and describe how they are used, showing examples.

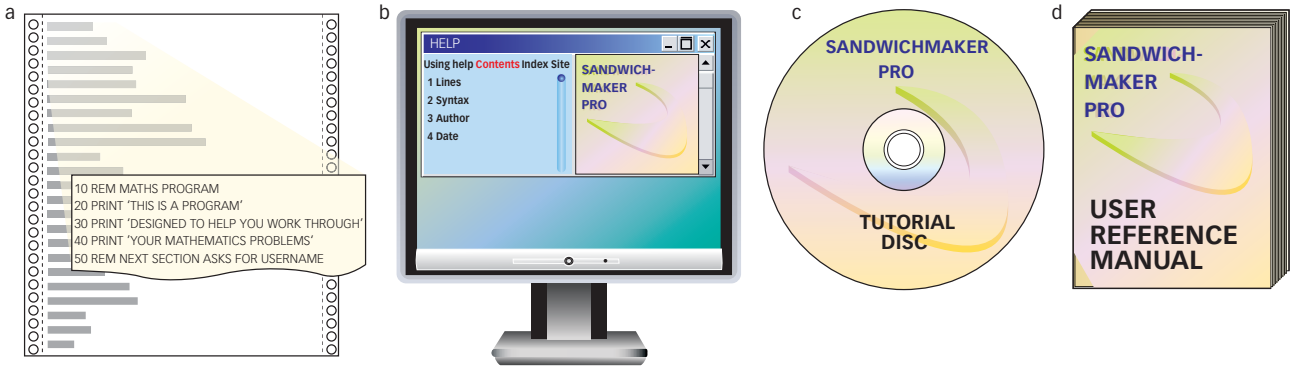


Figure 15.37 Documentation methods: (a) documenting program code with comments, (b) help files included with the software, (c) tutorials on disc or online, (d) a user reference manual

15.13 Project development and additional content

Please note: Full details of these projects, including marking matrices, are provided on the NelsonNet Teacher website.

Project 1: Nim

Program a fun game of logic.

Requirements

'The Game of Nim' is a game for two players. Many versions exist. Initially there are a number of 'sticks' (for example, pens or matchsticks) in play – usually 10, but it can be any number. In some games, more than one heap can exist, but here we will use just the one pile of 10 sticks. Each player takes it in turn to remove one, two or three sticks. The player who removes the last stick loses the game.

Your task is to design a program in which the computer plays this game against a human opponent.



Defining and planning

1. Research this game online using Wikipedia and discover its history and its various versions.
2. We will assume a version of Nim with 10 sticks where players take either one, two or three sticks. Play this game a number of times with pens, matches or similar.
3. Before we can design an algorithm that determines how many sticks the computer should take on each of its moves, we need to know how to win the game. What follows applies to all games, regardless of how many sticks you begin the game with. Since the player who removes the last stick loses, if we are to win, we want our last move to leave our opponent with only one stick. This can be achieved if there are two, three or four sticks remaining for our move, since we can then choose to take one, two or three sticks respectively. How can we ensure that on our move there are only two, three or four sticks remaining? How many should we leave our opponent on our previous go? Work backwards to get this value (call it x). Draw up a table or diagram to help you.
4. So now we have a new goal: instead of aiming to leave our opponent with only one stick, we want to leave them with x. We can repeat the above argument, this time using x as our starting point instead of 1. You may find you need to leave your opponent with nine sticks. This suggests a pattern of 1, x, y, z and so on. As long as we always try to aim for the nearest of these 'critical points', we are guaranteed to win. This of course assumes our opponent doesn't get there first. There are more complex approaches to solving the game, and you can read them online if you wish.
5. Select a programming language for your project. And justify your choice.

Designing

1. Complete columns for Input, Output and Processes.
2. What questions did you have to answer to do this? Did you have to make any assumptions?
3. Design an interface for your game.
4. Draw a flowchart for your program.

Producing

1. The first version you may wish to code could test the interface by only playing another human opponent.
2. Next, code the complete game against a computer using your in-built logic.
3. Code your algorithm and debug syntax to produce an executable program.

Evaluating

Test the program yourself and then with others to ensure the program works correctly. You may need to rethink your logic to improve the program.

The process we apply to developing software solutions is common to all solutions. The steps in the process are:

- defining and analysing the problem
- designing possible solutions
- producing solutions
- evaluation.

Project 2: Quiz show

Requirements

The project we are working on is a quiz game called 'Double or Quit' for a television show. The quiz game starts each contestant with $1, then asks them up to 20 multiple-choice questions. Each time they answer a question correctly, their money doubles.

As soon as a contestant answers incorrectly, they are out of the game and they take with them just the dollar they started with. If the contestant does not know the answer to a question, they can quit with half of the prize money from their last correct answer.

The software program drives the pace of the show by displaying questions and providing contestants with a limited time to respond. For each question, there is a time limit.

The contestant can click a button on the screen to go to the next question.

Name and score should be stored, along with the date and time of the competition, the maximum prize won, the number of questions correctly answered.

The project requires you to properly design, code and test the program so that it fulfils the requirements described above.

Defining and analysing

You have read a written version of the rules of the game 'Double or Quit'. In this stage of the project, you should redefine the problem using both flowchart and pseudocode.

Ask your teacher to check your problem description before proceeding to the design stage.

Designing

You will need to draw a sketch of the GUI screen layout, showing how you will arrange the required elements.

1. Decide what should appear on the scoreboard.
2. Work out how to display the questions. They should be clear and easy to read.
3. Identify the controls or buttons the contestant will need in order to respond to the question, proceed to the next question, quit the game and so on.
4. Figure out how the game will ask the contestant their name before proceeding with the quiz.
5. Decide where you will display the timers, and how they will show how much time is left to answer the question.
6. Decide whether the questions will be completely text-based, or whether photographs will be included.
7. Consider the algorithms required to develop the program. The first version of the program might use a built-in set list of questions, then a later version might enable the program to load the questions from a file.
8. Initially set the timers to a lower value, such as 10 seconds, then increase it later when you know the timers are working properly.

Producing

A prototype is a version of a program that gives the overall look and feel of the program, but perhaps with some parts not working fully. It is an 'under-construction' version of the program. It remains a work in progress until the evaluation of the program finds it working to specification. Here are some suggestions for developing the prototype:

1. Prototype version 1 might load the user screen and ask the user their name, then display it on the screen. It might show the score board and set some score indicator so that you can see that the quiz is about to start. The program should load a single question.
2. Prototype version 2 might do everything that version 1 does, but asks the competitor to start the quiz within 10 seconds.
3. Progressively modify the prototype. For each improvement, save the program with a new version number and document the changes.

Evaluating

The evaluation phase should be a simple matter of comparing your project with those criteria.

The evaluation criteria might include:

- graphical user interface is easy to understand so that users are prompted to respond to the quiz game appropriately
- design elements are used consistently.

Additional content

Working with data files

Programmers have a range of choice about where to store data on a computer system. We can recognise two main approaches used in software development. These are:

- using a relational database management system and storing data in one or more tables
- using ordinary operating system files of one or more types that are read and/or written to by the software.

The choice about which method should be used depends on the nature of the software and the type of data the software works with.

For graphics software – working with bitmap images such as digital photographs – the programmer might store the data in files that conform to industry standards, such as TIFF (tagged image file format) or JPEG (Joint Photographic Experts Group).

Word processing software might read and write data using several different file types, such as text files (.txt), rich text format (.rtf) or Word document files (.docx).

Software that needs to store structured data, such as data about students, customers or products, usually makes use of database management systems, and stores the data into one or more tables within the database. Chapter 10: Database design, contains more information on how this is done.

File access

Many situations require programmers to read from or write to particular types of files.

The types of file access a programmer can choose from depend on the language, but may include:

- sequential file access
- random access.

Sequential file access

Sequential files are commonly used for storing plain text in continuous blocks, such as log files on a computer system. The data in the sequential file is typically stored as text characters – even numbers are stored as strings of digit characters.

Programs we write may need to read data from a sequential file. Programs typically treat file access as streams. The data is read into the program, starting at the beginning of the file. The programmer can choose to read the data one line at a time or one character at a time until the end of the file is reached.

Counting names in a sequential text file

If we needed to count the number of names in a sequential text file, where each name is on a separate line, the program logic would look something like this:

```
BEGIN NameCount
   Set Counter to zero
   Open file for input
   WHILE not at EndOfFile
     Read next line from file
     Add 1 to Counter
   ENDWHILE
   Close file
   Display value of Counter
END
```

Notice the use of the term EndOfFile. In most languages, the EndOfFile marker is coded with an abbreviation, such as EOF. Similarly, the beginning of a file is abbreviated as BOF.

If we needed to copy these names into an array, we would need to know how many names there are, or we would have to keep increasing the size of the array as the program runs. A simple method is to use the program above to count the number of names, then perform a similar procedure to copy the names into a string array called Names().

So, let us assume that we have a function, Count Names(FileName), which works like the NameCount example, and returns an integer equal to the number of names in the file. The program pseudocode to copy the names into an array would be similar to:

```
BEGIN CopyNamesIntoArray
   Create Array(CountNames(Filename))
   Open file for input
   WHILE not at EndOfFile
     NextArrayElement =
        NextLineOfFile
   ENDWHILE
   Close file
END
```

Writing to sequential files

Sequential files may also be written to in two main ways – we may choose to write over the existing file contents or we may append data to the end of the file.

Random access

Some data that we deal with is organised into regular, structured, repeating units that we describe as records. A record is a collection of data items about a real-world item such as a customer. A program that works with records will usually need to go straight to a specific data item in the file. In order to be able to do this, the file needs to be organised in one of two ways:

- using separators between the fields
- using fixed-length fields.

Separators that are commonly used are the comma or the tab characters. Comma-separated value files (.csv) separate the records into lines of data, with one record per

line. Each record is divided into fields, which are separated by commas. In this file type, string data is usually enclosed in quotation marks, while numbers are not. Programs such as Word and Excel are able to open and read .csv files, importing them into either a Word document or an Excel spreadsheet.

The records in a file that use separators may be of different lengths. For example, family names can vary in length.

A programmer may have decided that fields will all be the same size, particularly if the data is known to have the same size in each record. A programmer working with student records for an educational institution may define the field sizes for a random access file.

Different programming languages have special keywords or functions to enable programs to read from or write to random access files.

Object-oriented software development

Object-oriented (OO) software development treats the world as objects. Software objects are representations of things, and are created in an object-oriented programming language. An object type is usually defined as a class, and whenever our program needs to work with an object, we create a new object that is a copy of the original class.

A software object has some data, usually in the form of attributes or properties, each of which has a value. An object may also have methods, which are actions that can be performed on the object.

For example, if we chose to write an object-oriented music jukebox program, we might create a SoundTrack class, which would have properties such as Title, Artist, MusicPublisher, PlayLength and so on.

Methods of the SoundTrack class might include Play, Pause and Stop.

Object-oriented programming (OOP) requires a different design approach to conventional procedural programming.

In object-oriented programming, programmers define classes of objects. In figure 15.38, all the boats shown are instances of the Boats class. As well, classes can be split into subclasses. Here, Sailboats, Powerboats and Canoes all inherit the characteristics of the Boats class. The subclass Canoe, for example, contains not only its own characteristics, such as the need to be paddled, but also all the characteristics of the class it belongs to, such as the ability to float or sink. Objects receive messages and know how to respond to them. If a canoe is told to move, its methods can tell it how to do that. In OOP, an object has all its methods built in. It doesn't need to be told how to act by other parts of a program.

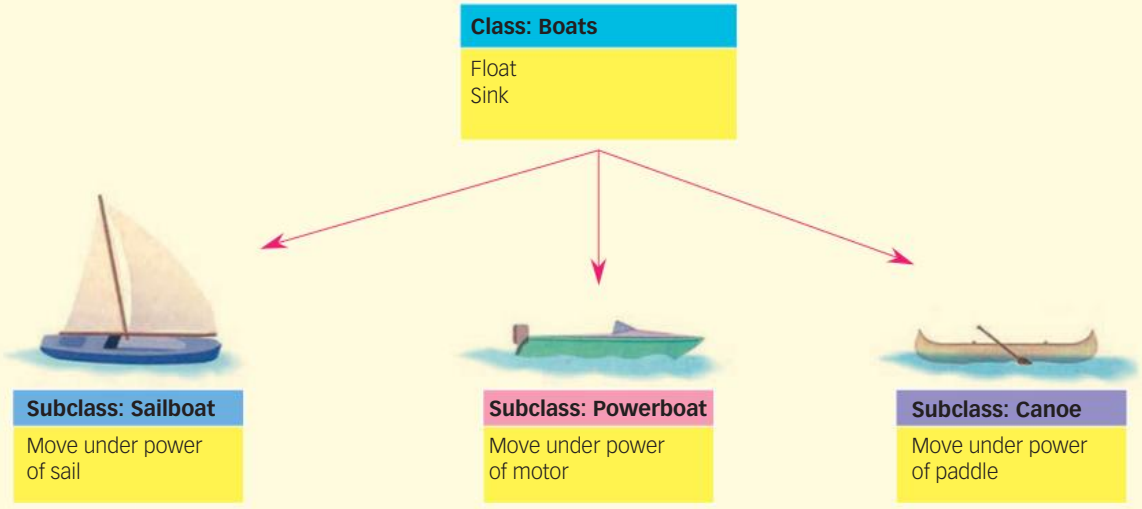


Figure 15.38 In object-oriented programming, programmers define classes of objects.

TASK 10

Alice

Alice is a free innovative 3D programming environment that uses object-oriented programming techniques to teach programming by creating an animation for telling a story, playing an interactive game or a video to share on the web. In Alice, 3D objects (for example, people, animals and vehicles) populate a virtual world and you create a program to animate them.

In Alice's interactive interface, you drag and drop graphic tiles to create a program, where the instructions correspond to standard statements in an OOP language. You will gain experience with the programming constructs typically taught in an introductory programming course.

Your task is to view the introductory tutorial and to create your own simple game. You will find a link to Alice at http://infosoftwaretech.nelsonnet.com.au.

Weblink

INDEX

A

A&R talent spotters 77, 113
AAC audio format 177
abacus 58
access and equity 85, 253
accuracy of data 83
active sensors 312
actuators 208, 305, 316
ADSL service 228
agents 91
ALGOL (programming language) 353
algorithms 339–40, 343
  desk checking and correcting 346, 349
analog data 46, 176
analysing problems 5
Analytical Engine 60, 88
AND operator 336
Android phones 271
animation 48, 67, 125, 176, 199
  file formats 195, 199
  manipulation 212
  sequences 190–1
animators 198
animatronics engineers 299
answer engines 238, 240, 241
Antarctica, robot use 300
anti-discrimination legislation 81
antivirus programs 250
App Inventor 271
Apple personal computers 66, 67, 68
AppleTalk® 267
application interface 38
application servers 277
application software 28
  features 32–3
  and operating system 34
  types of 30–1
apps 31, 271
arithmetic operators 36
ARPANET 64, 224
arrays 354
  listing all the values in 354
  searching for a value in 354
artificial intelligence (AI) 64–6, 88, 89
  applications 90–5
  historical perspectives 88–9
  human concerns about 311
  requirements 96–7
  weak and strong 88
  what is it? 88
artificial intelligence systems 88
artificial neural networks (ANN) 93, 97
ASCII 47, 194
Asimov's Laws of Robotics 293
ASIO 287
assembly line robots 302
assignment statements 329, 333, 336–7
audio 48, 176, 196
  compression techniques 204–5
  digitising 124, 194, 202
  file formats 52, 195, 196
  manipulation 206
  multimedia use 124
audio sequences 188–9
augmented reality 57, 63, 67, 118, 201, 209
  creating (case study) 210
Australian War Memorial databases (case study) 162
authoring software methods 130–2
authoring software systems (multimedia) 66–7, 119, 130–3
  case study 132–3
  choosing the best applications 132–3
  methods 130–2
  special modules 132
  tasks 134–5
automated control 308–10
automated control systems 69, 308
  actuators and controlling devices 316–17
  components 308
  sensing devices 312–15
  types of 310
automatic doors 314
Avatar (3D movie) 175

B

Babbage, Charles 58, 59, 60, 88
backups 128, 265, 280
  generational 281
bandwidth 54, 263, 270
bar codes 154, 155, 158
BASIC (programming language) 63, 326, 353
batch control systems 310
baud 270
Berners-Lee, Tim 222, 225, 229, 239, 248
biased data 83
binary code 47
binary data 47, 51
binary numbers 46
binary selection 330
bioinformatics 74
biometric devices 55, 154
biometrics 94
BIOS 50
bitmapped images 49
bits 46
bits per second 270
Bletchley Park 59, 61, 89
blogs 233
Blue Brain Project 99
Bluetooth 267
Boole, George 58, 60, 334
Boolean data type 334
borders and white space 37
brain model 99
breakpoints 358
broadband 228
broadband network 214
browsers 242–3
bus lines 21
bus topology 282
business data sharing (case study) 269
business software 31
bytes 46

C

C (programming language) 327, 352, 353
cable connection 228
care and maintenance (hardware) 24–5
career paths 76
cars, navigation systems in 313
CASEWHERE 330
cathode ray tubes (CRTs) 128
CD-ROMs 116, 214
CDs (compact discs) 50
cel-based animation 190
central processing unit *see* CPU
characters (programs) 334
charge-coupled devices (CCDs) 203
chat rooms 233
chemical sensors 312, 314
chips 20, 21, 64, 65
choose-your-own-adventure story (project) 257
client-server networks 274
client-side scripts 243
clients 275
climate models 102–3
closed-loop systems 317
cloud computing 66, 84, 264
COBOL (programming language) 63, 352
codecs (compressors-decompressors) 204, 205

codes of practice and conduct 82
Cole, Matt 296
collaboration 12
collecting data 154–5
Colossus (computer) 59, 61
colour palette 203
command buttons 350
command line interface (CLI) 35
commerce, digital media use 178
communication networks *see* networks
communication protocols 246, 266
communication software 30
communication techniques 10
compilers 353
compression of data 284
compression techniques 52–3, 204–5
computer application copyright 80
computer-based training 117
computer forensics analysts (CFAs) 73
computer-generated images (CGIs) 176
computer graphics 41
computer models 98, 99, 100–3
computer programmers 74
  desk checking and correcting algorithms 346
computer programs and programming 69, 322–5, 326–7
  algorithms 339–40
  correcting errors and program documentation 358–9
  data structures 354–5
  data types 334–5
  in different languages 328
  inputs, processing and outputs 327
  parts of a program 329
  structured programming 329–33
  subprograms 340, 347–8
  testing program code and detecting errors 356–7
  which language is best? 327–8
  see also programming languages
computer scientists 74
computer size and cost 62
computer system implementation (case study) 5, 7, 9, 13
computer systems
  components 16–19, 21
  processing and control 20–1
computer vision 95
computers
  care and maintenance 24–5
  classification 22–3
  disposal and recycling 70–1
  generations of 59
  intelligence 64–6
  and the nature of society 85
  troubleshooting 24, 25
concatenation 336
concept maps 6
conferencing 234
connecting to the Internet 228
connection devices (networks) 278–9
constants 339
continuous control systems 310
control (access to information) 85
control elements (software applications) 36
control structures (programs) 329
control systems
  automated 308, 310, 312–17
  historical perspectives 309
controller cards 20, 21
controllers 308, 317
  feedback 317
controls (programs) 329
convergence 60, 62, 141
Convict database (project) 171
cookies 250
coprocessor chips 20, 21
copyright 45, 80, 141, 176, 214, 252
CPU (central processing unit) 20, 40, 46, 50
credit card fraud 93
criteria (project elements to be met) 6, 8
CSIRAC 62
CSS (cascading style sheets) 243
current and emerging technologies 60–7
cyber actors 67, 193
cyber safety 251
cyber security experts 4
cyborgs 291

D

daemons 91
dangerous tasks, robot use 296, 298
data
  collecting 154–5
  and information (databases) 150
  organising 156
  privacy 43
  processing and analysing (databases) 160–5
  sharing via a network 263
  types of (databases) 151
  versus information 44
data accuracy 83
data bias 83
data checking 155
data coding 46
data compression 52–3, 204–5
data dictionaries 151
data files, working with 362
data flow 20
data forms 46–7
data input devices 154, 155
data projectors 17, 129
data security 55, 80
data sources 45, 154–5
data storage 18, 50, 128, 140
  databases 156–7
  managing 280–1
  units of 51
data structures 354–5
data transmission 54
  media 272–3
  modes 268
  rates 270
data types 48
  digital media products 194–9
  digitisation 200–5
  innovation (project) 145
  manipulating 48, 140
  multimedia 122–6
  in programming languages 334–5
data validation 83, 151, 154
database administrators 157
database management systems (DBMS) 150, 151, 156
database servers 277
database technologies 244
databases 66, 148
  building and maintaining 148, 157
  collecting data 155–6
  components 148–9
  data and information 150
  definition 148
  design 67
  editing 160
  exporting data 168–9
  forms and reports 150, 166–7
  importing existing electronic data 168, 169
  macro use 165
  mathematical calculations 161
  organising data 156
  processing and analysing data 160–5
  projects 170–3
  purpose 148
  searching 161
  sorting 160
  storing data 156–7
  tasks 153, 163, 167, 169
  turning input into output 150
date and time (programs) 335
debugging 353
debugging output statements 358
debugging tools 358
decimal numbers 46
decision table authoring/method 132
declarative languages 353
declaring variables 333, 335
Deep Blue 64, 65, 68
degrees of freedom (robotic arms) 304
design, produce, evaluate (projects) 4–9
design techniques 6–7
desk checking and correcting algorithms 346, 349
desktop computers, system components 21
desktop publishing 180

device management 38
Difference Engine 59, 88
digital books 177
digital cameras 22
digital certificates 251
digital data 46, 176
digital learning tools 235–6
digital magazines 177
digital manipulation techniques 206–13
digital media 67
  in advertising (task) 179
  display and distribution 214
  jobs 198
  projects 216–19
  purpose of 176–9
  what are? 176
digital media products
  data types 194–9
  evaluation 219
  types of 180–93
digital music compositions 189
digital newspapers 177
digital thermometers 22
digital video, displaying 214
digital video interface (DVI) connector 19
digital watches 22
digitisation
  of data types 200–5
  factors affecting file size 203
digitising
  audio/sound 124, 196, 202
  graphics 202
  text 199–201
  video 202
direct digital control systems 309
dirty tasks, robot use 298
discrete control systems 310
display devices 16, 214
display and distribution
  digital media 214
  multimedia 140
disposal and recycling 70–1
distributed processing 264
distribution of digital media 214
documentation (programs) 358, 359
documents
  editing and formatting 32
  protecting 32
  versions 32
domain name system (DNS) 224
domestic robots 295
Dougiamas, Martin 235
drawing software 180–2
Dreamweaver 244
Dropbox 67
DVDs (digital versatile discs) 18, 50, 67, 116, 117
dynamic HTML 243
dynamic IP addresses 266

E

e-books 119, 177
e-commerce 234–5
e-learning designers 74
e-music 176–7
e-portfolio (project) 142–3
e-zines 119
EAN (European Article Number) 158
editing
  databases 160
  documents 32
educational products 116–17
educational robots 295, 297, 318–19
edutainment 121
electric motors 316
electronic books (e-books) 119
electronic magazines (e-zines) 119
Elias, Hugo 307
email 222, 230
  address 230–1
  emoticons 232
  junk mail 231
  netiquette 232
  passwords 232
  privacy of 232
  protocols in sending 231
  and viruses 231
email clients 230, 242, 246
emergency information (case study) 152
emoticons 232
employment trends 84–5
encryption 250, 265, 284
end effectors 294, 305–6
end-user needs 136
ENIAC 59, 62
entertainment products 117–18
environmental issues 9, 70–1
equal employment opportunity (EEO) legislation 81
equity and access 84, 253
ergonomics 85
error correction (programs) 358
error detection (programs) 356–7
ethernet port 19
ethical issues 9, 82–3, 154, 193, 208
evaluation (projects) 8–9, 140
expert systems 66, 92, 96–7, 172–3
experts 92
exploration, robots use 300–1
exporting data (from a database) 168–9
external documentation 358, 359
extrusion 185

F

Facebook 232, 233, 234
facial recognition 94
feedback (control systems) 317
fibre-optic cable 51
fields (databases) 149
file access 362–3
file extensions 52
file formats 17, 48, 52, 194–9
file icons 52
file-sharing servers 276
file size 203
file transfer protocol *see* FTP
file types 52
files (data structure) 355
files (database tables) 148
fingerprint identification 201
firewalls 55, 250, 263
flags 358
flash memory sticks 18, 50, 67, 214
flat file databases 148
flexible screens 15
flight simulators 100–1, 103
floppy disks 65, 66
flowchart authoring 131
flowchart method 131
flowcharts 322–3, 324, 329, 330, 331, 340–1, 343
FOR ... NEXT loops 332, 354
formatting documents 32
forms (from databases) 150, 166–7
Fortran (programming language) 63, 352
forums 233
FTP (file transfer protocol) 231, 246
full-duplex transmission 268
functionality 8, 36
functions (programs) 329, 338–9
  that round numbers 338
  to work with string data 339
future storage 67
fuzzy logic 66

G

Game of Life (project) 108–9
games 90, 96, 178
  gesture-based 91
  online 236
games consoles 178
games designers 74
Gates, Bill 65
gateways 278
generating ideas 6
generational backup 281
generations of computers 59
gesture-based games 91
gesture recognition 91
global positioning systems (GPS) 313
goal and purpose (multimedia projects) 136
goal seek function (spreadsheets) 106
Goldilocks (case study) 132–3
Google 238, 239

graphic artists 198
graphical communication 10
graphical design 181–8
  3D graphics and 3D printing 182–5
  creating 3D images 185–8
  painting and drawing 180–2
graphical user interface *see* GUI
graphics 48, 176
  2D bitmapped and vector graphics 123, 196–7
  3D graphics 182–5, 197
  digitising 202
  file formats 52, 195, 196, 197
  manipulation 206, 209–10
  multimedia use 123
  tools 350
group management 284
group work 12–13
GUI (graphical user interface) 27, 34, 35, 67, 137
  borders and white space 37
  consistency of elements 36
  control elements 36
  design 137
  design principles 138
  functionality 36
  inclusive design factors 37
  instructions to the user 37
  layout 350–1
  navigation 36, 138
  objects 350
  storyboards 138

H

hackers 80
half-duplex transmission 268
handwriting recognition 200
handwritten font (case study) 259
hard disks 18, 50, 51
hardware 16–25
  artificial intelligence systems 97
  models and simulations 100
  multimedia 128–9
  requirements 40
  robotic systems 304–5
hardware solutions 24–5
  developing 24
head-up displays 129
health, digital media use 178
help files 33
hierarchical storyboard 132
home of the future 67
home page 255
household control systems 310
HTML (hypertext markup language) 224, 242, 243, 248, 276
HTML coding 245
HTML5 244
HTTP (hypertext transfer protocol) 224, 225, 246
hubs 278
human body, comparison with robotic system 305
humanipulation 193
hybrid networks 282
hydraulic control systems 309
hyperlinks 248
hypermedia 114, 123
hypertext 48, 114, 122–3
  file formats 194

I

IBM (International Business Machines) 59, 60, 63
iBooks 177
IDE debuggers 358
IF ... ELSE selection 329, 330
IF function 107
images, searching 239
Imahara, Grant 299
IMAP (Internet message access protocol) 230, 246
imperative languages 353
importing data (into a database) 168, 169
impossible tasks, robot use 298
inappropriate usage 82
inclusive design 37
index page 255
industrial issues 85
industrial robots 294
information 44
  and data (databases) 150
  power of 222
  sharing via a network 263
  versus data 44
information kiosks 119
information products 119
infotainment 121
initialising variables 333
innovation 8
input devices 16
input functions 338
inputs 327
Instagram 232
instant messaging (IM) 234
instructions to the user 37
integers 334
integrity of information 8
intellectual property 80
intelligence
  of computers 64–6
  what is it? 88
intelligent cars 87
Intel® microprocessor (chip) 64, 65
interactive CD-ROMs 116
interactive digital television 117
interactive DVD movies 117
interactive product (project) 142
interactive TV (iTV) 177, 214
interactive whiteboards 129
interactivity with the user 34
interface design 34–5
interfaces 32, 38
  types of 35
internal documentation 358
Internet 66, 222
  connection methods 226–8
  control of access to information 250–3
  cross-platform interoperability 229
  describing the 223
  development 224, 237
  and equity 253
  and mobile phones 225
  overview website (project) 256–7
  and privacy 250, 252
  for research 240
  safe use 250–1
  sharing via a network 263
  software 242–4
  and the truth 253
  usage 229
  and the web 229
Internet banking 235
Internet protocols 223, 224, 230, 231, 246–7
Internet relay chat (IRC) 233
intranet 225, 263
inventions 58–69
  war and profit 58–9
IP addresses 246, 266, 276
iPad™ 69, 110, 114, 214
iPhone® 69, 114, 214
IPO table 7
IPX/SPX 267
ISDN connections 228
IT support staff 75
iTunes 176, 177
iView 177

J

Jacquard, Joseph 58, 59
Java (programming language) 327, 353
JavaScript 243, 327, 352
junk mail 231

K

key fields (databases) 156
keyboards 16, 64, 200
knowledge bases 90
Kripac, Dan 212–13

L

LAMS (Learning Activity Management System) 236
LANs *see* local area networks

laptop computers 23
laser printers 17, 18
lathing 185
learning management systems (LMS) 234
legal issues 80–1, 141
legislation 81
LEGO Mindstorms EV3 kit 295, 297, 318–19
Leibniz, Gottfried 58, 59
linear (sequential) navigation 138
LinkedIn 232
links (databases) 156
liquid crystal displays (LCDs) 16–17, 128
list boxes 350
local area network (LAN) port 19
local area networks (LANs) 274
  building (project) 288, 289
location-based services (LBS) 313
logical errors 357
logical operators 338
Logo (programming language) 352
look-ups 107
looping (programming) 329, 330–2
lossless compression 52–3, 205
lossy compression 52, 204–5
Lovelace, Ada 59, 88–9

M

machine language 326
Macintosh computer 67
macros 33, 111, 165
magnetic grippers (end effectors) 305
magnetic storage 18
mail servers 276
mailing lists 233
mainframe computers 23
maintaining a website 255
manipulating data types 48, 140
markup languages 224, 242, 243
Mars Exploration Rovers 300–1
mathematical calculations (databases) 161
mathematical functions 338
mechanical control systems 309
Medical Centre database (project) 170–1
medical expert systems 92
medical robots 302
memory, demands on 40
memory capacity 61
memory card reader slot 19
memory chips 20, 21
memory size, and processing speed 203
mesh topology 282
message boards 233
messaging 234
meta search engines 238
metadata 287
metaphor 137
Metcalfe's law 68
microcomputers, for process control
  309, 317
microprocessors 20, 22
microwave towers 273
MIDI (musical instrument digital interface)
  124, 189, 196, 202
MIME (Multipurpose Internet Mail
  Extensions) 231
minicomputers, for process control 309
mixed reality 209
mobile devices
  display 214, 351
  software applications (apps) 31
mobile phones
  creating apps for 271
  GPS functionality 313
  and the Internet 225
mobile robots 294–5
models and modelling 98, 99
  advantages and limitations 102–3
  requirements 100–1
  training and education 103
  variables to ensure accuracy 104
modems 19, 40, 228, 273
monitors 16–17, 40
monochrome laser printers 18
Moodle (Modular Object-Oriented Dynamic
  Learning Environment) 235
Moore's Law 61
morphing 209
motherboards 20
motion capture 110
motion sensors 312, 314
mouse 65
movie synopsis (project) 144
movies
  production (project) 217
  special effects (case study) 211
MP3 format 177, 188, 204
MP3 players 22, 214
MUDs (multi-user domains) 236
multi-way branching 329, 330
multimedia 114
  authoring software systems 66–7, 119,
  130–3
  data types 122–6
  future directions 115, 120
  legal and social issues 141
  people in 127
  processing power 122
  projects 142–5
  what is it? 114
multimedia databases 119
multimedia games 117
multimedia hardware 128–9
  for output display 128–9
  for storage and backup 128
multimedia messaging service (MMS) 234
multimedia presentations 116–17
multimedia product development 136
  content 139
  defining and analysing the problem 136
  designing possible solutions 137
  displaying and distributing 140
  evaluation 140–1
  GUI design 137–8
  manipulating data types 140
  producing solutions 140
  screen design 139
  scripts 139
  storing 140
  storyboards and navigation 138
multimedia products 116–21
  educational 116–17
  edutainment 121
  entertainment 117–18
  information 119
  infotainment 121
multimedia specialists 75
mural mosaic (project) 216
musical compositions 189

N

nanosensors 315
Napier, John 58
National Broadband Network 228, 261
national DNA database 161
natural-language-based search engines 238
natural language interface (NLI) 35, 65
natural language translation 65
natural languages 326
navigation 36
  and storyboards 138
NetBEUI 267
netiquette 232
network administrators 262, 265, 280, 285
  managing data storage 280–1
  managing users 280
  securing the network 281
network bridges 279
network cables 51, 272
network cards/network interface cards
  (NICs) 19, 21, 40, 279
network operating systems (NOS) 284–5
network printing 262–3
network protocols 266–7
network topology 282–3
networks 68
  advantages and disadvantages 262–5
  connection devices 278–9
  distributed processing 264
  extensibility and sustainability 287
  role 262
  security of information 265, 273, 280–1, 286
  servers 276–7
  sharing data and information 263
  sharing Internet services 263
  sharing network applications 264
  sharing peripheral devices 262–3
  transmission media 51, 286–7

types of 284–5
wireless 273
neural networks 66, 93, 97
newsgroups 233, 239
Nim (project) 360–1
non-linear (random or direct) navigation 138
NOT operator 336
notebooks 23
number guessing game 323, 324, 329, 333, 342, 344–5

O

object code 353
object-oriented programming 353
object-oriented software development 363
online gaming 236
online shopping 235
online streaming services 117
open protocols 266
open-loop systems 317
operating systems 28, 38–9, 68, 69
and applications software 34
functions 38
starting up 38
types of 39
operators (programs) 329, 336
optical character recognition (OCR) 200, 201
optical discs 51, 128
optical fibres 272
optical/light sensors 312, 315
OR operator 336
organising data 156
output devices 16–17, 327
output functions 338

P

packets 224, 229, 246, 247
painting software 180–1, 206–7
paperless world? 63
parallel transmission 54
Pascal, Blaise 58
Pascal (programming language) 64, 328, 338, 353, 354–5, 358–9
passive sensors 312
passwords 32, 55, 232, 280
path-based animation 190
pattern matching 64, 67
PDF (portable document format) 32
peer-to-peer networks 275, 289
people
3D special effects artists 212
animatronics engineers 299
building and maintaining databases 157
career paths 76–7
in digital media 198
in multimedia 127
network administrators 285
robot developers 307
roles and responsibilities 74–5
software developers 325
people with disabilities, robots to assist 302
peripheral devices, sharing 262–3
personal computers 23, 65, 66
phishing 81
Photoshop 207
PHP scripts 243
Pinterest 232
piracy 80, 141
plagiarism 45
plasma displays 128
plug-in technologies 243
POP (post office protocol) 230
ports 18–19, 278
post-test loops 331, 332
power supply 17
PowerPoint® 130
presentations 116–17
pre-test loops 331, 332
predicting the future 60
prefixes 51
pressure sensors 312
primary key 149
primary storage 50
print servers 277
printers 17
privacy 43, 55, 67, 82, 154, 313
of email 232
and the Internet 250, 252
problem solving 340
factors impacting 4
problems, identifying and analysing 4–5, 136
processing (by programs) 327
processing speed, and memory size 203
processor management 38
producing solutions (projects) 8, 137
program documentation 358, 359
program stepping 358
programming errors, detection and correction 356–8
programming languages 321, 324–5, 352–3
assignment statements 329, 333, 336–7
choosing 353
concatenation 336
data types used in 334–5
development 63, 352–3
functions 329, 338–9
natural languages 326
operators 329, 336
source code to object code 353
syntax 353
types of 353
using comments in program code 358–9
which language is best? 327–8
see also Pascal; Python; Visual Basic
project management 10–11
project managers 74, 75
projects 4
design phase 6–7
evaluation phase 8–9
production phase 8
protecting data 55
protecting documents 32
protecting people 55
protocols 223, 224
communication 246, 266
Internet 223, 224, 230, 231, 246–7
network 266–7
transfer 224, 225, 229, 230, 231, 246
VoIP 234
prototypes 6, 130
proxy servers 250, 277
pseudocode 323–4, 329, 330, 331, 332, 341, 348
pumps 317
Python (programming language) 325, 327–32, 336–8, 354, 359

Q

quality of information 9
queries 161
Quiz show (project) 361

R

radio buttons 350
RAM (random-access memory) 20, 40, 50, 51, 54, 65, 66
random access 362–3
real numbers 334
record structure 355
records (databases) 149
recycling 70–1
redundancy (databases) 156
relational databases 148
relational operators 336
relays 317
remote access 159
rendering 185
repeaters 278
repetition (programming) 329, 330–2
repetitive tasks, robot use 295, 298
reporting on the project 140
reports (from databases) 150, 166–7
research
software for 31
using the Internet 240
resources 6, 10, 136
RFID (radio frequency identification) tags 164
rights of access 85
ring topology 282
road maintenance and repair, robot use 302
Robonaut 2 (R2) 303
RoboOlympics (project) 319
robot developers 307

robot industry 293
robotic arms 294
  degrees of freedom 304
  end effectors 294, 305–6
robotic motion 304
robotic systems
  comparison with human body 305
  hardware 304–5
  software programs 206
robotics 69, 292–3
robots 69, 292
  building (project) 318–19
  and the changing nature of work 296
  early and modern 292
  functions 304–6
  history 292–3
  human concerns about 311
  movement 304
  types of 294–5
  use of 292, 296, 298, 300–3
ROM (read-only memory) 20, 50, 54
routers 278
run-time errors 357

S

satellite navigation systems (satnavs) 313
satellites 273
school network, documenting (project) 289
schools
  educational products 116–17
  software for 30
science and research, software for 31
Scratch (programming language) 324–5, 331, 339, 342
screen design 139
scripts 139, 243
sculpting 185
search engines 66, 222, 238–41
  how they work 238
  for research 240
  types of 238
search facilities 32
searching databases 161
searching newsgroups and images 239
secondary storage 50
secondary storage devices 18, 40, 50
security alarms 314
security management 38
security permissions 284
security and protection
  individual responsibility 265, 280
  information systems 80–1, 82
  Internet 250
  networks 265, 273, 280–1, 286
selection (programming) 329–30
sensors 33, 308, 312–15
sequence (programming) 329
sequential file access 362
serial transmission 54
server-side scripts 243
servers 18, 23, 262, 276–7
signal conditioners 308
simplex transmission 268
simulations 98, 99
  advantages and limitations 102–3
  requirements 100–1
  spreadsheets use 104–7
  training and education 103
  variables to ensure accuracy 104
simulators 100
Skype 234
sliders 36
smart cards 22
smart home networks 283
smartphones 23, 273
SMTP (simple mail transfer protocol) 230, 231, 246
social issues 84–5, 141, 154
social networking 79, 232–3
social trends 60
society, and computers 85
software
  drawing 180–2
  Internet 242–4
  models and simulation 101
  painting 180–1, 206–7
  robotic systems 306
software development 69
software engineers 74
software piracy 80, 141
software systems 28–9
  application software 28, 30–3, 34
  authoring software (multimedia) 66–7, 119, 130–3
  operating systems 28, 34, 38–9
  utilities 28–9
solenoids 316
solid state drives (SSDs) 67
sorting databases 160
sound *see* audio
sound cards 21
sound engineers 198
source code 353
space missions, robot use 300–1, 303
'spaghetti' code 326, 327
spam 231
speakers 129
special effects (movies) 211, 212–13
speech recognition 65
speech recognition systems 93
spin boxes 36
spreadsheets 66, 96, 104–5
  macros 111
  models (case study) 106–7
SQL language 244
SquareSpace 244
stacked slide authoring 130
stage play/timeline method 130–1
standard search engines 238
star topology 282
stationary robots 294
stepper motors 316
storage 18, 50, 128, 140, 156–7, 280–1
storage capacity, and Moore's law 61
storage management 38
storyboards 6
  and navigation 138
string-handling functions 339
strings (progams) 329, 334
strong artificial intelligence 88
structured programming 329–33
stubs 358
style sheet languages 243
subject directories 238
subprograms 340, 347–8
supercomputers 23
supermarket data 147
support staff 75
switches 278
syntax 353
syntax errors 357
system classification 22–3
systems analysts 74, 157

T

T_Visionarium 113, 119
tab controls 36
tables 156
tape cartridges 50
target audience 136
TCP/IP (transmission control protocol and Internet protocol) 223, 224, 225, 246–7
  transmitting data with 267
technological inventions 58–69
  and convergence 60, 62, 141
  current and emerging technologies 60–9
  from the past 58–9
  impact of technology on the environment 70–1
telecommuting 84
telephone connection 228
television 177
temperature sensors 308, 312
testing and validation (websites) 255
text 48, 176
  digitising 199–201
  displaying 214
  file formats 194, 195
  manipulation 206
  multimedia use 122–3
text boxes 350
text messaging (SMS) 234
3D animation 125, 190
3D graphics 182–5, 197
3D images 123, 185–8
3D models (project) 218–19

3D movie (*Avatar*) 175
3D printers 182–4
3D visual special effects artist (interview) 212–13
time management 10, 11
Titanic, search for 321
topology of the network 282–3
touchscreens 128–9
tour organisation (project) 109–10
traffic light sensors 312, 313
traffic navigation expert systems 92
training specialists 75
transfer protocols 224, 225, 229, 230, 231, 246
translating language 65
transmission control protocol see TCP/IP
transmission media (networks) 286–7
  cost factors 286
  extensibility and sustainability 287
  security 286
  transmission distance 286
transmission rates 270
troubleshooting 24, 25
truth, and the Internet 253
Turing, Alan 58, 61, 64, 89
Twitter 232
2D animation techniques 190
2D bitmapped graphics 123, 196–7
2D vector-based graphics 123, 196–7

U

underwater exploration, robot use 298, 301
UNICODE 194
unit testing (programs) 356
UNIX operating system 64
unshielded twisted pair (UTP) cables 272
URLs (uniform resource locators) 222, 248
  structure 248, 249
USB (universal serial bus) port 19
user interface 38
user management 280, 284
user profiles 284
usernames 280
utility software 28–9

V

validation checks 151, 154
validity of data 83
variable tracking 358
variables 324, 329, 332–3, 335
  naming methods 359
VDUs (visual display units) 128
verbal communication 10
verification of data 155
versions 32
video 48, 176, 197, 214
  compression techniques 204–5
  digitising 202
  editing 126
  file formats 17, 52, 195
  manipulation 211
  multimedia use 126
  production 192
  technical challenge of 192
video cards 21
video chat 234
video professionals 198
videoconferencing 12, 84
virtual assistants 237
virtual conferences 234
virtual offices 84–5, 237
virtual private networks (VPNs) 274
virtual reality 209, 214, 215
virus protection 250
viruses 231, 250
Visual Basic (programming language) 328, 331–2, 334, 336–8, 354–5, 358–9
visual display units *see* VDUs
voice recognition 200
voice-to-text (VTT) software 93
VoIP (voice over Internet protocol) 234
volatile memory 50

W

WANs *see* wide area networks
warping 209
Watson (computer) 64
weak artificial intelligence 88
web browsers 242–3
web browsing (task) 249
web pages 248
web servers 276
webconferencing 84
webinars 234
WebQuests 257–9
website authoring tools 244
website design tools 244
website designers 74
websites
  accessibility 239
  collecting content and building 254
  design 254
  home page 255
  maintaining 255
  testing and validation 255
Weta Digital 3
white space 37
wide area networks (WANs) 274
wind turbines 221
Windows 67, 68
wire-based media 272
wire-frame shapes 185
wireless networks 273
wireless transmission 273
WolframAlpha 41, 238
word processors 66
Work health and safety (WHS) legislation 81
work and study, nature of 63
World Wide Web (WWW) 222, 225, 229, 248–9
written communication 10

X

XML 243

Y

Y2K date crisis 335

INFORMATION AND SOFTWARE TECHNOLOGY

A project-based approach

nelsonnet

Register online at:

www.nelsonnet.com.au

to access digital resources to support improved learning & teaching*

- Fully updated to cover emerging technologies and practices.
- Includes new topics such as 3D printing, cloud computing and HTML5, as well as an extended section on augmented reality.
- In-depth coverage of the core topics, which provide a reference when studying the options.
- Chapter 15: Software development and programming has been completely reworked to meet the demands of teaching and learning in this course.
- Chapter opening pages list syllabus outcome numbers and outline the syllabus outcomes and key terms used in that chapter.
- Each chapter begins with an 'In Action' section that presents a real-life application of the following content.
- Core alerts in the option chapters identify sections that are closely linked to core material.
- New case studies present students with challenging material and highlight relevant examples of the theory.
- Infobits provide snippets of interesting information to stimulate curiosity.
- Issues boxes explore legal and social concerns.
- Updated activities at the end of each section and a wealth of questions throughout ensure student engagement.
- Engaging, hands-on group and individual tasks and projects are balanced with theory.
- Project sections at the end of the option chapters have been completely updated to be more user-friendly and engaging.

NELSON CENGAGE Learning

For learning solutions, visit **cengage.com.au**

*Please note that complimentary access to NelsonNet and the NelsonNetBook is only available to teachers who use the accompanying student textbook as a core educational resource in their classroom. Contact your sales representative for information about access codes and conditions.

ISBN: 978-0170365987

9 780170 365987