# Exploring Information and Software Technology

FOURTH EDITION

Carole Wilson

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# Introduction

*Exploring Information and Software Technology* comprehensively covers the years 9–10 NSW Information and Software Technology syllabus. It offers a wide range of theoretical and practical experiences organised into an accessible and strong **project** approach to help students meet **syllabus outcomes**. The book caters for a broad range of student abilities and learning styles. Students are encouraged to analyse, design, produce, test, document, implement and evaluate their work and to become collaborators in the learning process, solving problems and developing skills in cooperation with others.

Each chapter in the text emphasises a range of core knowledge and skills, explains key concepts and introduces major issues. Chapter 1 covers **projects** and **core** basics. Core knowledge – including past, current and emerging technologies, data handling, hardware, issues, people and software – is also integrated in each of the option chapters 2–9.

Chapters 2–9 cover all eight **option** topics: artificial intelligence, simulation and modelling; authoring and multimedia; database design; digital media; the internet and website development; networking systems; robotics and automated systems, and software development and programming.

A core content mapping grid at the front of the book indicates where core content is located throughout the book.

There are extensive **exercises** throughout each chapter. **Project modules** at the end of each chapter use the knowledge base of that chapter. These projects are built on the processes of designing, producing and evaluating solutions so that students are encouraged to develop and demonstrate competence in using generic software applications and to select and justify software choices for set tasks and projects.

Students are able to become competent users of a range of hardware devices when solving problems, and to understand the ethical implications involved, including the impact of technology on the individual, the workplace and society.

Exercises and projects are designed so that students can apply the concepts with the type of resources available in the majority of schools. Students should be able to quickly discern that computing knowledge and skills are transferable between computer systems and this approach is strongly encouraged. A comprehensive **glossary** and **index** are provided to further support student understanding.

There is also a **dedicated website** for this book at www.cambridge.edu.au/education/exploring where teachers can find teaching programmes to assist with the use of this text in the classroom.

Answers to all exercises, projects and chapter reviews, as well as interesting websites, additional activities and projects can be found on the **teachers' CD**.

The **students' CD** contains a pdf of the textbook and a comprehensive set of interactive tests.



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# Core content mapping grid

| Core content | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Projects and project development** | | | | | | | | | |
| Defining and analysing the problem | | | | | | | | | |
| identification of need or problem to be solved | O | O | O | O | O | O | O | O | O |
| factors that impact on problem solving: | O | O | | | | | | | |
| – technical such as hardware | O | | O | O | O | O | O | O | |
| – operational | O | | O | | O | | O | | O |
| – financial | O | | | | | | | | |
| – ethical | O | | O | | | O | O | | O |
| Designing possible solutions using techniques such as | | O | O | O | O | O | O | O | O |
| concept mapping | O | | O | | | | O | | |
| brainstorming | O | | O | | | | | | |
| observation | O | | | O | O | | | | |
| research | O | O | O | | | O | O | | |
| prototyping | O | O | | | | | | | |
| input/processes/output table | O | O | | | | | | O | |
| storyboarding | O | | O | | | | O | | |
| Producing solutions | | | | | | | | | |
| producing the solution | O | O | O | O | O | O | O | O | O |
| Evaluation criteria | | | O | | | | | | |
| functionality of solution | O | | O | O | O | O | | | O |
| Quality of information such as | | | | | | | | | |
| accuracy | O | | O | O | | O | | | |
| relevance | O | | O | | | O | | | |
| integrity | O | | O | O | | O | | | |
| timeliness | O | | O | | | O | | | |
| ethics | O | | O | O | O | O | | | O |
| environment | O | | O | | | | O | | |
| Methods of evaluation | | O | O | O | O | O | O | O | O |
| individual | O | | | | | | | | |
| groups such as peer, end user, specific target group | O | | | | | O | | | |
| Management | | | | | | | | | |
| planning | O | O | O | O | O | O | O | | O |
| resources such as | O | O | | O | O | | O | | O |
| – time | O | | O | | | O | | | |
| – finances | O | | O | | | O | | | |
| – people | O | | O | | | O | | | |
| Communication techniques including | | | | | | | O | | |
| verbal | O | O | O | | O | | O | O | |
| written | O | O | O | O | O | O | O | O | O |
| graphical and visual | O | O | O | O | O | O | O | | |
| Collaboration and group work | | O | O | O | O | O | O | O | O |
| criteria for group formation such as expertise and group dynamics | O | | | | | | | | |
| roles and responsibilities of group members | O | | | | | | | | |
| effective collaboration strategies | O | | | | | | | | |



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| Core content | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 |
|---|---|---|---|---|---|---|---|---|---|
| **Past, current and emerging technologies** | | | | | | | | | |
| the impact of past, current and emerging information and software technologies on the individual and society including different cultural groups such as Indigenous peoples | O | O | O | O | O | O | O | O | O |
| environmental considerations such as: disposal of obsolete technologies – recycling | O | | | | | | | | |
| **Data handling** | | | | | | | | | |
| Data and information | | | | | | | | | |
| importance of information to society, particularly in electronic form | O | | O | O | O | O | | | O |
| Data forms | | | | | | | | | |
| analogue | | O | | | | | | O | |
| digital | | O | | | O | | | O | O |
| Data coding such as | | | | | | | | | O |
| decimal and binary | | | | | | | | | O |
| ASCII | | | | | | | | | O |
| Data sources such as | | O | | O | | | | O | |
| books | | | O | | O | | | | |
| internet | | | O | | O | O | | | |
| magazines | | | O | | O | | | | |
| journals | | | O | | O | | | | |
| Data types | | | | O | | | | O | O |
| text and hypertext | | O | O | O | O | O | | | |
| graphics | | O | O | O | O | O | | | |
| audio | | O | O | | O | O | | | |
| video | | O | O | | O | O | | | |
| animation | | O | O | | O | O | | | |
| Data transmission types | | | | | | | | | |
| serial | | | | | | | O | | |
| parallel | | O | | | | | O | | |
| Data storage and function | | | | | | | | | O |
| primary storage such as RAM and ROM | | O | O | | O | | | | |
| secondary storage such as random and sequential access | | | | | O | | | | |
| secondary storage media such as tape, disk and optical media | | O | O | O | O | | | | |
| bits and bytes such as kilobytes, megabytes, gigabytes and terabytes | | | | | | | | O | |
| file types | | | O | | O | O | | | |
| Data compression techniques | | | | | | | | | |
| lossy | | | O | | O | | | | |
| lossless | | | O | | O | | | | |
| Data security | | | O | | | O | | | |
| need for data security | | | | O | | O | O | | |
| basic security methods | | | | O | | O | O | | |
| **Hardware** | | | | | | | | | |
| Functions that hardware performs | | | | | | | | | |
| input | | | | O | O | | O | O | O |
| process | | O | | O | O | | O | O | O |
| output | | | | O | O | | O | O | O |
| storage | | | O | O | O | | O | O | O |
| control | | | | | | O | O | O | O |

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| Core content | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 |
|---|---|---|---|---|---|---|---|---|---|
| Hardware components and their functions | | | | | | | | O | |
| motherboard | | O | | | | | | O | |
| central processing unit (CPU) | | O | | | | | | O | O |
| co-processor chips | | | | | | | | O | |
| memory: random access memory (RAM), read only memory (ROM) | | O | O | | | | | | |
| hard disk | | | | | O | | O | O | O |
| controller cards | | | | | | | O | | |
| graphics adapter cards | | | O | | O | | | | |
| power supply | | | | | | | | O | |
| expansion slots | | | | | | | | O | |
| bus lines | | | | | | | O | O | |
| Hardware components | | | | | | | O | | |
| input/output ports | | | | | O | | O | O | |
| display | | | O | | O | | | | |
| Microprocessors such as those found in | | | | | | | | | |
| cameras | | | O | | O | O | | O | |
| monitoring devices | | | | | | O | | O | |
| Classification of computer hardware systems according to capabilities | | | | | | | O | | |
| Hardware solutions | | | | | | | O | O | |
| developing hardware solutions | | | | | | | O | O | |
| – defining the problem | O | | | | | | O | | |
| – designing a solution | O | | | | | | O | | |
| – evaluating a solution | O | | | | | | | | |
| Troubleshooting | | | | | | | | | |
| working through hardware problems | | | | | | | O | | |
| Care and maintenance of hardware systems | | | O | | | | O | | |
| **Issues** | | | | | | | | | |
| Legal issues such as | | | | | | | | | |
| copyright and/or licensing | O | | O | | O | O | | | O |
| piracy | O | | O | | | O | | | |
| intellectual property | O | | O | | O | O | | | O |
| security and protection including viruses | O | | | O | | O | O | | |
| legislation such as Anti-discrimination, Equal Employment Opportunity, Occupational Health and Safety | O | | | | | | | | |
| Ethical issues such as | | | | | | | | | |
| code of practice and conduct | O | | | | | | | O | O |
| privacy and security | O | O | O | O | | O | O | | |
| inappropriate use including hacking | O | | | | | O | | | |
| accuracy, validity and bias of data | O | | O | O | | O | | | |
| Social issues such as | | | | | | | | | |
| the changing nature of work and enterprise such as employment, telecommuting, virtual office, video conferencing | O | O | O | | | O | | O | |
| equity, access and control for all users with respect to gender, disability, and culture including Aboriginal and Indigenous | O | O | O | | | O | | | |

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| Core content | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 |
|---|---|---|---|---|---|---|---|---|---|
| Industrial issues such as | | | | | | | | | |
| rights and responsibilities of users of information and software technologies | O | O | O | O | O | O | O | O | O |
| ergonomic principles and industry standards | O | | | | | | | | |
| **People** | | | | | | | | | |
| Roles and responsibilities of people working in the information and software technology field such as | O | | | | | | | | |
| project manager | O | | O | | | O | | | |
| data entry operators | O | | | O | | | | | |
| systems analyst | O | | | O | | | | | O |
| users | O | | | O | | O | | | |
| technicians such as repair, maintenance | O | | | | | | | O | |
| multimedia specialists | O | | O | | O | | O | | |
| software engineers | O | O | | | | | | | O |
| support staff such as help desk | O | | | | | | | | |
| training specialists | O | | | | | | | | |
| programmers | O | O | O | O | | O | | | O |
| Careers in information and software technology | | | | | | | | | |
| career paths | O | O | O | O | O | O | O | O | O |
| **Software** | | | | | | | | | |
| Software systems | O | | | | | | | | O |
| the purpose of a software system | | O | O | O | O | O | | O | O |
| Types and examples of software | O | O | O | O | O | O | O | O | O |
| – operating | | | | | | | | O | O |
| – utility | | | | | | | | | O |
| application including | O | O | O | O | O | O | | O | O |
| – customised | | | O | O | O | | | O | O |
| Factors affecting hardware requirements such as | | | | | | | | | |
| central processing unit (CPU) speed | | O | | | O | | | | |
| demands on memory | | O | O | | O | | | | |
| communication and peripheral devices | | | O | | | | O | | |
| Interface design | | | | | | | | | O |
| the function of the user interface | | | O | O | | O | O | | O |
| interactivity with the user | | | O | O | | O | | | O |
| communication with application and operating systems | | | O | | | O | O | | O |
| Features and elements of a graphical user interface (GUI) such as | O | O | | O | O | | O | | O |
| consistency of elements | | | O | | | O | | | O |
| functionality | | | O | O | | O | | | O |
| navigation | | | O | | | O | | | O |
| radio buttons, list boxes | | | | | | O | | | O |
| borders and white space | | | O | | | O | | | O |
| instructions to the user | | | O | | | O | | | O |
| inclusive design factors | | | O | | O | O | | | O |

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CHAPTER 1

# Projects and project development

Projects are the planning, designing and production of solutions to problems. Project development requires the use of resources including hardware, software, people, data and procedures. Technology is the general term for tools that may be used by people to carry out a variety of tasks in the development of a project. Technology includes computer systems and other equipment that make our lives easier. Like most technology, a computer system has physical parts, such as a keyboard or a screen. These are known as hardware. The programs that carry out the tasks of the systems are called software. Data is the individual facts handled by the system and procedures are the steps taken or instructions that handle the data so that it becomes ordered and meaningful information for people.

Figure 1.1 Computer system components are important resources for projects

Projects are the planning, designing and production of solutions to problems.

**Career path**

Systems analysts play an important part in all stages of project development. They work as go-betweens with clients and programmers to solve problems. At the start of each project, the systems analyst helps a client decide what type of system or change they require. Then, they work with a team of programmers to design and develop software to fit the client's needs. The systems analyst also tests the developed products and may train the client's staff to use the system correctly.

## Project development

The two most important components of project development are the steps that need to be taken to achieve a solution and the components or tools required to carry out the tasks involved. Following a set of steps helps to develop quality projects, and makes sure that important tasks are not missed, and that all aspects of the content are included. Most importantly, this process ensures that the project solves the problem that it sets out to solve and not some other problem.

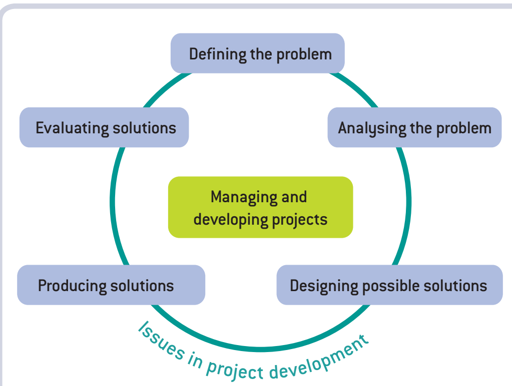


Figure 1.2 Steps in project development



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## Defining the problem

At the beginning of any project is a need to solve a problem. The first step is identifying and understanding the problem that needs to be solved. For example, if you wished to build a house you would need to determine the size and design, and the materials to be used. Similarly, an information and software technology problem has to be first identified and then defined to decide the content, scope (or size) and design of the project, and the tools that will be necessary to do the task or tasks required.

It is always best to have a clear problem definition for a project. A vague or general statement such as 'Artificial intelligence project' or 'All about the internet' is too difficult to work with. It is better to be specific, for example, 'Hardware needed for artificial intelligence systems' or 'Social and ethical issues related to the internet'. Each of the terms can then be understood and the project has a boundary or limits to work within.

Analysis is the investigation or study of a problem, particularly its components or parts.

## Analysing the problem

Analysis is the investigation or study of a problem, particularly its components or parts. When the problem has been identified and understood and the decision has been taken to proceed with the project, the next step is to analyse the problem. Analysis helps to further understand the problem and to determine a range of possible solutions.

### Factors that have an impact on problem-solving

Before the start of any project you should be aware that there will always be *constraints* or factors that will control the way you can solve the problem. If you were to build a house, for example, these constraints might be the cost, materials and tools available to you. This is also true in information and software technology.

**Table 1.1** Factors that may be important in the solution to a problem

| Factors | Description | Example |
|---|---|---|
| Technical | The availability of materials and skills to complete a problem solution | A student may wish to scan photographs for a project but may not have access to a scanner. |
| Operational | The way in which the project will work or operate in the given situation | A team has great ideas but those who will use their project have no interest in learning a different method of handling their work. |
| Financial | Money to complete the solution | Expensive equipment and processing is needed that is outside the budget. |
| Ethical | Social and cultural customs of a society | A team abandons a project plan as its solution involves breaking copyright. |

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## EXERCISE 1.1

1 Match each term in column 1 with its definition from column 2.

| Term | Definition |
|---|---|
| boundary | planning, designing and producing a problem solution |
| constraint | limits of a project |
| defining | size and inclusions of a project |
| ethics | process of understanding the problem to be solved |
| financial factors | factor that controls how a problem may be solved |
| project | the materials and skills needed to solve a problem |
| scope | acceptable customs and beliefs of a society |
| technical factors | the costs that may be involved in a project |

2 Answer the following questions.
  a Name the two most important components of project development.
  b Why follow steps when developing a project?
  c What is the value of a project boundary?
  d List FOUR factors that will be important in solving a problem.

3 Identify the factors involved in each of these project situations as technical, operational, functional and/or ethical.
  a The project requires animation software that the school doesn't have. The software is too expensive to buy.
  b A company needs images for its new website and downloads these from the internet without seeking the owner's permission.
  c A competition for small businesses involves a project that needs resources that would only be held by wealthy, successful businesses.
  d A project designed for very experienced users is intended for very young children who have not used computers at home.

### Great idea

**Throughout this book there are a number of examples of changing technology. The Great idea icon draws attention to some of these.**

## Cost–benefit analysis

*Cost–benefit analysis* is a term used to refer to the balance between the cost of a project and the benefits that are obtained for that cost. The costs refer to financial and other costs, such as environmental or ethical costs. For example, consider a project to build a much-needed bridge. The money may be available, the proposed location ideal for easy construction, the tools obtainable and the materials easily purchased. However, building the bridge may destroy an important ecosystem and remove an endangered animal's habitat. If something so important is lost, the benefits of the bridge may be less than the real costs. It may be better to look for another location or another solution than to continue with the project. In an information and software technology project it is also sometimes better to pay more or to abandon a project than to continue with a plan that has more costs than benefits.

## Methods of analysis

*Top-down analysis* or *refinement* breaks a problem into parts. This may require a number of steps – called a *hierarchy* – in which each step down is

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less important than the step above it. Refinement is a common technique as it makes solving problems easier. The smaller parts can be solved separately and then combined to solve the whole problem. For example, for the project 'Social and ethical issues related to the internet', figure 1.3 shows the process of refining the problem to two levels. Notice that each level needs some research in order to analyse the terms involved.

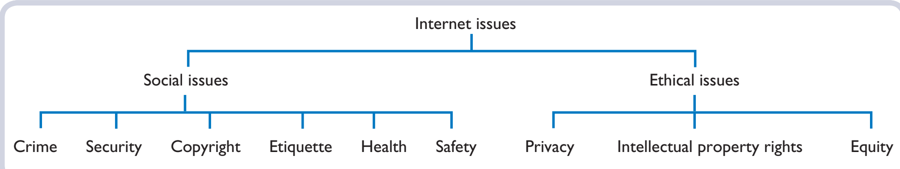


**Figure 1.3** Social and ethical issues related to the internet

*Bottom-up analysis* is also used to solve some problems. This will occur when the project has a number of parts that need to be constructed into a whole. For example, the project 'Hardware needed for artificial intelligence systems' might use this method. Information on many different types of hardware or physical devices could be collected separately. Once the concept of artificial intelligence has been thoroughly researched, the hardware could then be sorted and those devices useful for AI separated out and then combined into the project.

## Factors that may have an impact on the solution

One solution to a problem may be found to be more acceptable than others. Some of the reasons for this can be seen in table 1.2. For example, two project solutions are possible: one requires the use of a scanner and there is no access to this hardware. The other solution uses a digital camera to capture images. A digital camera is available. The second solution is chosen.

Once the solution is chosen, there are other factors that will need to be considered. Many of these relate to the data, or facts, that will form part of any project.

**Table 1.2** Factors that may have an impact on the chosen solution

| Factors | Description | Example |
|---|---|---|
| Inputs | Data that needs to be collected and the method by which it will be input into the project | Data collected on paper forms will need to be entered by keyboard, scanner or optical character reader if the project is to be electronic. |
| Outputs | The method and tools by which the data will be presented or displayed | Data may be displayed as hard copy (printed) or soft copy (on a screen). |

continued >

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| | | |
|---|---|---|
| Information processes | The means by which data will be stored, organised, retrieved, transmitted, received and displayed | Data may need to be sorted and stored on optical disks such as CD-R (Compact disk-Read only) |
| Participant or audience needs | The needs of those people who will use the solution or who will be affected by its use | The solution may need to cater for people with disabilities such as poor eyesight. |
| Scope of the project | A simple or a complex solution has boundaries or limits | A project on hardware needs to include only hardware but also has a maximum size. |
| Time | The period available to completion date | It is no good planning a large project if it is due to be completed in two days. |
| Type of project | Individual or group project | A group project requires team work and collaboration. |
| Skills required | Technical and non-technical skills | A chosen solution needs a C++ programmer; nobody has learned this language. Is there time to learn it or is there another solution? |
| Tools available | Hardware and software available, that is, the physical devices and the programs to run those devices | To write a program in C++ the language compiler must be purchased. Is the money available for this? |

## Designing possible solutions

Designing possible solutions to a problem is another step in furthering the understanding of how a problem might be solved. It is best to use a variety of tools to help design the solution, as this gives a much wider picture of how the problem could be solved, explains the operations of possible solutions and provides ways of documenting solutions for others to follow.

**Table 1.3** Methods of collecting information for project development

| Method | Description |
|---|---|
| Concept mapping | A mind map or diagram of the important tasks to be covered |
| Brainstorming | A random list of the tasks to be done contributed in any order by team members |
| Observation | Watching a similar project in operation and noting the important tasks involved |
| Research | Reading or hearing about a similar project and listing the tasks involved |
| Summarising | Reading a lengthy document about a project and noting down only the critical points |

The chapter review at the end each chapter in this book contains a concept map to assist you in understanding the most important parts of a topic.

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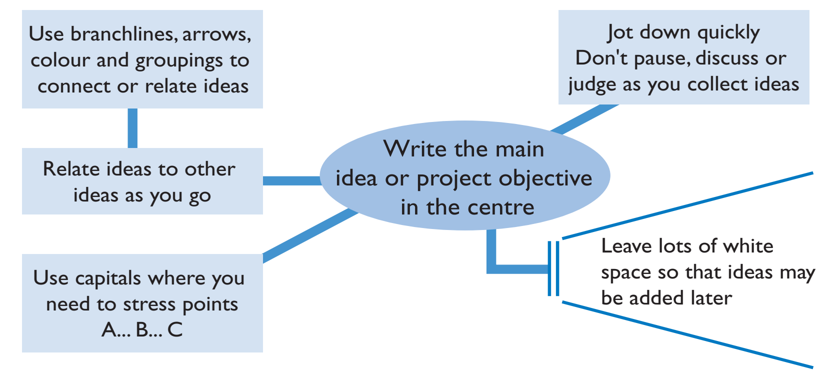


**Figure 1.4** Concept mapping

### EXERCISE 1.2

1 Complete the following sentences to make them true statements.
  a Top-down analysis may also be called ...
  b Joining parts together to form a total project is the process of ...
  c Describing a project as a set of levels with the most important level at the top is ...
  d The presentation and display of a project may be called its ...
  e Data and other resources collected to become part of a project are its ...

2 Write full sentence answers to each of these questions.
  a Why do project developers often carry out a cost-benefit analysis before starting a project?
  b Explain, using your own example, how technical factors may influence the choice of one solution over another.
  c Why are a variety of tools used to help design a solution?
  d Briefly discuss THREE methods of collecting the input for a project.
  e Describe how a concept map is developed.

## Displaying information

Display is the method of presenting a project. There are many different ways in which this can be done.

Display is the method of presenting a project.

A prototype is a working model of a project built in order to further understanding.

### PROTOTYPING

A prototype is a working model of a project which is built in order to further understanding. If a problem is complex or difficult to understand then a prototype will help to make the requirements clearer. A prototype needs to be built cheaply and quickly. It will not include all elements of the final system but only limited design structures such as a user interface (the screens and menus) and perhaps some limited files. It may be developed into the full project at a later stage.

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Prototyping is an excellent way of communicating. Users often have difficulty saying exactly what they want, but they will be able to relate to the model and can usually point to all the aspects they wish to keep and identify things they see are missing.

The creation of a prototype relies on the availability of tools that allow for easy and rapid development of models. Prototyping used to be difficult because it was a slow process. Today, software is able to assist this process by rapidly generating screens and reports.

Figure 1.5 Prototype of a wireless mouse

### INPUT-PROCESSES-OUTPUT TABLE

An *IPO* (input-process-output) table shows a project in its three main parts: what goes in (input), how it is manipulated or organised (process) and what comes out (output).

Table 1.4 IPO table of a project ('Social and ethical issues of the internet')

| Input | Process/es | Output |
|---|---|---|
| Social issues: crime, security, copyright, etiquette, health, safety | Sorting | Alphabetical list of issues: copyright, crime, etiquette, health, safety, security. |
| Ethical issues: privacy, intellectual property rights, equity | Prioritising | List of ethical issues in order of user-determined importance: equity, privacy, intellectual property rights |

### STORYBOARDING

A **storyboard** is the visual design of the project and has the added advantage of being able to represent the navigation between screens. It can be drawn manually or electronically, usually sketched on pieces of paper or by using a computer graphics program.

A **storyboard** is the visual presentation of a project, drawn as a panel or series of panels that show consecutive changes between screens and the navigation between them.

The storyboard consists of a series of illustrations or display screens showing what a program will look like at different stages and what choices the user has at each stage. Storyboards can have linear or non-linear design.

Many projects are designed to be read or viewed from the beginning to the end without taking any branches or side trips along the way. A videotape and most novels are meant to be experienced this way. *Linear design* is also used when simplicity and ease of navigation is the objective. One example of this is presentation software where each slide usually follows the next in a sequence.

Figure 1.6 Linear storyboard design

A *non-linear design* is any project design that is not sequential. This could be hierarchical or unstructured, or it could mix linear and non-

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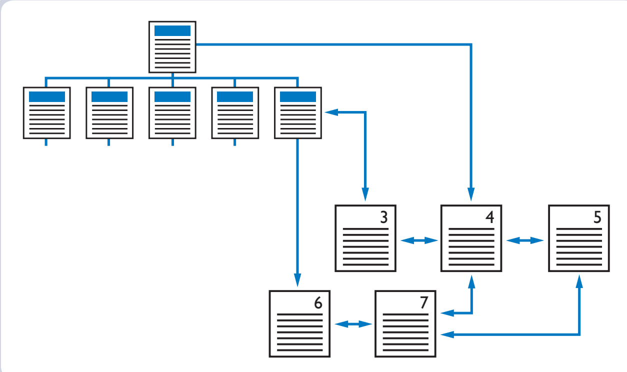


Figure 1.7 Non-linear storyboard design

linear components. In a non-linear design the user has more control and there is a higher degree of interactivity possible. An example would be the development of a website.

**Great idea**

ENIAC, built in 1946, was a great idea of the past. Humans were slow when making large numbers of calculations in a short period of time. ENIAC was the solution. The machine was built using about 20 000 vacuum tubes and could calculate up to 1000 times per second. However, ENIAC weighed many thousands of kilograms. Currently, a laptop or portable computer is able to work faster than ENIAC and weighs less than a kilogram. Laptops are being replaced for some tasks by the personal digital assistant (PDA), which is smaller, lighter and even more portable, and may also perform functions that the designers of ENIAC never even imagined.

## EXERCISE 1.3

1 What am I?
   a I am the working model of a project built to understand the design.
   b I am the screens and menus to be used in a project.
   c I am a grid designed to show the contents of the three major parts of a project.
   d I am a graphical design used to show the screens, components and interactivity of a project.
   e I am a project design in which screens follow each other sequentially.

2 Answer the following in full sentences.
   a Why are prototypes easier to develop today than in the past?
   b Explain the THREE major components of a project and how they can be organised.
   c Compare a linear and non-linear storyboard design.
   d Describe the type of project in which a non-linear design would be most appropriate.

3 The following data is used to describe a small project: 'The organisation of jumbled letters into words and sentences'. Design an IPO table to show the components of this project.

## Producing solutions

Project solutions can be produced using many techniques and tools. These may best be called resources. The choice of resources will result from the design.

### Tools used to produce solutions to common problems

Three examples of software tools used to produce solutions include the word processor, the spreadsheet and the database. The word processor

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primarily manipulates and processes text. The spreadsheet primarily manipulates and processes numbers. The database primarily organises, manipulates and processes collections of data.

The choice of the correct tool or tools is critical for developing an appropriate solution. For example, most databases have some ability to calculate numbers but they are very limited when compared to the calculation ability of spreadsheets. Choosing a database for a project that involved considerable mathematical operations would prevent the developer from carrying out many of the processes that might be needed for a successful solution.

Further information on the tools used to solve problems will be found throughout this book.

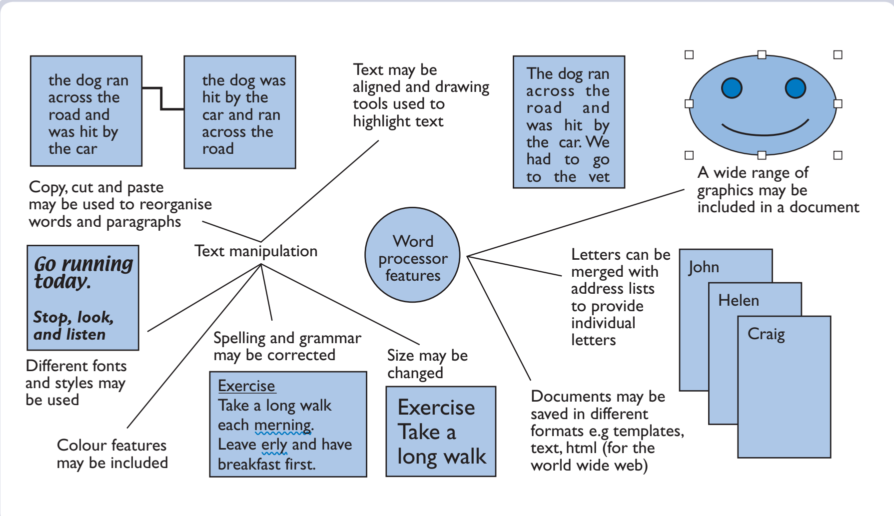


**Figure 1.8** Word processor tools

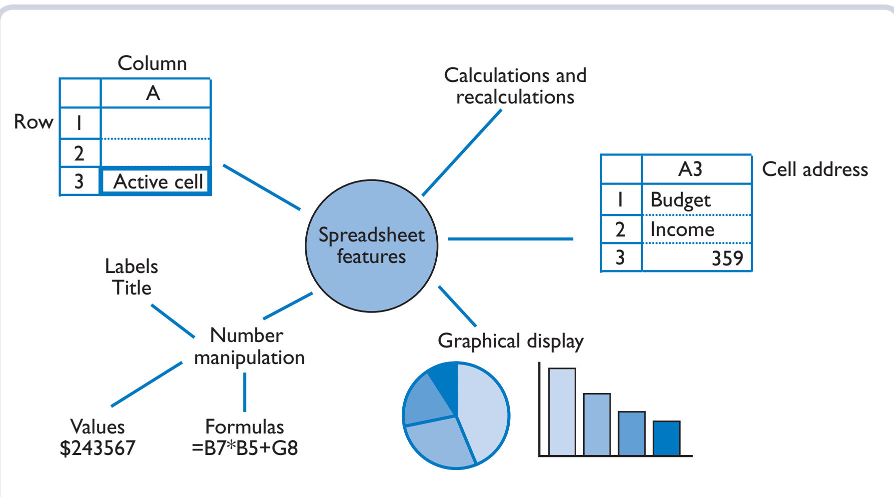


**Figure 1.9** Spreadsheet tools

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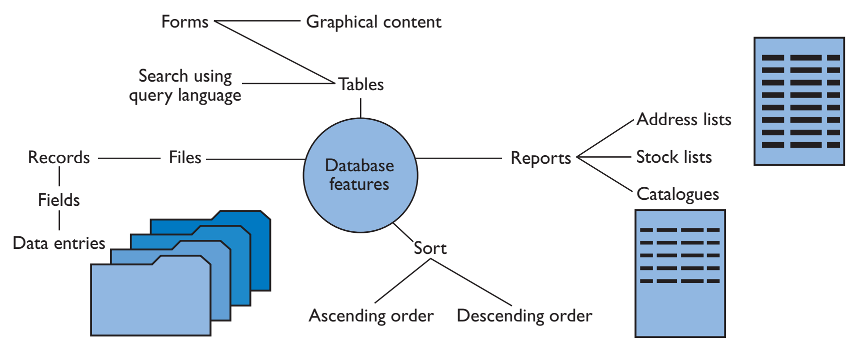


Figure 1.10 Database tools

## EXERCISE 1.4

1 Unjumble this data to make words. Define each word.
  a ADEEEHPRSST
  b CDEOOOPRRRSSW (2 words)
  c AAABDEST

2 Choose the most appropriate software tool to solve the following problems.
  a Store data in a very structured way so that very limited calculations can be carried out and a lot of reorganisation done.
  b Display a large amount of related text using a wide range of fonts and styles.
  c Organise and calculate many formulas from a large body of numbers.
  d Sort and search in a detailed way among a collection of related data.

3 From the list provided, select the best process to use for each of these tasks.

| | | |
|---|---|---|
| Align text | Calculate | Chart |
| Choose HTML | Create a table | Cut, copy and paste |
| Insert a graphic | Mail merge | Sort in ascending order |
| Use a new font | | |

  a Place data in order from A to Z
  b Insert data into named columns
  c See the result of a formula
  d Display numbers as a graph
  e Save a document for use on the internet
  f Merge a letter with an address list
  g Add a picture to a document
  h Change the typeface of text
  i Reorganise the contents of words and paragraphs
  j Move text to line up with a margin

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## Determining the most appropriate solution to a problem

The most appropriate solution to a problem will be the solution that best meets the criteria of the project task.

**Table 1.5** Criteria for judging the appropriateness of a solution

| Criterion | Questions to ask |
|---|---|
| Completeness | Will the solution do everything needed? |
| Output | Does the output meet the project specifications? |
| Simplicity | Are the tasks involved straightforward? |
| Tools | Are the tools available? |
| Skills | Can the developer do the required tasks (or learn how)? |
| Display or presentation | Is the solution clear and easy to follow? |
| Schedule | Can the solution be finished on time? |
| Functionality | Is the solution easy to use? |
| Cost | Is the solution possible within the budget? |

## Planning the solution

A plan for producing solutions in stages helps to ensure that all tasks in the project are covered within the time frame and that appropriate resources are available, and avoids problems in the development of the project.

**Table 1.6** Some steps taken during the process of producing a project solution

| | |
|---|---|
| Making decisions | • Deciding the start date of the project<br>• Determining constraints<br>• Assembling resources<br>• Making a list of major tasks and estimating how long each will take* |
| Planning solutions | • Splitting large tasks into manageable sections*<br>• Structuring the tasks into priority order*<br>• Setting start and end dates for individual tasks*<br>• Overlapping tasks where required<br>• Assigning resources to the tasks*<br>• Determining a budget for each task as part of the overall project cost<br>• Communicating with others in the team on all the above*<br>• Identifying critical stages in the project<br>• Continuing to review tasks to ensure they stay on schedule: reallocating resources and trying to resolve constraints on tasks |

*These are particularly important steps for a team project.

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Following these steps ensures that important tasks are covered, available resources are most effectively used and that all those involved in the project at any level are made aware of the status and outcomes of each stage during project development so that the goal or objective of the project is reached.

## Evaluating solutions

Evaluation judging a solution.

Evaluation of a solution means judging a solution. It can be done at any stage using benchmarks or other standards to make some decisions about the usefulness and/or suitability of the product for the task. Judging is best done using a checklist detailing the expectations of all those involved.

Evaluation of any solution should be positive, and help the developer to learn from their successes and failures, and apply the new knowledge to improvements or to future projects. For example, a comment such as 'This doesn't work' isn't helpful at all. A better judgement would be 'The link isn't working because the option to create a link needs to use the <a href>...</a> tag in the language you are using'. The emphasis is always on improvement, and knowing what criteria will be used helps to achieve this.

Methods of collecting evaluations include observation, interviews or question – answer techniques used to verbally discuss the project with users. Evaluations can also be collected using paper or electronic surveys and questionnaires that present the user with a structure for evaluating the project.

**Table 1.7** Checklist for evaluating a solution

| Criterion | Questions to ask | Problems to be considered |
|---|---|---|
| Functionality | Did the project operate as expected? | It is most important to test all functions in an electronic project. |
| Quality | How well has the user done the job? Some ways of judging quality include the accuracy of the information, its relevance to the project, the integrity of the information and its currency, that is, is the information reliable and up to date. | This might be a very objective decision based on the degree to which the user or judge was satisfied with the project. |
| Simplicity | Was the project straightforward with few unnecessary extras? | Too many illustrations or too much colour. |
| Output | Was the content satisfactory? | Too little or too much detail. |
| Tools | Did the developer use appropriate tools for the task/s? | Careful choice of the best tool for the job. |
| Display or presentation | Was the project tidy and delivered in a suitable form? Was the content presented in a clear and easy-to-follow way? | Electronic or manual display may be more appropriate depending on task. |

continued >

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| | | |
|---|---|---|
| Completeness | Did the project meet all the specifications set? | Use a checklist to make sure everything is covered. |
| Schedule | Was the project delivered on time? | Lateness can be expensive if the project is for industry. |
| Acknowledgement | Is all content original? Are sources documented? | Plagiarism must be avoided and a bibliography provided. |

## Methods of evaluation

Evaluation methods include individual and group methods. The same processes can be applied to one person or to many, although some processes are simpler when only one person is involved. *Self-assessment* is one form of individual evaluation. It is possible to gain valuable feedback from your own assessment of your project by following the checklist in table 1.7 and being honest with yourself. This is a good step to take before finally submitting a project for others to evaluate.

### TYPES OF GROUP EVALUATION

*Peer evaluation* is evaluating a project by others who are operating at the same level. For example, a year 9 information and software technology project might be evaluated by another student in the same class.

*End-user evaluation* is evaluation by those people who are using the project. They would be expected to have tried it a number of times and be very familiar with its good and bad points.

A *target group* is a specific group of people with a particular interest who are chosen to provide feedback on the project. For example, if the project is related to year 10 English then an appropriate target group might be an English class which has just completed the year 10 course.

### THE USE OF FEEDBACK

*Feedback* is the result of evaluation, the giving back to the developer of information on a project. Feedback helps to modify current solutions and improve future solutions. For this reason it is a good idea to spend some time reading or listening to feedback and to document such feedback for future reference.

### EXERCISE 1.5

1 True or false? Rewrite each false statement to be true.
   a People with the same background and skills as the developer make good peer evaluators.
   b End-users never use the project.
   c Feedback is of no value after the project is finished.
   d A checklist is a list of tasks that need to be done.

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exercise 1.5 continued

- **e** Display is the method by which a project is presented.
- **f** Functionality refers to how a project works or operates.
- **g** An inaccurate project containing unreliable data is of good quality.
- **h** Lots of colour and many different fonts make a good project.

**2** Answer the following questions.

- **a** Out of all the possible solutions, how is it possible to choose the most appropriate solution?
- **b** Why is a plan needed for producing a solution?
- **c** How is it possible to judge the appropriateness of a solution?
- **d** Why is it important to be positive when making judgments about projects?
- **e** Discuss THREE important criteria for evaluating a project.
- **f** How does self-assessment work?
- **g** Name THREE types of group evaluation.
- **h** What is feedback?

# Project management

## Management techniques

Project management is the use of knowledge, skills, tools and techniques to meet the requirements of a project.

Project management is the use of knowledge, skills, tools and techniques in order to meet the requirements of a particular project. People have been planning and managing projects since they first became organised human beings. Management requires people to develop timelines, determine resources and allocate tasks.

The advantages of using project management techniques include:

- cost control
- development of a project in specified times
- organised use of the available hardware and software
- an improved end-product

Underlying all project management is the need to always consider the social and ethical implications of the project so that not only are the competing demands for project content, time restraints, cost restraints and quality balanced to achieve the best outcome, but also the issues of meeting social, cultural, gender and disability standards are met.

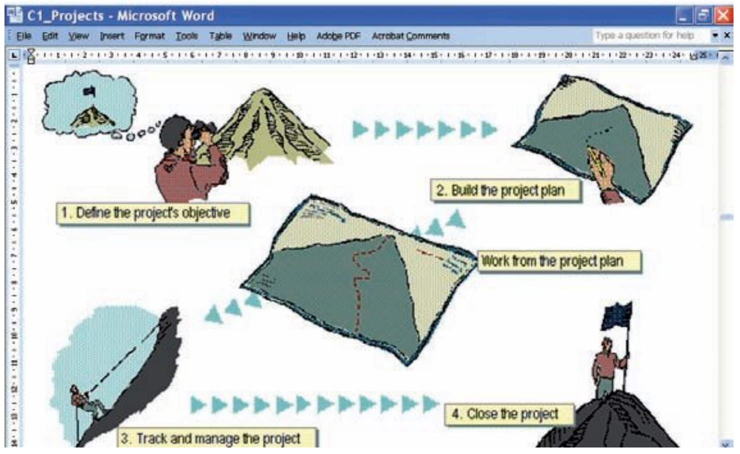


**Figure 1.11** Project management software

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## The project plan

A project plan provides the structure of a project. It sets out the tasks to be done, the people who will do these tasks and the time schedule, costs and use of project resources. The time schedule includes dates for starting and finishing each task as well as the overall project time frame.

One of the most important tools is the *Gantt chart*, a chart used to handle the scheduling of a project. Each stage is clearly recorded and tracked, and any problems can be more easily identified.

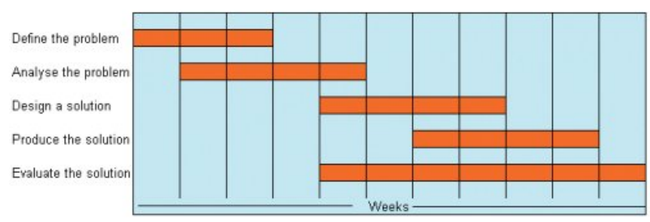


**Figure 1.12** Gantt chart

## Communication techniques

Communication skills are important when projects are being developed. These start with team-building, whereby a group of people learn to work effectively towards a common goal. Each team member has a role and is responsible for certain tasks. All team members must actively contribute to the team.

Communication includes documenting the decision-making and problem-solving involved in the development of solutions. This helps with evaluation and any maintenance that may be required for the project to function over the longer term. For example, if a project developed on 'Hardware devices used in artificial intelligence' was to be useful in future years, new hardware would need to be added and some older hardware may be removed. Good documents on the project would communicate to others how the original project was designed and produced, and make updating the content much easier.

**Table 1.8** Communication techniques

| Technique | Explanation | Example of use |
|---|---|---|
| Verbal | The ability to clearly speak and listen actively | • Discussion<br>• Brainstorming |
| Written | Reporting the project for different people, for example, users and developers | • Training manuals<br>• Troubleshooting guides<br>• Project documentation |
| Graphical | Pictorial directions to provide information through a range of imagery | • Video training<br>• Diagrams |
| Visual | Step-by-step guides to performing a task that a user can see | • Online help programs<br>• Wizards to help with project components |

### Try this

**Using scripts and storyboards**

A childrens' electronic book is to be created to show 6 to 10 year olds how to use file formats.

1. Research and create a simple text explanation in a word processor to define and analyse the task.
2. Use a script to list the resources needed for this task.
3. Number the list in order of priority. The Help menu of a word processor program will tell you how to use automatic numbering and also be a good place to start your research on file formats.
4. Use the drawing tools in a word processor and roughly sketch and label a linear storyboard design suitable for this book. Include labels to show the navigation to be used, that is, links from one page or section to another.

Optional: produce and evaluate your design.

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# People, information and software technology

Computer systems are designed by people for use by people, and their use affects people. The *user* is the person for whom a project is designed. A user does not have to touch a computer, just be in contact with the output of a computer. For example, when you withdraw money from an ATM you are a user of a bank computer system, and when you make a concert booking over the phone, you are a user of the booking agency computer system.

**Table 1.9** Computer users

| Group | Title | Tasks |
|---|---|---|
| Designers | Engineers | Design and construct the system e.g. software engineers design programs |
| | Systems analysts | Plan the system development and organisation |
| | Project managers | Oversee project development |
| | Programmers | Write the software |
| | Consultants | Provide advice on the system |
| | Multimedia specialists | Design and develop digital media |
| Managers | Operators | Control and oversee work on the system |
| | General operators | Run the system on a daily basis |
| | Data entry clerks | Enter and edit data into the system |
| Maintainers | Technicians | Repair and upgrade the system |
| | Support staff | Assist users to operate the system e.g. help desk |
| Educators | Trainers | Teach the use of specific software programs |
| | Teachers | Teach the general use of hardware and software |
| Users | Example: customers | Use or interact with a computer system |

Collaboration is the ability of the people in a team to work together.

**Figure 1.13** Most projects involve groups of people in teams

## Collaboration

Collaboration is the ability of those people who make up a team to work together to achieve the best possible outcomes in a project. Once there was talk, signs, face-to-face meetings and telephones so that people could collaborate. Now, we also have mobile phones, PDAs, bulletin boards on the internet, email-based discussion lists and chat groups (see chapter 6 for more information). Software exists that allows for voice exchange and for blackboards to be used during discussions. One emerging idea that is becoming popular is the web log or blog, a type of web forum. Web forums allow people to collaborate by exchanging ideas, documents and sharing and managing projects across a website that may contain written material, links and photos posted by one

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or more contributors. The contributor (blogger) logs in to the site and may then add to the discussion using links to support what they say or investigate what is being said on other blogs. This allows project blogs to be restricted to members of the team. A public blog that is open to anyone may cover political issues, sports, special interests, such as, stamp collecting or any other idea on which people may want to collaborate. There are now more than thirty million blog sites on the internet and even special search engines to find blogs. Some industries follow blogging closely to gauge emerging trends and interests.

## Collaboration and group work

Most projects in industry and government require collaboration as they are on a large scale where development by a single individual is often not feasible. This results in a need to understand how teams are formed and how they operate.

### Roles and responsibilities of team members

Teams are formed from groups of people with different skills. There may be different numbers of people involved in the development of a project depending on the size and budget available and the type of project. Smaller projects may use fewer people and combine some of the roles and responsibilities. Larger projects may use more than one person to carry out each role.

**Table 1.10** Some roles taken by team members in an electronic project

| Job | Role |
|---|---|
| Systems analyst | Overall responsibility for deciding if a problem solution is available and how the solution may best be implemented |
| Project leader | A manager who organises the day-to-day development of the project including tasks, schedules and the general running of the project team |
| Programmers | People responsible for converting problem designs and descriptions into programs |
| Designers | Members of the team responsible for the graphic design of components in the project, such as screen interfaces and illustrations |

### Strategies for effective collaboration

An effective team is one that achieves its goal efficiently within the given time frame. This requires communication skills that allow people to collaborate or work together in the best possible way. Effective collaboration is improved when:

- team members listen to one another by allowing each member to have their say without interruption. A good method to achieve this is to hold a team meeting where each person is given an object such as a stick to

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hold when it is their time to speak. No person may speak unless they hold the object. The amount of time should be roughly equal for every person in the team.

- comment is positive. Team members should always try to help others to improve their task and suggest ideas for this when possible.
- team members are prepared to solve any disputes and arguments sensibly so that they do not delay the project. This will be encouraged by leaders with good negotiation skills who can lead team members to accept compromise when needed.
- interview techniques used to gain feedback on progress have well thought out strategies and questions to achieve answers that will positively add to the project and allow all participants to contribute to achieving the goals

## Benefits of group projects

Group projects add immense benefits to project development as they provide:

- a wider range of skills than would otherwise be possible
- opportunities for team members to specialise in things they do best
- opportunities to learn new skills from others in the team
- support and/or assistance for team members finding difficulty achieving their tasks
- the ability to develop a large project more rapidly than would otherwise be possible
- the ability to develop a better quality end-product

### EXERCISE 1.6

1 Match the terms in column 1 with the best description from column 2.

| Term | Description |
|---|---|
| Gantt chart | use of knowledge, skills, tools and techniques to achieve a project's outcomes |
| management tasks | people who design and invent the parts of the computer system |
| programmer | person with overall responsibility for a large project |
| project management | timeline or project schedule |
| project plan | organise timelines, resources and jobs to be done |
| system analyst | person who writes problem designs as programs |
| engineers | support staff who maintain and repair the system |

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exercise 1.6 continued

| | |
|---|---|
| operators | educators who teach the use of specific computer programs |
| technicians | the structure of a project |
| trainers | people who run the computer systems on a daily basis |

2 True or false? Rewrite each false statement to be true.
- a System designers do not need any training for the job.
- b A programmer writes software for a computer system.
- c A trainer and a teacher are exactly the same type of educators.
- d Managers oversee the computer system and make sure that personnel and machines are working efficiently.
- e Operators write programs to run their computers.
- f Consultants are contract employees who give advice on the computer system needed to solve a problem.
- g Data entry operators maintain their computer and update software on the system.
- h Collaboration works best when people constantly criticise the work of others.

3 Answer the following questions in full sentences.
- a Briefly explain the advantages of using project management.
- b Which TWO important issues need to be considered in every project?
- c Describe the importance of collaboration in a group project.
- d Outline FOUR different ways of communicating.
- e What makes an effective project team?
- f List the advantages of developing projects as a group.

**Think about this**

The world has people of many different cultures who speak many different languages and work together as teams. Some people do not have those opportunities. Should advances in technology be available to all peoples? If so, how can we collaborate to share technology?

## Issues involved in project development

Those involved in the development of projects need to be aware of the many issues related to the way computers have changed the lives of people in countries such as Australia. It is also important to understand health and safety issues that relate to the way in which computers are used.

**Table 1.11** Some issues related to project development

| Type of issue | Issue | Description | Example |
|---|---|---|---|
| Legal issues | Copyright | The owner of the project or their agent has the sole right to make copies of projects and to sell them to other people | Licensing gives the purchaser the right to use the software. Piracy is the theft of computer software by copying programs illegally. |
| | Security | Protection of data against crime and viruses | Cracking of codes to access data for industrial espionage |
| Social and ethical issues | Code of practice and conduct | Voluntary agreement between organisations to maintain high standards | Privacy of information policies |

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| | | | |
|---|---|---|---|
| | Privacy | Increasing amount of personal information stored on computers without consent of those who 'own' the information. | Computers monitor people in public places. Computers are used to moderate behaviour e.g. speed cameras |
| | Inappropriate use | Individuals accessing data or systems that they are not authorised to see | Hacking of systems to access the information of others for 'fun' or 'challenge' is illegal. |
| | Equity | The availability of computers to all who need to access the technology | Cost restricts the use of computers to those with the ability to pay. Distance can restrict computer availability e.g. rural areas with limited internet access. |
| Industrial issues | Changing nature of work | Computers have altered the jobs of many people and have led to deskilling and retraining in many industries. | Computers have taken over many repetitive, boring jobs. |
| | Ergonomics | The study of the relationship between people and their working environment | Occupational Health and Safety Act regulates work practices. |
| | Power | The ability to use the technology to gain power over others | Employers may now have information on work rate, accuracy, rest breaks and other habits that the employee does not realise is being collected and analysed. |
| | Employment | Changes are occurring in the types of jobs available | New jobs are being created in the technology industry. Some traditional jobs are disappearing. |

## EXERCISE 1.7

1 Complete the following paragraph by choosing the most appropriate words from the list.

| | | |
|---|---|---|
| copyright | equity | ergonomics |
| ethical | health | illegally |
| machines | ownership | personal |
| piracy | privacy | resources |
| security | social | virus |

Project development involves a large number of (a) ___ and (b) ___ issues. One of these is (c) ___ or the legal (d) ___ of projects by the developer or agent. Copying programs (e) ___ is called (f) ___ . Some other important issues are (g) ___ or the protection of data against theft or (h) ___ infections, and (i) ___ or the use of peoples' (j) ___ data without their permission. (k) ___ issues result when some people do not have access to the same level of (l) ___ as others. Computers also lead to problems with (m) ___ and safety of users. The study of the relationship between humans and (n) ___ is called (o) ___ .

2 Read the following information and answer the questions.

Centralised police database systems have grown enormously in the last few years. These hold data in central computers rather than in many widely distributed computers. Many privacy committees – organisations

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exercise 1.7 continued

that investigate developments that may interfere with the privacy of individuals – are alarmed by this situation.

A number of central police databases – many established for over 20 years – contain details on large numbers of innocent people, including victims, witnesses, anyone interviewed about a crime and people who are the subject of unproven allegations. Previously, much of this type of information was kept for a much shorter period, usually only until the case was finalised.

Privacy committees want governments to introduce safeguards in line with privacy principles. Such privacy principles include:

- information given for one purpose should not be used for another without permission
- people should know where their information is going and should be given the opportunity to correct it

Police departments claim there is nothing new about police databases; computers have just made them more accessible.

Privacy committees are concerned about the gathering and storing of a very large volume of information that has been collected from several departments for use as intelligence and in general operations work by the police, unknown to the people who are recorded in this way and with no way for outside groups to check the accuracy of the material. This data is now very easily searched, sorted and organised in different ways.

Previously this mass of information was stored at local police stations or on several computers. The committees are not satisfied that the high level of centralisation and access throughout the police force is worth the substantial risk to privacy.

a How is a centralised database different from a number of databases distributed in many areas?
b Why are privacy committees becoming more concerned about this situation?
c Name THREE types of information held on such a police database that is of concern to some groups of people.
d Explain the phrase 'computers have just made them (police databases) more accessible'.
e What advantage do the police gain from holding information for longer periods of time?
f How is it possible to protect people's privacy while still having a centralised police database?

## Environmental issues

Rapid advances in computer technology have brought with them shorter useful equipment life for each successive generation of equipment. The useful life of a desktop computer purchased in 1997 was around 6 to 7 years. By 2007–08, the average life span of a new desktop computer is less than two years. We are constantly looking for faster, more powerful, smarter equipment to increase productivity, efficiency and profitability

### Great idea

**DNA computers**

DNA computers based on material from living things, that is, DNA (deoxyribonucleic acid) molecules, have the potential to perform calculations many times faster and store billions of times more data than the world's most powerful silicon chip computers. DNA works in a very similar way to a current computer hard drive. Instead of using electrical signals to perform logical operations, DNA computers use logic gates made of fragments of genetic material as input and join these fragments to form a single output. We are years from being able to use a practical DNA computer but the science is possible. There are several advantages to using DNA-based computers instead of silicon-based: they would be cheaper after the investment in production, cleaner for the environment and smaller than today's machines.

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in business and personal activities. Computers, PDAs, mobile phones, consumer electronics, etc. have become disposable items.

Rapidly changing technology and the reduced useful life of equipment has produced consequences for those of us who use technology: a build-up of obsolete, broken and less efficient hardware and software. The problem of how to safely dispose of outdated, unwanted technology is huge and growing each year. This problem is complicated by the materials used in some hardware. Electronics can contain lead, mercury, phosphorous, chromium, cadmium and more, which can produce toxic waste products that may leach into water supplies and cause illness and death. Traditional methods of waste disposal, such as landfill, are not satisfactory in these situations.

**Figure 1.14** Computers in landfill

Temporary solutions include recycling to schools, non-profit organisations and less affluent nations. This is usually not a long-term option as older computers, etc. are often incompatible with later software. Much of this technology then becomes 'stuff hanging around', that is, stored in warehouses, garages and other spaces. The problem is not solved, just suspended. Technology that may be obsolete in one situation may still be an improvement on technology in use elsewhere. If the technology is able to do the job required, simply updating it because something new is available does not make economic sense.

More permanent solutions include recycling the parts of devices so that they may be reused in the more advanced models, and building newer models without the toxic products or with less toxic alternatives. Much more research is needed before these options become more widespread.

Another environmental issue is data, particularly sensitive data, held on the hard disks of machines that need to be replaced. Unless this is removed completely, it is possible to recover confidential and personal information, such as credit card details, health records, industrial designs, etc. from old machines. Simply reformatting a disk doesn't get rid of the data; it only deletes the addresses of files. Completely removing data requires an expert with a thorough method of removing all traces of sensitive files.

## Ergonomic issues

Ergonomics is the study of the relationship between people and their working environment.

**Ergonomics** is the study of the relationship between people and their working environment, particularly with machines. When people develop information and software technology projects they work with computers, and factors have to be considered which may have an impact on the health of those who operate these machines.

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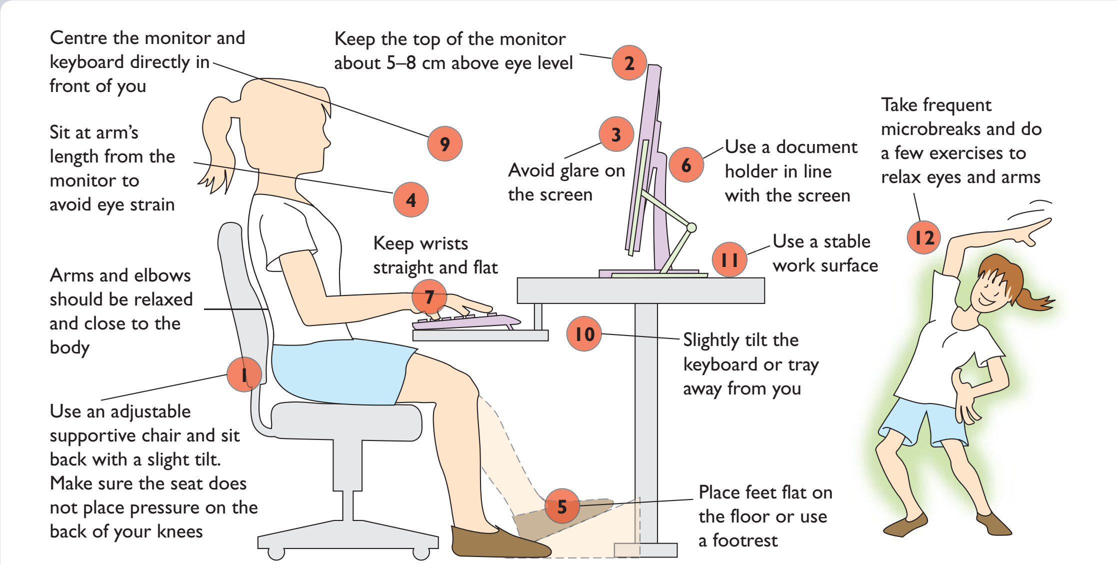


**Figure 1.15** Good ergonomic practices

Good work practices help users to avoid problems. Typing can be minimised by using a mouse or the function keys, the numeric keypad, touch screens and special input hardware called scanners such as laser pens and barcode readers. A regular break or exercise can help to overcome tiredness, and a quiet and bright environment provides a good working atmosphere.

Software design can make tasks easy to perform: this involves software that is user friendly, uses appropriate colours, has menu-driven programs to minimise typing and presents commands or requests at eye level on the screen.

## EXERCISE 1.8

You may need to investigate ergonomics in order to complete all these questions.

1 Define the term 'ergonomics'.

2 List FOUR important requirements for the safe use of a monitor or VDU.

3 What are the advantages of the following to the computer user?
   a a separate keyboard
   b a well-designed mouse
   c an adjustable desk
   d an adjustable chair

4 Give FIVE examples of the correct way to sit (posture) when using a computer.

5 List FOUR ways to minimise computer-related injuries.

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exercise 1.8 continued

6 Explain the best environment for a computer user in relation to:
   a lighting
   b climate
   c noise
   d software

7 Optical character recognition (OCR) is a process whereby a hardware device called a scanner can be used to copy data into a word processor without the need for a person to type the data. Explain the ergonomic value of a procedure such as OCR.

Past technologies are tools such as hardware, software and procedures no longer in common use.

Current technologies are those in common use now.

Emerging technologies are those that are available but which are not yet being used widely.

## Past, current and emerging technologies

Technology is always changing, often as the result of teamwork.

Past technologies are tools such as hardware, software and procedures no longer in common use in our society. For example, vacuum tubes have been replaced by transistors in computer systems.

Current technologies are those we commonly use now, for example, the world wide web. In the past, new hardware connected to a computer had to be set up, that is, the software had to be added and the system configured or changed to accept the new device. Current technology is the plug-and-play software supplied with the operating system. With plug-and-play, a new device can be added to your computer without having to add an adapter card or even having to restart the computer to accept the new device.

Figure 1.16 Current technology often develops from older technology

Emerging technologies are those that are available but which are not yet being used by large numbers of people. Not long ago, email (see chapter 6 for more information) was only being used by a few people and was an emerging technology. Today it is used by most people in many different settings and is a current technology whereas a blog (see the Collaboration section in this chapter for details) is used by only a few people and is an emerging technology.

Sometimes, technologies survive for a long time because they are too useful to abandon. Books are still current technology even though the internet has become the current source of much information.

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## EXERCISE 1.9

Throughout this book there are a number of examples of changing technology. The Great idea icon draws attention to some of these. Such technologies will be important for many people in our society, particularly those that affect the disadvantaged and minority cultural groups.

Use table 1.12 and any available resources (books, magazines, the internet and CDs, etc.) to research the changes in technology that have taken place. Present this information as an expanded version of table 1.12.

Discuss your table with others and explain why the content will need to be changed regularly.

**Table 1.12** Past, current and emerging technologies to assist the disabled

| Group | Past technologies | Current technologies | Emerging technologies |
|---|---|---|---|
| Visually impaired | Glasses, braille | Speech support | Voice recognition |
| Physically impaired | Wheelchairs | Concept keyboard<br>Specialised devices such as helmet wands | Simplified email<br>Podcasting<br>Smart cards |
| Isolated students | Radio School of the Air | World Wide Web<br>Email<br>CDs, DVDs | Video and podcasting |
| Indigenous people in remote areas | Paint, chalk | Internet<br>Webcam | Open source software<br>Web services e.g. blogs |
| Aboriginal and Torres Strait islanders living in cities | Pens, pencils | Email<br>Bluetooth devices<br>SMS (short message service) | MMS (multimedia messaging service)<br>VoIP (voice over Internet Protocol) |

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# Projects and project development

## Multiple choice questions

Select the best answer to each of the following questions.

1 Project development involves steps including
- A Functionality and refinement of a program
- B Planning, design and production of solutions to problems
- C Using a word processor to list team members
- D Deciding to use three or more solutions to a problem

2 The first important step in project management is
- A Finding the available tools
- B Evaluating the product
- C Defining the problem to be solved
- D Producing a solution

3 Analysis covers a range of problems associated with the project, such as
- A Storyboards, constraints, solutions and tools
- B Scripting, defining and listing resources
- C Researching and producing
- D Refinement and costs-benefits comparison

4 Storyboarding is part of the stage in project development called
- A Defining
- B Analysing
- C Designing
- D Producing

5 Producing a project involves developing
- A The most appropriate solution to a problem
- B Two different solutions to a problem
- C All possible solutions to a problem
- D None of the solutions to a problem

6 Judging a project can also be called
- A Deciding
- B Organising
- C Evaluation
- D Modelling

7 People who work well together as a team are said to be
- A Collaborating
- B Functioning
- C Listening
- D Programming

8 The relationship between people and machines is the study of
- A Management
- B Technology
- C History
- D Ergonomics

9 A prototype will enable the project team to
- A Draw a storyboard
- B Take photographs of the system
- C Study a working model
- D Use the available hardware

10 When a problem has been refined, it is possible to completely develop a project by
- A Using a word processor only
- B Developing the parts separately
- C Designing only the graphics
- D Automating the parts



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## Extended answer questions

Figure 1.17 shows the important stages of project development.

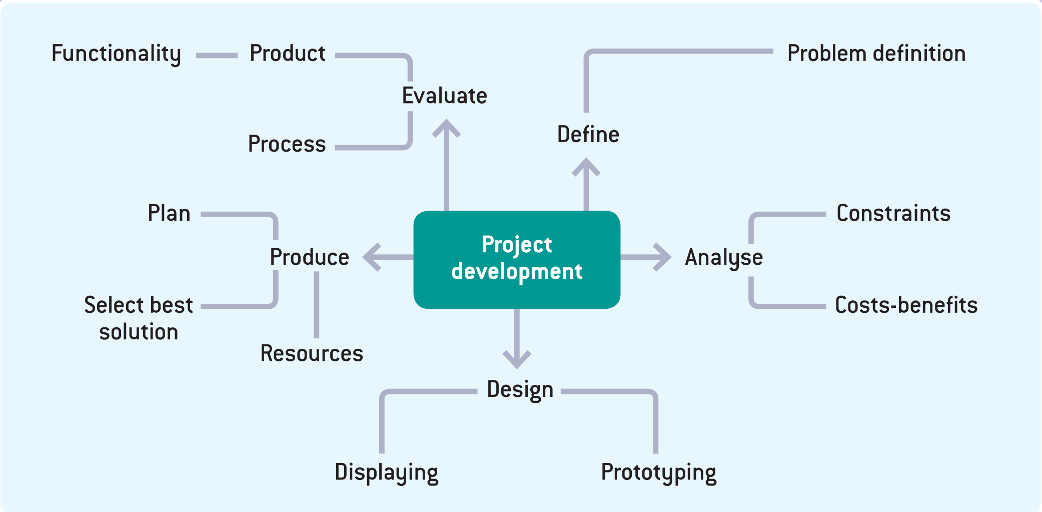


**Figure 1.17** Stages of project development

Write answers to each of the following questions:

1. Name the type of diagram used in figure 1.17.
2. List the FIVE main stages of project development in the order they would occur.
3. What are the TWO main parts of analysis?
4. Explain the concept of a prototype.
5. Why are available resources an important part of producing a project?
6. Why is it not always possible to select the best solution?
7. Discuss the role of FOUR different categories of computer users who may be involved in the development of the project.
8. Outline what is meant by the term 'functionality'.
9. Draw and label ONE example of a user interface that may be used in the design.
10. What is ergonomics? Why will ergonomics need to be considered during project development?

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# PROJECT 1: DESIGN AN INFORMATION SYSTEM

The following information is provided as a guide only. The project can be completed using a wide range of applications focusing on designing and producing and may be an individual or a group project. The content could be extended to cover other aspects of core topics. Information for the project will be found throughout this book.

## Define the problem

A project is need that will introduce the major aspects of computer resources: software, hardware, data and people.

## Analyse the problem

A word processor or other application with hypermedia capabilities will be used to develop a linked set of documents on the topic. The intention is to use internal links (links within a document) and external links (links to other documents), as well as styles, comments, images, tables and text boxes. To provide consistency and save time, a template will be used (a document containing the basic elements for all documents in the project). Word processing (Microsoft Word) is used as the example.

A guide is provided for developing a main document and one sub-document. The skills used in the guide should enable the remaining sections of the project to be completed.

## Design a solution

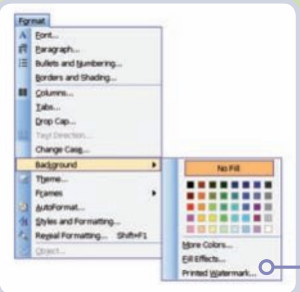

Figure 1.18 The Format menu

### Designing the template

1 Open a new word processing document.
2 From the **Format** menu select **Background...Fill Effects** and choose a colour, gradient fill or texture for the background. Choose the background so that text will easily be seen.
3 Select the colour of the text you intend to use from the **Format...Font** menu or the colour palette.

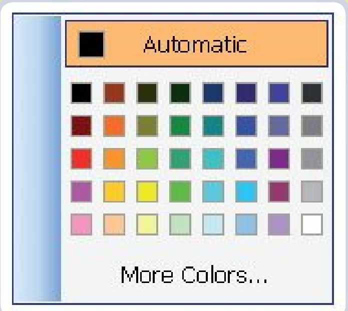


Figure 1.19 Colour palette

4 Put your name at the top of the page as a header (**View** menu) in 12pt font and align it to the right. Close the header box.
5 Set the alignment for the next line to the centre of the page.
6 Set the style for this line as Heading 1 from the **Style** menu.

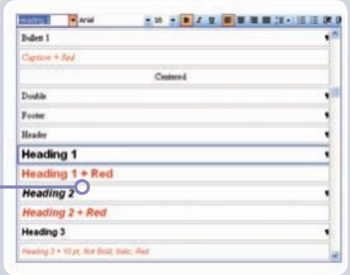


Figure 1.20 The Style menu

7 At the start of the line, add a bookmark to indicate the top of the page. Select **Bookmark** from the **Insert** menu, type 'Top' into the Bookmark name box and click **Add**.


Figure 1.21 Inserting a bookmark

8 Press **Enter** to go to line 3. The text should revert to normal style.



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9 Insert a table of 2 columns and 2 rows and use the **Merge** and **Split** cells options on the **Table** menu to create the following cell arrangement in the table.

| Information and software technology resources | | | |
|---|---|---|---|
| Software | Hardware | Data | People |

This table will provide a hyperlinked menu to other documents. The menu will be used at the top of each document in the project.

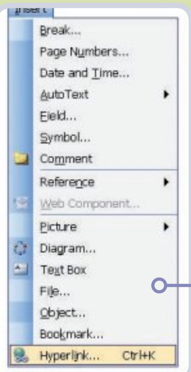


**Figure 1.22** The Hyperlink function

The table can be formatted with borders or colours of your choice. Choices on the format menu will allow you to do this.

10 Create the hyperlinks (the documents will be created later so make sure you know the location where they will be stored if it is not at the same level as other documents, and use the correct names for each document).

11 Highlight the phrase 'Information and software technology resources' in the table. Use the **Insert** menu and open **Hyperlink**.

12 In the box labelled **Type the file name**, type 'Index.doc' (or the file extension of the program you are using). If you are saving to another directory you will need to include the path name. Click **OK**.

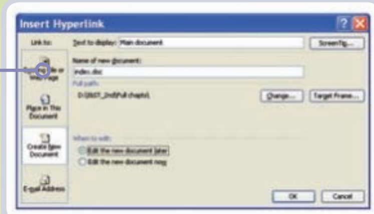


**Figure 1.23** Creating a hyperlink

13 Do the same for each of the remaining cells in the table, matching the text in each cell to the following filenames for hyperlinks: Software/software.doc, Hardware/hardware.doc, Data/data.doc and People/people.doc.

14 Leave two blank lines under the table.

15 On the next line type the words: 'Go to the top of the page'. **Centre** the words. Highlight the words and select **Hyperlink** from the **Insert** menu. Navigate to the **Bookmarks** and locate **Top**. Select this bookmark and click **OK**. Click **OK** to complete the process. This link should now take you to the top of the page and will prove useful when you have added detail to documents in the project.

16 **Save** the document under the name 'Project' as a template.

## Produce the solution

### Step 1: Produce the main page as an index

1 **Open** a copy of the template as a document.

2 **Save** the file as **Index**

3 Type in the heading: 'Introduction to information and software technology'.

4 Under the heading write a summary of the terms 'information and software technology'. Follow this with a list of the three major components of the computer system (procedures, processors, resources) and an explanation of each.

5 Use a comment to give a simple definition of terms.

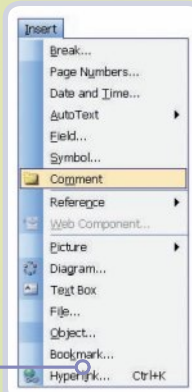


**Figure 1.24** The Comment function

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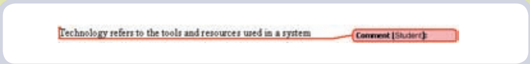

**Figure 1.25** Creating a comment

To do this, highlight the word 'Technology'. Select **Insert comment** from the **Insert** menu and type the following information into the box that appears on the bottom of the screen: 'Technology refers to the tools and resources used in a system.'

6 Close the box. Test the comment to ensure that it pops up when your mouse goes over the commented words.
7 On the next free line type in the heading: 'Information and software technology resources'
8 Give the heading the style Heading 2 using the **Style** menu.
9 Under this heading, summarise the meaning of each of the four resources in a computer system (software, hardware, data and people).
10 Add a comment to each resource with examples of the resource e.g. 'Software: databases are application programs.'
11 If you wish, use the Insert menu to illustrate the page appropriately.
Note: You may like to remove the hyperlink to the Index from the table menu as this is referring to the current document. Use the Insert menu: Hyperlink and the Remove Hyperlink button to do this.
12 Save the file Index.

### Step 2 :Produce a second document for the project

1 Open a copy of the template as a document.
2 Save the file as Software.
3 Type in the heading: 'Software'
4 Complete the document by including a brief description of each of the following:
   - Definition of software
   - Examples of software: word processors, databases, spreadsheets
   - Software issues e.g. piracy, copyright...
5 You may wish to add comments to some of the terms and add appropriate graphics to the page.
6 Save the file when you are finished.
7 Return to the Index document by clicking the hyperlink and check that the link back to the Software document operates correctly.
8 Complete the remaining documents for the other resources (hardware, people, data) by following the guidelines for the Software document. The project may also be saved in HTML format where this is an option.

## Evaluate the solution

1 Test and evaluate the project by checking every link. Make any needed improvements.
2 Use table 1.7 to decide if the solution solves the problem.

# PROJECT 2: THE GRAPHICAL USER INTERFACE

This project uses an application such as Microsoft Word or any suitable word processor, presentation program or drawing program.

## Define the problem

An electronic drawing of a GUI or graphical user interface is needed to identify the parts of such software.



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## Analyse the problem

An interface is a meeting place between two or more parts. The screen of a computer is the meeting place between the user and the software and hardware of the system. A GUI is made up of icons, windows, menus and other graphics or images. The drawing will need to include and label these parts.

**Figure 1.26** Drawing toolbar (Microsoft)

## Design the solution

Two possible solutions may be used to create the GUI drawing.

Solution 1: Use screen dumps or screen captures. This solution will be rapid and give an exact image of the screen.

Solution 2: Use drawing tools such as those shown in figure 1.26. This will take a variable amount of time according to the skill of the user.

Both solutions are used in this project. Each solution will require the basic GUI elements to be displayed and labelled: windows, icons, menus, pull-down menus and pop-up menus.


**Figure 1.27** GUI image

## Produce the solution

### Solution 1

1. **Open** a new document and save it with the name '**GUI**'. Type in a heading for the document.
2. **Minimise** the window in which the document is shown so that it is about one quarter of the size of the window. Use the **Print Screen** button on the keyboard (or the **Print Screen** command) to save a copy of the desktop to the clipboard.
3. **Maximise** the GUI document to the size of the desktop and use Control+V or **Edit…Paste** to insert the image of the desktop into your document. Figure 1.27 shows one possible result.
4. **Save** the document.

### Solution 2

Drawing objects in a word processor (such as Microsoft Word) or a presentation program (such as Microsoft Powerpoint) is a skill that can be used to create your GUI design in both two and three dimensions. The steps needed to do this are given here.

1. Display the Drawing toolbar by clicking the icon or by using the **View…Toolbars** menu.
2. Click on the toolbar **Move Bar** and hold the mouse button down so that the toolbar may be dragged around the screen. When the mouse button is released, the bar will stay in that spot.
3. To assist with accurate drawing, use the **Draw** menu and choose **Grid**. Check the **Display gridlines** box on screen. Uncheck the box to remove the gridlines if they are not needed. The size of the grids may also be changed using grid settings.

*Use autoshapes to get basic outlines*

- Click on the **Autoshapes** button (its name), then click on the group (e.g. Basic Shapes) and then click the specific shape (e.g. rectangle). Leave it at the default size by clicking once on the page or use the handles to resize the object.

*Use the 3D tools*

- Click the **3D Drawing** tool and select a 3D style e.g. Style 2 (top row, last column).

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*Add colour, arrows and lines*

- Fill the object with colour by clicking the **Fill Colour** tool (Fill tool has a colour underline) and choose the colour. Drag the object into position by moving the cursor over the object. When a four-headed arrow appears, drag the object to where you want it.
- Cropping and rotating objects is also possible. Use the Office Assistant (Help menu) to find out how to do these processes and try both using Autoshapes.

*Draw menu options*

- Group Objects: Whenever you use more than one drawing object, it is important to group those objects so that they are held together at all times.

Select them first: Hold down the Shift key and click on each item or choose the **Select Objects** button on the Drawing toolbar and click and drag to surround the objects. When the objects are all selected, click on the Draw menu on the Drawing toolbar and choose **Group**. If you used the **Select Objects** button, turn it off or it will stay active. If you need to change the drawing at any time, you can ungroup the objects in the same way as you grouped them.

- Order of object layers: This allows objects to be rearranged so that layers cover other layers.
- Rotate or flip: This changes the perspective from which the object is viewed.
  Text wrapping: This changes the way in which the object/s relates to the text on the page.

*Create text boxes*

The **Text box** button (which looks like a small document with an A in the top left corner) lets you create boxes into which you can type text. These boxes may then be moved anywhere on the page just like any other drawing object.

1 Click on the **Text box** button and note that the cursor becomes a cross when it is moved onto the page.
2 Click at the start position and drag the box to the size you want. When you release the mouse button, the insertion point is in the box and is ready for text to be typed into it (it is surrounded by a diagonally striped border).
3 Type some text into the box e.g. Drawing objects.

*Format text boxes*

Formatting means changing the appearance of anything on the screen. Before you can format anything, it must be selected.

1 Select the text box: move your cursor over the border of the text box and when a four-headed arrow appears, click once. The border is now small dots to show that the box is selected. You can now change the font (type of letters), size, justify the text to left, middle or right in the box, fill the box with colour or remove/recolour the line around the box.
2 If you need to increase the text box at this point: move the cursor over one of the text box's sizing handles and, when the cursor turns into an arrow, drag the sizing handle away from the box (use a corner handle to keep the proportions).
3 When necessary, turn off the Drawing tools by clicking the **Draw** tool on the main menu so you can proceed with your document in the word processor.
4 **Save** your document after you have completed the outline drawing of a GUI.

Solutions 1 or 2: Use the text box to label each part of the GUI (see the design stage) and arrows to indicate their location.

5 **Save** the document.



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## Evaluate the solution

Evaluate the project by judging what you have gained from completing the project. Use a table such as table 1.13 to decide your personal outcomes. Tick the most appropriate box for each line of column 1.

**Table 1.13:** Project evaluation

| Knowledge | | | |
|---|---|---|---|
| I have learned about: | Same as before | Improved | Greatly improved |
| A computer interface | | | |
| A GUI | | | |
| The parts of a GUI | | | |
| Skills | | | |
| I have learned to: | Same as before | Improved | Greatly improved |
| Use screen captures | | | |
| Use a range of drawing tools | | | |
| Manipulate images | | | |

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CHAPTER 2

# Artificial intelligence, simulation and modelling

**Artificial intelligence (AI)** machines that mimic human behaviour.

**Artificial intelligence**, or **AI**, is difficult to define, although most people would recognise it when they met it. Many people would say it is some kind of machine using a program or set of instructions to simulate some or all of the attributes of human-like intelligence including the ability to learn, to reason, to use language and to come up with new ideas. Simulation is a process of using a model to imitate the real thing. It may be best to simply say AI is machine intelligence.

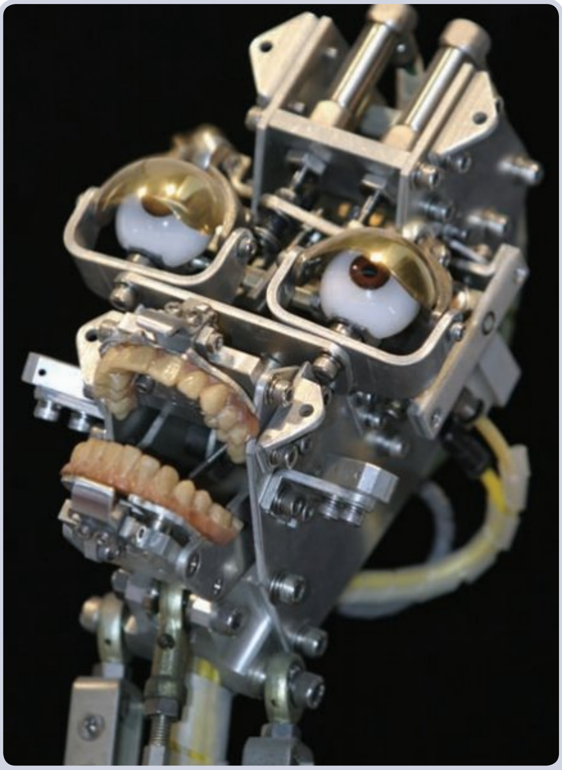

**Figure 2.1** Artificial intelligence is often associated with robotics

## Artificial intelligence

Intelligence involves solving problems independently, and learning by experience and reasoning, that is, being able to explain any decisions made. Computers solve problems, make predictions and learn from their mistakes in limited ways. They store data and use that stored data the next time the same or a similar situation is encountered.

However, computer intelligence is different from human intelligence. Computers can only solve the problems they are programmed to solve. Their abilities are specific to a problem, not general. Learning is limited, although they are very good at storing huge amounts of data. They do not yet have the ability to 'think' like humans although progress is being made in understanding the way our brains function and how machines might be made to mimic this complexity. An AI machine might be built to be as human-like as possible in the way it behaves but the appearance of the machine is only important in relation to the tasks it is designed to perform.

### Intelligence and artificial intelligence

Humans use reasoning, knowledge and feelings to react to data gained through their senses of sight, sound, touch, taste and smell. Human senses are the equivalent of machine sensors or data collection devices.



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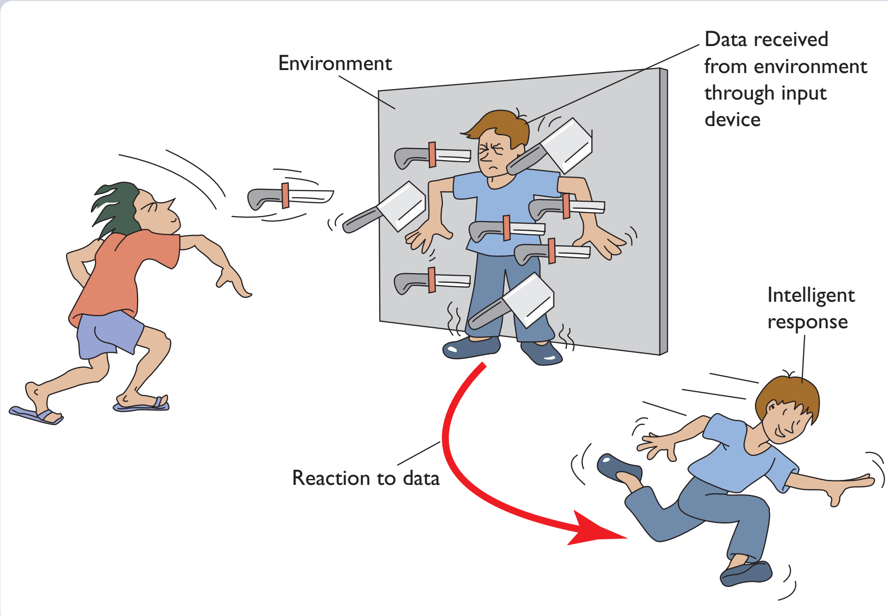


Figure 2.2 The human intelligent system

Humans communicate through written and oral language. They reason about the world around them, and they learn, think, make decisions and may be aware of the limits of their knowledge. This is intelligence. Computers are the basic building blocks of AI but many aspects of human intelligence are still too complex for computers to copy or emulate.

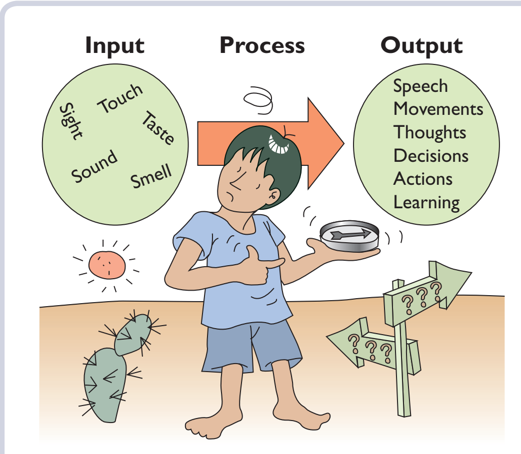


Figure 2.3 Input and output in the human intelligent system

## Historical perspective of artificial intelligence

Ideas related to machine intelligence go back a long way. Even in Ancient Greece, men such as Aristotle were working on logical reasoning systems but they did not have the technology to put their ideas into practice.

In 1936, Alan Turing developed the idea of a device called the *Turing machine* that could make decisions related to natural numbers. The Turing machine was designed to perform logical operations and could read, write, or erase symbols written on paper tape. Alan Turing also went on to say that a machine would deserve to be called intelligent if it could deceive a human into believing that the machine was human. This is called the Turing test. Not all scientists agree with this definition of AI but it is one of the best we have today.

However, it wasn't until computers became available in the 1940s and 1950s that it was possible to develop the hardware and software to build intelligent machines.

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**Table 2.1** Important steps in the development of AI

| Date | Person involved | Event |
|---|---|---|
| 1956 | Allen Newell, J.C. Shaw and Herbert Simon | First running AI program, the Logic Theorist, demonstrated |
| 1952–62 | Arthur Samuel | The first game-playing program, for checkers, had enough skill to challenge a world champion |
| 1958 | John McCarthy | LISP language invented |
| 1963 | Thomas Evans | ANALOGY program showed computers can solve analogy problems given in IQ tests |
| 1965 | Joseph Weizenbaum | ELIZA program able to interact with user to discuss any topic in English via the keyboard |
| 1967 | Richard Greenblatt | First chess playing program (MacHack) |
| 1968 | Marvin Minsky and Seymour Papert | Demonstrated limits of simple neural networks |
| 1970 | Terry Winograd | SHRDLU program able to understand limited English sentences |
| 1972 | Alain Colmerauer | Prolog programming language invented |
| 1974 | Ted Shortliffe | MYCIN expert system demonstrated for medical diagnosis |
| 1979 | Bill VanMelle | Showed that MYCIN could become the basis for expert system shells |
| 1981 | Danny Hillis | Built parallel processors to handle the large calculations needed for AI |
| 1985 | Harold Cohen | Aaron, the artist program, is demonstrated |
| 1997 | Garry Kasparov | Deep Blue, a computer program, defeated the reigning world chess champion (Kasparov) |

The number of advances made since the beginning of the 1990s has been huge, and will be covered as we progress through this chapter, along with many of the ideas developed by the people in table 2.1.

## EXERCISE 2.1

1 Write down the title: 'Comparing humans and computers'.
  a Draw up a table with three headings: 'Human activities', 'Computer activities' and 'Activities that can be done by both humans and computers'.
  b Place the items from the following list into the correct column of your table:

| | | |
|---|---|---|
| Receive input | Make very rapid calculations | Learn from the environment |

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exercise 2.1 continued

| | | |
|---|---|---|
| Modify or change behaviour as a result of changes in the environment | Process data<br>Invent new ideas | Output information<br>Store data |

c Highlight those activities in the table that you consider to be intelligent.
d Discuss the table with other students in the class and compare your results.

2 Match the terms in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| AI | person who invented the first game-playing program |
| Eliza | human input devices |
| emulate | machine intelligence |
| LISP | electronic input devices |
| Samuel | machine capable of making decisions related to natural numbers |
| senses | programming language invented in 1958 and used for AI |
| sensors | copying human behaviour |
| Turing machine | program supporting a conversation between a human and itself |

3 Name the FOUR criteria used to determine intelligence.

4 Explain which of the AI criteria would be the most difficult to achieve artificially.

5 Describe TWO different arguments about the meaning of AI.

6 What test did Alan Turing believe could be used to decide if a machine was intelligent?

7 Why didn't Aristotle or Alan Turing develop true AI machines?

## Areas of artificial intelligence

There are many areas of AI, each concerned with producing machines to automate tasks that require intelligent behaviour.

**Table 2.2** Major areas of AI

| Area | Description | Applications |
|---|---|---|
| Expert systems | Programs that hold the collective knowledge of many experts and are able to make decisions from this | Knowledge bases to hold large data stores |
| Neural networks | Systems that simulate the functions of the brain | Fuzzy logic that has no clear-cut answers |
| Games | Computers that challenge human competitors | Chess and checkers |
| Natural language | Simulate and understand human speech | Language translators |
| Robotics | Hardware and software able to adapt to change in the environment | Industrial and domestic robots |

For further information on robots refer to chapter 8.

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Intelligence involves solving problems independently, learning by experience and reasoning.

## Intelligent systems

Intelligence involves solving problems independently, learning by experience and reasoning. *Reasoning* is the way in which people make decisions using logic. When a young child sees a car for the first time, an adult may identify and name the object as a car. The young child stores this information. Next time the child sees a similar object and an adult uses the same term to describe the object, the child reasons that all objects of a similar type are called cars. Eventually the child develops a rule relating to cars. The rule controls how the facts about cars can be used.

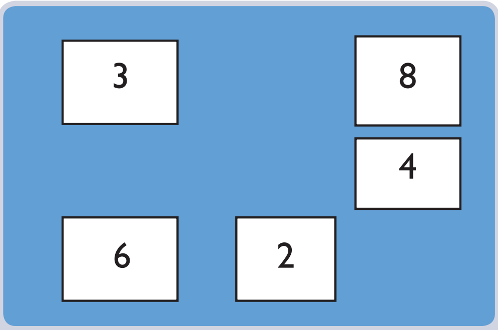

Figure 2.4 Using logic or reasoning

An intelligent system could also be taught to reason in this way, and use logic or an organised process of following steps, to reach a decision. For example, on the motherboard shown in figure 2.4 there are five locations. Each location holds a different hardware component that has a different function. Logic could be used to decide which component is found at each location and the name and function of each component.

The facts and rules include:

- One of the components on the motherboard is ROM.
- The number where RAM is found is exactly half of the number whose function is to process data. The unit that processes numbers is left of the control unit.
- The unit that functions as a controller is more to the right and has a lower number than the ALU.
- The register is further to the top than the unit that functions as permanent storage. The unit that functions as permanent storage has a higher number than the unit that functions as volatile primary storage.

A logic table such as table 2.3 could be used to work this out, taking one fact or rule at a time.

Table 2.3 Logic table showing the process of making decisions

| Number | Name | Reasoning |
|---|---|---|
| 2 | CU | To the right and 2 is lower than 6 |
| 3 | RAM | 3 is half of 6 and 6 processes data |
| 4 | ROM | ROM takes the only empty position |
| 6 | ALU | Processes numbers and left of 2 |
| 8 | Register | Further to the top than ROM |

In this way, an intelligent system can be given the ability to reason but it needs to have the facts and rules to build on, that is, a knowledge base. Intelligent systems also use demons and agents, and extend the use

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of knowledge bases to create expert systems in order to reason. Neural networks have also been developed to assist with reasoning in situations where answers are less obvious.

## Knowledge bases

Knowledge bases are collections of facts and rules related to a particular topic held in a database as the basics of reasoning. Each knowledge base is restricted to a specific area of information. The more limited the area, the more easily the knowledge base may be assembled and the more comprehensive its knowledge is likely to be. For example, a technology knowledge base would be huge whereas a knowledge base covering computer hardware (the physical parts of a computer) would be more comprehensive as it would be easier to collect all the needed information.

Knowledge bases are collections of facts and rules related to a particular topic, held in a database, as the basis of reasoning.

**Table 2.4** Types of knowledge in knowledge bases

| Knowledge | Sources | Description | Example |
|---|---|---|---|
| Fact | Books, magazines, internet, journals, experts | Item or characteristic known to be true | RAM is volatile primary storage |
| Rule | Experience and reasoning, particularly from experts | Sets of knowledge about how certain things are done or the steps needed to complete a task in logical order | RAM is empty when the power is off |

Computers can be programmed to reason with the use of *rules*. To build a rule, a premise (one or more conditions) and a conclusion (one or more actions) is required. A simple IF-THEN rule could be written as:

```
IF this knowledge exists (premise) THEN do this
(conclusion).
```

A computer could then be programmed to follow this rule, such as:

```
IF key press="A" THEN display "A" on the screen.
```

However, very few human reasons are based on just one rule. Hence, IF-THEN rules may use operators to join a string of rules together. These operators are the logical operators AND, OR and NOT. The IF-THEN rule may then be more complicated such as:

```
IF key press="A" AND key press="Shift" THEN display
"A" on the screen.

IF key press="A" AND (key press="Shift" OR key
press="Caps Lock") THEN display "A" on the screen.
```

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- AND means both parts of the premise must be true
- OR means either part of a premise must be true
- NOT limits possibilities

When a set of rules is determined for a particular action they are known as a *rule-set*. A rule-set is much closer to the type of actions a human user may make and is more valuable for AI machines.

## EXERCISE 2.2

1 What am I?
   a I am the use of logic to make decisions.
   b I am an item or characteristic known to be true.
   c I am a condition on which a rule is based.
   d I am a logical operator used to determine if both parts of a premise are true.
   e I am a collection of facts and rules related to a particular topic.
   f I am a regulation that provides knowledge of how a task is done.
   g I am the action/s required if a rule premise is true or false.
   h I am the term for the joining words AND, OR and NOT.
   i I am an organised storage medium for a knowledge base.
   j I am a table demonstrating the processes or steps in decision-making.

2 Here is an example of a rule that defines the concept of 'car'. It relies on an understanding of other objects.

| Object | Rule |
|---|---|
| Car | Has an engine |
| | Transports people, goods, pets AND |
| | Is smaller than a truck or bus AND |
| | Is larger than a motor bike |

Write the set of rules needed to identify the following objects:
   a a human baby
   b a basketball
   c a table

3 Use the rule-set given below to identify the object that is being described by these rules:
   The animal is a bird
   The animal has a long neck
   The animal has long legs
   The animal is black and white
   The animal runs quickly
   The animal does not fly

4 Write the above rule-set as an IF-THEN rule.

5 Complete the following sentences using words from the list.

| | | |
|---|---|---|
| data | eyes | feelings |
| human | input | intelligent |

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exercise 2.2 continued

| | | |
|---|---|---|
| knowledge | learning | nose |
| not | output | reasoning |
| senses | sensors | sound |
| speech | touch | why |

Intelligent systems receive data or (a) ___, react to that data and (b) ___ an (c) ___ response. Humans use (d) ___, (e) ___ and (f) ___ to react intelligently to the data that is fed into the (g) ___ system. Data fed into the human system comes through five major (h) ___: sight, (i) ___, (j) ___, taste and smell. Our sense organs are our (k) ___, ears, skin, tongue and (l) ___. These sense organs are similar to hardware devices called (m) ___ that are used to input (n) ___ into a computer system. To react to data in an intelligent way humans use (o) ___ and movement. Computers also have ways of outputting speech and movement but that does (p) ___ make them intelligent. Intelligence involves reasoning and (q) ___, making decisions for which we may explain our reasons or (r) ___ we took a particular action or performed a particular job in a particular way.

## Demons

*Demons* are independent programs that spring to life when they are relevant. After a first experience, the intelligent system stores the relevant data. The second experience of a situation or object then activates the appropriate demon and the system 'recognises' the situation or object. Think of the number of times you remember something when you need to, although you have not used that information for a very long time. Demons function like this in an intelligent system as they are only used when they are needed. Demons allow an intelligent system to 'learn' but the system needs to use a large number of demons to achieve intelligent responses.

## Agents

*Intelligent agents* are programs that are used to search vast bodies of structured and unstructured data to locate information that matches a goal rather than an inflexible set of criteria. The functions of intelligent agents include obtaining a mission, carrying out that mission using search techniques and reporting the output or results to a controller, normally a human user.

One group of such agents may search a database to find patterns or relationships in the data. This is known as *data mining*. For example, a database may hold all the incoming email messages for a company. The agents are used to search the messages for certain keywords or simple phrases and from this are able to redirect the email to the person best able to deal with the enquiry. Such intelligent agents are exhibiting some of the attributes of human intelligence.

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**Expert system** a computer program that consists of knowledge in the form of fact and educated guesses.

## Expert systems

**Expert systems** are computer programs that make the collective knowledge of various experts in a field available to the user. They are built on knowledge bases.

**Table 2.5** Components of an expert system

| Component | Description | Example |
|---|---|---|
| Knowledge base | Database of facts and rules/ rule-sets | Fact: Surface temperature of the sun is over 5500°C.<br>Rule: Temperatures over 60°C burn human skin. |
| Inference engine | Program that reasons from the knowledge base to solve problems by working through the rules in a certain sequence searching for matches to the facts held in the database | Conclusion or inference: Human skin will burn if it gets close to the sun. |
| Explanation mechanism | Program that decides which known facts support a decision or conclusion reached by the inference engine | The temperature at which human skin burns is lower than the known temperature of the sun. |

**Table 2.6** Methods used by inference engines to reason

| Method | Function | Example |
|---|---|---|
| Forward chaining | Begins with the known facts and works forward through the rules towards a decision | A car does not start<br>Rules are checked:<br>Are the lights working Y/N<br>If yes then<br>The starter motor needs fixing |
| Backward chaining | Begins with the decision and works backwards through the rules to determine whether the known facts are able to support the decision | A likely decision is: The starter motor needs fixing<br>The rules could be checked that relate to this decision<br>Is the engine turning over? Y/N<br>If no then<br>Are the lights working? Y/N<br>If yes then<br>The decision is supported by the facts |

## Examples of expert systems

Expert systems can be used to teach, give advice and help with decision-making. Some examples are voice recognition software, medical expert systems and business decision support systems.

*Voice recognition software* programs are able to 'read' voice input. These programs have very large dictionaries of known words and sounds, and use language models based on the most frequent ways of pronouncing words and phrases in a particular language. They can recognise when an exact match of a 'voice print' is made, attempt a close match when an exact

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match is not made, and can recognise and interpret single words, short phrases or a long flow of speech.

*Medical expert systems* are designed to help diagnose diseases when given the symptoms. If the illness is not known, the system has to work out the cause from many possibilities, that is, *forward chaining*. To do this the system asks questions one by one. The answer to one question decides what question is asked next. If the illness is known, the system starts from the possible cause and works backwards to check that the illness is the one the doctor believes it to be. For example, MYCIN is an expert system that helps doctors to diagnose infectious blood diseases. It contains a knowledge base, an inference engine and an explanation base to provide the doctor with the reasons for its decision. The doctor must make the final diagnosis, as the expert system might be right or wrong and it cannot handle unknown diseases. MYCIN is able to diagnose most known illnesses but it does not learn from its experience with each patient. Its internal model is fixed and must be redesigned if more facts are needed in the knowledge base.

*Decision support systems*, such as the ones available to most stockbrokers, are used in business. Information related to increases and decreases in share prices over long periods of time is included. When an investor needs to make a decision related to buying or selling shares, they consult the expert system. The expert system provides help but the investor needs to make the final decision.

## EXERCISE 2.3

1 True or false? Rewrite each false statement to be true.
   - a Demons are independent programs that spring to life when they are relevant in a program.
   - b Demons are in constant use in an intelligent system.
   - c Only one demon is needed in a program to output an intelligent response.
   - d Solving problems independently is not an aspect of intelligence.
   - e Reasoning is important in an intelligent response.
   - f Expert systems are programming languages.
   - g A knowledge base is an encyclopaedia on a CD-ROM.
   - h Intelligent agents do not use search functions.
   - i Knowledge bases store facts and rules for an expert system.
   - j Demons are methods of artificial learning.
   - k Inference engines are the reasoning components of expert systems.
   - l Explanation software explains the decisions or conclusions taken by a program.
   - m Forward chaining starts with a decision and finds the facts to support it.
   - n MYCIN is a well-known stock-market expert system.
   - o Voice recognition programs depend on language models to identify pronunciation.

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exercise 2.3 continued

2 Complete the following sentences to make them true statements.
 a The functions of an intelligent agent include ...
 b Data mining is the process of ...
 c An expert system is ...
 d Demons are ...
 e To emulate intelligence is to ...
 f The three major components of an expert system are ...
 g Two advantages of an expert system over a textbook are ...
 h An example of a decision support system is ...

## Neural networks

Neural networks are formed when hardware and software are joined so that a type of machine thinking can occur.

Neural networks are formed when hardware and software are joined so that a type of machine thinking can occur. Neural networks are modelled after the neurones or nerve cells in animal brains. Each neural network is designed for a specific application, such as data classification or pattern recognition. Just as in human systems, learning involves adjustments to the dynamic connections that exist between the neurones or processors, using a learning process called *training*. Training is simply providing more and more experiences of the kind in which the neural network specialises. The more training, the better the system is likely to reason.

Neural networks are useful in areas of intelligence where answers are not very clear, a type of reasoning called *fuzzy logic*. This makes their reasoning similar to human reasoning, that is, humans often make decisions based on *heuristics* or methods of solving problems for which few facts or knowledge are available and which depend on experience of what has happened in the past with similar problems.

The components of a neural network are the same whether the neural network is hardware or software, but software networks use instructions rather than physical parts and are relatively slow.

**Table 2.7** Components of neural networks

| Component | Description |
|---|---|
| Transistors | Switches that simulate the actions of human cells |
| Wires | Connect transistors |
| Resistors | Devices that determine the amount of current flowing from one cell to another |
| Processors | Work with transistors, wires and resistors to carry out operations |

## Features of neural networks

- The ability to learn by example – the network 'learns' by reorganising its connections as it responds to different situations. The more transistors

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it has, the more connections it is able to make. The more examples it is given, the more 'expert' it becomes.

- Pattern recognition – rather than being programmed, neural networks learn to recognise patterns. Pattern recognition is the ability of the system to recognise text, visual and audio similarities.

### Application of neural networks

Neural networks are being applied to an increasingly large number of real-world problems. Their primary advantage is that they can solve problems that are too complex for conventional technologies. In general, neural networks are well suited to problems that people are good at solving, but for which computers generally are not. These problems include pattern recognition and forecasting, the type of problem that requires the recognition of trends in data. Humans are then able to make decisions based on the output of such programs.

One example of the use of neural networks includes *natural-language processing*. Natural-language processing allows people to interact with computers without needing any specialised knowledge. A person can simply walk up to a computer and talk to it. Unfortunately, programming computers to understand natural languages has proved to be difficult. An intelligent system has to be taught to output even simple phrases. This means that the computer has to learn about context and other problems such as dialects (such as Australian English versus American English). *Context* is the sentence and paragraph in which words are placed and which may change their meaning. Most languages rely heavily on context to decide what any set of words mean. For example, if a computer was given the task of translating the phrase 'out of sight, out of mind' from English to Russian and then back to English, it could well produce the definition 'invisible, insane' which has an entirely different meaning.

Some basic translation systems for human languages have come from the use of neural networks but they are not nearly as good as human translators. There are also voice recognition systems that can convert spoken sounds into written words, but they simply take dictation. Such systems are still quite limited – the user must speak slowly and distinctly but the error rate is decreasing rapidly.

## Requirements of artificial intelligence

### Software

AI needs programs or software not only to receive input, to process and to output information but also to make logical decisions and react intelligently to changes in the environment. **Software** is any set of instructions that can be followed by a system to perform tasks. This includes programming languages and applications.

**Try this**

**Creating character graphics**

Computers may be used to create many different forms of communications. A set of special symbols used together like letters of the alphabet may create graphics. Different fonts will vary these but they are created best with monospaced fonts, such as Courier. Character graphics are still used, for example, to create barcharts or in email. Some common examples are

| | |
|---|---|
| :-) | smile |
| :-( | frown |
| ;-) | wink |
| :-D | wide grin |
| :-x | oops, "I shouldn't have said that" |
| O:-) | an angel |

A barchart created with character graphics may look like

| | |
|---|---|
| 3 | *** |
| 6 | ****** |
| 9 | ********* |

It is even possible to create simple pictures with characters. Draw a simple drawing of your choice using character graphics, for example, a ship, tree or building.

**Software** a sequence of instructions used to direct the operation of a computer.

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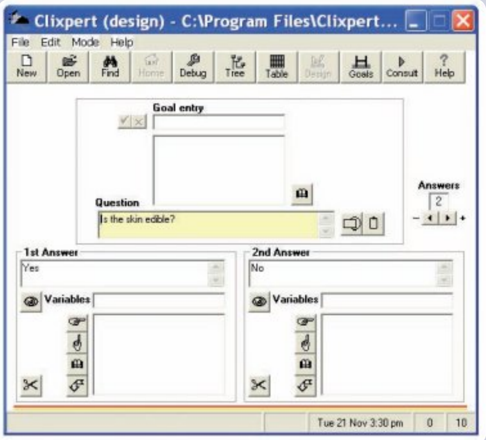


Figure 2.5 Shareware expert system shell

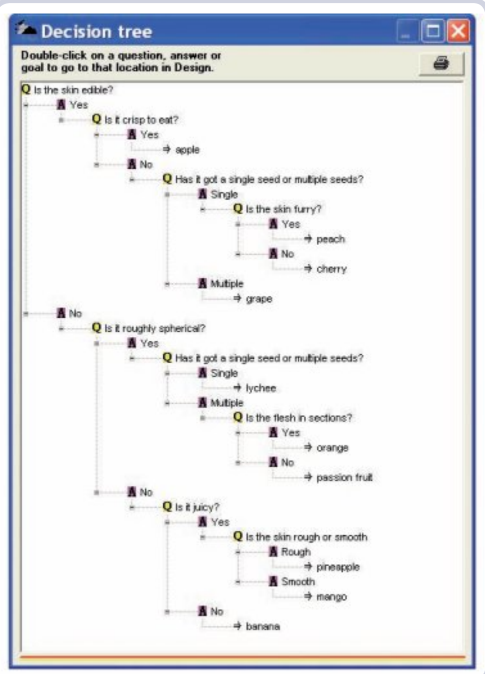


Figure 2.6 Decision tree to decide the type of fruit being eaten

Specialised programming languages for AI are called *non-procedural languages*. Non-procedural languages do not include each instruction in the order in which it is to be carried out. The programmer clearly sets out the problem that has to be solved and what has to be done to solve it. The non-procedural language then has structures that allow the system to decide how best to solve the problem. Non-procedural languages being used to develop AI are LISP and PROLOG. One of the AI applications of such programming languages is in the development of car navigation systems.

*Applications* include expert system shells. Shell programs contain the outline for a knowledge base into which the user may put specialised information. They then provide a reasoning or inference program and often an explanation mechanism.

These shell systems allow the user to insert their own data and use a decision tree to reason.

## Hardware

**Hardware** is the physical components needed for intelligent systems. AI needs hardware with large amounts of storage and very fast processing as many facts, rules and computations are required for reasoning and learning. Because of the very wide range of data that they need to receive and to which they need to react, computers used for AI also require many input and output peripheral devices. Many of these are devices that can be used with other systems, such as the mouse, keyboard, scanner, printer and monitor. It is the particular use and combination of this hardware that provides AI.

> **Hardware** is the physical components needed for intelligent systems.

### EXERCISE 2.4

1 Match each term in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| context | the ability of a computer program to recognise data trends |
| decision tree | switches used in neural networks |

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exercise 2.4 continued

| | |
|---|---|
| expert system shell | another term for reasoning |
| forecasting | physical devices used in AI systems |
| hardware | AI non-procedural programming language |
| inference | sets of instructions followed to complete a task in AI |
| natural language | program that allows a user to input their own knowledge into a knowledge base |
| PROLOG | ability of a computer to converse with humans in everyday human languages |
| software | the logical means of showing reasoning in an expert system |
| transistors | surrounding sentences and phrases that affect the meaning of words |

2 Answer the following questions in full sentences.
  a How is a neural network 'trained'?
  b Define the terms 'fuzzy logic' and 'heuristics'.
  c Name the FOUR components of a neural network.
  d How do software and hardware neural networks differ?
  e What are the TWO major processes by which neural networks learn?
  f Why are neural networks useful for natural language processing?
  g Describe what is meant by a non-procedural programming language.
  h What are the two main advantages of large hard disks and high speed processors when used to develop AI?

**Career path**

**Technical writers prepare specifications, user manuals and other technical publications, such as catalogues, parts lists, assembly instructions and project proposals. They are able to put technical information into easily understandable language. As well as text, they create and use illustrations, photographs, diagrams, and charts to explain the content.**

# Modelling and simulation

Modelling is the process of emulating or copying some aspect of the real world. Simulation is a demonstration or experiment involving the model, that is, using the model for a purpose.

Modelling the process of emulating or copying some aspect of the real world.

Simulation using a computer to represent a physical system, that is, to pretend to be something else.

## Modelling and simulation tools

Modelling and simulation use both non-graphic and graphic tools. Some examples include:

- a mathematical model used to show probability in a spreadsheet. A dice may be thrown one hundred times and a record kept of the number of times each side of the dice lands face up.
- a physical model using graphics software to create a realistic scene of the situation or object being simulated such as a model of a kitchen design. Well-designed, high-resolution animated graphics may improve the effectiveness of a simulation by enabling the user to feel that the simulation is 'real', such as walking through the kitchen design from a range of perspectives.

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### Great idea

People with physical disabilities find it more difficult to use computers. Many areas of modelling and simulation have worked on this problem and some have been successful. Some great ideas may be seen by using the Control Panel and Accessibility Options on a Windows machine. Software changes may be made to enable people to operate computers more easily. Examples include:

- Mouse keys so that the numeric keypad functions as a directional mouse e.g. key 9 sends the mouse cursor up and to the right of the screen
- Display changes so that the screen shows high contrast for those with visual impairments (see figure 2.9)

## Wireframe modelling and simulation

*Wireframe modelling* involves the use of a graphics program to produce an outline in three dimensions of an object being considered for construction.

*Simulation* is the use of that wireframe model. The object may be rotated in 3-dimensional space to view it from different perspectives or studied from different angles to decide its visual appeal or problems with its design. This would be a simple way of 'experimenting' with the model.

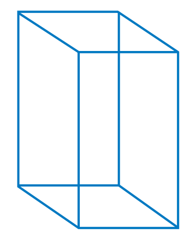

**Figure 2.7** Wireframe model of a cube

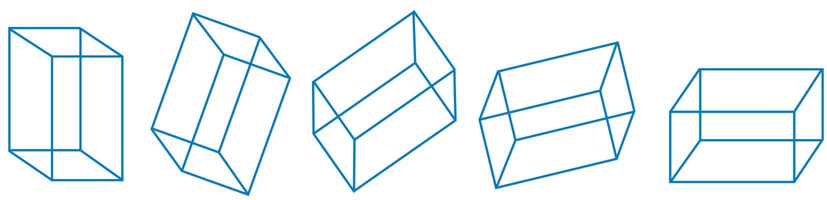

**Figure 2.8** Simulation using the model of a cube

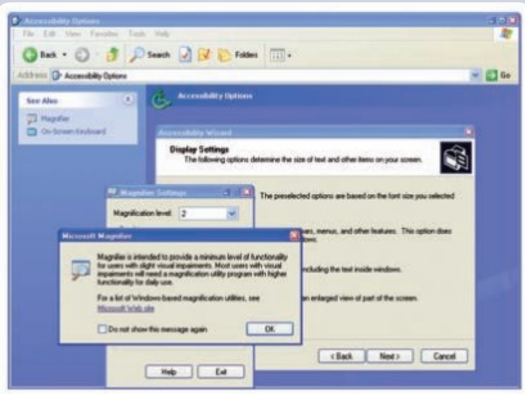

**Figure 2.9** High contrast display settings available on a Windows machine

## Purposes of models and simulations

Computer simulations are developed where the real situation is dangerous, expensive, time-consuming or impossible to conduct. The power of the computer in simulation lies in its ability to carry out large amounts of calculations quickly and with high precision and accuracy.

**Table 2.8** Purposes of modelling and simulations

| Purpose | Explanation | Example |
|---|---|---|
| Training | Simulation of situations and events related to specific tasks | Driving simulator to teach car-handling techniques |
| Scientific or other research | Simulation of a scientific phenomena for close study, particularly where it may be unethical to use animal subjects | A volcanic eruption or the study of DNA<br>Simulated space exploration to other solar systems |
| Medicine | Simulation of an event related to medical procedures | A heart bypass operation |

continued >

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| | | |
|---|---|---|
| Entertainment | Political, business, adventure and arcade games | Game related to an alien invasion |
| Business/industry | Simulation allowing closer study of future trends and possible actions | A new assembly-line process or the design for a nuclear reactor |
| Geography/ecology | Simulation demonstrating effects of climatic changes | Greenhouse effects and population trends |
| Weather forecasting | Simulations of weather patterns and related factors | Effects of excessive rain on a mountain range |
| Education | Wide range of situations may be studied in the classroom | Dissection of animals using a computer program to simulate the process |

## Virtual reality

Virtual reality is a computer generated, three-dimensional model with which people interact. Virtual reality simulations use animation, sound, movement and other sensing devices to create a situation that is as near to the real situation as possible. Virtual reality is a development in graphical simulation and is used in other areas apart from games. It is interactive and allows the user to become part of the computer-created world, to change it and to see the changes take place as they are made. It requires special equipment e.g. video headsets, data gloves and specialised surround structures. The most important hardware in a virtual reality system is the head-mounted display worn by users, including a mask and goggles. These displays block out the real world and present to the wearer a view that is under the complete control of the computer. The user is immersed in an artificial world away from the real environment. For this immersion to appear realistic, the system must accurately sense how the user is moving and relay this to the computer so that it can determine what effect that movement will have on the scene being rendered in the head-mounted display.

Virtual environments use virtual reality techniques and tools to create spaces that allow people to experience a real environment through the use of audio, video and hardware resources. They are not intended to be completely realistic. For example, a student may now work in a virtual classroom using a computer with internet connection and software that provides areas for instruction, interaction with other students and a teacher. The environment may include functions such as message boards, electronic blackboards, chat sessions, email and web cameras. A broadband connection is used to allow the rapid exchange of data. This virtual environment allows students to work from home, particularly in remote locations, and to study subjects that may be difficult to provide in remote areas where local expertise is unavailable.

## Augmented reality

Augmented reality (AR) is a combination of the real scene viewed by the user and a virtual scene generated by the computer, that is, it uses virtual

Virtual reality is a computer generated, three-dimensional model with which people interact.

### Great idea

**CT scans**

**Computed tomography (CT or CAT) is a current great idea for use in medical diagnosis. The process generates a three-dimensional model of the inside of an object by taking a long series of two-dimensional X-rays around a single axis of rotation, like a series of very thin slices. Modern scanners are able to convert the data to see various perspectives and 3D models. Doctors are able to see models of internal organs and parts of a patient's skeleton to decide on operations and other treatments.**

Figure 2.10 Tomography models of feet

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reality to add to the real environment. Virtual environments may be very simplistic such as the environments created for games, or they are extremely expensive as in flight simulators. The aim of AR is to make them more realistic and less expensive.

AR requires very high-quality computer-generated graphics and displays and real-time video image processing. A simple form of augmented reality has been in use on television news for some time with the weather reporter seen to be standing in front of changing weather maps. In the studio the reporter is actually standing in front of a plain blue or green screen augmented with computer-generated maps. In medicine, it is planned to develop imaging technology to the stage where augmented reality is used so that the surgical team can see scan data correctly overlaid on the patient while the surgery is progressing. Using AR, an image of the patient's brain showing the location of a tumour could be imposed on the patient's head. Applications in the fashion and beauty industry are also possible. If the clothing store does not have a pair of jeans in your size, a simulation could be used to augment the image of you. As you looked in the three-sided mirror you would see the image of the jeans on your body. Changes in length, style or other extras could be seen on you before you place the order. You could even see the effect as you moved in the jeans.

## EXERCISE 2.5

1 Follow the guidelines provided to construct a model of a cube.

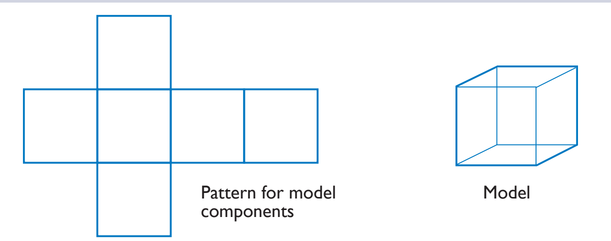


Figure 2.11 Pattern for modelling a cube

a Write the numbers 1 to 6 in the centre of each side of the cube, one number to each side.

b Toss the model 100 times. Keep a record of the number that lands upwards on each toss of the model.

c Write a prediction based on the number of times each number is likely to appear when a cube is thrown into the air.

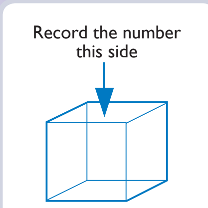


Figure 2.12 Simulation using the cube

2 Answer the following questions.

a When does the model become a simulation?

b What is another term for simulation?

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exercise 2.5 continued

- c What calculations needed to be made to arrive at your prediction?
- d Could this modelling and simulation activity be simulated on a computer?
- e Why would such a simulation be unlikely to become a computer simulation?

3 Describe how modelling and simulation could be used in ONE of the following situations:
- a building a bridge
- b designing an AI system

4 Complete the following phrases to make them full and correct sentences.
- a A model is ...
- b A simulation is ...
- c Computer simulations are most useful in situations that are ...
- d A computer is a useful tool in modelling and simulation systems because ...
- e A computation is a ...
- f Virtual reality is ...

5 Name THREE areas that a researcher could study using a modelling and simulation system.

6 What is meant when it is said that virtual reality is 'interactive'?

7 Simulations are often ways of allowing us to study situations that would otherwise be too dangerous, difficult or expensive. Draw TWO diagrams or explain TWO different situations in which a simulation would be the better choice than reality.

8 Draw a wireframe model of a common item of your choice.

9 Explain THREE different ways in which you could use your model as part of a simulation.

## Requirements of models and simulations

### Hardware needs

The most important aspect of hardware for simulation is the ability to perform complex computations or calculations quickly and with high precision. Large amounts of data also need to be stored. Hardware requirements cover analogue to digital converters (ADC/DAC), memory (RAM, ROM, secondary) and fast processors. ADC/DAC and the functioning of the CPU (central processing unit) are covered in detail in other sections of this book.

Simulations also require fast processing power. Processing changes input into output for use in the model or simulation. One way of increasing processing power is through the use of a fast CPU and parallel processors.

CPU speed is measured in *megahertz,* that is, the number of operations which the processor is capable of performing in a given time. A *word* is the amount of data that can be processed in a single operation by the computer.

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Simulation systems need large processing power and tend to work with word lengths of 32, 64 or even more bytes. This means that 256, 512 or more bits are processed in each operation.

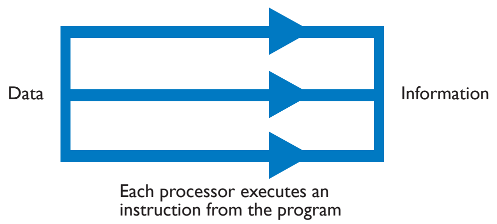


Figure 2.13 Parallel processing

Most simulations are made up of a number of continuous processes occurring simultaneously. Large simulations thus benefit from the speed of *parallel processing*. Parallel processors are two or more linked processors working together to carry out the program one instruction at a time. Parallel processing is only available for industrial, scientific or medical research where expensive equipment such as supercomputers is provided. The speed is increased according to the number of processors working together.

## LARGE STORAGE MEDIA

As a result of the storage needs of much of the data used for modelling and simulations (graphics, animations, video and sound), large devices are needed to hold this data for future use. The range of such devices includes magnetic storage devices such as hard disks and optical storage devices such as CD and DVD.

## SIMULATORS

Simulators are hardware devices that use a computer model as the basis for an experiment or simulation of a situation in the real world.

**Simulators** are hardware devices that use a computer model as the basis for an experiment or simulation of a situation in the real world. The simulator enables people to be trained in the use of equipment in situations that, in the real world, would be expensive and/or dangerous. It also enables new situations to be tested to determine their value without risking the life of the user. Simulators are used in a number of areas such as aviation and driver education.

Figure 2.14 Flight simulator

*Flight simulators* are used to train pilots. A model of a cockpit is constructed with real hardware and instrument panels. The cockpit might simulate movement and the 'windscreen' provides a computer display to provide realistic scenery and weather patterns. The trainee pilot is guided through a range of different conditions and responses. The flight simulator is adaptive, that is, it receives output in the form of trainee responses and this feedback goes back into the simulator which then makes decisions based on the way the trainee pilot responded. Once the basics have been mastered, the trainee can

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be presented with a number of scenarios (sets of real-life possibilities) and assessed according to the way in which they handled the situation. It would be possible for one scenario to simulate a fire in one of the plane's engines, another scenario to present the trainee with a situation in which a section of the plane came loose or, in still another scenario, the plane's landing gear may fail to work. Trainee pilots learn to handle each of these situations without risk to their own lives or damage to very expensive aircraft. When each stage of the simulator has been mastered, the trainee pilot is ready to progress to the real world.

*Driving simulators* are useful tools for learner drivers. Without going on to the road and facing danger and injury, a learner driver can experience a range of possible scenarios, problem situations and different driving environments. Advanced driving instruction is also possible. The driver can then proceed to use the skills acquired on the simulator in the real world and has a wider experience of the range of possible situations in which they may be involved.

## The role of data in modelling and simulation

**Data** is the raw facts input into the computer from which the model and simulation is created. Data in a computer simulation represents the state of the model at any particular time. Data may be edited when an experiment is undertaken to find the results of such changes so that predictions or decisions can be made. When data is edited in a computer model, the model changes and so does the simulation based on that model.

**Data** is the raw facts that can be input, stored, processed, output and retrieved from a computer.

**Table 2.9** Data storage for modelling and simulations

| Form of data storage | Explanation | Example |
|---|---|---|
| Variables | Storage locations for any data items that change during their use. In a modelling and simulation system when data is stored as a variable it has the advantage of being very easily changed. | In figure 2.14, the location A1 holds the data 56 when the program begins. Because A1 is the location of a variable, the data items in A1 can be changed. The entry 56 is changed to 13 and later to 45. Similarly, C3 is the location of a variable. Data items stored at C3 may also be changed. C3 originally held the data items 62. This is changed to 6. |
| Queues | Queues are the lines of data items waiting for processing. | Millions of calculations may be carried out during a modelling and simulation operation. Even faster computers cannot carry out all these calculations quickly enough for a continuous stream of data flow, so queues form. |

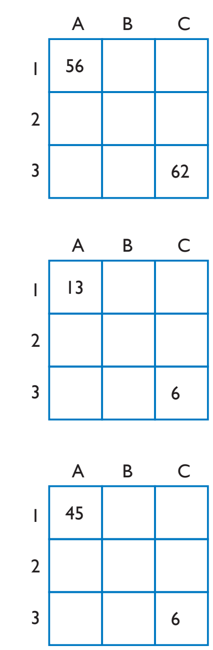


**Figure 2.15** Variables during program execution

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## Software requirements and languages

Modelling and simulation software is usually complex, as such systems must take as many relevant factors into account as possible and carry out huge numbers of computations in order to produce a valid and useful model. In turn, the accuracy of the model will determine whether the simulation is a reliable reflection of the 'real-life' situation. Modelling and simulation require programming languages and applications to provide the instructions for their operation.

Special simulation languages are used for the development of complex simulations, for example, DYNAMO and SIMULA. Such languages include special procedures to develop a model and then to test and observe the output from the simulation.

General purpose programming languages are also used for simulation. Fortran is a language developed for use in engineering and it contains procedures that make it easier to use for the development of engineering models. For example, an engineer might wish to design a building for a specific situation and then use a simulation to determine whether the building design will withstand the unique pressures of the particular situation, such as extremely high winds, by testing the model. Even more general purpose languages such as BASIC or Visual BASIC can be used for simple simulations as such languages allow a wide range of computations to be performed, and support the development of mathematical and graphical models.

### EXERCISE 2.6

**1** Which of the following two situations illustrates the function of an AD converter?


a b

**2** Answer the following questions in full sentences.

- **a** What are the advantages of a parallel processor over a computer with a single processor?
- **b** Give TWO examples of a specific programming language developed for use with modelling and simulation systems.
- **c** Name the programming language often used to develop engineering simulations.
- **d** What is meant by the term 'general programming language'?

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exercise 2.6 continued

- **e** Give an example of a general programming language that could be used to develop modelling and simulation systems.
- **f** Why are data queues necessary?

**3** True or false? Rewrite each false statement to be true.

- **a** Computer simulations need hardware but not software in order to work.
- **b** Experiment is another word for simulation.
- **c** A model mirrors some situation in the real world.
- **d** A simulator is a software program.
- **e** A model is better than a real-world situation.
- **f** Hardware in modelling and simulation systems must have the ability to perform computations.
- **g** An ADC converter is a device that converts digital signals into an analogue signal.
- **h** Modelling and simulation are both the same.
- **i** Spreadsheets cannot be used to create a model.
- **j** Flight simulators are used to train birds.
- **k** Variables are data items that can change during use.
- **l** A queue is a list of data items in a model.
- **m** Simulators are machinery used for modelling.
- **n** Models cannot be used to predict the effects of changes.
- **o** CPU speed is measured in megahertz.
- **p** Simulation does not need fast processing speed.
- **q** Floppy disks are suitable media for storing large models.
- **r** Supercomputers are easily available for research using modelling and simulation.

**4** Complete the following paragraph by choosing words from the list.

| | | |
|---|---|---|
| ADC | analogue | changed |
| computer | digital | facts |
| instructions | model | queues |
| serially | speeds | supercomputer |
| variables | | |

Data is the raw (a) ___ input into a computer system from which a (b) ___ is created. Data is usually in (c) ___ form and has to be changed to (d) ___ form by an (e) ___ converter. Digital data is the only form of data that a (f) ___ may understand. In the computer, storage locations for data that may change are called (g) ___. Such data items may be changed so that the model may be (h) ___. Data items are processed (i) ___, that is, bytes of data are processed one bit behind the other. The data moves more quickly than the computer can process the data and so (j) ___ or lines of data form as the data items wait to be processed. When a (k) ___ uses parallel processing to move data items through the system, this (l) ___ up the processing of data.

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Applications are programs that perform a specialised task for the user.

## APPLICATIONS

Applications are programs that perform a specialised task for the user. One of the most useful applications for developing models and simulations is spreadsheets that organise data into columns and rows so that mathematical calculations can be carried out on the data.

## SPREADSHEET APPLICATIONS

Electronic spreadsheets are popular for modelling and simulations for many reasons.

- Spreadsheets can calculate quickly and accurately.
- Mistakes can be easily fixed or data can be changed without having to redo the spreadsheet.
- It is easier to store spreadsheets and to find the data needed when they are on computer disks.
- Spreadsheets let the user present data in both numbers and graphical form, such as charts.

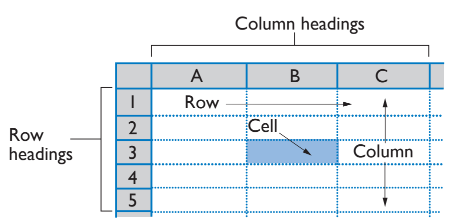


**Figure 2.16** Spreadsheet grid

Spreadsheets are worksheets in a grid or table. The grid has column headings across the top and row headings down the left side.

A *cell* is the intersection of a row and a column. Each cell is referred to by its coordinates. In figure 2.16, the coordinates of the active cell are column B and row 3, or simply B3. The spreadsheet is made up of rows and columns. A *row* is a horizontal arrangement of cells and a *column* is a vertical arrangement of cells.

When a cell is selected it becomes the active cell. Data is entered into the active cell. Its coordinates are the *address* of that cell, such as A1 or B5. The cell address can be shown at the top or the bottom of the screen.

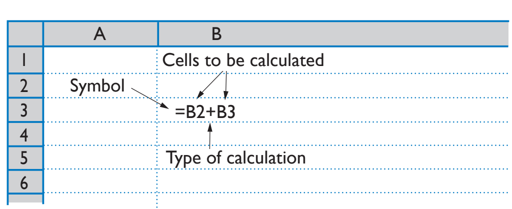


**Figure 2.17** Spreadsheet formula

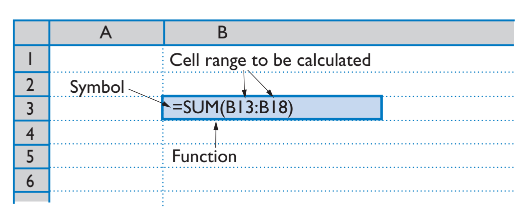


**Figure 2.18** Spreadsheet function

Formulas are the most valuable type of data in a spreadsheet because they allow the calculations that are the basis of the spreadsheet itself. They are not usually shown in the cell but can be seen in the entry bar when the cell is active. *Functions* are quicker ways of writing formulas. They name the type of calculation and the cell ranges to be calculated.

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**Table 2.10** Data used in spreadsheets

| Data | Description | Example |
|---|---|---|
| Labels | Column and row headings that give meaning to numbers | Pete's Budget, Income |
| Values | Whole or decimal numbers | 34, 2678, 9861.357 |
| Formulas | Basis for calculating answers from values and start with a symbol, usually = | =B2+B3 |

## EXERCISE 2.7

1 True or false? Rewrite each false statement to be true.
  - a Spreadsheet rows run horizontally across the screen.
  - b Spreadsheet columns run vertically down the screen.
  - c Every cell in a spreadsheet has the same cell address.
  - d Spreadsheet data may be labels, values or formulas.
  - e Formulas are used for labels.
  - f Copy and paste can be used to move a formula from one cell to another.
  - g Addition is always carried out first in a calculation.
  - h An active cell is one to which data has already been added.
  - i Functions are inbuilt spreadsheet formulas.
  - j Labels are values entered into specific cells.

2 What type of data is each of the following?
  - a Spreadsheet heading
  - b =A2*(C1-F8)
  - c 27.5
  - d =A5*C7
  - e Row title

3 A spreadsheet consists of 10 rows and 10 columns. How many cells are in the spreadsheet?

4 What is the cell address of the first cell in an alphanumeric spreadsheet?

5 Which column of the spreadsheet is most likely to contain labels?

6 If you need to enter a formula into a cell, what needs to be typed first?

7 This small spreadsheet has been organised to store data about school stationery.

| | A | B | C |
|---|---|---|---|
| 1 | Great High School | | |
| 2 | Item | Number | Price |
| 3 | Exercise book | 120 | 1.20 |
| 4 | Blue biro | 235 | 0.45 |
| 5 | Pencil case | 115 | 1.55 |
| 6 | Total | =B3+B4+B5 | |

  - a What is the data entry in cell B6?
  - b What type of data is stored cell B2?
  - c What is the cell address of the data item 0.45?
  - d What value will be shown in the cell B6?

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## SPREADSHEET ORGANISATION

Data is entered into individual cells but it is often necessary to work with a range or block of cells. To select a range or block of cells, the cells in the block or the range must be highlighted. A *range* of cells is a group of adjacent cells in either a row or a column. *Blocks* are whole sections of adjacent rows and columns.

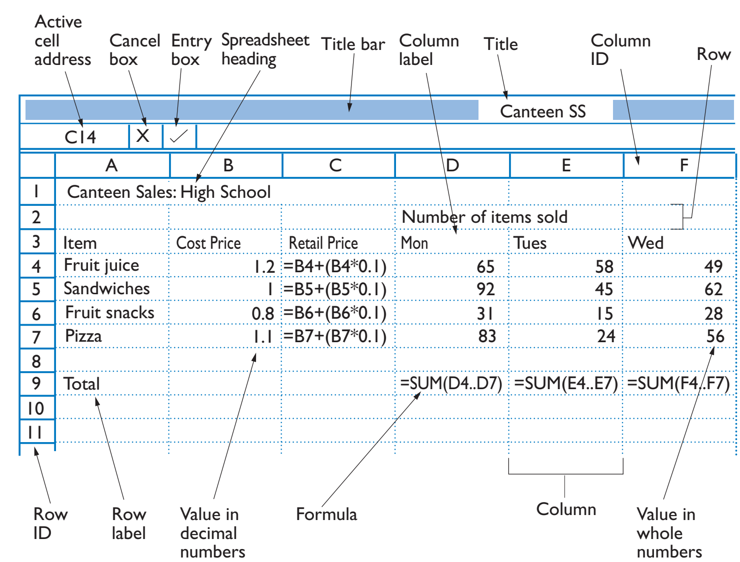


**Figure 2.19** Parts of a spreadsheet. (Note that formulas are shown in the cells but normally the values as a result of the calculation would be shown.)

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Canteen Sales: High School | | | |
| 2 | | | | Number of |
| 3 | Item | Cost Price | Retail Price | Mon |
| 4 | Fruit juice | 1.2 | =B4+(B4*0.1) | 65 |
| 5 | Sandwiches | 1 | =B5+(B5*0.1) | 92 |
| 6 | Fruit snacks | 0.8 | =B6+(B6*0.1) | 31 |

Range from B4 to D4

**Figure 2.20** Cell range (row)

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Canteen Sales: High School | | | |
| 2 | | | | Number of |
| 3 | Item | Cost Price | Retail Price | Mon |
| 4 | Fruit juice | 1.2 | =B4+(B4*0.1) | 65 |
| 5 | Sandwiches | 1 | =B5+(B5*0.1) | 92 |
| 6 | Fruit snacks | 0.8 | =B6+(B6*0.1) | 31 |

Range from B4 to B6

**Figure 2.21** Cell range (column)

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Canteen Sales: High School | | | |
| 2 | | | | Number of |
| 3 | Item | Cost Price | Retail Price | Mon |
| 4 | Fruit juice | 1.2 | =B4+(B4*0.1) | 65 |
| 5 | Sandwiches | 1 | =B5+(B5*0.1) | 92 |
| 6 | Fruit snacks | 0.8 | =B6+(B6*0.1) | 31 |

Range from B4 to D6

**Figure 2.22** Cell block

In a formula, a range is written showing the starting cell and ending cell of the range. Different programs use different symbols to separate the start and end of a range. For example, a range could be written as B4:B6 or B4..B6. When a formula is entered and the mouse is used to highlight the range needed, the program automatically includes the symbol when it records the range selected.

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## EXERCISE 2.8

1 True or false? Rewrite each false statement to be true.
 a Formulas cannot be copied within a spreadsheet.
 b Copying a formula to a range of vertical cells is called Fill Down.
 c Entering a formula into each cell of a spreadsheet is the most efficient method of data entry.
 d A formula does not need a special symbol to be recognised as a formula.
 e Spreadsheet design comes before the data is collected.
 f The formula =(A3+A4)/2 is the same as =AVG(A3:A4).
 g The formula =A1*A2*A3 is the same as =SUM(A1:A3).
 h Labels are more valuable than formulas in spreadsheets.
 i Formatting a spreadsheet is best done after data is entered.
 j 45 is a value, whereas 4*5 is a formula.

2 The following small spreadsheet contains formulas in some cells. Work out the values that would be shown on the screen in cells A3 and B3.

| | A | B |
|---|---|---|
| 1 | 10 | 11 |
| 2 | 2 | =A1+A2 |
| 3 | =A1+B1 | =SUM(A2:B2) |

3 What name is given to the following?
 a The intersection of a row and column
 b A vertical arrangement of cells
 c A horizontal arrangement of cells
 d The coordinates of a cell's location
 e A title or heading shown in a cell

4 What is the most valuable type of data that can be entered in a cell? Explain your answer.

5 Write each of the following groups of cells as a range of cells.
 a A1,A2,A3,A4,A5,A6,A7,A8,A9,A10
 b G4,G5,G6,H4,H5,H6

6 Explain the difference between a range of cells and a block of cells.

7 Answer the following using full sentences.
 a What are the THREE main types of data used in a spreadsheet?
 b Give ONE example of each of these data types.
 c What is the advantage of using a function (such as SUM) rather than adding each cell individually?
 d Rather than use Fill Down, it is possible to enter each formula for each cell separately. Why would Fill Down be a better method of completing formulas?

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### MODELLING TOOLS IN A SPREADSHEET

A spreadsheet program will allow the user to create charts to model data and to use the calculations and charts for simulations. Pie charts are most useful when the user wants to see the parts of a whole. Series charts (line, bar or column and stack graphs) are most useful when the user wishes to compare different parts of a concept.

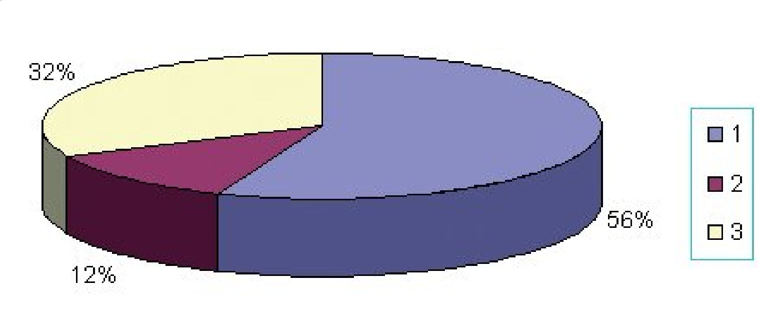


Figure 2.23 Pie chart

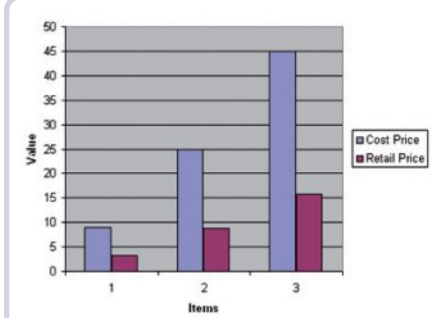


Figure 2.24 Column chart

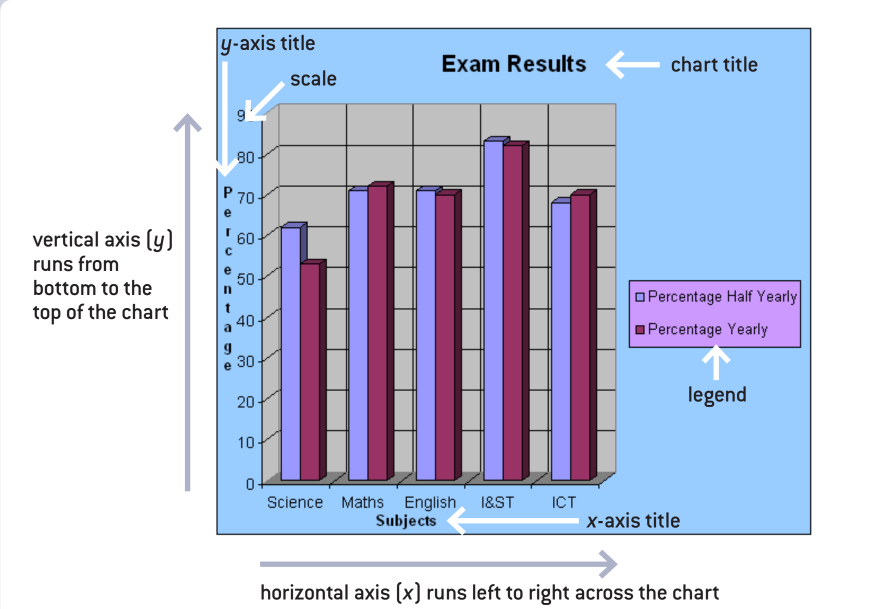


Figure 2.25 Parts of a chart

### SPREADSHEETS AS SIMULATION TOOLS

Spreadsheets are valuable for simulating the future, that is, making predictions. These are called ‘what if’ predictions because the user of the spreadsheet changes the data to see what would happen if the situation was changed in the future. For example, a manufacturing business could use a spreadsheet to see what would happen if the prices of raw materials changed. Managers could see how this would change the prices the business would charge for the manufactured goods.

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### SPREADSHEET TOOLS TO ASSIST WITH PREDICTIONS

*Goal seek* allows the user to change the value of a cell until a formula that depends on that cell provides the desired result. This is useful when the result is known but not the value needed to obtain that result. For example, a business might need to make $1000 profit on a sale, that is, the result is known. Managers have already totalled the cost and quantity of the sale items and goal seek will allow them to decide how much mark-up to give each item to meet their sales profit target.

*Lookup* is a function to obtain values from a cell that meets set criteria either in a row, column or block of cells. In figure 2.26, to find the value (department) in the cell range A2:B5 where the criteria is the employee Han Merit, the lookup formula would be

```
=LOOKUP("Han Merit",A2:B5)
```

and returns the value in the cell to the right of the lookup item.

This would be very valuable where there was a large amount of data, as it is easy to find that Han Merit works in department 27.

| | A | B |
|---|---|---|
| 1 | **Employee** | **Department** |
| 2 | Jan Simpson | 35 |
| 3 | Han Merit | 27 |
| 4 | Lilith Ang | 12 |
| 5 | Holly Wood | 9 |

**Figure 2.26** Lookup table

### SPREADSHEET FORMULAS

Cell references in formulas may include:

- relative references or variables, that is, the cell reference will change as its contents are copied from cell to cell according to the relative location of the cell to which the contents are copied
- absolute references or constants, that is, the cell reference will always refer to the same cell regardless of where the cell contents are copied

In *relative references*, the formula in a cell is relative to the position of the cell. So, in the example in figure 2.27, if the formula =B3*A3 is copied from C3 to C4 the formula will change to =B4*A4, that is, the formula will change to show its new location.

*Absolute references* always refer to the same cell. In some spreadsheet programs an absolute reference is given an @ sign before the column and/or row reference, for example @A@2. Other programs use a dollar sign before the column and the row coordinates e.g. $A$2.

| ◇ | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | 4 | 4 | =B2*A2 |
| 3 | 5 | 6 | =B3*A3 |
| 4 | 7 | 1 | =B4*A4 |
| 5 | | | |

**Figure 2.27** Relative referencing

Absolute references may refer to either the column or the row reference as well as to both. Examples show column B and row 4 as relative references.

- =B4*$A$2  Both column A and row 2 are absolute references

**Think about this**

Equity involves providing ways in which technology is available to all those who want to use it. The faster the changes in technology and the more options available, the greater the possibility of leaving disadvantaged people behind. For example, for many people, computers and mobile phones are expensive to buy and costly to maintain, and access to electronic modelling and simulation is an impossible dream. How can we give disadvantaged people a fair share of access to the advantages of technology?

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| | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | 4 | 4 | =B2*$A$2 |
| 3 | 5 | 6 | =B3*$A$3 |
| 4 | 7 | 1 | =B4*$A$4 |
| 5 | | | |

**Figure 2.28** Absolute referencing

- =B4*$A2 Column A is an absolute reference and row 2 is relative
- =B4*A$2 Column A is a relative reference and row 2 is absolute

In the example in figure 2.28, if the formula =B3*$A$2 is copied from C3 to C4 the part of the formula that is an absolute reference ($A$2) will stay the same. The formula in C4 will become = B4*$A$2.

## Advantages and limitations of models and simulations

In many situations, models and simulations are cheaper and more controllable than the real-world event they represent. However, they can also have major limitations. To be effective, they must include all the relevant factors in their design. Sometimes this isn't possible, as human knowledge may not yet understand the situation fully or human error may leave out some factors. The more factors the model or simulation neglects the less likely that it is accurate.

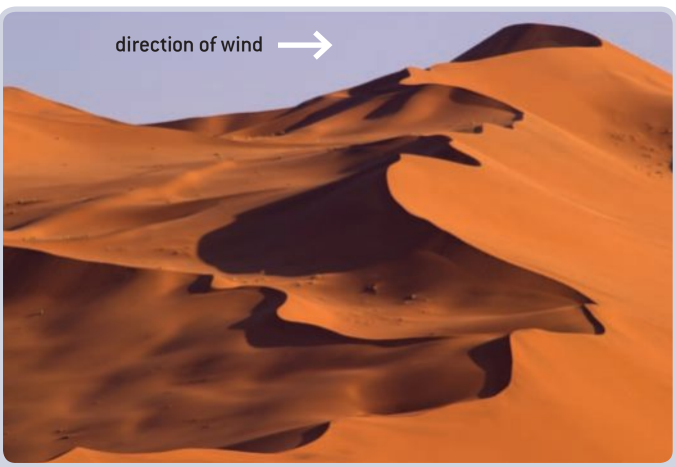


**Figure 2.29** Environmental model

Models and simulations might only cover one aspect of a problem. For example, a model of the effect of wind on a desert landscape can only consider one type of landscape. Other elements in a landscape may need to be studied in another model.

Because of the limitations of models and simulations, it is important to remember that predictions such as global warming, ozone layer changes and weather forecasts only consider those factors they have available to them. It is impossible for them to provide more than general guidelines in these situations.

### EXERCISE 2.9

1 Match each term in column 1 with the best description of that term from column 2.

| Term | Description |
|---|---|
| absolute reference | copy of cell values or functions, but changes cell addresses so that they relate to the destination |
| alphanumeric | graphical display of parts of a whole based on spreadsheet data |
| block | letters and numbers used to locate the intersection of a column and row |

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exercise 2.9 continued

| | |
|---|---|
| cell address | always used to begin a formula in a cell |
| constant | cell value or formula that changes in relation to its position in the spreadsheet |
| coordinates | cell value or formula that does not change |
| formula | group of adjacent cells, vertical or horizontal |
| pie chart | row/column location of a cell in a spreadsheet |
| range | spreadsheet using letters to identify columns and numbers to identify rows |
| relative reference | equation displayed as a value in a cell |
| sign e.g. = | horizontal and vertical group of cells |
| variable | exact copy of formula, with the cell references remaining the same |

2 Answer the questions based on the following spreadsheet.

| | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | 4 | 4 | =B2*$A$2 |
| 3 | 5 | 6 | =B3*$A$2 |
| 4 | 7 | 1 | =B4*$A$2 |

a What name is given to the cell reference $A$2 found in the formula in C2?
b How is this type of cell reference different from the other part of the formula, B2, found in C2?
c What values would appear in the cells C2, C3 and C4?
d If Fill Down was used to copy the formula in C4 to cell C5, what formula would be used in cell C5?
e What value would appear in cell C5?

3 Answer the following questions in full sentences.
a Does formatting change the contents of the cell or just the way the data appears on the screen?
b Give an example of a 'what if' prediction or a forecast.
c Explain the use of Goal seek and Lookup in a spreadsheet.
d Give TWO reasons why models and simulations need to be used with an understanding of their design limitations.

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# Artificial intelligence, simulation and modelling

## Multiple choice questions

Select the best answer to each of the following questions.

1 The ability of machines to learn, reason and to use language is known as
- A Modelling
- B Management development
- C Artificial intelligence
- D Logical reasoning

2 Reasoning is best described as the ability to
- A Suggest new ideas
- B Learn
- C Explain the decisions made
- D Describe the appearance of intelligent hardware

3 At present, artificial intelligence is
- A At the same level as human intelligence
- B Different from machine and human intelligence
- C Superior to human intelligence
- D Not as complex or as capable as human intelligence

4 In 1936, a machine able to perform logical operations was developed. It was called the
- A Eliza engine
- B Turing machine
- C SHRDLU
- D LISP logical engine

5 A collection of facts and rules that form the basics of machine reasoning are known as a
- A Knowledge base
- B Intelligence base
- C Expert base
- D Logic base

6 Unstructured data in an AI system is usually searched by a
- A Demon
- B Data miner
- C Expert system
- D Intelligent agent

7 The type of reasoning used to search for answers among unclear facts and rules is
- A Debating
- B Deliberating
- C Fuzzy logic
- D Furred argument

8 To use a simulation, it is important to
- A Use a programming language
- B Develop a model first
- C Construct a virtual system
- D Copy the real world exactly

9 A simulator works best when it uses
- A As many factors from the real situation as possible
- B A wide range of hardware devices
- C Many different programming tools
- D Complex and colourful graphics

10 Hardware used in a simulation usually has the capacity for
- A Large data storage and no processing
- B Large data storage and simple processing
- C Small data storage and parallel processing
- D Large data storage and parallel processing



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## Extended answer questions

Figure 2.30 is a concept map showing the major parts of spreadsheets.

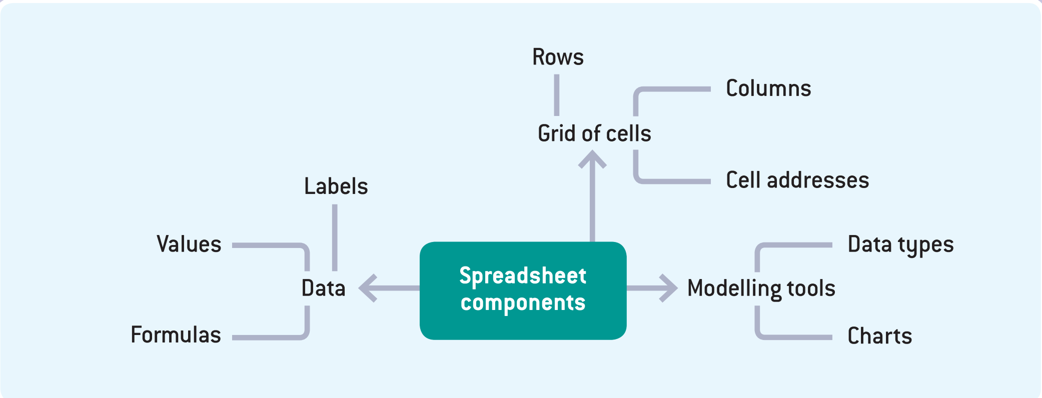


Figure 2.30

Write answers to each of the following questions.

1. Name the TWO parts of a cell address and give an example.
2. Draw ONE OR MORE diagrams to show how a cell range is different from a cell block.
3. Write an example and use it to explain the parts of a spreadsheet formula.
4. If you clicked on a cell containing a formula, where would you normally look to see the formula?
5. Why are formulas such an important type of data?
6. Explain the difference between a relative and an absolute reference in a formula.
7. When would a 'what if prediction' be used?
8. What is a spreadsheet function?
9. Describe the use of the Lookup function in a spreadsheet.
10. Which situations would be best modelled by using a pie chart and in which situations is it better to use a series chart?

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## PROJECT 1: RESEARCH THE CONTENT FOR A KNOWLEDGE BASE

Note: The solution to this problem could be presented electronically or manually and may use a range of tools to collect and produce the output.

### Define the problem

Decide the problem to be solved. Choose a topic that is not too wide. For example, don't try to find everything about animals, choose just one type of animal. Better still, choose one example of one type of animal – for example, instead of selecting spiders, choose to find all you can on the subject of redback spiders.

### Analyse the problem

1. Collect the data. Research the topic from every source you can locate, using at least five of the following types of sources: books, CD-ROMs, encyclopaedias, magazines, journals, the internet, people (experts).
2. Produce a list or bibliography of the sources you used.

### Design a solution

1. Organise the data in an appropriate manner. This may involve the use of a table, alphabetical order, specific headings for each characteristic or item to be recorded, graphics or other material ordered in a useful way.
2. Decide the most appropriate method of recording and storage based on the tools you have available and the material you have collected. Some suggestions include card files, a small exercise book or pad, a database, hypermedia or electronic card system.
3. Plan the solution carefully so that it is consistent, and accurate, and lacks bias. What headings are best? What type of data will be included with each heading? Is it possible to use scanners and other devices to store graphical data?

### Produce the solution

Follow the decisions you have made in the analysis and design stages.

### Evaluate the solution

1. Display the solution to others and ask for verbal or written feedback
2. Explain the additional components needed to expand the solution into an expert system. Use an expert system shell to develop the project if one is available.

## PROJECT 2: USE A SPREADSHEET FOR MODELLING AND SIMULATION

### Define the problem

Your local cinema wants to model its recent use patterns.

### Analyse the problem

The cinema has already collected the data for you (see table 2.11).

### Design a solution

The collected data is in table form. The required data is numeric and the outcomes will be shown best as a spreadsheet.



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## Produce the solution

1 Enter this data onto a spreadsheet and save the file as CinemaModel, then carry out the following tasks.
2 Add a column, labelled 'Total Tickets', to show the total number of people that attended on each day. Use the formula =SUM(B5:C5) or its equivalent and the Fill...Down option to carry out the calculations.
3 Add a row, labelled 'Total', to show the total number of:
- adults who attended over the period
- children who attended over the period

4 Use a function and range for the needed calculations.
5 Leave a row.
6 Add a row, labelled 'Maximum', to show the maximum numbers of adults and children that attended on any day during the period covered by the data.
7 Add a row, labelled 'Minimum', to show the minimum numbers of adults and children that attended on any day.
Note: Max and Min are available functions
8 Challenge: Add a row, labelled 'Days', to show the number of days during the 'run' (Note: a COUNT function is available in most spreadsheets).
9 Format the spreadsheet labels as bold.
10 Save the spreadsheet as Cinema1.
11 Insert two columns (%Adults, %Children) and use calculations to show the percentages of the audience that were adults or children for each day. Format the two columns as percentage.
12 The numbers of adults who attended the production on September 8, 9 and 10 have been incorrectly given. Edit the contents of the appropriate cells to change the data to: September 8 – 516, September 9 – 463 and September 10 – 402.
13 Save the spreadsheet.
14 Use appropriate charting tools to graphically model the following data. Save each chart on a separate worksheet.
- Total tickets sold for each day between September 10 – September 16
- Comparison of maximum and minimum numbers in attendance between September 2 – 22
- Percentages of adults and children attending over the total period.

15 Save the spreadsheet.

**Table 2.11** Cinema daily attendance over a three-week period

| Local cinema Date | Adults | Children |
|---|---|---|
| September 2 | 385 | 843 |
| September 3 | 411 | 715 |
| September 4 | 334 | 664 |
| September 5 | 401 | 1012 |
| September 6 | 346 | 782 |
| September 7 | 433 | 875 |
| September 8 | 481 | 918 |
| September 9 | 411 | 808 |
| September 10 | 417 | 845 |
| September 11 | 393 | 722 |
| September 12 | 477 | 904 |
| September 13 | 578 | 976 |
| September 14 | 468 | 953 |
| September 15 | 364 | 899 |
| September 16 | 463 | 927 |
| September 17 | 459 | 932 |
| September 18 | 593 | 1007 |
| September 19 | 694 | 996 |
| September 20 | 755 | 1016 |
| September 21 | 742 | 951 |
| September 22 | 569 | 962 |

## Evaluate the solution

1 Judge the usefulness of the spreadsheet by carrying out the following task: Given that the management expects a 5% growth in cinema attendance in October, model the expected figures, that is, make a 'what if' prediction for the month of October.
2 Save this spreadsheet as Cinema2.

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CHAPTER 3

# Authoring and multimedia

**Multimedia systems** an information system that combines at least two types of media.

**Multimedia systems** are information systems that combine at least two or three types of media. These systems use media such as text, including hypertext and numbers; audio or digitised sound; images, both static and animated; and video. They usually involve the participant interactively in their use, that is, the user has control of the direction the program follows. Authoring programs support the development of multimedia. They generate programs quickly, handle the range of data needed for multimedia and generally make it easier for those with limited programming experience to develop a professional program.

## Multimedia products

One of the most important factors in the development of multimedia is the choice of software tool that will do the required task. These tools cover multimedia products already developed as well as authoring systems that support the development of multimedia and programming languages. They are used in many areas including education, entertainment and information.

### Education

Educational multimedia systems involve the learner in a learning environment that uses all media. They can provide computer-based training and remote-distance learning, as well as track sporting performance. The major advantage is that the presentation is interactive, and the learner is engaged and is able to read, understand and select the direction of their learning at their own pace. A simple multimedia product to give a lecture or seminar in an interesting manner can be produced relatively quickly.

Multimedia also provides a cost-effective mechanism to train people. These programs are usually more specialised – such as tutorials using screen shots, picture, sound, and video to train people in a specific task.


**Figure 3.1** A multimedia help menu



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**Table 3.1** The benefits of multimedia education and training

| Benefit | Description | Example |
|---|---|---|
| Consistency | Each lesson follows the same structure and uses the same components to cover different topics | Menus are always in the same screen location |
| Adaptability | Lessons can be set to meet the participant's needs | User levels from beginner to advanced |
| Self-paced and self-directed | Control of learning given to the user | Hyperlinks allow non-linear navigation |
| Customisation | Program can be set to adapt to the user as the program reacts to various types of feedback | Program may identify from a test module that the user is having difficulty with a concept and provide additional training modules on that concept |
| One-on-one tuition | Non-judgemental | Only the machine is aware of results unless they are being monitored by others |
| Expert content | Allows a teacher with a lot of knowledge to provide that knowledge to many more students than would have been possible in the past | A physics module written by Stephen Hawking and developed into a multimedia tutorial |

## Entertainment

Multimedia systems can be used for computer games and other leisure activities. Computer games include video clips, animation, integrated sound and advanced 3D graphics to challenge users with fantasy or realistic situations. This form of multimedia requires a very high level of interactivity. Special hardware such as a joystick, mouse or trackball may be needed to interact with the game and the machine needs a lot of RAM, a good graphics card and a good sound card to take full advantage of the multimedia. The graphics card plays an essential role in the display by processing the required data.

Computer games have large memory and processing requirements because of their complex graphics, and their reliance on multiple graphics and video. Little text is included in most games. One of the increasingly popular uses of computer games is the online interactive game. These allow users to network computers to play with multiple competitors or to play games across the internet. Games are now developed using dedicated game engines and custom languages.

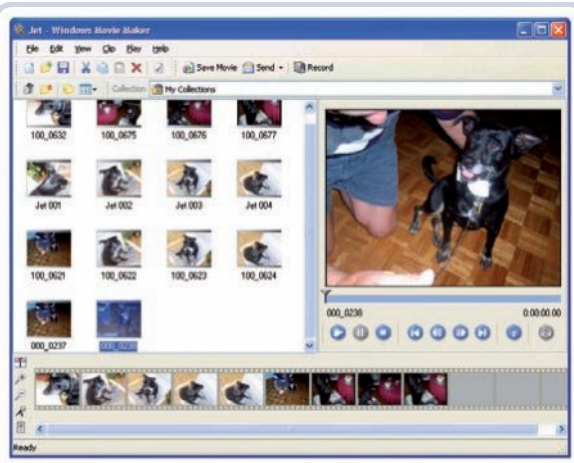

**Figure 3.2** Multimedia assistant for video development

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## Information

Multimedia can be used to provide information in an interesting and interactive manner, replacing human assistants. For example, the Powerhouse Museum in Sydney has information kiosks at the entrance to the museum. Users can see what displays are available and find out how to get to the correct area in the museum to see the full display. Visitors to large office buildings can be guided via directories in the foyer to the companies and businesses in the building. The visitor has some basic knowledge about the building's occupants and is given guidance on how to locate each business. Businesses can use multimedia to demonstrate new products, to show users how to use specific products and to compare products and services. Bank websites could guide visitors through loan calculators and investment options with the intention of attracting more customers via a more user-friendly, interactive presentation of the information.

All kinds of data can be combined to create many different types of online, CD-ROM (compact disk-read only memory) and DVD (digital versatile disk) multimedia. The amount of information on CD storage is up to 700 MB or about an entire encyclopaedia. A DVD holds far more. Sounds, images and video take up massive storage space but it is still possible to include a lot of text. The use of a search mechanism, combined with the computer's ability to search for any data the user needs, means that information is available in a very different way from using a book. Instead of turning to the book index or using the table of contents, a keyword can be typed into the system and all references to that subject located in a very short time. The user can structure the way information is displayed in a way that isn't possible with a book. All the pictures could be studied or the video clips viewed before the text was read. For example, an information CD about basketball could be created to include skills training. The user would have the option to 'freeze' any particular movement and study the ideal approach needed for that type of skill.

Figure 3.3 Multimedia messaging systems are now part of mobile phone technology

## Communication

Messaging systems have used one medium in the past, for example, flag signals are visual and telephones are vocal. IRC (internet relay chat), email (electronic mail) and SMS (short message service) followed this tradition when they first started. These systems then expanded to include other media so that IRC now supports real-time conversation across the internet but may also include web cameras so that those speaking can

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be seen, whiteboard space so that diagrams and text are visible to all, and application sharing. Some software allows remote assistance or control of one computer by another person using a computer from a remote location. Such forms of messaging allow people to interact with others, giving support particularly to those who live in isolated areas and those people with disabilities who find it more difficult to communicate with others. More information can be found in chapter 6 under VoIP (voice over Internet Protocol).

**Great idea**

Messages, once sent by smoke signals and in modern times by memos, may now be sent by other means: SMS (short message service) and MMS (multimedia messaging service). SMS can now use talking text to deliver a message, combining two media. MMS uses WAP (wireless application protocols) to send photographs, video clips, sound files, text messages and email. Currently, the most common use of SMS and MMS is communication between mobile phones.

## EXERCISE 3.1

**1** Match each term in column 1 with the best descriptions from column 2.

| Term | Description |
|---|---|
| audio | product using more than one type of media |
| authoring | types of data such as text or video |
| graphics card | process of game playing across a network connection |
| interactive | programs supporting the development of multimedia |
| kiosk | set of instructions to complete a task |
| media | digitised sound |
| MMS | user actively controls the direction of program display |
| multimedia | electronic information centre |
| online | hardware needed to provide display of images and video |
| program | mobile phone service that supports audio, video and text messaging |

**2** Answer the following questions.

- **a** List the types of data stored on multimedia.
- **b** Why is multimedia referred to as 'interactive'?
- **c** Why is multimedia data usually stored in digital rather than analogue form?
- **d** Compare information multimedia to a reference book.
- **e** What takes up most of the storage space on multimedia?
- **f** Name TWO areas in which multimedia is being widely used.
- **g** What hardware is required to use multimedia information systems?
- **h** How is multimedia different in its presentation on CD-ROM from its presentation on the internet?
- **i** Give FOUR advantages of using multimedia in education.
- **j** Name TWO hardware devices, apart from general computer hardware, needed for the use of multimedia in entertainment.
- **k** Why do multimedia games have large processing and memory demands?
- **l** Compare online interactive games with conventional computer games.
- **m** Describe ONE example of interactive multimedia used to deliver information.

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# Data types

Data is the raw facts used by a system. Data in a multimedia system is digitised, that is, it is digital data or data that has been changed into digital form. Digital media has one major advantage: it may be copied perfectly. Digital data is represented by a series of numbers expressed in the 1s and 0s of binary code, that is, digits. Data types including text, hypertext, images, animation, audio and video (as shown in table 3.2) may all be handled as a series of these digits.

**Table 3.2** Common multimedia data types

| Type | Description | Importance | Use |
|---|---|---|---|
| Text | A meaningful string of characters – letters, numbers, symbols or punctuation | Text should accent the main message as well as provide a body of information on each screen | Fonts<br>Menus<br>Animated text |
| Hypertext | The presentation of text in non-sequential ways | Allows nonlinear user navigation between or within documents | Hot text or hot links to other documents or parts of a document activated by the user |
| Audio | Digital sound consisting of waves that represent change in air pressure | Enhances the presentation by giving it greater reality | Illustration and demonstration of concepts<br>Speech and music |
| Images | Digitised pictures (graphics) | Communicate more widely than text; add interest; used for analysis, to aid visualisation and to communicate information | Line drawings, photographs, scanned diagrams, icons – information, illustration and navigation |
| Animation | The illusion of movement achieved by displaying a seriesof static images, called frames, in a rapid sequence | Allows movement to be demonstrated and adds interest | Information and illustration of processes and events |
| Video | Continuous stream of data (graphics and sound) first created and then broken down into separate frames | Provides reality to a program | Small video windows to illustrate and inform users |

## Issues related to the use of data types

Use of multimedia implies the availability of hardware and software to support various data types. For example, in order to benefit from audio files, or sounds, a computer must be equipped with the appropriate hardware such as a sound card and speakers and software to play sound files.

Multimedia that uses any data types apart from text requires a large amount of storage space and a lot of processing by hardware. Graphics, animation, video and sound files are particularly large. This has led to the development of techniques to reduce these hardware demands. Two important techniques, streaming and compression, are explained here. Further detail on these will be found in other chapters of this book.

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*Streaming* is the process that allows video or audio frames to be loaded and played before later frames are loaded. As the frames are loaded, some are being played, others are being discarded from memory and still others are being loaded into RAM. The user believes the whole video is loaded but the memory only retains a few frames at a time. The method depends heavily on getting the stream of frames to move at the right pace.

Data compression makes files smaller. Data compression techniques are needed as secondary storage has limited capacity and many data files require considerable space to store. Compression reduces the physical size of large files using techniques to remove or summarise redundant or repetitious data. There are various methods of compressing files depending on the type of media, but the result can reduce the file by between 5 and 95 per cent.

**Try this**

**Working with a digital camera**

Use a digital camera to take a series of photographs of the computer hardware used for multimedia. Import the images to a computer. Use the images for at least two different reasons, for example:

- to email to a friend as attachments with a message explaining each image
- to import into a report on hardware
- to design and present a slide show on the range of hardware available to you

**Table 3.3** Methods of data compression

| Technique | Description | Use | Compression |
|---|---|---|---|
| Lossless | Repetitive patterns are coded into a summary and data retrieved is the same as data stored | Most text files where it is vital that no data is lost e.g. database files | File may be reduced to 30% or more of original size |
| Lossy | Data is discarded during compression e.g. shades of colour in a graphic or soft sounds in a sound file; some data is irretrievably lost | Sound, images and video files where lost data can be masked by other data | File may be reduced to 5% of original size |

Data compression techniques for reducing the size of files.

Other issues associated with the use of data types in multimedia will determine the type of data chosen and the balance of data types used in a multimedia product.

**Table 3.4** Some issues related to the choice of data type

| Data type | Issue | Explanation |
|---|---|---|
| Text | Amount of text on a screen | Too much text results in an overcrowded screen lacking interest; too little text and the number of screens needed increases as well as leading to endless navigation between those screens. |
| | Amount of text on a page | Preferably text should fit on a page with minimal scrolling. |
| | Legibility | Text should be clear and easy to see so fonts should be chosen for style, size and typeface. |
| | Readability | Sans serif fonts (no 'tails' on letters) are a better choice of font for electronic presentation of data. |
| | Consistency | Use of the same fonts, styles, colour and size over multiple page documents |
| | Meaningful menus | Minimal direct text e.g. GO menu on a web browser |

continued >

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| | | |
|---|---|---|
| Hypertext | Meaningful, intuitive (easily understood) links | Users should easily understand where links are going and the nature of the links. It is better not to overuse links in documents. |
| Audio | Form of storage: WAV or MP3 | Choosing a compressed form will save on space and improve loading time. |
| | Storage space | Due to the size of audio files their use needs to be restricted. |
| Images | Type of graphics | Bitmapped images take more space but allow more detail to be shown. Vector images need less space and are good for line drawings. Animated images need more memory. |
| | File formats support different outcomes | GIF (graphics interchange format) for drawings and illustrations supports transparency, animation and interlacing. Interlacing means that each line of the graphic can be refreshed when the graphic is displayed on the screen. Images saved in GIF are restricted to 256 colours. JPG or JPEG (Joint Photographic Experts Group) is mainly used for photographs and medical imaging. It allows very high compression ratios and thus speeds up download of such images. JPG allows files to be stored using many more colours than GIF, up to 24-bit colour (over 16 million different colours). |
| Video | Standards and formats | Some programs do not accept video. It is preferable to use more common standards such as Quicktime or MPEG where programs have such capability. |
| | High demands on processing and storage | Video should only be used when the other multimedia data types cannot do the task and needs processes such as streaming and compression to reduce processing demands. |
| | Complexity of editing process | Dubbing is the process of adding sound to a video, and titling is the process of adding titles (text) to frames or overlaying titles on existing frames. This is a skilled procedure. |

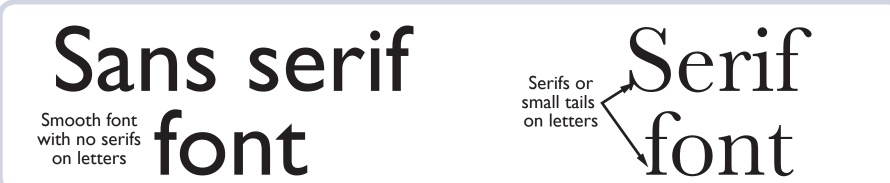


**Figure 3.4** Sans serif and serif fonts

## Data sources

Data sources are important to multimedia, as much of the data used is imported into a multimedia program from outside the program. They are often created elsewhere and by people other than the multimedia author.

**Table 3.5** Sources of data

| Source | Description | Type |
|---|---|---|
| Book | Hard cover or soft cover collection for information and/or entertainment | Paper |
| Internet | Worldwide dynamic set of linked computers | Electronic |
| Magazine | Periodic publication | Paper or electronic |
| Journal | Professional publication | Paper or electronic |

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Problems encountered during the collection of data from sources include:
- bias – distortion of information to suit a particular purpose or present a one-sided argument
- accuracy – the difficulty of deciding the reliability or truthfulness of data from sources
- validity – the usefulness and currency of the data source

Often these factors are judged from the type of source and the author's credentials, and by comparing more than one source.

Other very important factors concern the ownership or copyright of source material and the issue of piracy or theft of material developed by others. Copyright is legal ownership and applies even when no copyright notice exists. More information can be found on data sources and these issues in chapter 6.

**Think about this**

Security involves making data on a computer safe from those who do not have the right to touch that data or system. Many people working with multimedia and authoring systems go to a great deal of trouble and expense to protect their designs from electronic theft. Existing security measures include locks, passwords, firewalls, anti-spyware and anti-virus software. The last three types of software are the minimum protection needed to keep a computer 'healthy' and prevent its functions from being controlled by external sources. Why is total computer security so difficult to achieve?

## Features of data types imported to multimedia products

Multimedia systems are easily identified by the range of different media they use: text, audio, images, animation and video. MIME (Multi-purpose Internet Mail Extensions) is a standard that defines types of media for multimedia applications. Multimedia products import many of these data types from other programs or as already created files. Given the many kinds of multimedia information (e.g. text, images, sound, animation and video), and even more formatting standards associated with them, it is essential to provide a guide that the software can use to decide how particular files should be treated or displayed. The standard way of doing this is to associate particular extensions of filenames with given types of media. For example, any file xxx.txt would be treated as ASCII text and any file xxx.gif would be treated as a GIF (Graphical Interchange Format) image.

**Table 3.6** File extensions used for data imported by multimedia products

| Medium | File extension/ format | Description | Use |
|---|---|---|---|
| Text | ASCII (.txt) | Raw unformatted text | All multimedia |
| | .HTML | Text marked up with tags so that it can display data | Web pages |
| | .RTF | Rich text format – text that includes formatting instructions | All multimedia |
| Images | .GIF | Compressed (lossless) bitmapped graphics supporting 256 colours, transparency and animation | Web pages and other multimedia |
| | .JPEG or .JPG | Compressed (lossy) bitmapped graphics supporting over 16 million colours | Web pages needing good quality photographs |

continued >

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| | | | |
|---|---|---|---|
| | .TIF | Tagged image file format, some of which use compression | Most multimedia will support TIF except the web |
| | .PNG | Portable network graphics | Web pages |
| | .WMF | Windows metafile format often used for vector graphics | Most multimedia except the web |
| | .CGM | Computer graphics metafile for vector graphics | Multimedia requiring line drawings |
| Sound | .MIDI | Musical instruments digital interface holds details of notes to be played | Multimedia using the necessary additional MIDI interface |
| | RealAudio (.ra) | Used to transfer sound data across the internet. Requires a real audio player (integrated with most browser software) | Web pages and other multimedia where the real player is included |
| | MP3 | MPEG standard – compressed audio sound | Web pages and other multimedia |
| Video | Quicktime | Available for both Macintosh and Windows and handles animation | Most multimedia |
| | .MPEG | Group of compressed standard formats | DVD multimedia |

## EXERCISE 3.2

1 What am I?
   a I am underlined text that allows navigation between documents.
   b I am digital sound.
   c I am the process of reducing the physical size of a file.
   d I am hardware used to control multimedia display through the monitor.
   e I am a meaningful string of characters.
   f I am the legal ownership of any data source.
   g I am a series of static images displayed rapidly to give the illusion of movement.
   h I am a method of display where the media begins to play before the download is complete.
   i I am the theft of data from the legal owner.
   j I am a continuous data stream broken down into frames for display.

2 Explain the use of each of the following data types in multimedia: text, hypertext, audio, images, video and animation.

3 Compare the following ideas:
   a legibility and readability of text
   b GIF and JPG image files
   c sans serif and serif fonts

4 Why would a computer with 2 GB of RAM be more useful for multimedia than one with 512 MB of RAM?

5 Describe the value of graphics cards for multimedia.

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exercise 3.2 continued

6 Name TWO techniques used to reduce the memory and processing needs of multimedia.

7 Identify the correct file type from the following descriptions.
- a compressed (lossless) bitmapped graphics supporting 256 colours, transparency and animation
- b compressed (lossy) bitmapped graphics supporting over 16 million colours
- c computer graphics metafile for vector graphics
- d MPEG standard – compressed audio sound
- e musical instruments digital interface holds details of notes to be played
- f portable network graphics
- g raw unformatted text
- h rich text format – text that includes formatting instructions
- i tagged image file format, some of which use compression
- j text marked up with tags so that it can display data
- k used to transfer sound data across the internet – requires a real audio player (integrated with most browser software)
- l Windows metafile format often used for vector graphics

## Display hardware used by multimedia

Display hardware refers to the physical components that visually present the data to the user, that is, screens, and the hardware that supports display. Screens or monitors come in many sizes, qualities of display and types. They are basically divided into three groups: video display units (VDUs), liquid crystal displays (LCDs) and plasma displays.

Display hardware the physical components that visually present the data to the user, i.e. screens.

Each type of screen has a different quality of display called *resolution*. Resolution refers to the number of individual dots of colour, known as *pixels* (picture elements), contained on a display. The pixel is the smallest display unit on the screen that can be controlled by the computer. Resolution is typically expressed by identifying the number of pixels on the horizontal axis (rows) and the number on the vertical axis (columns) of the screen, such as 1024 x 1024. The more pixels that can be supported by the display, the higher the resolution.

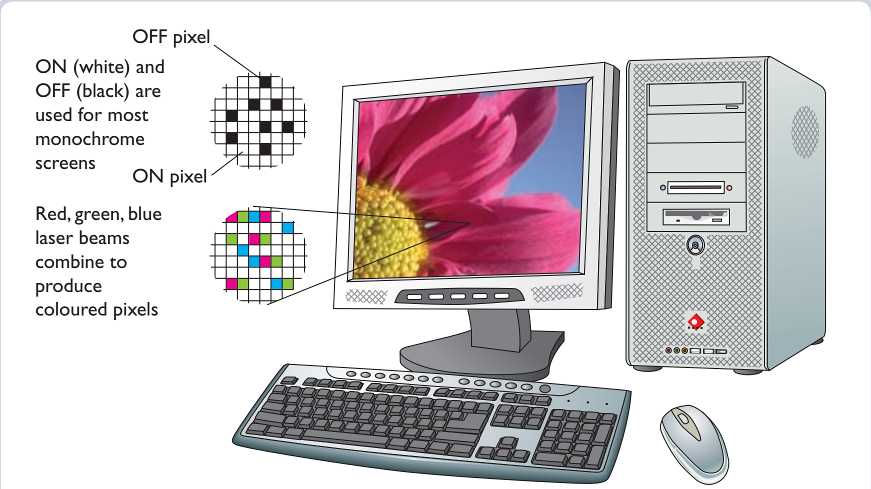


Figure 3.5 Pixels and screen resolution

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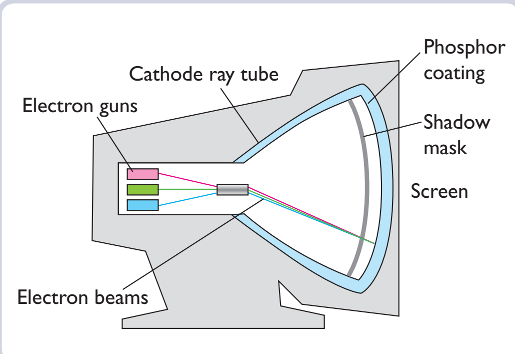


**Figure 3.6** Cathode ray tube components

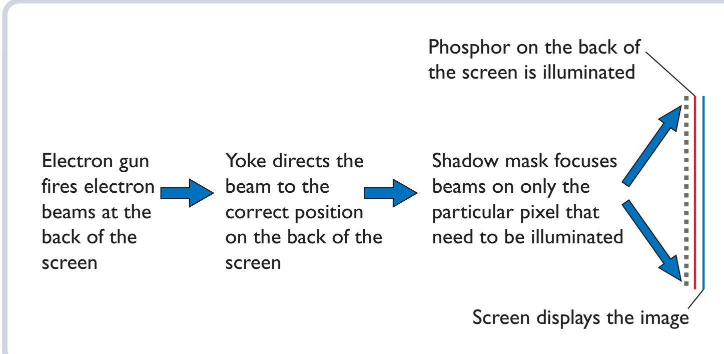


**Figure 3.7** Steps for creating an image on a screen by the CRT

## Video display units

The video display unit or monitor used on some personal computers uses a CRT or cathode ray tube to create images on the screen.

CRT display is produced when the phosphor coating on the back of the screen is lit or illuminated. Electron guns fire the beams of electrons toward the screen inside a glass tube. The electrons cause the phosphor to light up, that is, they cause the pixels on which the light is focused to glow. In order to focus on the selected pixels, electro-magnets in the yoke help to direct the beam/s toward the screen. To improve the focus so that only the exact pixels are lit up, a mesh called the shadow mask is located directly behind the phosphor coating. Three holes in the mask are aligned with one pixel (one for red, one for green and one for blue – called a triad). This, plus different intensities of light, produces the wide range of colours seen. An RGB (red, green, blue) or colour display screen has three electron guns and three types of phosphor coating.

The electron beams sweep the screen many times per second, renewing the light so that the screen display is constantly being renewed. This is known as refreshing the screen. CRTs produce a good image but they are very bulky and need both width and depth to work.

## Liquid crystal displays

LCDs are found on everyday items such as televisions, calculators, portable computers, digital watches and clocks, microwaves and CD players. They are thinner and lighter than CRT displays. LCDs are capable of displaying the same unlimited colours as a CRT but at a greater cost. They require less energy, which makes them capable of operating as battery powered as well as mains powered, such as in portable computers. There are three types of LCDs: common plane, passive matrix and active matrix.

Common plane LCDs are the cheapest and are used on inexpensive items such as handheld games and small calculators. They have very limited use for multimedia.

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Computers use either passive or active matrix LCD screens. Passive matrix LCDs use a grid connected to integrated circuits that control the charge that lights a pixel at the intersection of the row and column on the screen, that is, at screen coordinates. The response time is relatively slow, that is, they are slow to refresh the screen image.

Active matrix LCDs use thin film transistors (TFTs) arranged in a matrix. The pixels can be charged more accurately and hold the charge longer than in a passive matrix LCD. The brightness level is also more easily controlled. Most displays today offer 256 levels of brightness per pixel.


Figure 3.8 Plasma display

## Plasma displays

Plasma is a type of thin flat panel display using gas and electrical voltage to create images. To form an image, tiny coloured fluorescent lights are illuminated. Each pixel is made up of three of these lights (red, green and blue). The intensity of the lights is varied to produce a full range of colours. Plasma displays can be used to produce very wide and very thin screens. The display is bright and can be seen clearly from nearly every angle. However, plasma screens are very expensive.

## Graphics cards

Graphics or video cards function as co-processors to assist the micro-processor with display tasks. They have their own CPU (central processing unit). The driver software (a program to run the graphics card) sends all display instructions either directly to the graphics card or to the main CPU that then directs them to the card. The most recent cards are able to carry out millions of tasks per second and are of considerable importance for multimedia, modelling and simulations.

## Other hardware

Multimedia makes use of a range of multipurpose hardware. For example, scanners are useful in many computer operations but are valuable in multimedia for their ability to digitise text and graphics by copying them from paper. Keyboards and devices such as optical character readers are also used to input text.


Figure 3.9 USB jump drive

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**Great idea**

A USB or universal serial bus drive (also called a jump drive, flash drive, thumb drive or keychain drive) is a plug-and-play portable storage device that uses flash memory. It may be used in place of a floppy disk, zip drive disk, or CD. When the user plugs the device into their USB port, the computer's operating system recognises the device as a removable drive and assigns it a drive letter. A jump drive is particularly useful for storing large multimedia files.

## EXERCISE 3.3

1 Design a table with two columns. In the right-hand, smaller column, list the terms given below. In the left-hand column, write the corresponding description of that term.

| | | |
|---|---|---|
| co-processor | CRT | display |
| driver | laser | monitor |
| phosphor | pixel | RGB |
| scanner | | |

- a screen that can display text and graphics
- data presented on a screen
- method of storing data on CD-ROMs
- the smallest unit of display that can be controlled by a computer
- machine capable of copying an image or text electronically
- chemical capable of illumination
- a program to run a hardware device
- the hardware inside the VDU that produces the image on the screen
- another term for a colour display unit
- hardware that assists the microprocessor to carry out tasks

2 Answer the following questions.
   a List FOUR hardware devices of particular use to multimedia.
   b Name THREE different types of display screens.
   c Define the term 'resolution'.
   d A graphic is displayed at 64 x 64 pixels on the screen and again displayed at 128 x 128 pixels. Give an explanation for which resolution is higher.
   e How does a CRT produce an image on the screen?
   f Why are CRTs sometimes referred to as RGBs?
   g Name TWO types of LCDs used on computers. Which of these types is preferable for multimedia? Why?

# Authoring software

Authoring systems software applications that are specially designed to create programs or files that combine all or some of the data types for multimedia output.

Authoring systems are software applications that are specially designed to create programs or files that combine all or some of the data types available for multimedia. People who create programs in authoring systems are called *authors*.

There are many authoring systems available, each with their strengths and weaknesses. Some, for example, are very good at delivering classical text presentations but have few hypermedia functions. Others handle text and graphics well but are less efficient at handling audio and video. Most will allow you to:

- create new material – text or simple graphics
- import materials created in other software such as video clips, audio files, specialised graphics and animations

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## Interface design

An interface is a meeting point between any two parts of a system. The most familiar interface is the user interface, that is, the screen that allows the user to interact with the machine.

In a *command interface*, the user enters commands via a keyboard to carry out tasks. This is not common today and is difficult for those who have little understanding of computers. The user learns commands or uses a manual to copy commands. The spelling and the setting out for the command must be input exactly.

Authoring software uses a graphical user interface or GUI. A GUI is often called a WIMP (windows, icons, mouse and pull-down menus) to refer its four main parts. The user clicks or double-clicks on a command using a mouse. The command is usually in the form of an icon or a menu item. This interface is much easier to use, particular for those unfamiliar with computers.

An interface is a meeting point between any two parts of a system.

Graphhical user interface (GUI) a screen interface which uses windows, icons, mouse and pull-down menus.

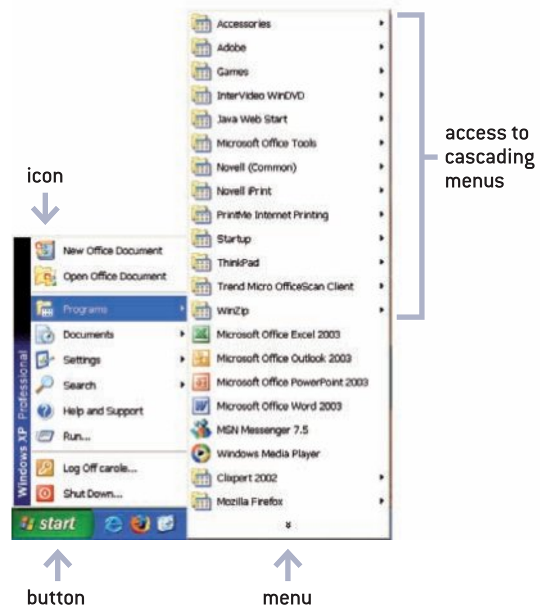


Figure 3.10 GUI interface

## Features and elements of a graphical user interface

The interface affects the way in which users interact with and perceive a computer system. Those using a GUI are more likely to perceive the computer as less threatening and find it easier to use. A GUI is simpler for less-experienced users and allows the author to see the output of their programming as they progress.

Table 3.7 Features of a GUI system

| Feature | Description | Examples |
|---|---|---|
| Consistent elements | Components that are similar in location and appearance from program to program | Close, restore and minimise buttons on a window (screen) |
| Functionality | Each item has a specific task | Menus that expand as the user requires e.g. right button menu |
| Navigation | Items that allow the user to move from one document or tool to another | Icons that can be clicked to open programs or files |
| Radio buttons, list boxes | Items that allow selections or choices to be made | Program menu |
| Borders and white space | Items that contain and isolate groups of items from others | Application windows as distinct from operating system window |
| Instructions to the user | Balloon help, feedback windows and help menus | Microsoft Office Assistant |
| Inclusive design | The ability to manipulate display to suit the user's needs | Large icons for those with sight problems; voice feedback |

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## Basic types of authoring software

Authoring software can be divided into four main types (see table 3.8). To varying degrees, these allow someone with little programming experience to write simple learning programs.

**Table 3.8** Types of authoring systems

| Type | Description | Advantages/disadvantages | Examples |
|---|---|---|---|
| Electronic slide show | Functions in a similar manner to a photographic slide show | Relatively cheap, easy to learn and use, provides templates and hyperlink capabilities but limits user interaction | Microsoft PowerPoint, Adobe Persuasion |
| Card stack or book | Interactive set of cards | Allows basic elements to be created in the program including graphics and simple animations, provides templates, easy to use and learn but often restricted to one hardware platform e.g. Windows | Hypercard, Asymetrix Toolbook |
| Icon-based | Symbols are dragged on to a flowline to create a series of events | Structure of the program is easy to follow and edit but more expensive and less easily learned than other types | Macromedia Authorware |
| Time-based | Functions like a movie with frames and pauses for branches to other actions | Very interactive, supports a wide range of user control, good for animations but very expensive and much harder to learn than others due to need to handle programming languages for advanced features | Macromedia Director |

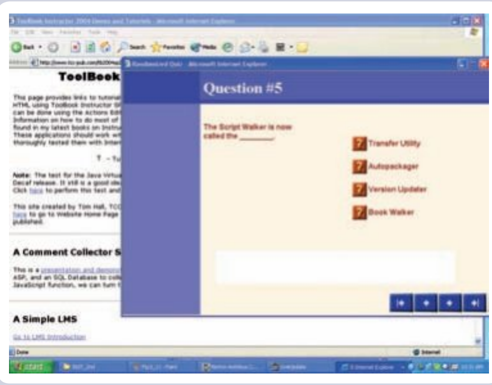

**Figure 3.11** Multimedia Toolbook development environment

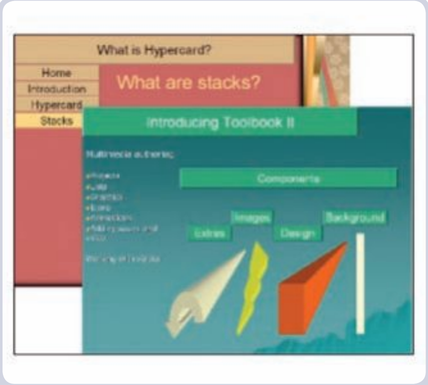

**Figure 3.12** Two cards from an Asymetrix Toolbook stack

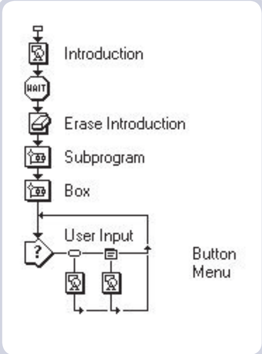

**Figure 3.13** Flowline from Macromedia Authorware (icon based)

**Programming languages** a set of instructions in which a program is written for a computer system.

## Programming languages

**Programming languages** are sets of instructions in which a program is written for a computer system. Authoring tools developed specifically for creating multimedia can be supplemented with, or substituted by, programming languages suitable for the task. The programming languages normally used are fourth generation languages (4GL) such as Visual BASIC and C++.

Programming languages require a skilled user called a programmer but they are more flexible than authoring software. Multimedia products will

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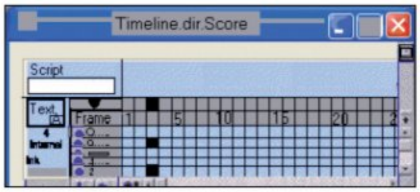


**Figure 3.14** Series of frames in Macromedia Director (time based)

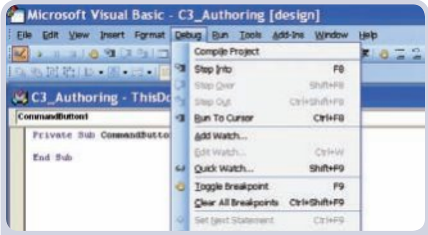


**Figure 3.15** Visual BASIC programming for applications

take more time to develop as the programmer has to create many of the tools that are already available in authoring systems. The programmer writes the code or instructions and is able to make the application very specific. This may be very important if programs are needed to run on different operating systems.

## Factors to consider when choosing authoring systems

The choice of an authoring system depends on the multimedia product to be created, the experience of the author and the audience to which it is to be delivered.

**Table 3.9** Basic factors to consider when using authoring systems

| Issue | Explanation |
|---|---|
| Functions available | Most authoring systems have functions to present text, integrate graphics, video and audio, create tests and provide feedback to users. |
| Data type requirements | Authoring systems may have restrictions on the use of certain data types, for example, video clips can't be controlled by the user but must always run at the same time and in the same place in the program. |
| Range of possible tasks | Many authoring systems have provisions for creating tests but only of certain types and following a rigid pattern e.g. multiple-choice questions only. |
| Help available | Help menus and wizards are built into many programs. Some also have internet support to assist with problems and user groups that will provide guidance. |
| Ease of use | The more complex the product the more training will be needed for its use. Some products also require programming skills in order to carry out all but the simplest processes. |
| Ability to import data | Some products restrict data to that prepared within the development environment. Others allow developers to move materials created in other programs into the development environment provided they are saved in acceptable formats. A few products directly link to other tools without having to take the steps needed to open, create, save and import a file. |
| Program output | Depending on what is required, the appearance of the final product may or may not be desirable in the authoring system being used. |

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| | |
|---|---|
| User control features | The authoring system may allow you to include only limited interactive features or it may have the ability to link to other products or documents. |
| Display properties | The authoring system needs to create executable programs (programs that can run outside the authoring environment) as the end result of a product. |
| System requirements | Final multimedia products are best when they are independent of an operating system and will work on most of the major computer platforms e.g. at least on Macintosh and Windows systems. |

## Multimedia authoring products: an example

*HyperStudio* is multimedia authoring software for teachers and students. It combines text, sound, graphics and video into technology-based learning activities in a book or stack format. It is easy to learn but lacks some of the functions of many more professional products. HyperStudio Player is part of the package, and allows the user to create programs that can be run without the full version of the authoring system. The player is a free program so that it can be included on disks holding HyperStudio programs and downloaded from the internet if it is needed. Using a plug-in for Netscape or Internet Explorer and some simple programming, HyperStudio programs can also be viewed using a browser. During the creation of a HyperStudio presentation, links can be embedded that will enable users to access internet sites directly, download files and display them in the presentation. This needs an active internet link but may be used to reduce the size of the HyperStudio file.

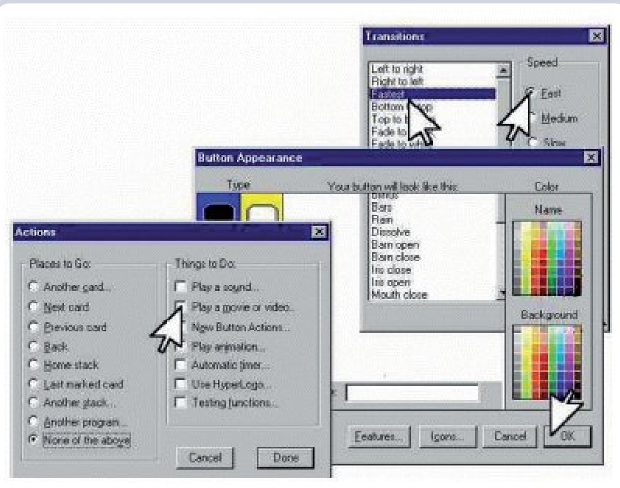


**Figure 3.16** Some HyperStudio multimedia options

HyperStudio offers assistance on the world wide web, updates, resources and technical advice. There is a demonstration application, samples of programs written for the authoring system, tutorials and discussion groups to help programmers.

### EXERCISE 3.4

1 Complete these sentences to make them correct.
- a Authoring systems may be described as ...
- b There are many different authoring systems available because ...
- c Most authoring systems have TWO major capabilities ...
- d GUI stands for ...
- e A GUI is a valuable interface for multimedia because ...
- f 4GL means ...

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exercise 3.4 continued

2 Answer the following questions.
   a Compare the FOUR main types of authoring systems.
   b Why would an inexperienced multimedia developer choose an authoring system rather than a programming language?
   c Name TWO programming languages used for multimedia development.
   d Describe FOUR main factors to consider when choosing an authoring system for a project.

3 Use the Print Screen button on a Windows machine or another alternative to capture an image of the operating system window. Open a Paint or word processor application and Paste (Edit menu) this image from the clipboard. Use the tools available to you in the application program to label the 'screen dump' with the features of a typical GUI. Save the file as GUI.

4 Using the information provided for HyperStudio and using table 3.9, write a report to evaluate the HyperStudio product or another multimedia authoring system available to you. In the report, note down any issues which require further investigation.

# Project development

Learning to use any product involves experience of the processes and techniques available to perform the necessary tasks to create the required program.

## GUI design for the multimedia product

Any form of product developed for users to enjoy requires good design. The very best team of skilled specialists, using the highest quality content and the latest technology, still has to consider the 'look' and behaviour of the final product as its most critical job. Good design principles are the same for all forms of media, although there may be some differences in the way they are interpreted for each media type.

## Good design principles for all forms of data

### Consistent layout and format

Each page or screen should use the same structure: menus in the same place, navigational elements in the same place, colour scheme and fonts the same throughout, with the same level headings the same size and any body text of the same kind and size. Frames are used to hold similar items and white space to increase the readability of the screen. There may be minor variations for different forms of media but, in general, consistency is the single most important factor in good design.

Figure 3.17 Graphical user interface of DVD multimedia

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### Easy navigation

Navigation provides the interactivity of a product. It should be easy to understand and easy to use as it is the means by which the user is able to choose the direction they follow in the program. Response time should be reasonable, and feedback should be provided to the user if there is any delay in the response to a navigational link.

### Design elements

It is best to use simple design elements that are understood by most people. Too many colours, too much sound, or overuse of animation and video will slow the response time and become distracting to users.

## Good design principles for different types of data

### Text

Text is used in many ways: for headings, content, labels, captions, menus and navigation. Multimedia text differs from the use of text in other situations in that the body of the text should usually be:

- able to be resized to suit the user. This is often a capacity of the operating system and caters for people with visual difficulties.
- displayed in a sans serif font as this is more readable on a screen. Sans serif fonts are those without the small hooks on the characters.
- restricted or limited to small amounts of text on any one screen. Scrolling text is useful but links at the top of the screen to other text later on the page are more valuable as people are more able to jump to where they wish to go.
- a good contrast with the background so that it is easily read
- 'chunked' in some way, that is, divided into smaller groups of text. This can be done using lists, tables and white space, and makes text more readable. Dividers could also be used to logically group text or to provide visual relief.

**Table 3.10** Some other uses for text in multimedia

| Use of text | Explanation | Design features |
|---|---|---|
| Headings | These should be noticeable, but underlining should be reserved for hypertext. | Distinguish them from body text using colour, italics or a different font. |
| Menus and navigational elements | Pop-up menus are often used to provide a list of choices without cluttering the screen. Pull-down menus that drop down from the menu bar at the top of the screen usually initiate some action directly. | Menus should not clutter the screen. Examples: right mouse button menus available in most Windows products, menu items that open a dialogue box such as the 'Print...' dialogue box that asks for further information before printing actually takes place. |

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## Images

Static images and animated images are used for illustration and interest. The important aspects to remember are number, size, position and balance. Too many images take too long to load and are less interesting. Images that are too large have the same problem for loading. Images should be placed to enhance text and to balance with the rest of the 'page'. People also forget about the other forms of images: icons. Icons are interactive images and should be used for the purpose for which they were originally intended, as people have an expectation as to how they will perform.

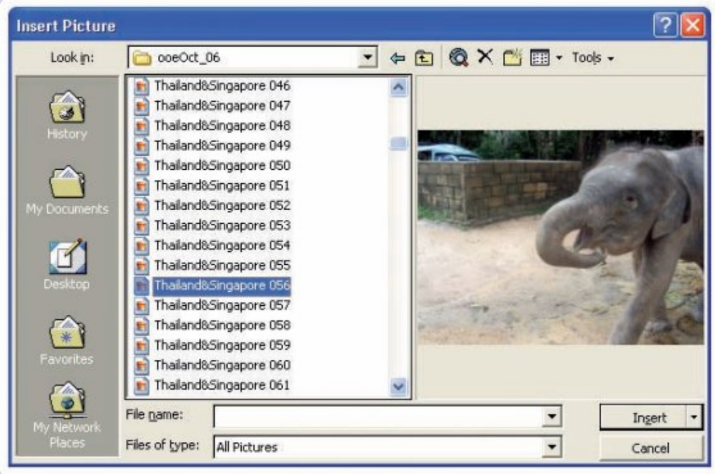


**Figure 3.18** Good design helps the user

**Table 3.11** Examples of icons and graphical elements used in multimedia

| Icon type | Description | Use |
|---|---|---|
| Buttons | A graphic usually labelled with text to indicate its function | Usually perform an instantaneous action to initiate an action. |
| Cursors | Often used to indicate the state of the system | Watch or hourglass cursors indicate a short pause, or change to indicate a change in the interactive possibilities offered by the interface (like the window resize arrow cursors that appear at the edges of windows). |
| Dialogue boxes | Special windows that pop up to provide information or choices to the user. Dialogue boxes are usually modal, that is, they must be dismissed (with the 'Cancel' or 'OK' buttons) before further action can take place. | Some dialogue boxes provide many buttons, pop-up menus, or other choices; others may just contain a text message with an 'OK' button used to dismiss the dialogue box. |

## Audio and video

Small video clips and sound files can be invaluable at the right time and can supplement information or substitute for other forms of information in a way that no other media can. However, audio and video both require considerable processing power and download time. They should be carefully chosen for their value to the multimedia product because they cannot usually be added for interest alone. Video clips should appear on the screen in the same location and provide user control, that is, start, pause and stop controls. Most operating systems provide some volume control for sound, but the user should be able to choose not to display video or sound if it is not required.

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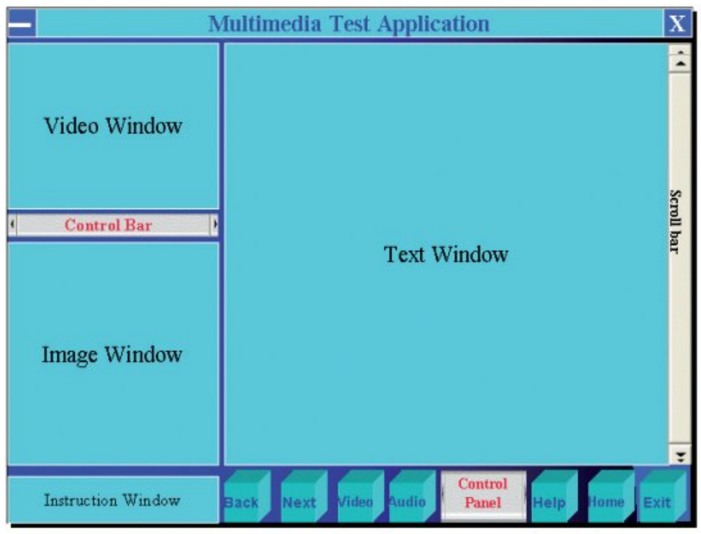



Figure 3.19 Template for the development of a multimedia test

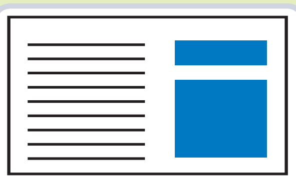
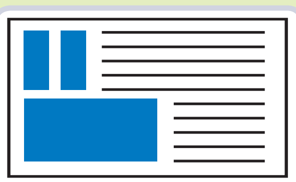
## Layout

Design principles involve a careful analysis of the requirements of the multimedia product and methods of understanding the structure to be developed. Electronic templates may be available in authoring programs to simplify these processes. These are documents that already incorporate overall design structures but which need to be customised by the user with their own content. Alternatively, templates can be designed by the developer in most authoring software.

## Balanced layouts

Balanced layouts balance the use of data types. Sound might be background sound or sound effects. Background sound should not intrude on the main purpose of the program but should add to the objectives to be achieved. Sound effects are brief sound tracks used to illustrate or inform. For example, a multimedia adventure game could use the sound of doors slamming and people running to add realism. Text, graphics, animation and video can be integrated to provide interest, challenge, information and entertainment in the one product. Video is usually limited to a small window to reduce the size of the file and the demands on processing.

Table 3.12 Layout issues

| Issue | Description | Example |
|---|---|---|
| Page layout: Portrait or landscape | The orientation of the screen page, that is, widthways or lengthways. Most screens are wider than higher (landscape). |  Figure 3.20 The landscape layout |
| Design layout: Asymmetric or symmetric | Symmetrical layout regularly places items on both sides of a screen or page. Asymmetrical layout is more difficult for inexperienced users as it is harder to achieve balance in an irregular design. |  Figure 3.21 Asymmetrical layout |

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## EXERCISE 3.5

1 Complete the following paragraph using words from the list.

| | | |
|---|---|---|
| author | consistency | distract |
| eyesight | good | group |
| large | load | memory |
| one | operation | problems |
| read | resizable | sans serif |
| simple | split | user |

When designing a multimedia program the (a) ___ needs to be aware of (b) ___ design principles. The most important of these is (c) ___ as this gives the program a unified appearance and (d) ___. As well it is better to keep to (e) ___ design elements as they are less likely to (f) ___ the user from the content. When using text some extra issues will help the (g) ___. (h) ___ text or different potential sizes caters for users with (i) ___ problems. (j) ___ fonts are more readable on screen for most people. It is better to (k) ___ a large amount of text to make more than (l) ___ page and to chunk or (m) ___ text so that it is easier to (n) ___. (o) ___ images should be avoided as they usually take too long to (p) ___. Audio and video clips that take too much (q) ___ may also cause (r) ___.

2 True or false? Rewrite each false statement to be true.
- a Sound effects are usually small sound files.
- b Portrait design has a page longer than it is wider.
- c Templates can save the author a lot of time.
- d A modal dialogue box closes automatically.
- e Video using the full window size needs less memory.
- f User control is good design for audio and video clips.
- g Symmetric design uses irregular placement of elements.
- h Templates that can be customised are not available in most programs.
- i Users should not be given the choice of not displaying video or sound.
- j Cursors always use exactly the same icon.

**Career path**

**Animators create cartoons, films and animated graphics for a variety of projects including websites, online advertisements, video games and films for television and cinema. They have strong artistic skills, are familiar with the latest in computer animation technologies and work with a range of authoring software.**

## Scripts and storyboards

Scripts and storyboards are both methods of designing multimedia products. They are rough outlines of what will be included: data types, content and hyperlink structure and the relationship between all the objects to be used. Both can be created manually or electronically.

A *script* is the text representation of all the elements to be included in the multimedia product. A *storyboard* is the visual presentation of the project. A storyboard is drawn as a panel or series of panels on which small sketches or drawings show consecutive changes between screens in a planned multimedia program. It has the added advantage of being able to represent the navigation between screens.

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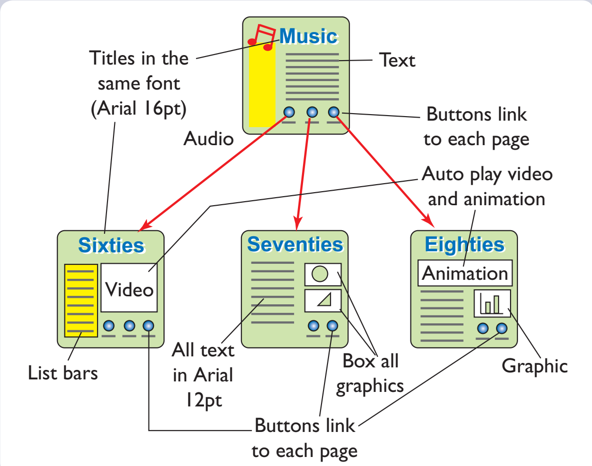


Figure 3.22 Multimedia storyboard design

Types of storyboard design include linear and non-linear. *Linear* is development of a product where one screen follows the other in a way similar to the pages of a book. It is very useful for straightforward products and for children. *Non-linear* development allows screens to be linked in any way similar to a website or to a hierarchy, where pages link to each other in any useful way. This is useful for products where user interactivity is very important and users can determine the direction they take to navigate the content.

Table 3.13 Advantages of using scripts and storyboards

| Advantage | Storyboards | Scripts |
|---|---|---|
| Simple to construct | Storyboards are easy to draw as elements are represented by symbols e.g. graphics can be shown by a rectangle with a cross through the shape. | Scripts are lists, and most people are familiar with working from lists. |
| Simple to read | Storyboards number each page or screen. | Scripts act as a checklist as the project progresses. |
| Easily modified | Storyboards are developed as separate pages, and it is easy to rearrange, change, insert and delete pages. | Electronic script files are easily edited to change, add or subtract elements. |
| Comprehensive | All elements of design can be shown as either objects or labels e.g. colour scheme/s. | Templates can be used to avoid missing any elements e.g. graphic sources. |

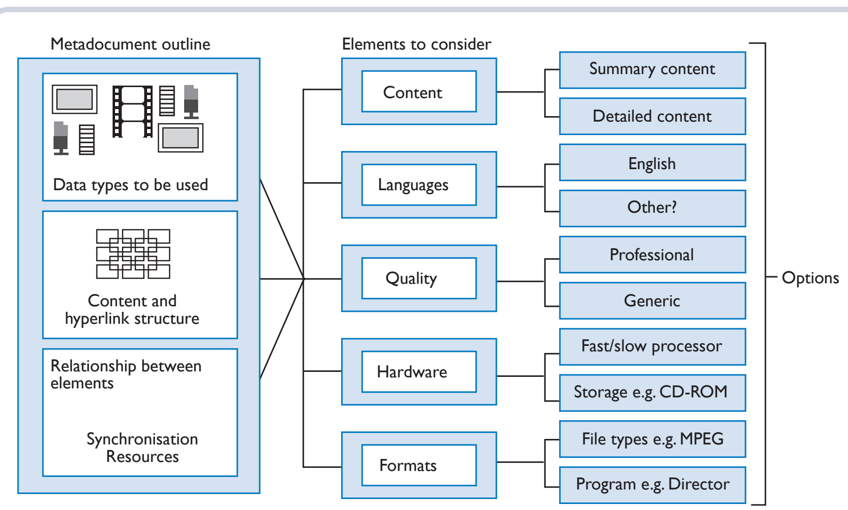


Figure 3.23 Aspects to consider in multimedia design

A *metadocument* is a document that gives details about all other documents in a project. This document allows the author to develop each screen (or document) using the same consistent design and elements and to always be aware of the various types of users, hardware and software that may be relevant to each task.

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## EXERCISE 3.6

1 Match each term in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| consistency | general term for small interactive images |
| cursors | too much of one data type creating display problems |
| dialogue boxes | use of the same structure across multiple screens |
| feedback | amount of time taken by a program to react to user commands |
| icons | ability of the user to move between screens or parts of documents |
| navigation | icons that indicate system status |
| overuse | information provided to the user to help understand delays or problems |
| response time | graphic elements used to provide feedback, information or choices to users |

2 Explain why consistency is the most important design consideration when developing multimedia programs.

3 Name FIVE criteria used to judge text design in a multimedia program.

4 What is the difference between a symmetrical and an asymmetrical design?

5 Define the term 'storyboard'.

6 Compare the use of storyboards and scripts in multimedia design.

7 Explain the different storyboard structures which would result from a linear development, hierarchical development and non-linear or web development. Use diagrams if you prefer.

8 Why are different types of storyboard designs used?

9 Discuss the advantages of using structured forms of design such as storyboards and scripts.

10 For what reason is a metadocument created for large projects?

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# Authoring and multimedia

## Multiple choice questions

Select the best answer to each of the following questions.

1 What is the minimum number of media types needed to create multimedia?
- A One
- B Two
- C Three
- D Four

2 An interactive multimedia program gives the user
- A Scripts to allow for content to be created
- B Control over the direction of program use
- C Logical steps to follow in sequence with no choices
- D No method of personally navigating the program

3 MMS on the internet or a mobile phone stands for
- A Multimedia metadocument service
- B Multiple multimedia series
- C Multimedia management system
- D Multimedia messaging service

4 Hypertext is a type of
- A Interactive text navigation
- B Interactive video navigation
- C Linear design element
- D Unusual font with no extra qualities

5 Authoring software allows the user to create multimedia using
- A Text only
- B More than one media type
- C Animation frames only
- D No hypermedia at all

6 The truthfulness and reliability of data in a multimedia system is a measure of data
- A Validity
- B Accuracy
- C Bias
- D Security

7 Data compression results in files that are usually
- A More graphical
- B Of a larger size
- C Smaller in size
- D Text content only

8 Generally the largest file sizes would be found with the following data type:
- A Text
- B Image
- C Audio
- D Video

9 A multimedia program using an asymmetric design could also be said to have a page layout that is
- A Balanced
- B Irregular
- C Standard
- D Even

10 Professionally designed documents available in many authoring programs that allow the user to add custom features are called
- A Scripts
- B Files
- C Templates
- D Software



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## Extended answer questions

Figure 3.24 summarises some ideas related to hardware used for multimedia.

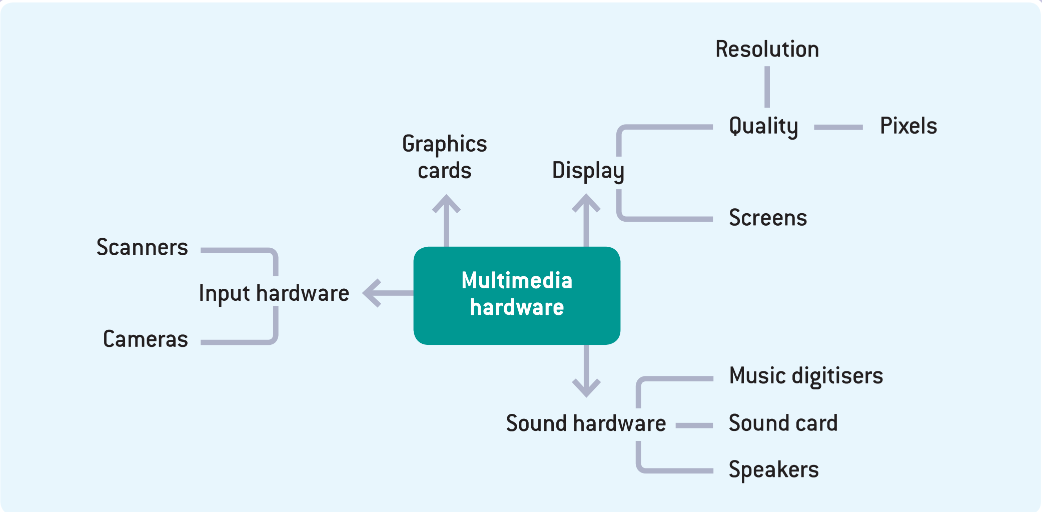


Figure 3.24

Write answers to each of the following questions.

1 Explain what is meant by 'display hardware'.
2 Compare pixels with screen resolution.
3 Why is a speaker an example of output hardware?
4 Multimedia hardware handles digital data. What does 'digital data' mean and what are its advantages?
5 When would a computer system require a graphics card?
6 Why is a scanner valuable hardware in creating multimedia?
7 List TWO different types of camera that may be used to create multimedia.
8 A number of different types of input hardware are not included in figure 3.24. Expand the diagram to include ONE example of the hardware used in playing multimedia games.
9 Name TWO different types of screen display.
10 Describe how ONE major type of screen produces its display.

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# PROJECT 1: STORYBOARDING

## Define the problem

Create a storyboard as a graphical representation of a complete multimedia project. Choose from one of the following situations:

- a simple children's multimedia product (ages 2–5) on a topic of your choice
- an adventure game for young people (ages 12–16)
- an information kiosk for a small shopping centre

## Analyse the problem

Determine the important guidelines that will need to be followed in your project. Use these suggestions:

- Each diagram in the storyboard should have the instructions, text blocks, graphics and navigation buttons arranged in the format that would be used on the computer screen.
- The storyboard can be sketched on pieces of paper or drawn using a computer program.
- The collection of all the diagrams should provide a graphical draft of the proposed multimedia project.
- The storyboard should be neat enough to be read clearly.
- The storyboard must cover all screens in the project. Every card or every document should be included.
- Every element to be included on each screen should be labelled or drawn in the storyboard including:
  - any menus or other consistent items. Use of a template will help in the design.
  - headings as they would appear in the program
  - text objects/blocks – use a lined box as the symbol
  - links/buttons and their locations on screen
  - graphics images (photos, animations or line drawings) – use a box with a cross as the symbol
- Video windows should be shown.
- Arrows should clearly indicate links between cards or documents.
- Cards and documents should be numbered.
- File names should be included if needed.

## Design and produce the project

Use the guidelines you have worked out to outline a design and produce a storyboard.

## Evaluate the project

1. Evaluate your project before it is finalised by using this checklist.
   - A storyboard diagram exists for each page, screen, or frame.
   - Each diagram is numbered.
   - All relevant elements such as colour scheme/s, graphics, sound, font, interactivity, video, sound are indicated.
   - All text blocks or speech are indicated and cross-referenced with corresponding diagrams.
   - A list is included of the project team, each of whom will need to receive a copy of the storyboard.
2. To judge the quality of your project, use this checklist and the guidelines provided in table 1.7 of chapter 1.



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# PROJECT 2: DEVELOPMENT OF A MULTIMEDIA PRODUCT USING AN AUTHORING SYSTEM

## Preparing for the project

Presentation software such as Microsoft PowerPoint is slideshow authoring software. It is a way of delivering information in a form that is similar to the slide shows of the past. The software allows the creation of individual slides using graphics and text as well as video clips, animated text, animated graphics and sound. Data can be created in the program or imported from files created elsewhere. The program then automates the task of creating the slide show as a screen display that can be presented to others. The screen display can also be connected to a display on a television monitor or large screen so that it can be viewed by a large number of people simultaneously.

Presentation software is easy to use but the skills required to design effective presentations are not as straightforward. To overcome this problem and allow users to create professional presentations, most programs have templates or wizards to help with the development of the presentation. This provides consistency of design between the slides and the objects that are common to all slides. For more complex functions, some programming is needed.

## Understanding the authoring system's development environment

Onscreen presentations use slides. Slides are frames or display screens containing objects.

Objects that can be added to a slide include:

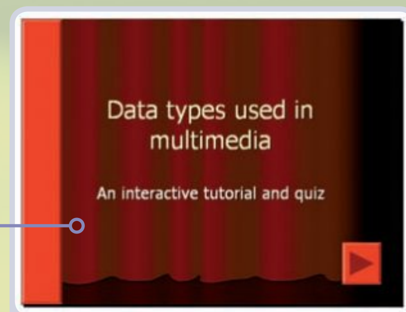

Figure 3.25 Slide or frame

- text boxes
- graphics – drawings, clip art, word art, diagrams and charts
- animated graphics
- video clips
- sound clips
- hyperlinks such as navigation buttons which can be included to allow the presenter or user to progress to the next slide when they wish to do so, or web links so that the slide can be used to access a website

Figure 3.26 Navigation command and button

Objects that are usually static, such as text and graphics, can be animated for the presentation. Text can be set to move on to the screen a section at a time from a particular direction. This can be done in various ways.

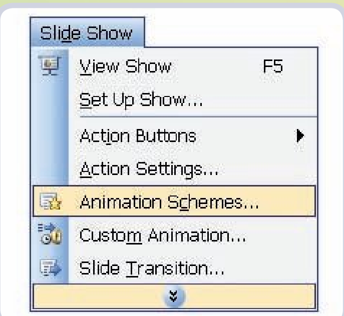

Figure 3.27 Text animation methods

Each of the objects and its associated actions or formats can be repositioned, resized, cropped, aligned to different parts of the frame, distorted or overlapped with other objects.

The display can also be varied in a number of ways. Background designs and colour schemes can be easily changed.

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## Define the problem

An interactive multimedia quiz on data types used in multimedia is needed

## Analyse the problem

- The quiz will be presented on a full screen.
- A screen will be included that shows the topic and provides simple instructions.
- Three (or more) question screens will be included. Each one will present a question and three alternative answers.
- A message is given each time a correct answer is selected. The designer may choose to use different feedback for an incorrect answer or omit the message for these responses.
- The user should not be allowed to change an answer once it is selected.
- The user should not be able to return to the previous screen once they have progressed to the next question.
- The last screen should display appropriate feedback to the user.

## Design a solution

- Design the storyboard using a combination of linear and non-linear screens.
- Design a script.

## Produce the solution

The diagrams show the way in which this design could be implemented for the first three screens:


Figure 3.28 Screens

1 Use the **Design** templates to select a design.
2 Once you have a design, add new slides using the **Insert...New** slide menu and choosing slides that are appropriate for each frame in your design.
3 When you have created the structure, include content on the data types where required. For the quiz frames, follow the steps given here.

### Step 1

Add the text that will be used. The following example is given:

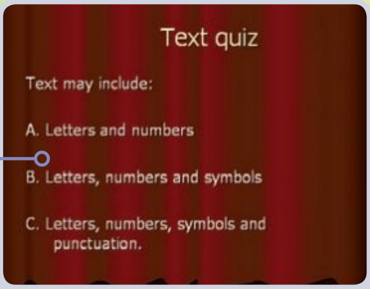


Figure 3.29 Frame including text

When you are writing question frames, don't forget to vary the position of the correct answer for each question. For example, the correct answer to text quiz may be answer C and the correct answer to hypertext quiz may be answer A.

### Step 2

Note: This step needs to be repeated for each slide containing a quiz question.

1 Generate the buttons for the alternative quiz answers using the **View...Toolbars** to show the **Control Toolbox**.

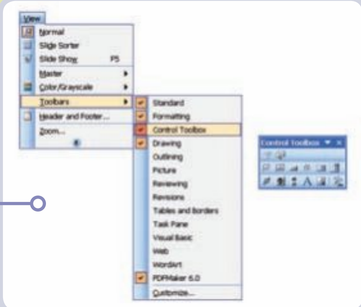

Figure 3.30 Control toolbox

2 Click the **CommandButton** icon on the toolbox and move the mouse over the position on the slide where you wish to place the button. Click and drag to create the button.



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3 Use the right-button menu to select properties and change the caption to A and the BackColor and ForeColor properties of the button (if required).

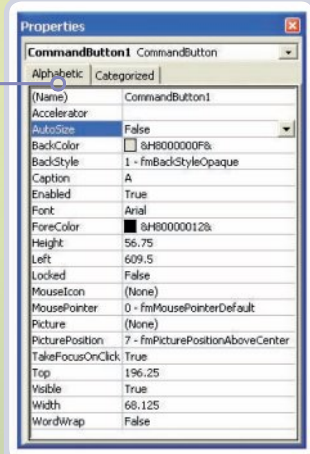

Figure 3.31 Properties of a command button

4 Click on the slide outside the button to deselect the button.
5 Repeat the above instruction to create buttons for each of the other answers. Remember to change the text to B and C respectively.

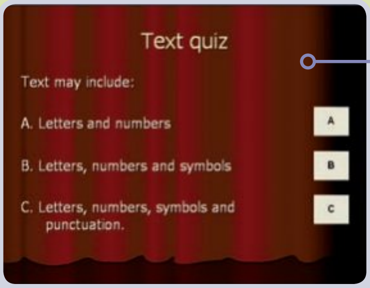

Figure 3.32 Screen output

## Step 3

Note: This step needs to be repeated for each slide containing a quiz question.

1 Double-click on the button for an incorrect question.
2 In the window that appears, type the following instructions between the two given lines. (N* refers to the number of the button and will vary according to the button selected.)

```
Private Sub CommandButtonN*_Click()
MsgBox "Try Again"
CommandButton1.Enabled = False
CommandButton2.Enabled = False
CommandButton3.Enabled = False
End Sub
```

3 Close the window.
4 Repeat the above step for each incorrect question. The button number will be different for each button.

## Step 4

Note: This step needs to be repeated for each slide containing a quiz question.

1 Double-click on the button for a correct question.
2 In the window that appears, type the following instructions between the two given lines. (N* refers to the number of the button and will vary according to the button selected.)

```
Private Sub CommandButtonN*_Click()
MsgBox "You are correct. Well done!"
CommandButton1.Enabled = False
CommandButton2.Enabled = False
CommandButton3.Enabled = False
End Sub
```

3 Close the window.
4 Repeat the above step for each correct question. The button number will be different for each button.

## Step 5

Note: This step needs to be repeated for each slide containing a quiz question.

1 Double-click on the button for any question.
2 In the window that appears, type the following instructions at the very top of the window. (N* refers to the number of the slide and will vary according to the button selected; ** change the button numbers if required.)

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```
Private Sub SlideN*_Load()
CommandButton1**.Enabled = True
CommandButton2**.Enabled = True
CommandButton3**.Enabled = True
End Sub
```

3 Close the window.
4 Test the project by running the slide show.
5 Save the document.

You might consider adding additional answers to each question, additional frames and extra detail to this quiz.

## Evaluate the solution

1 Present the quiz on suitable media and include the PowerPoint player for users who do not have the full version of the program. To do this, use the file menu to 'Pack and Go' the product.
2 Design a simple form for others to complete using the good design principles included in this chapter.
3 Distribute copies of your product and the form to three users.
4 Add these reports to your final project documentation, along with an analysis of how your product could be modified or improved.

One example of a modification as a result of evaluation could be:

You may find that an additional button would allow users to retry the quiz question on each slide. The button could be labelled 'Try Again'. Coding for this extra button would be similar to the code given below:

```
Private Sub CommandButton4_Click()
CommandButton1.Enabled = True
CommandButton2.Enabled = True
CommandButton3.Enabled = True
End Sub
```



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CHAPTER 4

# Database design

A database is a collection of related records organised and stored so that information can be obtained by the user. The data is the most important component of the database. Databases have been in use for a very long time. Familiar databases include the telephone book, card catalogue systems and indexes that store personal details such as the names and addresses of friends.

A database is a collection of related records organised and stored so that information can be obtained by the user.

## Data

Data is the raw facts or material held in a database. Data has no meaning by itself. Data can take various forms: text, including numbers and letters, images including graphs, pictures and symbols, sound and video.

Data that has been processed or organised in a way that is meaningful to the user is called information. Information can be used by people to make decisions.

Data in a processed form can be interpreted by the user, that is, it can be given meaning. For example, consider the following data items – cost,$,7,$,8,+, total,is. They mean very little by themselves, but in a processed form they could be made meaningful to the user as: total cost is $15.

A database makes it easier for people to utilise data as information.

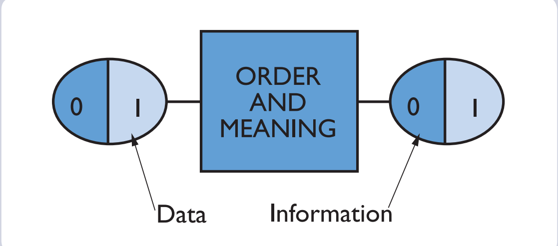


Figure 4.1 The relationship between information and data

Figure 4.2 Computer technician working on a server

## Database development

Databases were developed to allow users to manipulate data and obtain information more easily.

### Types of databases

#### Manual databases

Manual databases were the first type of database and are still valuable to many people. The address book that



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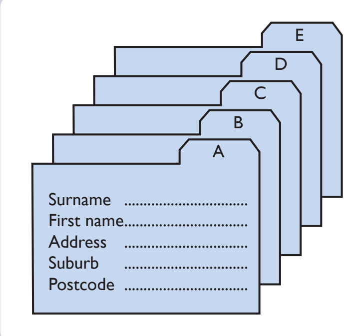


Figure 4.3 Manual card database

exists in nearly every home is a database to keep the addresses and telephone numbers of friends and relatives. It is organised alphabetically to locate the desired reference quickly and easily. Card catalogues are still used in small libraries or in doctor's offices to hold records. Filing cabinets contain data organised in different files. You might use a folder to document each subject you are studying. The set of folders becomes a database for those subjects.

### Electronic databases

Electronic databases are now the most common form of data storage and retrieval. Most organisations and many individuals no longer use manual systems for the major part of their data resources. Electronic databases can be one of two types: closed or open databases.

*Closed databases* are databases bought with data already entered about a particular topic. The First Fleet database is a well known example of this. Detailed data on each ship, officer and convict in the First Fleet who arrived to settle Australia in 1788 is contained in the database. Data cannot be added to the database but the user can obtain a great deal of information on such topics as the crimes committed by convicts, their ages, sentences and the ship they sailed in.

A *shell* or *open database* program can be bought that allows the user to develop data to their own design.

## File systems and database management systems

Electronic databases are either file systems or database management systems. *File systems,* also called *flat files*, were the first to develop, and are what many people commonly know as a database. A file system is small but will store many thousands of records in a single table. Each file stands alone and is used as a separate unit when information is required. One file cannot link to another. For example, a personal address book is a database file containing the phone numbers of friends. A similar database file exists containing the birthdays of the same friends. In a flat file system it is not possible to link the two files. They must be used separately.

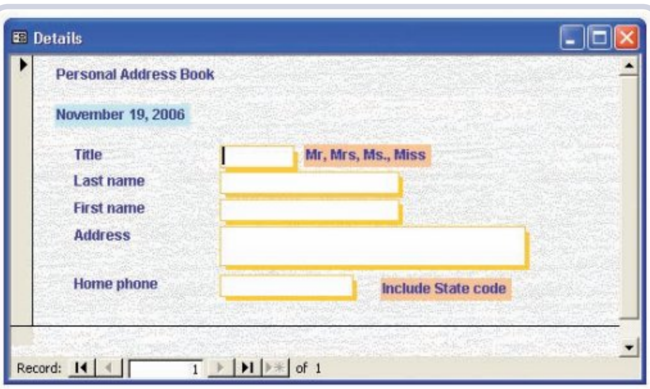


Figure 4.4 A file system

*Database management systems* or DBMS are the software that controls very large databases, able to contain many millions of records that link together. One large file can be divided into separate storage areas called *tables*. Each table can be created and used separately, but when

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information from many tables is needed, links can be set up between the tables and information obtained that takes data from more than one table. Governments and large businesses find such DBMS very useful for storing huge amounts of data.

Figure 4.5 shows three tables in a veterinary database: one contains customer details and the others contain pet and visit details. Because the tables have common fields between each pair (Customer Number and Pet ID) it is possible to link the data and obtain the pet details and visit details as well as the addresses of customers.

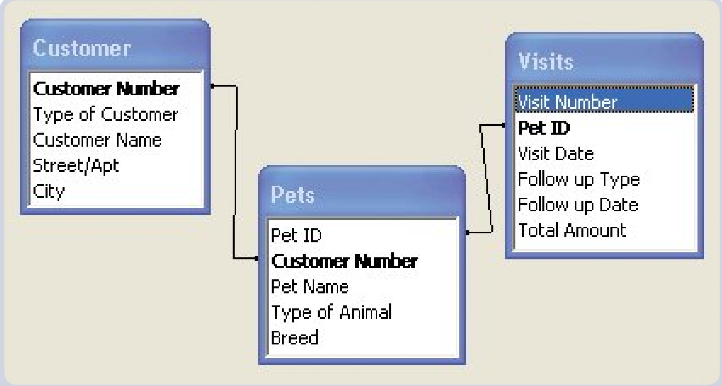


Figure 4.5 Database management system

Another way of classifying electronic databases is to divide them into offline and online databases. Offline databases are held on individual machines without any connection to other systems during their use. They are used for small businesses and personal use and may often hold relatively small amounts of data.

Online databases are those accessible across a network or available on the internet. Many internet search engines use online databases to store the data they collect about the many web pages available. Large organisations may store a database on a central computer of their network and make it available to network users. Online databases are usually up to date, contain specialised information, have an interface that makes it easy for users to query the database and they are usually very large in comparison to other databases. They are more expensive to use and it may be difficult to determine if they are accurate as their rules for use may vary from those with which some users are familiar. They may also be biased, that is, they may hold data from only one or a limited number of sources.

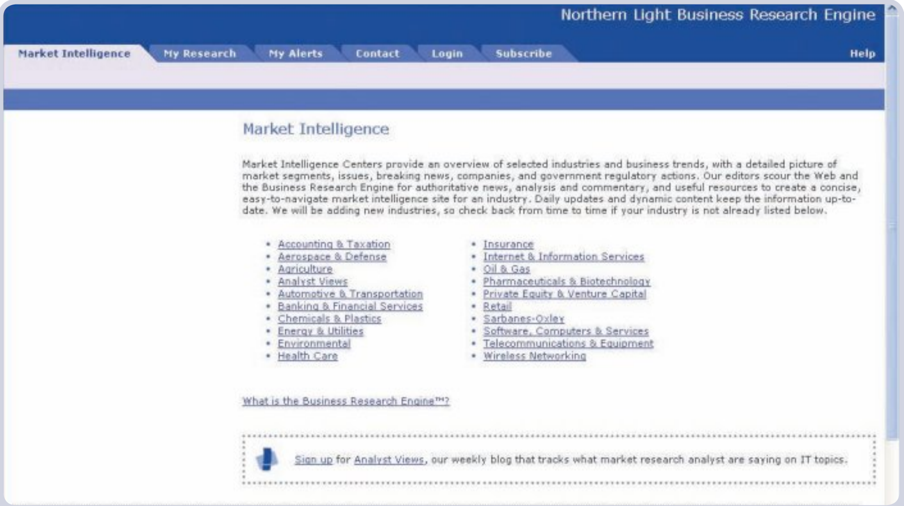


Figure 4.6 Accessing an online database

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Figure 4.7 Searching a hypertext database on the world wide web

A recent adaptation of online database design is the hypertext database, which is particularly useful for organising large amounts of dissimilar information. In this database, any object, whether it is a block of text, a sound, an image, or a video, can be linked to any other object. The chunks or blocks of data are called nodes. These database types will be familiar to users of CD-ROM encyclopaedias and pages on the world wide web (WWW). Entire technologies have built up on the internet to search them e.g. Google and Yahoo. Graphical browsers are one way of searching hypertext databases. For further information see chapter 6.

**Table 4.1** Comparison of manual and electronic databases

| Comparison | Manual database | Computer database |
|---|---|---|
| Size | These systems must remain small if they are to be useful. | Vast amounts of data can be stored in relatively small amounts of space compared to the same amount of data stored on paper. |
| Data retrieval | A small amount of data can be quickly and easily retrieved and no extensive processing is needed. | Retrieval is fast and accurate from large data stores and information may be analysed more thoroughly than in manual systems. |
| Cost | Relatively cheap: the cost of purchasing the computerised system is not cost-effective for some forms of data organisation. | Data storage is cheaper the larger the system becomes but set-up costs are high. |
| Training | Usually no special training is required. | Some computer databases are very complex and users need a lot of training to use them effectively. |
| Availability | Data entry and storage need to be duplicated if data is to be held on more than one site. | Data is very quickly accessed from multiple sites and can be electronically transmitted from one organisation to another at a much cheaper rate. |
| Security | Storage may be more secure because it can be held in locked drawers or offices and is not accessible across a network. | Electronic security can be used for sensitive data, for example, password access and encryption. |

## EXERCISE 4.1

1 Write a simple definition of a database.

2 Give THREE advantages of an electronic database over a manual database.

3 Explain the difference between a flat file system and a DBMS.

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exercise 4.1 continued

4 Explain the type of data stored be the following examples of everyday databases.
  a telephone directory
  b library databases
  c motor vehicle registration records

5 What are online databases?

6 Where would you find online databases?

7 Give TWO advantages and TWO disadvantages of online databases.

8 Use the word list provided to correctly complete the following paragraph.

| | | |
|---|---|---|
| added | address book | closed |
| complex | data | DBMS |
| developed | electronic | file system |
| functions | link | manual |
| one | organising | shell |
| small | source | tables |

A card catalogue or an (a) ___ is a good example of a (b) ___ database. These are still common methods of (c) ___ a (d) ___ amount of data. Databases designed and (e) ___ on computers are called (f) ___ databases. If the database is supplied complete with (g) ___, that is, sealed, it is called a (h) ___ database. Open databases allow data to be (i) ___ by the user and are also known as (j) ___ databases. Smaller electronic databases that use (k) ___ file to hold all data are called (l) ___. Larger, more (m) ___ systems called (n) ___ provide more (o) ___ and use multiple (p) ___ or files to hold data and (q) ___ these when data is required from more than one (r) ___.

## Purpose of a database

Data is often one of the most important resources of an organisation. The purpose of a database is to store, organise and manipulate data in order to extract information.

Databases have become a very useful form of computer program. A computer database can hold a very large amount of data, and can be updated easily and searched very quickly when specific data is needed. Users are able to input data in the form of text, sounds, images and video, to organise the data into records and fields, and to change the data to useful information by sorting the data or by selecting only some of the data and making reports. A computer database is a very quick and easy way to access information and to keep information up to date without having to retype all the original data.

Figure 4.8 GIS on a hand-held PDA

### Great idea

A geographic information system (GIS), a computerised form of a map and associated data, depends heavily on databases. It may link to another system called GPS (global positioning system) as a way of locating ourselves and other objects in the world. Paper and computer maps are static and difficult and expensive to keep up to date. GIS is a more flexible system. By employing several satellites and analysis and modelling, locations can be determined from the considerable data about roads, vegetation and buildings that can be stored in the database. Any immediate changes in a location can be stored in the database e.g. roadworks or landslides, so that GIS maps can remain current.

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## Components of a database

A database has components to store individual facts or data in an organised way. The components form a *hierarchy* in which the most important level is at the top.

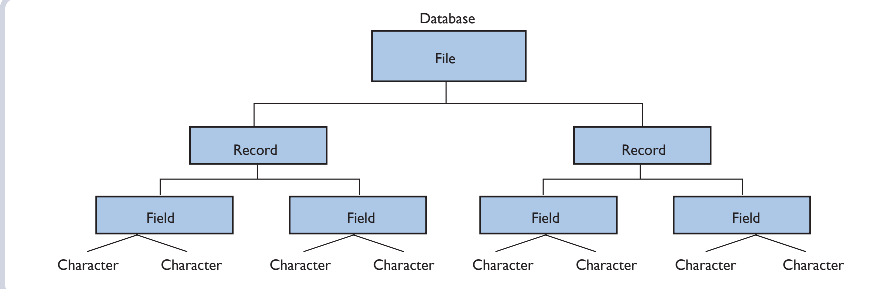


**Figure 4.9** Database components

**Table 4.2** Explanation of database components

| Component | Explanation |
|---|---|
| Database | The collection of related data stored and organised so that information can be quickly and easily obtained |
| File | All the information on a particular topic, such as all the information about students |
| Record | A section of the file containing all the data about one entity, such as all the information about one student |
| Field | A section of the file that contains data about one section of each record, such as all the surnames of students. A field may contain data that is<br>• alphabetic, that is, letters of the alphabet<br>• numeric, that is, numbers (either whole numbers or decimals)<br>• alphanumeric, that is, letters, numbers and symbols<br>If a field is a number field it can be used to calculate data from other number fields: add, subtract, multiply or divide numbers |
| Character | Any letter, number or symbol contained in a field |

A school database could be used as an example of such a simple database. The data needed to be stored would include details about the students attending the school.

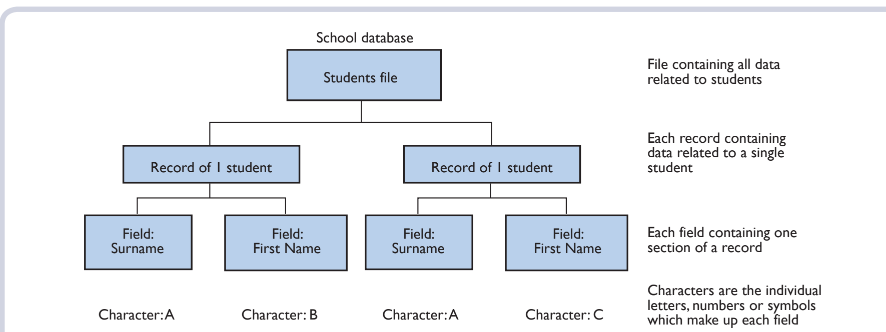


**Figure 4.10** Part of the school database structure

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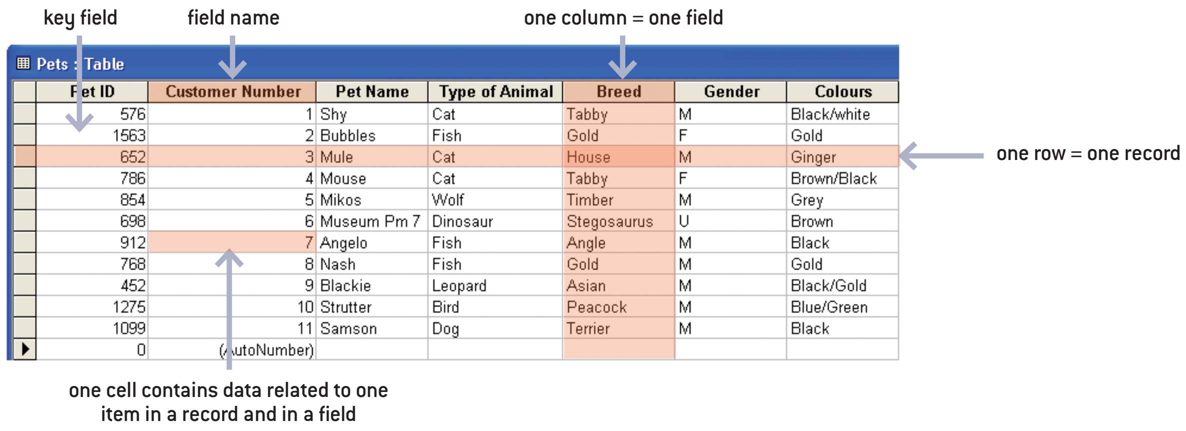



Pets : Table

| Pet ID | Customer Number | Pet Name | Type of Animal | Breed | Gender | Colours |
|---|---|---|---|---|---|---|
| 576 | 1 | Shy | Cat | Tabby | M | Black/white |
| 1563 | 2 | Bubbles | Fish | Gold | F | Gold |
| 652 | 3 | Mule | Cat | House | M | Ginger |
| 786 | 4 | Mouse | Cat | Tabby | F | Brown/Black |
| 854 | 5 | Mikos | Wolf | Timber | M | Grey |
| 698 | 6 | Museum Pm 7 | Dinosaur | Stegosaurus | U | Brown |
| 912 | 7 | Angelo | Fish | Angle | M | Black |
| 768 | 8 | Nash | Fish | Gold | M | Gold |
| 452 | 9 | Blackie | Leopard | Asian | M | Black/Gold |
| 1275 | 10 | Strutter | Bird | Peacock | M | Blue/Green |
| 1099 | 11 | Samson | Dog | Terrier | M | Black |
| 0 | (AutoNumber) | | | | | |

**Figure 4.11** Database components

Database software also has components that allow data to be viewed in different ways.

**Table 4.3** Database views

| View | Description | Use |
|---|---|---|
| Table or list view | A table is many records held in a grid where each column is a field. A table holds related data. | Display many records on the screen at one time. Scrolling can be used to see a complete record or all field entries. |
| Form view | An individual record is displayed with fields from multiple tables (DBMS), pictures or other details. | Data entry and update. Display where it is necessary to show only a limited view of data. Many forms can be used to display different data. |
| Query view | Shows only information that answers the question asked of the database and filters out all the other data. | Display of specific information from the database that meets set criteria. Many different queries can be made of the same data. |
| Report view | A view of the results of queries or table data including headers, footers and additional data to summarise the report data. | Allows data to be analysed and printed in the way a user requires. Multiple reports are possible from the data in tables. |

The most common way to view databases is in a form or list. In order to obtain information from the database, other views can be created, such as report or query.

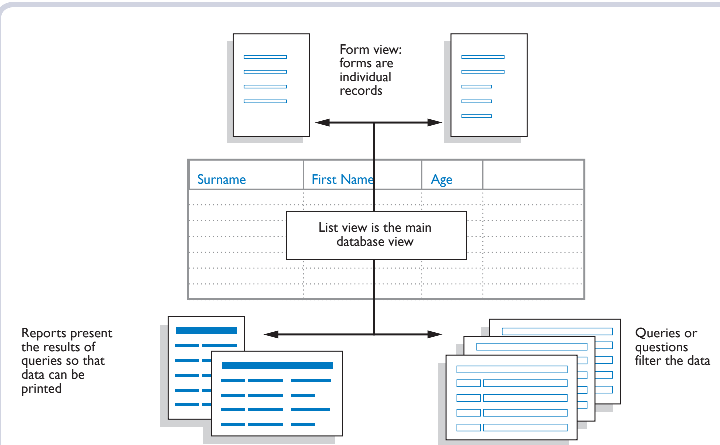



**Figure 4.12** Database views

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## Try this

**Capturing database screens**

1 Use a graphics program that enables screen capture or use the print screen command on a keyboard to capture THREE images of different parts of a database program e.g. a table, form, report or query.

2 Save each image under the name of the database part.

3 Import these images into a word processor document and explain the function of each part of the database you have shown in your images.

4 Save the file as 'Database views'.

## EXERCISE 4.2

1 Write down and complete the following sentences.

a Characters are grouped in a database to form ...

b A character can be a ..., ... or ...

c Fields are grouped together to form ...

d Data in a field may be one of ... types: ..., ... or ...

e Records are grouped together to form a ...

f A record contains all the data about ... entity.

g When all the data about one topic is collected together it is called a ...

2 Using the telephone book as an example, draw a chart to illustrate the structure of the book as a database.

3 List the names of four extra fields that could be included in a school database, other than Surname and FirstName.

4 Using all six fields for the school database, write down the characters that would become the data entries for your record as a student.

5 Match each term in column 1 with the best description from column 2.

| Term | Description |
|---|---|
| data | an individual record display used for data entry |
| database | a database view that allows analysis and printing of data to user specifications |
| electronic | a collection of related records organised and stored so that information can be obtained by the user |
| field | data that has been processed in a way that is meaningful to the user |
| file | all information related to a single item in a database |
| form | a grid of rows and columns holding related data and also known as a file |
| hierarchy | one of a number of components each holding an item related to the record |
| information | diagram of database components in order of their importance |
| record | database developed on a computer system |
| report | an organised collection of records |
| table | words, numbers, symbols or codes entered in a database |

## Inputs of a database

Database inputs consist of data entries. Data input can be text or graphics. Text is made up of characters: numeric, alphanumeric and letters. Symbols and punctuation are rarely used in a database. Codes are often preferred as they minimise data entry and make errors less likely. Common codes include M or F for male and female, and identification numbers such as barcodes.

Once collected, data needs to be organised. Tables keep all data related to a specific topic together. Data is stored only once in a grid of fields

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(columns) and records (rows). Tables require good design. This includes careful choice of field names and decisions as to the form in which the data will be entered.

**Table 4.4** Important factors to be considered in data entry

| Factor | Explanation | Example |
|---|---|---|
| Consistency | All data in one field must be of the same type. | All dates must be entered in the same way e.g. 28/07/04. |
| Simplicity | Data entry should be kept to a single character or the smallest number of words possible. | Use of a code to simplify data entry such as M or F for gender. |
| Accuracy | Data should be verified to make sure it is entered correctly. | Fields should be set to prevent some forms of unacceptable entry e.g. numbers where letters are expected. |
| Currency | Data should be kept up to date. | A change in address for an employee database should be entered as soon as possible. |
| Understandable | Field names should make sense to any user. | Surname is meaningful, Field1 is useless. |

To achieve the best outcomes when entering data into a database it is important at design stage to design a *data dictionary*. The data dictionary will hold details related to the data to be used including field name, field width, data type and description of purpose. Further information about data dictionaries can be found later in this chapter.

In database management systems, a major advantage of data input is that once data is stored in a table it can be viewed from many different locations, such as queries or forms. When the data is updated, it is automatically updated everywhere it is used in the database.

## EXERCISE 4.3

1 On a database form related information should be kept together. Divide the following fields from a customer database into THREE groups by placing each field with fields of a similar nature.

| | | | |
|---|---|---|---|
| AccountNo. | Address | Cost | FirstName |
| ItemCode/s | Phone | PostCode | Purchases |
| Retail Price | Suburb | Surname | Title(Mrs/Ms/Mr) |

2 Explain why designing a database is the most important step in creating a database.

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exercise 4.3 continued

**3** The following data has been collected for a music database.

| Songtitle | Artist | Album |
|---|---|---|
| How long | Ace | HD One Hit Wonders |
| Prince Charming | Adam Ant | One And Only 80's |
| Ant Music | Adam Ant | Ultimate Retro 2 |
| Classic | Adrian Gurvitz | 80's Complete 2 |
| Classic | Adrian Gurvitz | Number 1 Hits of 80's |
| Uninvited | Alanis Morrisette | HD 57 |
| Thank you | Alanis Morrisette | HD 61 |
| Uh La La La | Alexia | HD 58 |
| Gimme Love | Alexia | HD 60 |
| Schools out | Alice Coope | Best rock album |
| Poison | Alice Cooper | Unleashed |
| Department of youth | Alice Cooper | Unleashed in the 70's |
| Lady Marmalade | All saints | 1005 hits Best of 98 |
| I know where it's at | All saints | HD 47 |
| I know where it's at | All saints | HD 48 |
| This is your night | Amber | HD 39 |
| This is your night | Amber | Party mix |
| Knock on wood | Amii Stewert | Video Hits 1000 |
| I just want to be your everything | Andy Gibb | 70's Complete 5 |
| Am I ever gonna see your face again | Angles | Best Rock Album |
| No secrets | Angels | Unleashed |
| Take a long line | Angels | Unleashed in the 70's |
| Take a long line | Angels | Wild turkey CD |
| Suddenly | Angry Anderson | Rock Ballads |
| House of rising sun | Animals | 60's Complete 2 |
| We gotta get out of this place | Animals | Non Stop party |

**a** Note down any problems with the data entry that could make this database less useful.

**b** Write down some of the information that could be obtained from this database in the form of 10 questions, for example: How many albums contain the song title 'Take a long line'?

**4** The publishers of the local newspaper require a customer mailing list. Use a copy of the local newspaper and the phone book to collect data that could be useful for such a database.

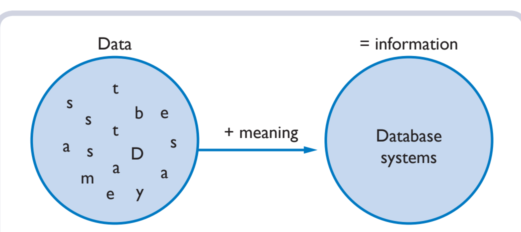


Figure 4.13 Meaningful data provides information

## Outputs of a database

Organised data is meaningful to people. For example, an assortment of letters (data) becomes meaningful when it has been arranged into words and sentences.

Data output as forms or reports can help to make data more meaningful for the user. These require the user to make decisions about the types of information required. *Forms*

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can be used for a range of purposes: data entry, links to open other forms or reports or for display. *Reports* allow the user to control the size and appearance of all data. Many different forms can be developed for different purposes. Graphics, music or video may be added to a form.

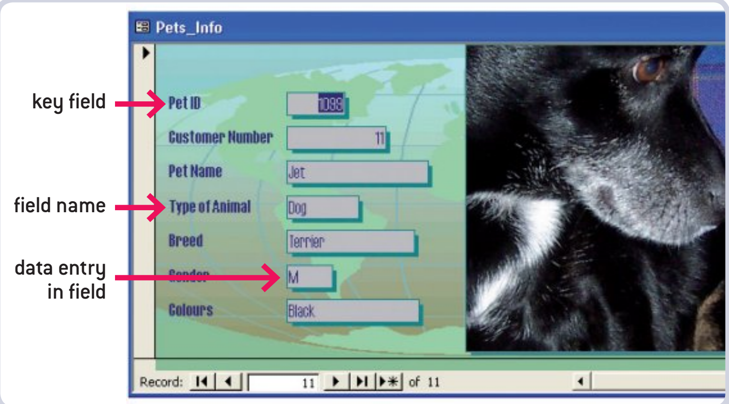


**Figure 4.14** Form view of a database showing a single record

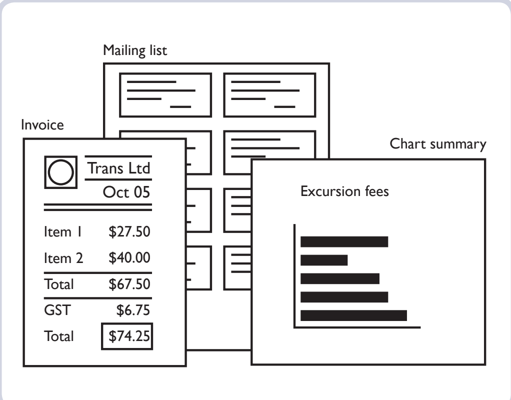


**Figure 4.15** Examples of database reports

## EXERCISE 4.4

1 What am I?
   - a I am text made up of both letters and numbers.
   - b I am a table used to describe the data to be stored in a database.
   - c I am the most important factor to consider when naming a database field.
   - d I am a numeric or alphanumeric data entry used to reduce errors in typing.
   - e We are two ways of presenting data to meet user specifications.
   - f I am the process of making sure that data is correctly entered in a database.
   - g I am the term for keeping data up to date.
   - h I am a type of report that is useful for addressing large numbers of envelopes.

2 Using the requirements given below, design a database form for each of these situations. Use an appropriate field name for each item of data to be stored. List those fields where a code could be used to reduce data entry input and suggest a code.
   - a An advertising department needs to know each customer's title, full name, business name, full address.
   - b The accounts department wants to know each customer's account number and their monthly balance as well as the type of advertisement the customer normally requires.

## Data types required to solve a problem

Simple data types such as numbers and letters are the basics of data entry, but data structures are the ways in which data is organised. Data structures include files, records and arrays.

**Simple data types** numbers and letters that form the basics of data entry.

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### Files, records and arrays

A database organises data into a hierarchy. The *file* contains all the data related to a particular topic. The file is divided into *records*. Records contain all the data about one particular item. Records are divided into *fields*. Fields hold the data about one section of a particular item. In a school database, a file could hold all the students in the school. A record would be all the data about one student. One field would hold the data about one aspect of that student, such as their surname. A database system can hold many files, subdivided into many thousands of records, each subdivided into a large number of fields.

Because a database is organised into files and records it is said to have *structure*. The structure is what allows the database to be used to locate information. Some databases also contain pictures, such as photographs. These are also held in fields so that they can be used to provide information in visual form as well as text.

*Arrays* are another data structure used by a database. An array organises data into a grid so that each item of data can be found by using its subscript or location. A simple array or one-dimensional array can be called a *list*.

Videos : Table

| Video_Name |
|---|
| belinda.avi |
| ben.avi |
| bianca.avi |
| cass.avi |
| cat.avi |
| cathy1.avi |
| cathy2.avi |
| cathy3.avi |

Figure 4.16 One-dimensional array of video names

When there is a set of data items that stay together, they can all be given a single name. For example, one set of data items might be the names of video files. They can be given a single name such as Video_Name. Each Video_Name can then be identified by its location or subscript, such as Amun as Video_Name (1) or Johannes as Video_Name (6).

Databases store data in more complex arrays than one-dimensional arrays. Two-dimensional arrays allow data to be stored in a grid. The columns of a table represent the fields and the rows represent the records. This means that all fields related to a particular record are kept together during data manipulation such as sorting.

Videos : Table

| Video_Name | Words |
|---|---|
| belinda.avi | You did that |
| ben.avi | You can do better than that |
| bianca.avi | That's really good |
| cass.avi | Fantastic |
| cat.avi | Purrrrfect! |
| cathy1.avi | You're a real brain box |
| cathy2.avi | Think harder |
| cathy3.avi | Don't be despondent |

Figure 4.17 Two-dimensional array in a database with two fields

## Collecting, organising and storing data

The first step to a database is data collection. Data can be collected from a range of sources including newspapers, books, magazines, the internet, surveys and questionnaires. The user will need to know exactly what data is needed and locate the sources from which this may be obtained.

Primary sources are those that come directly from the data source. For example, an interview is a primary source as it gathers data from people. Secondary sources provide data indirectly. This data has been used in another form and the collector takes it from that source. Data collected from the internet is an indirect source, as others have collected it previously.

Primary sources provide data direct from the origin.

Secondary sources provide data indirectly.

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## Data organisation

Data that is usable in a database has been organised. A good way to model the data before creating a database, and improve organisation, is to set it out so that data entry into fields and records is easily understood. A data dictionary makes it easy to see the structure of the data and to design the database. A flat file database has only one table and so data organisation could be shown in one data dictionary. A large database would have more than one table and would need more than one data dictionary. The name of each table is best written in a row at the top of the data dictionary so that it is easier to read.

**Table 4.5** Data dictionary design

| Table: Customer | | | |
|---|---|---|---|
| **Field name** | **Field width** | **Data type** | **Description** |
| CustomerID | Set by DBMS | Autonumber | Automatically sets a unique number for each customer |
| CustomerName | 25 | Text | Business name or individual's surname |
| StreetNumber | 8 | Text | Allows for numbers for units or flats |
| StreetName | 25 | Text | Includes full street location e.g. Drive |
| Suburb | 20 | Text | As per postal guidelines |
| Postcode | 4 | Integer | Four-digit Australian code only |
| Phone | 10 | Integer | Includes state code, area code and fixed line phone number |

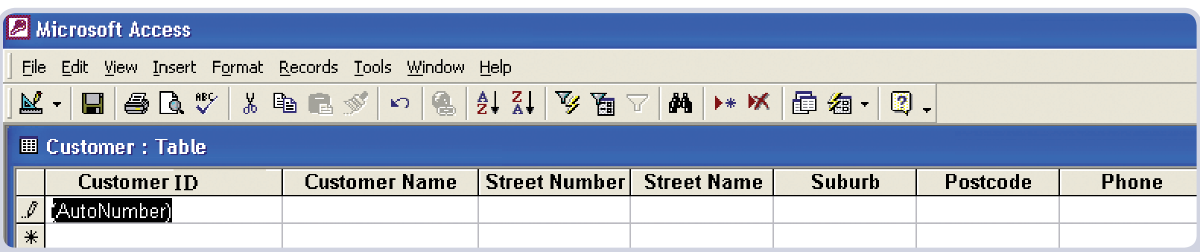


**Figure 4.18** Data table design based on data dictionary

Once the data organisation has been decided, the database table or tables may be created. Data can then be stored in these tables.

## Data storage

Data is stored in a table in one of two ways:

- Manually by scanning or keyboard input into the correct field
- Automatically if the field has been set up to read information from manual input

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### Great idea

In the past, databases were limited in that they could not always be transferred from one computer system to another. Hardware of one type often did not work with hardware of another type. Then along came the great idea of hardware built to connect to other hardware. For example, in the past a computer was contained within itself. Today the computer connects to television, DVD, speakers, jump drives and many other devices. Emerging technology is providing systems that will interact with our mobile phones, home security and entertainment networks. Interoperability is the term used to describe how devices work with each other to connect and exchange data.

For example, a video store database holds data organised into three tables: customers, videos and loans. Each new customer's details are entered in the customers table (see figure 4.18). CustomerID is automatically allocated by the DBMS so that each customer has a unique number. Each video is entered in the videos table. The database is set to enter the loan date automatically and to calculate the return date (next day for overnight and a week away for weekly) from the video name. The video shop assistant only has to scan the customer's membership barcode and the video barcode and handle the cost of the transaction. This data is stored in the loans table. All fields in the loans table are connected to data stored in the other two fields.

Data is also stored on storage media. The type of media will depend upon the type of database, its size and the circumstances in which it is used. Table 4.6 covers some of the issues related to storing data.

**Table 4.6** Issues related to the use of storage media

| Issue | Description | Examples of suitable media |
|---|---|---|
| File size | The physical size of the database file will be determined by the amount of data, the number of fields, forms and reports, and additional data such as graphics | • Small databases: floppy disks, hard disks<br>• Large database files: hard disks, laser storage media such as CDs or compact disks |
| Portability | The ability of a database to be relocated when needed | • Manual card or paper systems that are reasonably small<br>• Electronic storage on floppy disks, tapes and laser media |
| Updatability | The ease of access to the database to keep data current | • Electronic media that use random access such as hard disks and laser media |

## Validation and verification checks of data

**Data validation** is performed to check that the data entered into a database is accurate, that is, error free. As a first step, data should be accurate before it is entered into the system. **Data verification** is the check made on the data once it is in the system to make sure it is correct. Some programs have ways of helping with the validation process. For example, a database field formatted as a date field might be set up to take a date in one form only, such as December 13, 2005. If the date is entered in another form, such as 13/12/05, the data will be rejected and will have to be re-entered correctly.

Data verification becomes more important as the size of a database increases. Changes need to be made regularly if many databases are to be kept up to date, that is, new addresses and phone numbers etc. An organisation holding a very large database on a network may have many points where changed data is entered and edited. One centralised database

**Data validation** a check to ensure that the data entered into a database is accurate and error free.

**Data verification** is the check made on the data once it is in the system to ensure it is correct.

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held on a server helps to maintain the accuracy of records. To assist with this, the server might use special processes to ensure problems don't happen during the updating. One example is to lock a record while it is being updated so that it cannot be updated simultaneously by different people.

## Methods of processing and analysing data

### Editing records

It is important to edit databases in order to keep them accurate and to make sure they continue to meet the needs of the users. Editing could include activities such as proofreading and correction of data entries, adding, deleting and altering data entries and inserting and deleting records.

A database must be updated regularly if it is to be of greatest use. For example, a phonebook is a database in which records have been sorted on the Surname field. It would need updating regularly because:

- people ask for a new phone number or are given a new phone number when they move
- businesses get bigger or smaller and add or take away phone lines
- people change to private phone numbers that are not listed
- new phone lines are installed in new houses.

### Sorting records

Data in a database can be reorganised quickly, making it easier to find particular records. Reorganising the data is done by sorting the information in various ways according to the needs of the user. Sorting data is the process of arranging items of data in a particular order. Sorting could include:

- sort the field Surname in ascending order (A–Z), or
- sort the field Surname in descending order (Z–A).

For example, in a database of cars, the records may be easier to locate if the type of car were listed in alphabetical order or if the cars were listed from most expensive to least expensive.

When a database is sorted, records are actually moved to a different position in the database file. Different fields are part of a record and cannot be separated from it. To understand this, consider a card catalogue of used motor vehicles (see figure 4.19). Each card is a record containing details of one vehicle: its make, model, engine size, price and other details. If the catalogue is sorted into alphabetical order by make, all the details on each card remain with that card. There is no way to sort just the model of the car while leaving the cards in the order of make of car. When a computer database is sorted, the same thing happens. All the data that makes up a record stays together.

**Career path**

**Database administrators create, test, debug and coordinate changes in database management systems software. They are also responsible for system security and write programs to automate tasks in a database, write documentation and manuals and develop policies for database procedures.**

| | |
|---|---|
| Make | Holden |
| Model | 2006 |
| Engine size | 4 cylinder |
| Price | $30,000 |
| Mileage | 25,000 km |

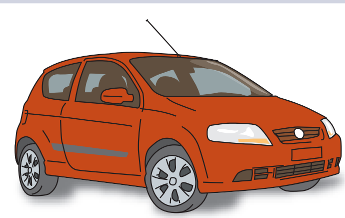

**Figure 4.19** Card catalogue

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## EXERCISE 4.5

1 The following is an example of a small database called Hardware. It holds employee records.

| ID | Surname | FirstName | Department | Phone | Wages |
|---|---|---|---|---|---|
| 54 | Willit | Henry | Tools | 95678900 | 351 |
| 32 | Hanna | Mary | Paint | 95678809 | 297 |
| 45 | Allena | Jona | Timber | 95678932 | 465 |
| 51 | Decon | Ilya | Office | 95678000 | 397 |
| 24 | Danit | Czarlex | Paint | 95678809 | 429 |
| 55 | Encomen | Hilary | Office | 95678000 | 516 |

Suppose the sorting options for a field in the database contained the following rules:

```
sort A-Z
sort Z-A
sort 0-9
sort 9-0
```

a What rule would you choose if you were asked to:
  i sort an alphabetical field in ascending order?
  ii sort a numerical field in ascending order?
  iii sort an alphabetical field in descending order?
  iv sort a numerical field in descending order?

b Rewrite the database so that it is sorted into the correct order from smallest to largest based on the field ID.

c Rewrite the database so that it is sorted into alphabetical order from A to Z based on the field Surname.

2 The following is an extract from a large database.

| Plant | GrowerSN | GrowerFN | Max.Height(m) |
|---|---|---|---|
| Rose | Heinemann | Yvette | 1.0 |
| Daisy | Glenys | George | 0.5 |
| Hibiscus | Power | Jennifer | 2.2 |
| Ivy | Williams | Larry | 0.4 |
| Tree Fern | Raintree | Kyle | 2.5 |
| Jacaranda | Williams | Anton | 5.8 |
| Jonquil | Engersil | Jill | 0.3 |
| Lily | Fransyski | Pierre | 1.2 |

From the above database:

a Write down the first record that would appear if GrowerFN was sorted into descending alphabetical order.

b Draw up a table for a data dictionary. Include headings as follows: Field name, Field Width, Data Type, Description
Use the data from the above table to complete the data dictionary.

c Name the last character in the extract shown above.

d Explain the most efficient way to sort the database on Grower names (SN=surname, FN=firstname).

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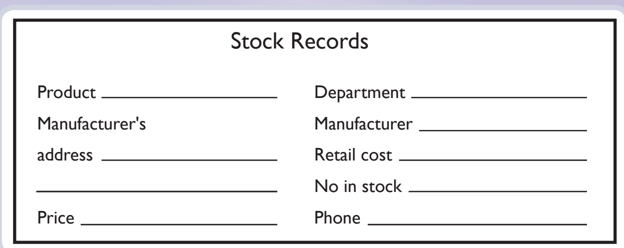
exercise 4.5 continued

3 During the last decade all Australian telephone numbers were changed by adding extra digits to the front of the number. Without this change, there would not have been enough phone numbers for those who wanted a new number. Explain how failing to update the phone database as changes were made could have resulted in the collapse of our phone system within 5 or 10 years.

4 Use the following sample database form:


Stock Records

Product ______ Department ______
Manufacturer's address ______ Manufacturer ______
Retail cost ______
______ No in stock ______
Price ______ Phone ______

**Figure 4.20** Database form

a Give examples of:
   i TWO numeric fields
   ii TWO text fields

b Write one data entry for the Price field and explain why you chose to enter the data in the form you selected.

c Explain why the following field names are not the best choice:

   Name
   Field1
   Manufacturer's Price as at Today's Date

d A code is being used for the phone field. What's the problem?

e Redesign the form so that it better meets the needs of the users.

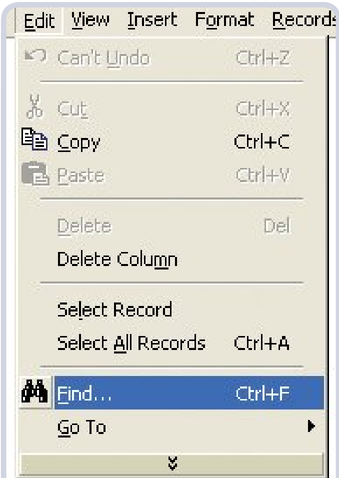


**Figure 4.21** Edit menu: Find command

## Searching a database

One of the other features of a database that allows the user to locate information that meets their needs is called searching. Searching is a way of selecting those records that meet particular criteria.

Searching for information can be done by using the *Find* command or a query. Find will locate information within a field or record. A *query* language will locate records that answer the question asked.

**Searching** examining data to find all elements which meet a set criteria.

**Table 4.7** Comparison of a find and a query

| Find | Query |
| --- | --- |
| Displays the first occurrence of the data sought | Displays every field in every record that meets the criteria |
| Provides one item at a time | Provides many items at a time |

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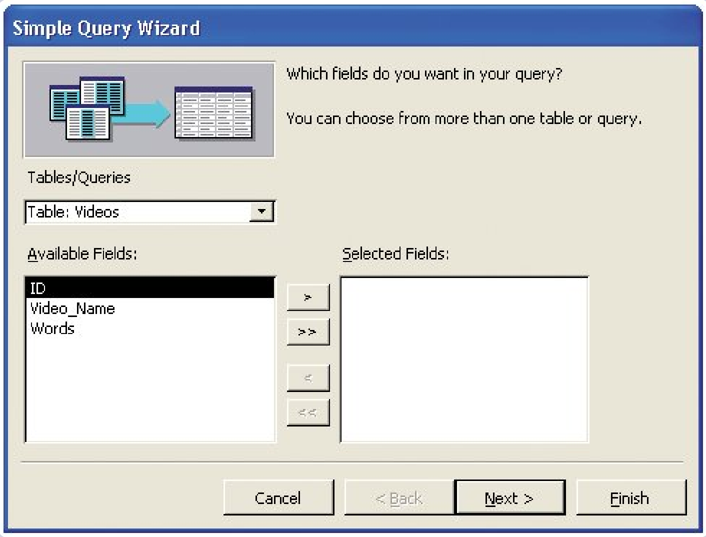


Figure 4.22 Query wizard

## Querying a database

One of the most powerful tools in a database is the use of *queries* to provide information that answers questions asked by the user. Queries allow data to be viewed, changed and analysed, and can be used as the source of data for forms and reports.

Queries use a query language to search the database and locate answers. *Query language* is a high-level English-based language that people with no formal programming training can use to get the information they need. A query is used to filter out those records in the database that do not meet the user's criteria. Only those records that meet the criteria are passed through the filter.

Table 4.8 Example of query language

| Question in English | Query language | | | |
|---|---|---|---|---|
| | Logical operator | Field name | Relational operator | Criteria to be met |
| Find all entries for which the name is Harris | | Name | Equals | Harris |
| Find all entries for adults | | Age | Is greater than (>) | 18 |
| Find all entries where price is under $10 000 and the owner is male | AND | Price<br>Gender | Is less than (<)<br>Equals (=) | $10 000<br>Male |

A query language uses operators to join the field name to the criteria and to join one query to another. The two types of operators found in a query language are relational operators and logical operators.

*Relational operators* join the field name to the criteria on which the query is based, such as equal to in Name=Harris. Other common relational operators include:

- greater than >
- less than <
- not equal to <>
- greater than or equal to >=
- less than or equal to <=

*Logical operators* join one item of a query to another, such as the logical operator AND in Price <$10 000 AND Gender=Male. Other logical operators include OR and NOT.

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## How a query works

During a query, all data not required in the result is filtered out. The display shows only the data that meets the criteria.

First query: From the school database, a list is needed of those students who take Information and Software Technology (figure 4.24). The circle represents those students who will be listed as a result of this query.

Second query: From the school database, a list is needed of all those students who take both Information and Software Technology AND Aboriginal Studies (figure 4.25). The section where the two circles overlap represents those students who will be listed as a result of this query.

Third query: From the school database, a list is needed of all those students who take either Information and Software Technology OR Aboriginal Studies (figure 4.26). Those students in both circles will be listed as a result of this query.

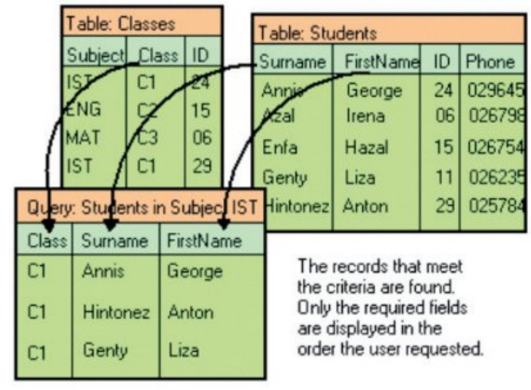


**Figure 4.23** A query in a DBMS

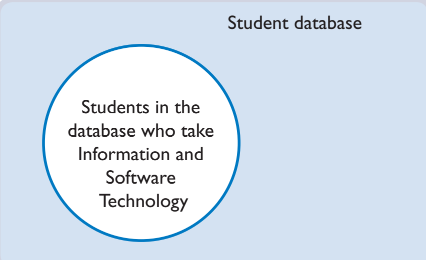


**Figure 4.24** Query 1

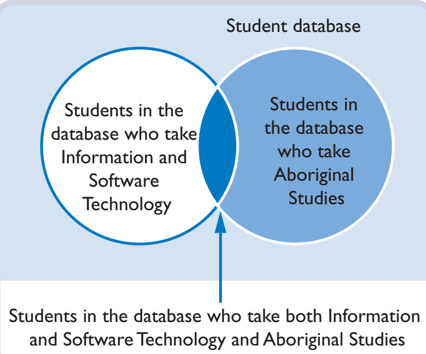


**Figure 4.25** Query 2

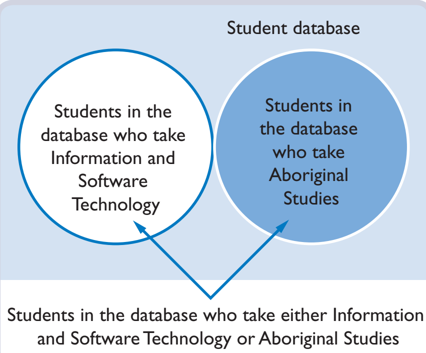


**Figure 4.26** Query 3

### EXERCISE 4.6

1. What is a filter?
2. Draw a diagram to explain how a filter could be used to find all those in a database who are under 12 years of age.

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exercise 4.6 continued

3 The following two fields have been extracted from a large database.

| Item No. | Quantity |
|---|---|
| 1 | 10 |
| 2 | 30 |
| 3 | 20 |
| 4 | 45 |
| 5 | 15 |
| 6 | 25 |

a Use these fields to give the results of these queries.
   i How many items have 20 or fewer in stock?
   ii How many items have more than 26 in stock?
   iii How many items have 15 or more in stock?
b Write the query to find the number of items with fewer than 40 in stock.
c How many items have an item no. less than 4 and have fewer than 21 in stock?
d Write the query to find the number of items with an item no. higher than 3 and with fewer than 20 in stock.
e Which of the following queries will give a list of those people in a database who are aged 28?
   i Age is greater than 27
   ii Age is less than 29
   iii Age equals 28
   iv Age is greater than 28

4 True or false? Rewrite each false statement to be true.
a A query is a search of a database for records that meet a certain criteria.
b Ascending order arranges data from largest to smallest (9–0) or from last to first (Z–A).
c Sorting records is the most efficient way of finding data.
d Searching is the process of arranging data in a particular order.
e Relational operators (AND, OR, NOT) are used to combine simple queries.
f Finding information from a database can only be done in one way.
g Descending sorts arrange data from the largest to the smallest.
h Searching is the process of ordering data.

## Mathematical calculations

Many databases offer some mathematical options that are useful to a user. These options can be used in reports and queries.

*Arithmetic operators* are used for addition (+), subtraction (–), multiplication (*) and division (/) and to produce percent (%) and exponentiation (^). *Relational operators* such as equal (=) or less than (<) are also used to compare two values in fields. When these are used the result

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is a logical value (True or False). The result of either type of calculation can be stored in a field or used as a report component and stored with the report design. When the results of a calculation are displayed in a field, the results aren't usually stored in the table. Instead, the database recalculates the formula every time the report or query is executed so that the results are always based on the most current data in the database.

Database calculations often use the field names as part of the formula. For example, the total of two fields shown as =Sum[ExcursionFee]*[Students] could calculate the total excursion fees due by a count of the students multiplied by the excursion fee.

Examples of the use of calculations for records in a report include total and average for a group or all records. There are many types of calculations possible in a query. For example: the sum or average of the values in one field or calculation of the date three months from the current date. The results of a calculation in a query might not be displayed in a field. Instead, the calculation may be used as criteria to source data from a table and decide the records to be selected. So a query could be written to specify that those records required must have a date in the Date field, that is, between today's date and a date six months from today. The query criteria may resemble the following:

```
Field: Date
Table: Orders
Sort: A-Z
Criteria: Between Date() and DateAdd("m",6,Date())
```

## Methods of presenting information

Forms are used to collect data and also to present that data in a structured fashion so that it is more easily understood. They may display fields, areas for data entry and have links to open other forms or reports.

A *report* is created so that data sorted or queried from a database can be presented as information. It is important to design reports so that they can present the information needed in an ordered way. Reports are stored with the database, but each report has a separate name so that the information can be easily found if it is needed again or after the database has been updated.


Figure 4.27 Forms help the user obtain information

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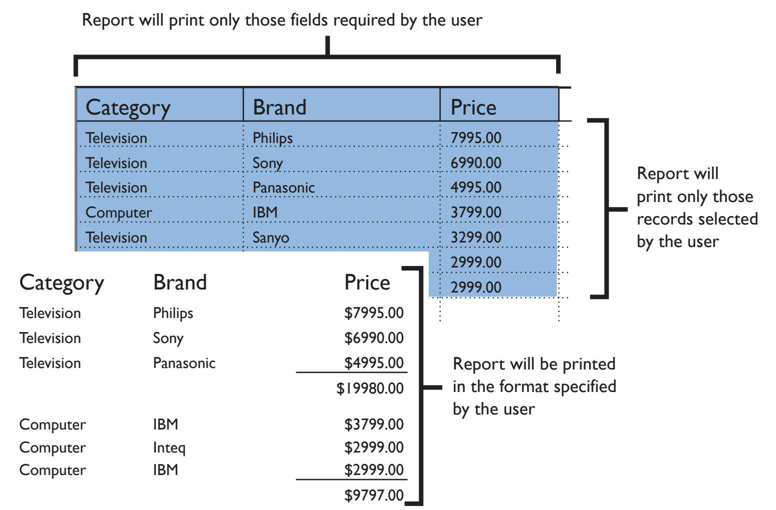


**Figure 4.28** Features of reports

There are many ways of presenting a report including the use of mathematical calculations. When designing a report the database user should ask:

- what information is needed?
- how is this information to be presented?

**Table 4.9** Options available when presenting information

| Option | Explanation |
|---|---|
| Page layout | Wide reports might require sideways printing (landscape) on rectangular paper such as A4. Other reports will use the default (portrait) layout. |
| Margins | Reducing the margins of the page or the size of fields on a report may enable the report to fit on a single page. |
| Queries | Can be used as the basis of reports |
| Grids | Presentation can display lines if needed |
| Headers and footers | Headers and footers can include graphics such as logos or icons, dates, file names or other details. They appear on each page of the display. |
| Summary data | Mathematical calculations included in the design and recalculated each time data is displayed |

## Design features on forms and reports

Forms and reports allow the user to decide their appearance. They include features that allow for custom design or the use of templates. Templates are frequently used designs that are built into the database program. Design features become part of the design and not part of the database itself. They only affect the form or report in which they are included. Thus each form or report can have an individual design.

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Some of the features that could be used include:

- descriptive labels or text including explanations to guide the user or the data entry operator. The text could use a different font to distinguish it from the text in fields or field names.
- graphic elements such as lines, rectangles and pictures, which might also include graphical backgrounds that are appropriate to the content of the report
- calculations stored as expressions, which can be held in the design where they are not relevant elsewhere
- buttons and links to aid the display of other forms, reports or files.

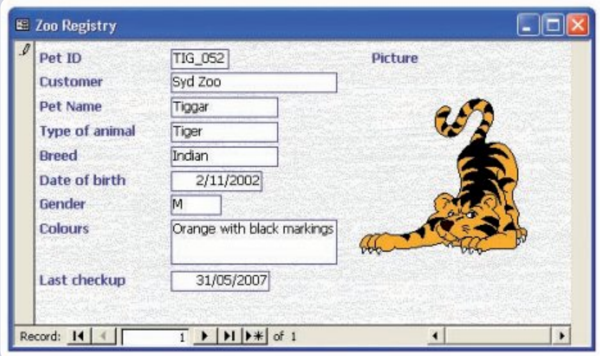


**Figure 4.29** Design features on a form

## EXERCISE 4.7

1 True or false? Rewrite each false statement to be true.
  - a Reports organise and collate data for printing.
  - b Many reports can be created in a database.
  - c A report cannot be created as a list.
  - d Queries are not used to help organise reports.
  - e Reports may only include the data from the data source.

2 The following data has been collected as a small part of the process of data collection before establishing a large database on school students.
  - Sam Adams was born on the 5th of May, 1979 and began high school on January 23rd, 1991. He is now in Year 10 and is studying History, English, Music, Computing, Mathematics and Science. He lives at 2 New Street, Blacktown.
  - Jona Feruk is in Year 11 and she is taking English, Modern History, Mathematics, Information and Software Technology and Science for Life. She lives at 49 Lalor Ave., Marayong. She was born on 14/6/78 and began high school on 29/1/91.
  - Brian Albert Poisson began high school on January 30th, 1988 and finished year 12 in October, 2000. Brian studies Geography, Economics, English, Mathematics, Information and Software Technology and General Science. He wants to become a carpenter. Brian's address is 2 Ink Crescent, Quakers Hill. His birthday is January 4th and he was born in 1975.
  - Helen Natan entered high school in 1991, starting classes on 31 January. Her date of birth is 13/4/78. She is in Year 11 and is studying Mathematics, English, Society & Culture, History and Information and Software Technology. Currently she lives with her grandmother at 16 Spillane Drive.

  a Design a database in Table View that has the following field names.

  Surname FirstName DOB Gender Address Suburb DateEnrolled

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exercise 4.7 continued

- **b** Write a set of rules for each field so that the data entry will be consistent.
- **c** Enter the data provided.
- **d** Comment on the method of data collection.
- **e** List TWO other fields it would be useful to have in this database.
- **f** If you had a large database containing all 900 records to cover all the students in the school, explain how you would most efficiently arrange the full database alphabetically according to students' names.
- **g** If you needed to locate all the students in the full database whose first name was Jona, describe TWO ways in which you could do so.

**3** A database has the following query language:

| Fields/Conditions | Operators |
|---|---|
| Surname | AND |
| FName | OR |
| Address | NOT |
| Suburb | CONTAINS |
| Postcode | EQUALS |
| D.O.B. | IS GREATER THAN |
| GrossIncome | IS LESS THAN |
| Tax | IS BLANK |
| NetIncome | IS NOT BLANK |

The command DISPLAY shows all records on the screen.
The command DISPLAY "FIELD" shows the selected individual field (or fields with the use of AND).

- **a** Name TWO relational operators used in this database.
- **b** Name ONE logical operator used in this database.
- **c** Write a query to display:
  - **i** all records in the database of those who live in ASQUITH
  - **ii** all records of those whose surname has a Z in its spelling
- **d** Write a query to display FIVE important fields for an alphabetical mailing list to all those on the database:
  - **i** whose date of birth is before 1972
  - **ii** whose date of birth is after 1980 and who have a gross income over $1000
- **e** Write a data dictionary to include the details for the fields: Surname, Postcode, D.O.B. and GrossIncome.

## Integration

Databases are capable of integrating their operations with other software. This process is possible whether they are part of an integrated package or independent programs. Microsoft Works is an example of an integrated program with a database module. An *integrated program* means that the user cannot install one module of the program without installing each of the other modules. The database can be used alone or merged with other programs in the package. Such databases are often flat file systems.

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Other database programs are part of a suite of programs that work together but that are not integrated into one modular program. Each program in the suite can be installed separately. Microsoft Access is also part of the Microsoft Office suite of programs. The other programs in the suite provide other types of tools for the user: Microsoft Word is a word processor, Microsoft Excel is a spreadsheet and so on, but they do not need to be installed for the database to work. The programs form a group as they have a consistent appearance, use similar menus, toolbars and icons, and can easily use data from each of the other programs in the suite when this is needed.

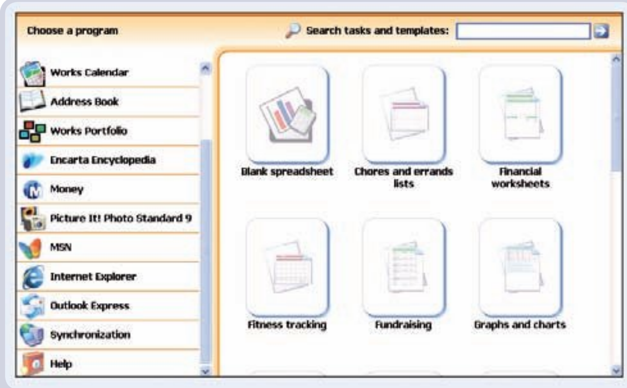

**Figure 4.30** Modules in an integrated program

One example of integration is *mail merge*. A database or a data file holding the names and addresses of many people can be used to integrate that data with a word-processor file such as a form letter. A *form letter* is a letter that is designed to go to many people and can be customised to display the data as a personalised letter for each person. The letter only needs to be written once and then merged with the data source. The data source can be used to merge with many different form letters or other documents.

## Importing and exporting data

Databases are able to collect data by importing electronic data from existing sources. This may involve some reorganisation of the data, but many databases have facilities to accept data in more than one form. Examples include importing data from tables in word processors, tabbed data, and paragraph organisation. Data can also be exported for use in other software.

## Data security

Data is a very precious and valuable asset of businesses, governments and other organisations and needs to be protected against deliberate or accidental damage. There are those who deliberately attempt to access data (hacking), some doing so with criminal intent (cracking). The data is often sensitive personal data.

**Table 4.10** Examples of data security methods

| Security | Description | Usual form taken |
|---|---|---|
| Locks | Any means of securing a system from data locks on floppy disks to door locks and screen locks | Physical |
| Data backups | Copy of data held on a separate site to the original data in case of data loss or corruption | Electronic |

continued >

### Think about this

The increasing digitisation of information creates greater needs for the security and protection of sensitive and private data, and for the validation of official, certified information. As the number of databases grows and the access to them increases, the more problems there are likely to be with the invasion of people's privacy. Should people have the right to know who is storing and accessing their personal information?

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| | | |
|---|---|---|
| Passwords | Unique identifier for system or data access by authorised users | Electronic |
| Encryption | Conversion of data into a form unreadable by those who do not have the key to decrypt the data | Electronic |
| Firewalls | Barrier placed on a network to prevent unauthorised access | Hardware or software |

## Expert systems

An expert system holds a large data store on a specialised topic. One component of such systems is a knowledge base or a database of all knowledge on the topic. This knowledge consists of both the known facts and the rules related to use of that knowledge. One such database may be designed and developed to hold all knowledge related to emus. The knowledge would be gathered from all expert sources: encyclopaedias, books, magazines and human experts. Each fact would be verified against other sources before being included in the system. Rules would be taken from the facts and from the experience of experts in the field. For example, emus are birds is a fact, as is the fact that they have wings. However, emus do not have wings developed for flight, so a rule related to emus states that they do not fly. The rule has come from the study of emus by experts. Further information on expert systems may be found in chapter 2.

### EXERCISE 4.8

Read the information and complete the following activities related to the use of databases.

> Databases are a very important part of life today. They are used by large and small businesses, on the internet to support search engines, and to ease many everyday enquiries over the telephone. A decade ago, if you rang directory assistance to ask for a telephone number in another area, the operator would look up a telephone book for that area. Today the telephone numbers for all Australia, except for a few private numbers, are available as huge databases on the internet. If you ring directory assistance to find a number, the database is searched automatically to find it using the information you give and then a recorded voice provides the number.
>
> Along with the advantages of databases, new problems have arisen. Modern databases are available on large networks and need to be accessed by a lot of people for many different reasons. The database must be kept secure. Unauthorised people need to be kept out completely. Other people may need the right to read the data in the database but not the right to change

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exercise 4.8 continued

or add any new data. A few people need rights that allow them to change the contents of the database. Security may involve methods such as encryption, passwords and firewalls.

1 Use ONE of the database activities you have finished and write a code to encrypt ONE record in the database.

2 Explain why the following passwords would be good or bad choices: Fido (user's dog's name), 1987 (user's year of birth), 0296561532 (phone number), Aabrac81d, hoT2dAY4U.

3 Provide an example of when the use of physical security would be the best choice.

4 Explain how different types of security might be merged to provide a very high level of security for a particularly sensitive database.

5 The database form below shows some of the items of information that a company is considering collecting for a personnel database of its employees.

| | |
|---|---|
| Full name | Address |
| Telephone no. | Years at above address |
| Single/married/widowed/divorced | |
| Union membership | If yes, which one? |
| Is s/he an active member? | |
| Potential danger of union activity to the company? | |
| Owns own house? | |
| Mortgage? | If yes, how much owed? |
| Bank account number | Has s/he ever been bankrupt? |
| Credit rating | |
| Outstanding debts | |
| Salary | |
| Tax file number | |
| Criminal record (Y/N)? | If yes, give details |
| Mother's occupation | |
| Father's occupation | |

a List the items that might be an invasion of the employees' privacy. Explain your answer.
b From an employer's point of view, explain why you would wish to include all the items on the form.
c Explain THREE security measures that could be taken to protect such sensitive information in a database.

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# Database design

## Multiple choice questions

Select the best answer to each of the following questions.

1 Data and information differ because
- A Data is tables; information is forms and reports
- B Data is text; information is images and video
- C Data is raw facts; information is interpreted data
- D Data is up to date; information is out of date

2 Searching dissimilar information using an internet browser is usually done through a
- A Hypertext database
- B Offline database
- C Manual card database
- D Flat file database

3 Common components of a database include
- A Characters, views and lists
- B Levels, records and symbols
- C Information, facts and charts
- D Files, records and fields

4 DBMS stands for
- A Database memory standard
- B Database multipart scheme
- C Database management system
- D Database manifold storage

5 A grid of fields and records is also known as a
- A Table
- B Query
- C Row
- D Column

6 A single record in a file named 'Class' would most likely hold data in the form of
- A One character
- B A list of surnames
- C All details related to one student
- D Teachers' home addresses

7 An example of a one-dimensional array in a database is a
- A Table
- B Record
- C Query
- D Form

8 A check on the accuracy of data as it is entered in a database is called
- A Updating
- B Locking
- C Validation
- D Verification

9 During the process of sorting data, the field entries in individual records are
- A Altered to keep them up to date
- B Moved but not separated
- C Searched to locate data for a form
- D Organised into other records

10 The process of querying a database may also be called
- A Sorting
- B Operating
- C Filtering
- D Designing



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## Extended answer questions

Figure 4.31 summarises the design features on database forms and reports.

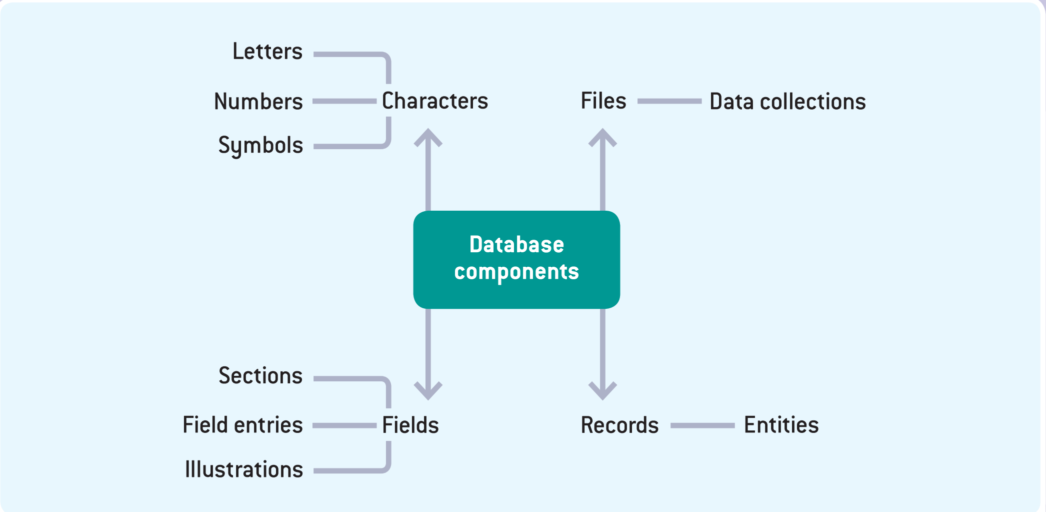


Figure 4.31

Write answers to each of the following questions.

1 List the FOUR major components of a database in ascending order.

2 Define the term 'database'.

3 Briefly compare a flat file database with a DBMS.

4 Explain the function of a data dictionary.

5 When would the user need to sort a database?

6 Why would the FIND command be used to locate data in a database rather than using a query language search?

7 Draw and label a table showing ONE record for a music database.

8 How is a relational operator different from a logical operator in a query?

9 The data in a database includes the following:

| Dog | Breed | File_Name | Size |
|---|---|---|---|
| Terrier | Tenterfield | Terrier1.gif | 45kB |
| Beagle | Golden | Beag8.gif | 125kB |
| Great Dane | American | Dane9.jpg | .547MB |

Write the record/s that would result from the following queries:

i Size<50kB

ii Breed =Terrier AND Size>40kB

iii File_Name CONTAINS .jpg OR Breed=Golden

iv Comment on the design fault in the field Size.

10 Describe the main difference between a standard database and a hypertext database using the example shown in question 9.

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# PROJECT 1: DATABASE DEVELOPMENT

Projects are based on Microsoft Access but could be developed in a similar relational database.

## Define the problem

The school library needs an electronic database to keep track of the resources in its stock.

## Analyse the problem

The database needs to keep the title and author of each book, the number of copies in stock, type of book, classification and the cost of each copy.

## Design a solution

1 Design a data dictionary for the database, showing the field names and the type of data to be entered in each field (see the data below for clues).

2 Open a new database. Save the database as Library.

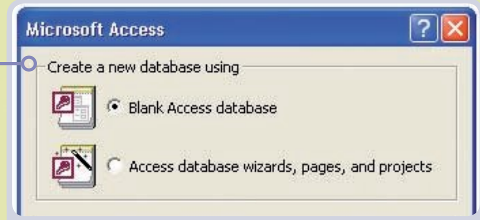


Figure 4.32 Selecting a new database

3 Open a new database table and enter the fields from your data dictionary.

4 Save the table, name it Books and create a primary key when asked to do so.

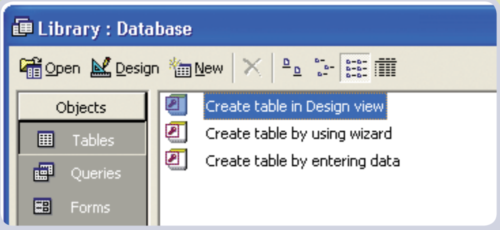


Figure 4.33 Using Design view to create a table

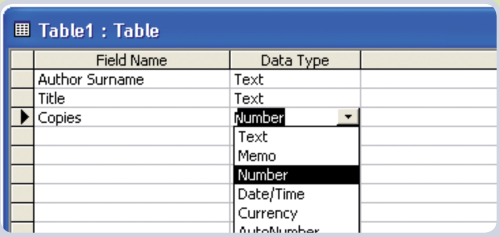


Figure 4.34 Examples of a few fields in Books table

## Produce the solution

1 Enter the following data into the correct fields of the database. To do this change to Datasheet view.
- *Modern Mathematics* by A. Krupp, 190 copies, Non-fiction, 510 KRU, $29.95
- K. Limber's *Algebra for Year 10*, 35 copies, Non-fiction, 512 LIM, $22.90
- 67 copies of the non-fiction book *Everyday English* by V. French, $26.95, 420 FRE
- *Great Adventures*, $14.95, by L. Rathby, 72 copies, Fiction, F RAT
- *French for Starters*, J. Fleur, 25 copies, $18.90, Non-fiction, 440 FLE

2 Change the field widths in Table view so that the data in each field can be seen on screen where possible.

3 Visit the library and collect data related to another 20 items held in the library collection: at least 5 additional books, 5 CDs or videos, 5 magazines and/or journals must be included in the collection. Make sure you have the number of copies for each item. This information is usually displayed when you query the library database.

4 Add the data to your database. To do this add separate tables for CDs/videos, magazines/journals. A data dictionary will be useful for the design of these tables. Name the tables appropriately and give each a primary field when asked to do so.

5 Sort the Books table from the smallest number of copies to the largest.

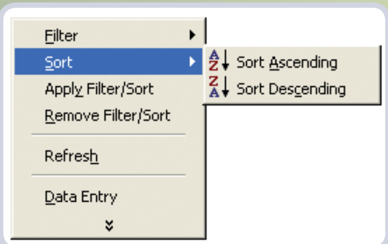


Figure 4.35 Sorting the data



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6 Create a form for one table (using a form wizard where one is available) to improve data entry.

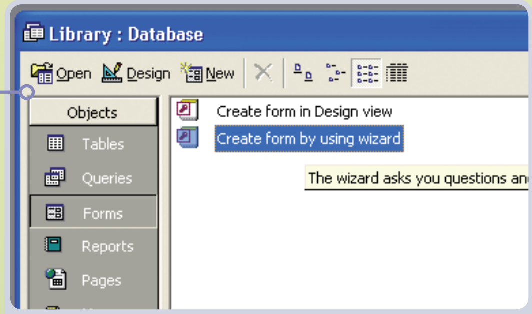

Figure 4.36 Using the Forms wizard

7 Include a graphic and/or graphic background on the form if the application supports this data type (Access does).

8 Where your database has the function, set up a validation rule for data entry in the 'Copies' field of the Books table.

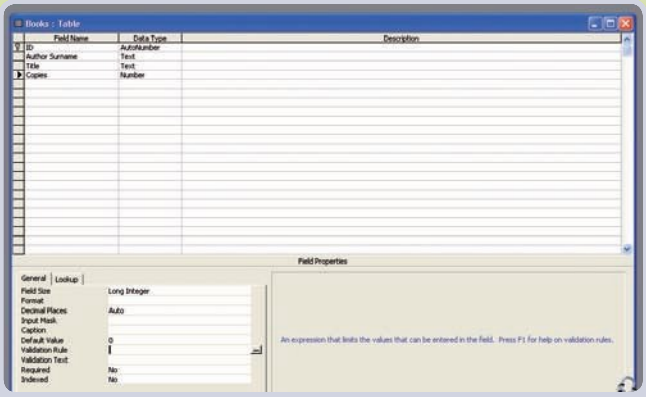
Figure 4.37 Setting a validation rule

One useful validation rule could be 'Between 0 and 100'. The validation text could be 'Copies over 100 are removed from circulation in order of oldest or damaged copies first'. In datasheet view test the validation process by entering 105 in the copies field for one book.

9 Explain the use of data validation rules.

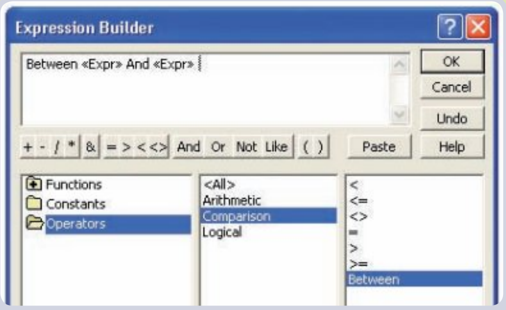

Figure 4.38 Writing the validation rule

10 Write FIVE queries that could be used to search your database using a table like the following. At least one of the queries must be a complex query that includes a logical operator.

| Question in English | Query language | | | |
|---|---|---|---|---|
| | Logical operator | Field name | Relational operator | Criteria to be met |
| | | | | |
| | | | | |
| | | | | |

11 Use the database to see the results of each query.

12 Design and produce a report for the library. The report must include an appropriate header and footer and statistics related to the total numbers of each type of item held in the database. This may be done using the Report wizard.

13 Save the database.

## Evaluate the solution

Use table 1.7 in chapter 1 and write a report outlining the good and bad points of the project solution.

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## PROJECT 2: QUERYING A RELATIONAL DATABASE

This project requires that a student has completed the previous project. It also assumes that Publisher is a field in all tables. Sample fields may not be the same as student fields.

### Modify the solution from Project 1

1 Open the database Library.
2 Create a query based on the Book table.

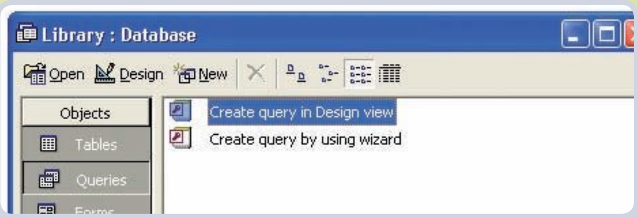

Figure 4.39 Creating a query in Design view

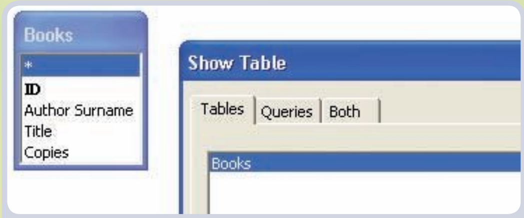

Figure 4.40 Adding the Book table to the window

3 Drag the title, author surname and copies fields into the bottom half of the query design window. Type the criteria given in the figure into the Criteria cell.

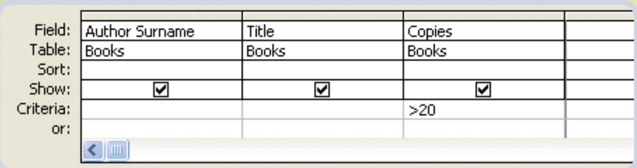

Figure 4.41 Result of adding fields and criteria to the query

4 Change to Datasheet view to see the result of the query. All books with over 20 copies should be shown. Return to Design view and remove the tick from the copies field. View the data again.
5 Close and save the query as Book copies>20.
6 Design a second query. Include Books and CDs tables in the query.

The tables should be related through their primary field.

Figure 4.42 Adding two tables to a query

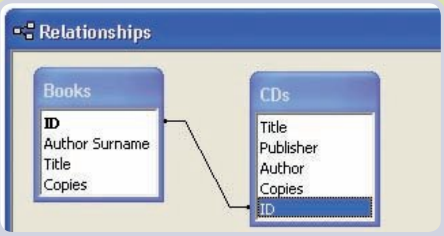

Figure 4.43 Making sure tables are related

7 Drag the Publisher fields from each table into the grid at the bottom of the query design window.

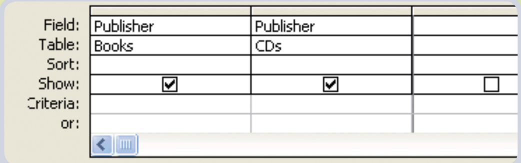

Figure 4.44 Adding Publisher fields from two tables

8 Use the Datasheet view to see the result of the query. Return to the design view and change the sort order of one list. Check that this change has occurred. Close and save the query as Publisher List.
9 Save the Library database.

### Evaluate the solution

Using your evaluation from Project 1, judge whether the modifications to Project 2 have improved or reduced the ability of the database to solve the problem given at the start of Project 1.



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# Digital media

Digital media is any method of storing, transmitting, receiving and manipulating data in digital form. Sound, images, text and video are all available in digital format for use on a computer system.

Digital media is any method of storing, transmitting, receiving and manipulating data in digital form.

## Characteristics of digital media

Digital media is the product of digital data processed electronically, stored as a file, and transmitted within computer systems and across networks, including the internet.

Digital data is represented by a series of numbers expressed in the 1s and 0s of binary code, that is, digits. Text, images, sound and video can all be handled as a series of these digits.

Digital media can be copied perfectly. To understand the importance of this, consider a standard videotape. It holds analogue or variable data. Every time you copy or transfer the analogue data on the tape there is a degradation (reduction) of quality. Digital data on a DVD (digital versatile disk) or other source can be copied perfectly, with no degradation of quality, as many times as required.

Digital media needs digitising devices to convert data from analogue to digital data for use in computer systems. Such devices collect data from scanners, optical character readers, barcode readers, digital and video cameras, pointing devices such as the mouse, trackball, joystick, light pen, touch screen, touch pad, digitising or graphics tablet, keyboard, music synthesisers and microphones. The data is then available for manipulation, transmission and display across the computer system and any networks.

### Think about this

Digital data makes it easy for people to copy data, including music and websites, that is, the intellectual property of others. Should data be freely shared or should we continue to have copyright laws (see chapter 1) to protect the data that comes from the creativity and effort of individuals?

### EXERCISE 5.1

1 Define these terms: digital media, digit, digitising.

2 Name ONE major advantage of digital media.

3 List FIVE devices that could be used to collect data for digital media.

4 How is digital data represented by the binary code?



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exercise 5.1 continued

5 Give FOUR examples of digital media types.

6 Read the following information related to capturing digital media using a digital camera and identify the terms in questions a–j that follow the text.


**Figure 5.1** Digital camera

A digital camera can be used to collect still images (photographs) or moving images (video). The digital camera used for photographs uses a light sensitive silicon chip to collect an image. The amount of detail the camera can collect is called the *resolution*, and it is measured in pixels. A *pixel* or picture element is the smallest element of graphical data that can be manipulated in an electronic display. It is like one spot on a grid of many thousands of such spots. A collection of pixels can be manipulated to display letters, numbers and graphics. In general, the more pixels the camera has, the more detail it can collect.

An image is taken by the camera through a process of sampling the light that bounces off the subject. The sensor, usually a CCD (charge coupled device), converts this light into electrical pulses. The sensor is made up of light-sensitive diodes called *photosites*. Some photosites are not used to collect the image; instead, they function to measure the electrical voltage in the other photosites. The brighter the light at a photosite the greater the build-up of electrical pulses. The value of the build-up is read and an ADC (analogue to digital converter) turns this value into a digital value to record brightness. The sensor also splits the light into three primary colours (red, green and blue) using separate filters to respond to each colour. This can also be held as a digital value. Once these digital values are stored on the camera's memory card, each pixel can be reproduced in almost the same form as the original image and the digital camera is able to provide a display on its liquid crystal screen so that the user can see the image almost immediately.

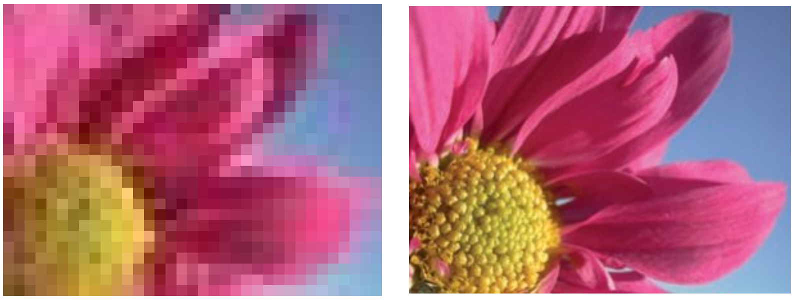


**Figure 5.2** Image resolution

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exercise 5.1 continued

The quality of the image taken depends on the resolution of the camera and the amount of compression used. The higher the resolution the more detail is recorded. Resolution is measured in pixels. For example, a 2.1 megapixel camera may produce images with a resolution of 1600 x 1200 pixels. Compression is a formula used to reduce the size of the image and is covered in detail later in this chapter.

Once it has been collected, the image, stored in digital form on a chip or a small disk, can then be downloaded to a computer, manipulated in many ways using special software, and then stored, transmitted and/or printed.

What am I?

- **a** I am the term used for the quality or detail of a digital image.
- **b** I am the type of display used on a digital camera.
- **c** I am a light-sensitive diode on a CCD.
- **d** I am a type of sensor used in many digital cameras.
- **e** I am the smallest element of graphical data that can be manipulated electronically.
- **f** We are the three primary colours into which digital data can be split.
- **g** I am a process used to reduce the physical size of a file.
- **h** I am the term used for changing or editing digital images.
- **i** I am a device able to convert data from analogue to digital form.
- **j** I am a type of still or static image taken by a digital camera.

**7** How is resolution measured?

**8** Why are pixels important?

**9** What hardware is used to store digital images?

**10** Name the process used to transfer digital images to a computer.

**11** How many pixels are contained in an image taken by a 2.1 megapixel digital camera?

## Purpose of digital media

Digital media allows for the easy exchange of information in a huge range of forms. The information can be for purposes such as entertainment, illustration or communication.

### E-music

E-music or electronic music is digitised music. One such file format is MP3 (MPEG is a standard of the Moving Picture Experts Group). MP3 has allowed music files to be reduced to a much smaller size so that they are more easily downloaded from the internet or other networks. They take up less space on a computer because they are compressed, so more of these files can be stored in any given space than other types of music files. An MP3 file can be easily copied with no reduction in music quality. This has

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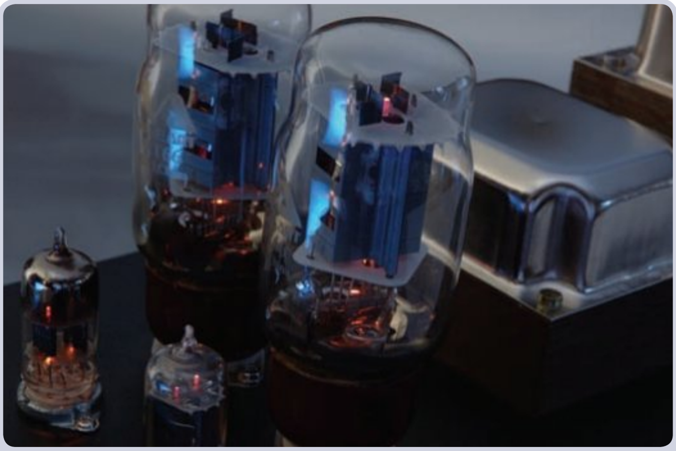

Figure 5.3 Audio amplifier

led to problems with copyright where others illegally copy or 'pirate' songs in this format. Such piracy reduces the income of musicians and music developers and has led to a crisis in the music industry whereby the quality and availability of new music will eventually suffer if some way is not found to prevent the illegal distribution of MP3 files.

## Digital newspapers

Digital newspapers communicate information rapidly over networks such as the internet. They have many advantages, including their currency, that is, they are more likely to be up to date than paper versions. It is easier to update the digital version and to reprint more rapidly than in the past if paper copies are needed. They are not restricted to text and images – they can include animations, sound and video in their display. Electronic versions are also more interactive, allowing users to browsers their contents more flexibly than is possible in other forms of newspapers.

### Great idea

RSS or really simple syndication is an emerging digital development that allows the user to choose what to read from the world wide web. The user may become a subscriber to newspapers such as *The Sydney Morning Herald* or *The Australian* whereby a 'permanent link' is set up. Users choose what news items they wish to know about, e.g. politics and/or sport, and then sit back and wait for the content to be delivered to them. For example, from their choice of 'feeds', they could have their news delivered as an online newspaper customised to their interests and delivered to their email inbox or accessed using a browser or PDA (personal digital assistant).

## Interactive TV

Interactive digital TV allows the viewer to interact or communicate through the screen interface. The TV program can be networked to allow two-way communication, that is, the machine is both a receiver and transmitter. This is unlike the analogue TV receiver many of us still have in our lounge rooms. For example, consider a television quiz show. With interactive TV, the host asks questions and viewers press buttons on their screens or handhelds to send answers to the program. According to the criteria used, the host then selects viewers to participate in the program alongside the competitors already in the studio. Other viewers can vote for the competitors or send replies to surveys, for example: How many of the audience want the competitor to choose this answer? The remote audience is no longer passive – instead it can be actively involved. Viewers have greater control over the content of a broadcast and may be able to stop, edit, replay or even change the direction of a show in the future.

Figure 5.4 Digital television

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## Games

There have been major improvements in games as a result of digital media. The range of options, degree of interactivity and the level of reality are changing fast. The degree of interactivity refers to the amount of involvement by the user in the game, that is, the options available to the user to determine what components they play, what direction to take and the influence the user can have on the outcome of the game.

Games use digital media in two different forms: offline and online. *Offline* is when a computer is not connected to any other node in a system, such as a stand-alone personal computer or a computer that is not using its network connection. The user could operate a game from the hard disk, a CD or DVD. *Online* refers to a computer that has an active connection to another computer or to many computers on a network. The user could be involved in a game with others across the internet or play a game available on an internet site. Viewers have greater control over the content of a broadcast and may be able to stop, edit, replay or even change the direction of a show in the future.

**Table 5.1** Types of games that use digital media (some games use more than one type)

| Type | Description |
|---|---|
| Action | Simulations of adventure situations e.g. War games |
| Arcade | Board games of different types e.g. Pinball |
| Casino | Gaming e.g. Card games such as Blackjack |
| Sports | Games that allow the user to participate in a simulated sport environment e.g. Golf |
| Multiplayer | More than one user can participate |
| 3D (three dimensional) | A form of virtual reality game needing special hardware |
| Jigsaw | Games involving the combination of parts into a whole |

Computer chess programs are an example of computer games using digital media. They work with a graphical user interface and may involve the computer as the opposing player. These games are a step towards the development of artificial intelligence, that is, the use of computers to simulate human behaviour. In May 1997 an IBM supercomputer called Deep Blue defeated Gary Kasparov, the world chess champion at the time. Such games work by using formulas, that is, they make moves based on the calculated value of different positions on the chessboard.

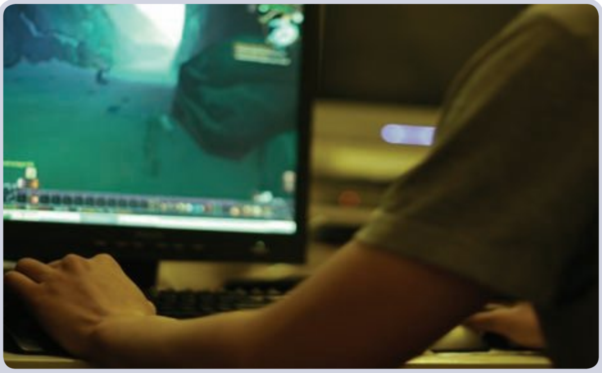

**Figure 5.5** Playing a computer game

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## Hardware for game playing

Joysticks have been a traditional form of game controller. They convert the analogue data from hand movements into digital data that can be read by the computer. This allows the user to interact with the game more flexibly than by using a keyboard or mouse.

AGP or accelerated graphics port improves the performance and speed of graphics hardware. The card plugs into a dedicated graphics slot and connects directly to the CPU, giving it the ability to improve the streaming of video and 3D graphics. AGP speed is also increased due to the use of *pipelining*, that is, a process of retrieving data in chunks rather than as individual characters.

3D enhancers such as 3D glasses can be used with some 3D games to increase the sense of reality. Head-up displays (specially adapted helmets) and data gloves (gloves with sensors to detect hand movement) are expensive options for some of these games.

### EXERCISE 5.2

1 True or false? Rewrite each false statement to be true.
   - a Complex 3D games need an AGP to operate correctly.
   - b MP3 is a type of digital text.
   - c Piracy is the illegal copying of digital media.
   - d Digital newspapers are usually more up to date than printed newspapers.
   - e MP3 files are compressed music files.
   - f Interactive TV is both a receiver and a transmitter.
   - g Offline games will always be played across the internet.
   - h No computer has yet defeated a human player.
   - i No type of newspaper is able to display video clips.
   - j Piracy will not harm the music industry.
   - k All computer games need data gloves and head-up displays to operate.
   - l High interactivity increases a game player's involvement in the game.
   - m Audiences involved in interactive TV are very passive.
   - n Keyboards are more useful than joysticks for game playing.

2 Write full sentence answers to these questions.
   - a Why is an AGP valuable for some forms of digital media?
   - b Explain the advantage of streaming data.
   - c Describe the term 'interactive' when referring to games, newspapers or TV.
   - d What is the value of downloading an MP3 file from the internet rather than another type of music file?
   - e Briefly discuss TWO electronic games you know about. Make sure to include their type, the digital media and an outline of how to play the game in your discussion.

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# Types of digital media products

Digital media products can be stored, transmitted, received and downloaded or retrieved from the internet, CDs, DVDs, hard disks, large capacity disks such as zip disks and, in limited ways, from floppy disks. Many use add-ons or plug-ins – software designed to expand the capabilities of the original application. As examples, iQfx is an add-on that is used by Real Player to improve audio quality, and to see Flash animations on a web browser a Flash player plug-in is needed.

**Table 5.2** The range of digital media products

| Type | Description | Example |
|---|---|---|
| Single task | Products that handle one type of digital media | An animation program that takes graphics designed in another program as frames and then merges the series of graphics into an animated file |
| Multiple task | Products that handle more than one type of digital media | Desktop publishers (dtp) integrate many types of media from other programs and have some tools to create more than one type of media within the dtp program |

## Desktop publishing of magazines and newspapers

Newspapers, magazines, reports and brochures are produced with special programs called desktop publishers and some advanced word publishers. These products combine text, hypertext, graphics and other media in very flexible ways to produce very professional publications at much less cost than using older methods of laying out documents on paper and cardboard. Desktop published magazines and newspapers are far more flexible and also help to standardise layout and page structures. They usually allow the finished product to be saved in different file formats, for example, as a document for screen display or printing, or in html (hypertext markup language) to allow for the electronic use of the document by a web browser.

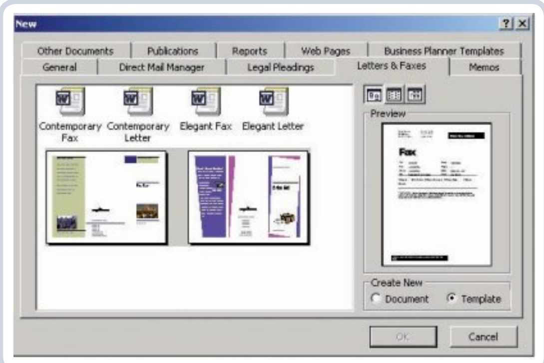


**Figure 5.6** Desktop publishing templates

### Features of desktop publishing products

*Master pages* allow the background elements of all pages to be created once and to be carried through to all pages in a publication. The master page is like an opaque page, and other pages act like transparent sheets that overlay the master page. Each transparent layer can have its own elements as

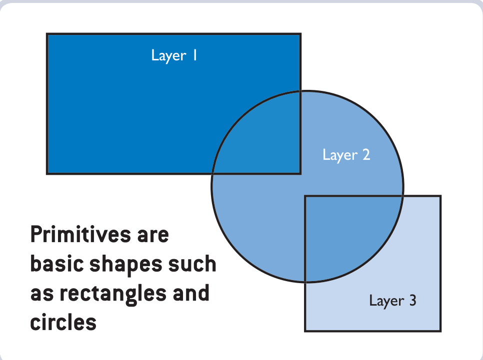


**Figure 5.7** Layering objects in desktop publishing

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well as the background elements common to all pages. Image layers need to be transparent so that underlying layers are seen through the top layer.

*Wizards* are tools to help with the creation and editing of publications. They guide a user through the steps of a process or task by asking a series of questions or presenting options. For example, a wizard could help to set up a magazine format for the first time.

*Tutorials* are more general sets of instructions that help the user learn how to carry out tasks or generate full documents in the program.

*Templates* or predefined documents may be customised by the user. Templates can be available in categories e.g. brochures, business cards, flyers or business forms. Design templates are a collection of styles and colour schemes that have been placed together by experts and are easily applied to any document.

*Layouts* are page setouts of various kinds suitable for different types of publications. Layout guides assist with dividing pages to achieve good design by applying grids.

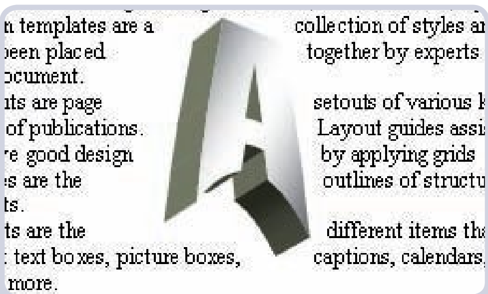


**Figure 5.8** Text wraparound graphics

*Frames* are the outlines of structures that can be used in layouts.

*Objects* are the different items that may be included on pages: text boxes, picture boxes, captions, calendars, borders, video clips and many more.

*Draw tools* allow different shapes to be created within a publication such as lines and boxes.

*Object tools* help the creator to manipulate objects by layering, rotating, grouping and other tasks related to objects.

## EXERCISE 5.3

1 Answer the following questions in full sentences.
   - a How is a single tasking digital media product different from a multitasking product?
   - b Why do some products use plug-ins or add-ons?
   - c Write a simple description of a desktop publisher.
   - d How is it possible for a dtp document to be used by a web browser?
   - e Describe FOUR tools used in desktop publishing.

2 Match the descriptions in column 2 with the correct terms in column 1.

| Term | Description |
|---|---|
| layering | predefined documents available for user customisation |
| master page | large storage capacity portable disk |
| templates | method of having text follow a graphic outline |
| text wraparound | opaque layer in a desktop publication |
| zip disk | process of creating different levels in a publication |

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## Graphic design

**Graphics** are images or pictures used in computer systems, that is, in digital form. Graphic design products come in many forms for different uses. They might have a primary purpose of creating and manipulating drawings and icons or laying out windows and displays using buttons, dials, cursors, sliders, scroll bars, bubbles and other tools, or they can manipulate graphics already created in another program. Many combine more than one use in a single product.

**Graphics** a pictorial representation of data used in computer systems, i.e. in digital form.

### Career path

**Graphic designers are responsible for creating designs including product logos and packaging. They produce designs for book covers, brochures, road signs, advertising posters, websites, CD-ROM pages, magazines and newspapers. To be a graphic designer requires artistic talent and an ability to use the computer as a creative tool.**

**Table 5.3** Major types of graphical design products

| Product | Description | Example of design output |
|---|---|---|
| Paint program | Produces bitmapped graphics for logos, illustration and other purposes. They are easily edited at pixel level and can have much detail. | Digitised pictures (from scanners or digital cameras), photographs, icons |
| Draw program | Produce vector graphics from primitives (basic shapes) for computer-aided design (CAD) and line drawings. Vector graphics can be resized without losing clarity, and stored as smaller files than bitmapped graphics. | Building plans, sewerage, water and electrical diagrams |

### Graphics created in paint and draw programs

**Paint programs** create raster or bitmap graphics made up of many pixels. They have many advantages: they are cheap, easy to learn and are very good for changing small parts of a graphic as each pixel can be edited. However, the graphics do have a more jagged appearance and use a lot of storage space, and it isn't easy to move parts of a picture without changing the rest of the picture. The jagged appearance can be smoothed out by a process called *anti-aliasing* where edge pixels are blended into the background using shades of the adjoining pixels.

**Draw programs** use objects to produce vector graphics. Draw programs allow for more accurate drawings than paint programs, the drawings are usually clearer and they need less storage space. Draw programs use a range of basic objects called *primitives* to create pictures including lines, rectangles, circles and curves. Parts of the picture can be changed without altering other parts of the picture. Draw programs are harder to learn at first, and adding shading and other fine detail is not as easy.

**Paint programs** create raster or bitmap graphics in which individual pixels can be manipulated.

**Draw programs** use objects to produce vector graphics.

Graphic design takes advantage of the power of graphics. Images or graphics can be used for illustration, analysis, to aid visualisation and to communicate information. Graphics communicate to all groups of people except those with visual impairment – just think about all the signs along roads and on shops,

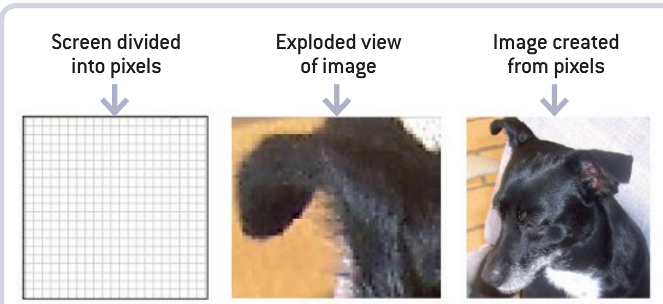


**Figure 5.9** Bitmap imaging

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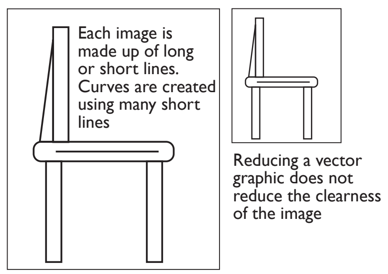


Figure 5.10 Vector imaging

Figure 5.11 Map making and graphic design

and the logos we see every day. People find graphics more interesting and stimulating than text and hence images often accompany text to provide interest as well as information.

Graphic design requires a skilled user of the graphics product. For example, CAD or computer-aided design is specialised 2D/3D software used in design work. An architect will use it to design the framework of a house on computer. The basic design can be changed into a computer model or viewed from a range of perspectives. This can then be altered so that the client can 'walk through' the design.

### Features of graphic design products

Graphic design products have tools to create and manipulate a range of objects. These include specialised tools such as those to capture an image or screen or animate a series of images. Rotation and perspective tools can also be available to change the image and 3D tools provide depth to the image.

Most products have the ability to save graphics in a range of different file formats for different purposes such as GIF files for including in the world wide web or TIF files for publishing in print form.

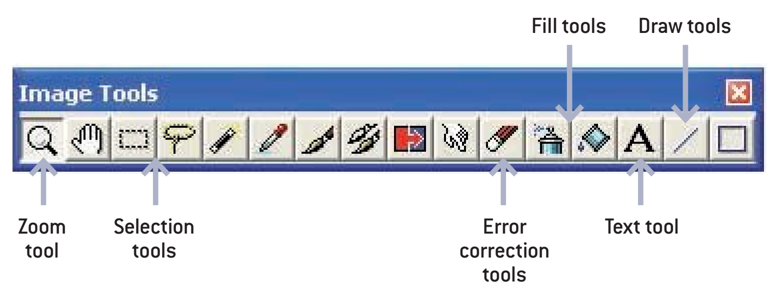


Figure 5.12 Tools available in a paint program

## Audio sequences

**Audio sequence** a sequence or continuous series of sounds or waveforms.

Audio sequences refer to the handling of digital sounds as a sequence or continuous series of sounds or waveform.

Table 5.4 Use of audio sequences

| Use | Description | Example |
|---|---|---|
| Sound effects | Short sounds used to emphasis movement or change | Button clicks |
| Voice | Narration or delivery of information | Verbal instructions or help |
| Underscore | Background sound behind other media | Theme music or sound effects |
| Ambient sound | Sound to set a mood or the environment for other media | Busy traffic noise or the sound of wind in the trees |

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Audio is captured from analogue data. Sounds consist of waves of varying pressure (vibrations) in the atmosphere with both frequency and amplitude.

*Frequency* is pitch. High-pitched sounds move faster than low-pitched sounds and display as a closer wave (waveform). Frequency is measured in hertz (wave cycles per second). Each cycle includes both the peak and the trough of the wave.

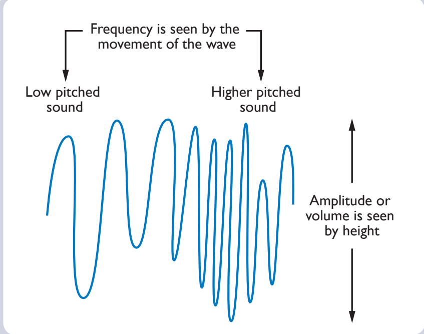


Figure 5.13 Sound waves

*Amplitude* is volume or loudness of sounds. The height of the waveform determines amplitude.

For sound to be digitised, it needs to be converted from its natural analogue state using equipment including microphones, sound cards, mixers and signal processors such as amplifiers.

Figure 5.14 Audio controls

## Features of an audio product

- Volume controls
- Playback and recording of audio files
- Editing tools such as setting sample rates or analysing a file and splitting or joining a file to others
- Burning or copying files to a CD
- File handling e.g. converting files to another sound format such as .wav files to MP3

Two examples of digital data storage hardware are the PDA (personal digital assistant) and the PDE (personal digital entertainment device). These have functions to allow for the input of data via a stylus (pen), an add-on keyboard and/or a computer connection. PDAs are small and portable and have a calendar and organiser, and other basic software such as word processing, spreadsheets and email. They usually have wireless ability to collect data on the move.

PDEs have become very popular. One form is the MP3 player. The user may download, store and play audio, including podcasts, music, photo and video files, and in many cases, also undertake tasks similar to a PDA.

Figure 5.15 PDA

## Try this

**Using paint techniques**

1. Using a paint program, open any icon (a small picture) available on your computer system.
2. Zoom the icon to 800% and identify the pixels in the icon. Note: The Help menu of a program will provide instructions on how to carry out tasks like this.
3. Use the available tools to create some simple shapes (called primitives). Examples are circles, rectangles and ovals, etc. Overlap some of the shapes.
4. Copy the entire image and paste it to another part of the page.
5. Select this second copy and flip the image.
6. Paste a third copy of the image. Select and rotate this copy.
7. Use the Fill and colour tools to fill a section of one image. Zoom out to see the filled area more closely.
8. Choose the Pen tool, change to another colour and carefully change the colour of some individual pixels by clicking in the filled area.
9. Save the file as ‘Pixels’.

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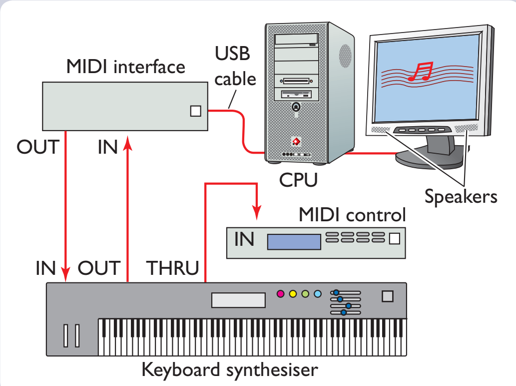


Figure 5.16 MIDI connection from keyboard to computer

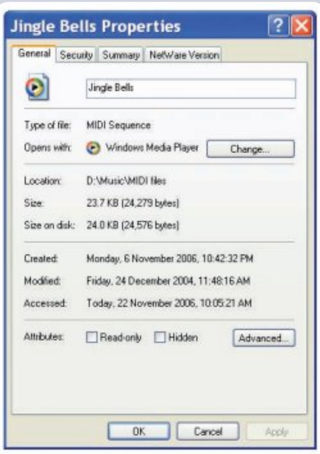


Figure 5.17 MIDI file

## Musical compositions

Musical compositions are produced using MIDI. MIDI (musical instruments digital interface) is a protocol or rule for handling music in digital form. A MIDI file has no sounds, but includes instructions that describe the notes to be played and commands to instruct instruments when and how high to start and stop playing notes. For example, MIDI files played through web pages use a sound card specification called General MIDI that describes a set of 128 instruments.

A special hardware interface is needed to connect a computer to a MIDI device as they use a data transmission rate of 31.5 Kbps that is different from other computer interface rates.

MIDI files are smaller than audio waveform files. This is a big advantage when transferring files on networks. However, the quality of MIDI sounds depends on the quality of the samples stored in the sound card wave table and on the quality of the speakers to output the sound.

### EXERCISE 5.4

1 Compare a paint program with a draw program.

2 Find TWO examples of digital graphics and explain why they are valuable types of digital media.

3 What is CAD?

4 Describe FOUR tools used in graphic design products.

5 Compare frequency and amplitude in a sound wave.

6 Use the words provided to complete the following paragraph.

| | | |
|---|---|---|
| analogue | continuous | digital |
| instructions | instruments | MIDI |
| quality | smaller | sounds |
| speakers | waveform | waves |

An audio sequence is a (a) ___ series of (b) ___ stored as (c) ___ data. Sound is variable or (d) ___ data made up of (e) ___. Another type of digitised music is the (f) ___ or musical instruments digital interface. MIDI files contain no sounds but instead record (g) ___ about how a sound is to be played, that is, the (h) ___ and notes. MIDI files are (i) ___ than audio or (j) ___ files but their (k) ___ depends on other factors such as the quality of the system (l) ___.

**Animation** the process of making graphics appear or move as if alive, as in an animated cartoon.

## Animation sequences

**Animation** tricks the eyes into seeing lifelike movement by showing a rapidly changing sequence of still images on the screen. The images change so fast

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that it appears as if the whole image is moving. Animation is possible because of the functioning of the human eye. An object seen by the eye remains on the retina for a brief time after viewing. This makes it possible for a series of images that are changed very slightly and very rapidly to seemingly blend and give the illusion of movement.

Each animation method is based on the concept of frames. Frames are like a window or a page used to hold other objects. Each frame follows the previous one in rapid sequence, and the rate of display or frame rate determines the quality of the animation.

Animation is not only useful for producing cartoons and animated feature films but is also a valuable tool in industry. For example, a car manufacturer might wish to model the latest design. If the design is animated, it can be rotated to show all dimensions and the appearance from many angles. This allows design changes to be made before the car is produced and can save a lot of money.

Animation products use two different methods to produce animated sequences. *Cell* or *cel animation* creates total frames. Each frame consists of a background and a sprite/s (small movable image/s).

*Path-based animations* are created by setting a path for the sprite to follow using special software. Background frames change when needed but the sprite/s follows an independent path and is handled separately.

## Video production

Video production differs from animation, although there are many similarities between the end products. Video is captured as a continuous image rather than separate frames. The continuous image is then divided into frames and the frames are displayed at a frame rate to provide the illusion of continuity. Because of this method and the colour depth or amount of colour involved,

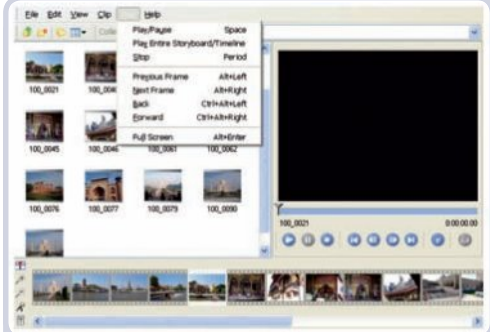

Figure 5.18 Creating an animation

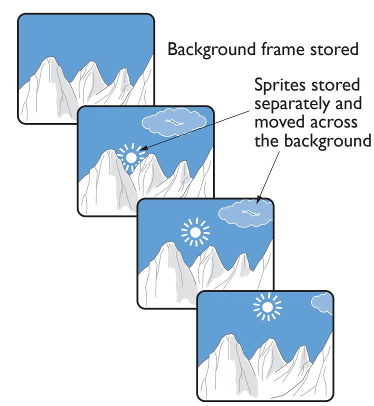


Figure 5.19 Cel animation

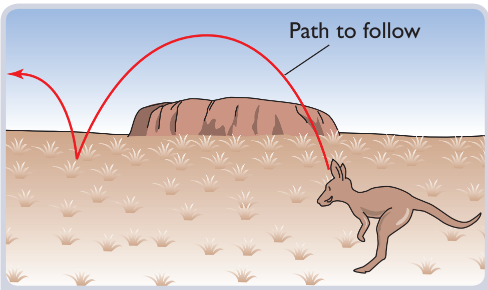


Figure 5.20 Path-based animation

Figure 5.21 Video frames

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Figure 5.22 Video camera viewfinder

video requires the greatest amount of storage space of any digital media. Video production requirements include:

- video digital camera
- software to edit and manipulate the camera output

### Features of video production products

- Video recording and playback
- Audio support to allow for the recording and playback of digital sound
- Titling or adding text to the video frames
- Dubbing or the addition of sound to video tracks. Sound can be recorded with the video or added later.
- Screen size control. A smaller screen and lower resolution will reduce the memory needed for storage and processing.
- Screen capture functions allow single frames to be paused and edited
- Skins or user interface options to allow the user to change to a preferred interface display when editing and using the product
- Brightness and colour controls

### EXERCISE 5.5

Complete each of these sentences to make them true statements.

a Animation is a sequence of ...

b Frames can be described as ...

c Cel animation includes frames composed of ...

d A sprite is ...

e Path-based animation uses background frames and ...

f Video is produced in a different way to animation as ...

g The two major requirements for video production are ...

h Dubbing is the video process whereby ...

i Skins is a term used to describe ...

j Video clips are usually displayed in small windows because ...

## Data storage and function

Computers process digital data by moving on/off pulses of electrical current. However, they have to change the pulses into another system of on/off code in order to store or 'remember' data (memory). There are a number of ways in which ON and OFF pulses can be stored, depending on the media used: magnetism, static electric charges in integrated circuits or laser burning.

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## Secondary storage media

**Secondary storage** holds digital media for future use and provides easy copying and backup of data. Its use is normally slower than primary memory. There are two methods of secondary storage.

**Secondary storage** permanent storage provided on a peripheral device, such as a hard disk, DVD or CD.

*Direct access storage* enables data to be retrieved by going directly to its corresponding address. This is fast access, as the address is recorded for each data item in a virtual file allocation table (VFAT) on the media.

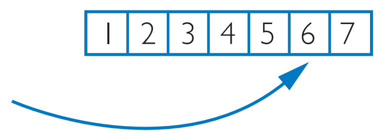


**Figure 5.23** Direct or random access

*Sequential access* occurs when, to find the target item, we start from the beginning and search through all the elements until the target item is found. This type of access is slow.

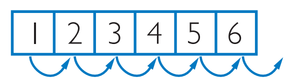


**Figure 5.24** Sequential access

**Table 5.5** Secondary storage media

| Device | Type | Features | Access | Measured capacity |
|---|---|---|---|---|
| Tape | Magnetic | Plastic tape on a reel; very cheap; large capacity | Sequential | Gigabytes |
| CDR, CDRW, DVD | Optical | Data is burnt into the surface of the disk by lasers; large capacity (4.7 GB+ on DVD) | Direct | Megabytes (CD); Gigabytes (DVD) |
| Hard disks | Magnetic | Multiple platters and read-write heads; large capacity; fast access | Direct | Gigabytes |
| Floppy disks | Magnetic | Single platter, small, cheap, portable; limited capacity | Direct | Megabytes (1.44) |
| Zip disks | Magnetic | Large capacity (100 MB to 250 MB); portable | Direct | Megabytes |
| Flash drives | Magnetic | Large capacity; very portable; need USB connector | Direct | Gigabytes |

## Data types for digital media products

**Data types** are the methods used to save and store particular types of data. Data types can also be called media types. They may also refer to the characteristics of the data type or file format. The data type and file format identify the programs that can use the file.

**Data types** are the methods used to save and store particular types of data.

Different data types are stored in different ways for different types of media, file formats and media products. Some file formats are more

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useful for some types of products and others are suitable for any type of products.

**Table 5.6** Common file formats for digital media

| Data type | Explanation | File formats | Description |
|---|---|---|---|
| Text | Any meaningful series of characters | ASCII (.txt) | Raw unformatted text using the American standard code for information interchange that can be used by most personal computers |
| | | HTML | Text marked up with tags so that it can display data in the form of web pages |
| | | RTF | Rich text format – text that includes formatting instructions |
| Graphics | Digitised images | GIF | Compressed (lossless) bitmapped graphics supporting 256 colours, transparency and animation |
| | | BMP | Bitmapped, uncompressed graphics that need a lot of storage space |
| | | JPEG (.jpg) | Compressed (lossy) bitmapped photographs supporting over 16 million colours |
| | | TIF | Tagged image file format used in publishing but not on the Web |
| | | PNG | Portable network graphics used on the Web |
| | | WMF | Windows metafile format used for vector graphics |
| | | CGM | Computer graphics metafile for vector graphics |
| Audio | Digital sound | MIDI | Musical Instruments Digital Interface holds details of notes to be played and needs MIDI interface |
| | | RealAudio | Used to transfer sound data across the internet. Requires a RealAudio player (integrated with most browser software) |
| | | MP3 | MPEG* standard – compressed audio sound |
| | | WAV | Waveform file |
| Video | Digitised moving images | MOV (QuickTime) | Available for both Macintosh and Windows and handles animation |
| | | MPEG* | Group of compressed standard formats |
| | | AVI | Standard video format |

*MPEG is a set of digital compression standards for music and video developed by the Moving Picture Experts Group. There are three major MPEG standards: MPEG-1, MPEG-2, and MPEG-4.

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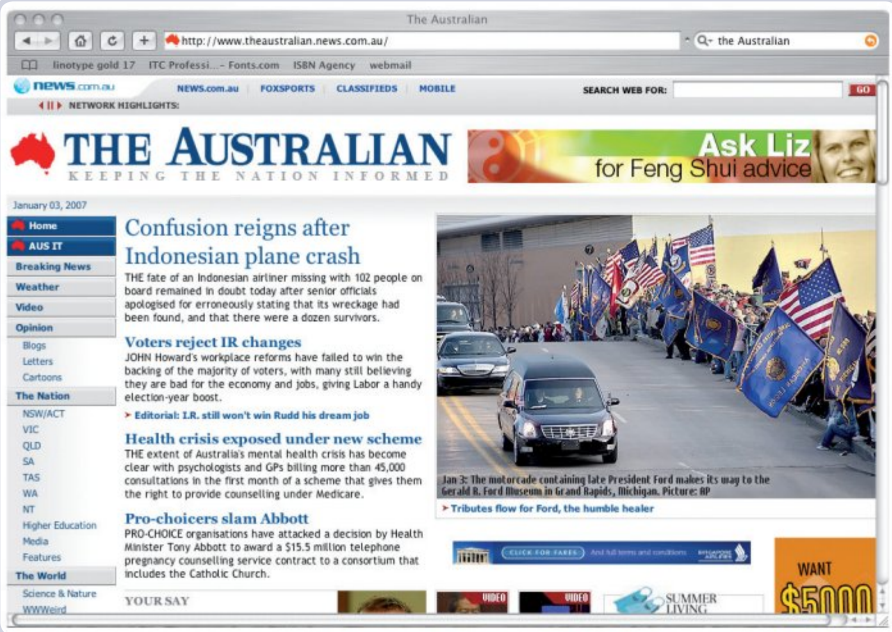
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news.com.au NEWS.com.au FOXSPORTS CLASSIFIEDS MOBILE SEARCH WEB FOR: GO
NETWORK HIGHLIGHTS:
THE AUSTRALIAN
KEEPING THE NATION INFORMED
Ask Liz for Feng Shui advice
January 03, 2007
Home
AUS IT
Breaking News
Weather
Video
Opinion
Blogs
Letters
Cartoons
The Nation
NSW/ACT
VIC
QLD
SA
TAS
WA
NT
Higher Education
Media
Features
The World
Science & Nature
WWWeird

Confusion reigns after Indonesian plane crash
THE fate of an Indonesian airliner missing with 102 people on board remained in doubt today after senior officials apologised for erroneously stating that its wreckage had been found, and that there were a dozen survivors.

Voters reject IR changes
JOHN Howard's workplace reforms have failed to win the backing of the majority of voters, with many still believing they are bad for the economy and jobs, giving Labor a handy election-year boost.
Editorial: I.R. still won't win Rudd his dream job

Health crisis exposed under new scheme
THE extent of Australia's mental health crisis has become clear with psychologists and GPs billing more than 45,000 consultations in the first month of a scheme that gives them the right to provide counselling under Medicare.

Pro-choicers slam Abbott
PRO-CHOICE organisations have attacked a decision by Health Minister Tony Abbott to award a $15.5 million telephone pregnancy counselling service contract to a consortium that includes the Catholic Church.

YOUR SAY

Jan 3: The motorcade containing late President Ford makes its way to the Gerald R. Ford Museum in Grand Rapids, Michigan. Picture: AP
Tributes flow for Ford, the humble healer

WANT $5000

Figure 5.25 Online newspaper using a range of data types for display

## Manipulation techniques

Digital data can be manipulated or changed in many different ways. The methods used depend on the type of digital data and the purpose for which the data is needed.

Table 5.7 Techniques used to manipulate digital media

| Technique | Explanation | Example |
| --- | --- | --- |
| Cropping | The process of trimming a file to select only those parts that are required. | Cropping a family photograph so that only one person is visible |
| Rendering | The process of covering or coating an item to create a whole item or 'image' | Rendering a sound creates an image of the sound; rendering an image covers the basic framework of the image with a covering of colour, texture or pattern |
| Special effects | Any draw tools that provide additional functionality to a digital media file | An image filled with a gradient fill |
| Time coding | Time code is set to the number of frames per second (fps) | 24 fps is used for 35 and 70 mm film; 29.97 is used for most video editing (some European products use 25 fps; 30 fps) is used for audio only |
| Sampling | The process of converting analogue sound (the sound that we hear as continuously variable volume and pitch) to digital sound (sound represented in two states) | The number of times a sample is taken from the sound wave is equal to the sampling rate. For 44.1 kHz there are 44 100 samples per second. |

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Figure 5.26 Cropping

## Use of manipulation techniques

*Cropping* is a valuable tool for selecting sections of a file without damaging the rest of the file. Cropping a sound file allows a short section of music to be selected for play; a video can be cropped to display only one short scene for study.

*Rendering* is of particular importance when converting wireframe models to realistically display a final product. It is also used to improve the quality of sound or video.

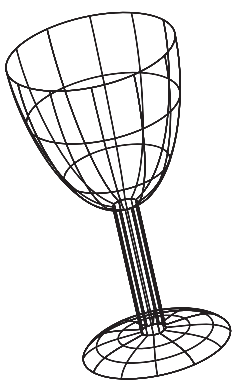

Figure 5.27 Wireframe model created in a graphics program

*Sampling* allows sound files to be manipulated. Analogue sound can vary over an infinite range. (A dial is an analogue controller as it can be turned to control sound over many levels.) Converting an analogue signal into a digit audio file requires an ADC (analogue-to-digital converter). These are usually found on a sound card.

Put simply, sampling takes a variable wave and records a wave peak as 1, or high, and a wave trough as 0, or low. To get the variation in frequency and amplitude, sampling uses a sample size (bit rate) and a sample rate. *Sample size* is the number of bits used to represent each sample: the more bits, the more faithfully variations in volume can be represented. Bit rate measures the number of bits transmitted per second. Common bit rates are:

- 8 bit – a poor audio quality but good for voice recording
- 16 bit – standard CD audio (256 times better than 8 bit)
- 24 bit – professional quality audio.

*Sample rate* is the number of times per second a wave is analysed and recorded (sampled). The sampling rate (samples per second or hertz) determines the fidelity (trueness) with which different frequencies can be


Figure 5.28 Sound card

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reproduced. High frequencies are lost if the sampling rate is not high enough. The rate needs to be set to twice as fast as the highest frequency on the sound track sampled. Common sample rates used in digital audio include:

- 44100 or 44 kHz – used for most CDs
- 32000 or 32 kHz – used for broadcasts.

Thus a CD has better quality sound than a broadcast.

Audio sequences assist the sound card to capture and edit sound using a sound meter to view the level of the wave as it is input in order to avoid the top levels of the waves being clipped off and distorting the sound.

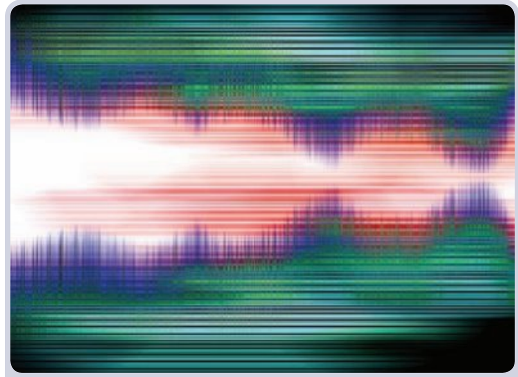

**Figure 5.29** Audio wave seen in a sequencer program

Editing tools can be used to remove pops, spikes and static, or to clip the sound to size. The sound file can then be stored on media such as a digital audio tape, CD audio, mini disk or DVD audio.

## MORPHING AND TWEENING TO MANIPULATE MEDIA

**Morphing** is the organisation of graphical and audio data so that, across a series of frames, one image or sound changes to another by blending into the next one. Morphing allows transitions to occur smoothly.

> **Morphing** is the organisation of graphical and audio data so that, across a series of frames, one image or sound changes to another by blending into the next one.

Morphing images may be done by tweening. *Tweening* basically begins with one framed image in an animation or video and ends with a totally different image, or the same image in a different position. A program allows the user to create the first and last scenes of an animation and then generates all the frames in between. When morphing is not involved, tweening changes the original image to give the illusion of movement. Tweening involving morphing uses a different image for the start and end frames. The program creates the in-between frames.

Two of the main advantages of tweening are the time saved during production of the file, and the reduction in the amount of storage needed for the file compared to methods that create individual frames.

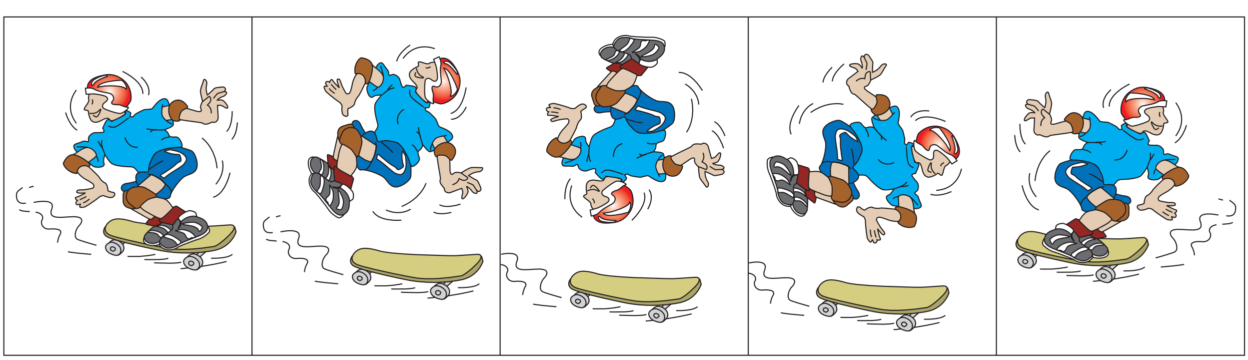

**Figure 5.30** The tweening process

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## EXERCISE 5.6

1 From the list provided, choose the most appropriate type of file format to use for the tasks given.

| | | |
|---|---|---|
| GIF | HTML | JPG |
| MIDI | MOV | MP3 |
| TIF | TXT | WAV |
| WMF | | |

| | Data type | Task |
|---|---|---|
| a | Graphic | Save a still photograph |
| b | Audio | Produce a list of musical notes and instruments as a file |
| c | Graphic | Locate a suitable image for a publication to be printed |
| d | Video | Add a clip to a document that is to be used on both Macintosh and Windows systems |
| e | Text | Produce a web page including hypertext |
| f | Audio | Add a background sound to a web page |
| g | Graphic | Display an animated cartoon |
| h | Audio | Include a downloadable music file that will transfer quickly |
| i | Text | Produce a simple text file with no formatting |
| j | Graphic | Save a graphic created as a line drawing |

2 Draw and label the following processes:
   a a frame including two figures, one of which is selected for cropping
   b a cube that has been rendered
   c a rectangle with a gradient fill
   d a video time code showing 5 fps (outline only)
   e a diagram to describe analogue data
   f five frames including a stick figure throwing a stick to show tweening

3 Describe how sample rate is different from sample size.

4 Why is CD sound of better quality that sound used in a radio broadcast?

5 Explain the process of morphing a sound.

6 Give reasons for using tweening during animation.

# Digitisation process of data types

**Digitisation** is the process of converting data from analogue to digital form.

**Digitisation** is the process of converting data from analogue to digital form. Analogue data is infinitely variable, for example, analogue sound covers an almost endless range from very high-pitched sound to very low. Representing such data in digital form requires that it be reduced to two electrical states, that is, in the case of sound, low volume or high volume – also called OFF and ON or represented as 0 and 1. Different types of data use different methods to achieve digitisation of data.

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## Frame grabbing

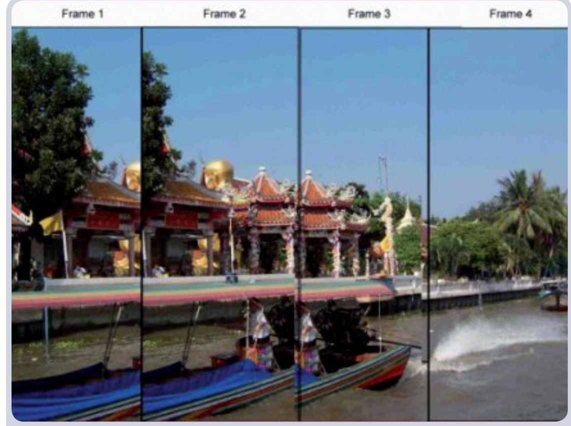


**Figure 5.31** Frame grabbing

*Frame grabbing* literally captures or grabs frames from continuous analogue data including sound and video. Video cameras capture video using video-capture cards. Full motion video cards convert analogue to digital data at a rate of frames per second, up to around 30. This gives the illusion of motion but takes a huge amount of storage space.

Frame-grabber video cards capture and digitise one frame at a time. These are not as effective in producing smooth continuous motion but require less storage space for frames. Video captured as frames or still images can display these images rapidly to give the illusion of motion. To grab frames, a frame rate is set (the number of frames to be captured per second). Then the data is captured at the set number of frames. The higher the number of frames grabbed per second, the better the digitised output will be.

The captured digitised frames can be downloaded to a computer and 'played' in frame order at the speed of the selected number of frames per second. The storage and speed will have limitations, depending on the speed of the computer, but between 20 and 30 frames per second are common. The frames can also be manipulated on the computer: the order of the frames can be changed or the content of the frames altered.

**Figure 5.32** Biometrics works on unique individual attributes

**Great idea**

**Biometrics is a type of scanning used to measure human attributes so that an individual may be identified. In the past we used height, weight, hair and skin colour, etc. to recognise people. Currently there is a move to use digital measurements, such as fingerprints, the iris of the eye and DNA, to increase security with a range of technologies. In the future, technologies may be able to allow access to data based upon bio-dynamics, such as the way a person writes their signature, their voice characteristics or even the manner in which an individual logs in to a network.**

## Scanning

**Scanning** is the process of 'reading' data from paper documents and converting it to digital form.

A scanner works by feeding paper with the image or text on it past a bright light source. Reflected light off the image or text is converted into a

**Scanning** is the process of 'reading' data from paper documents and converting it to digital form.

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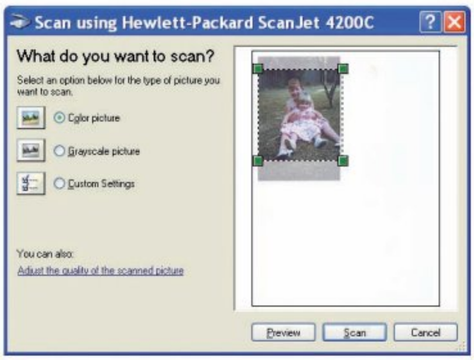


Figure 5.33 Scanning software

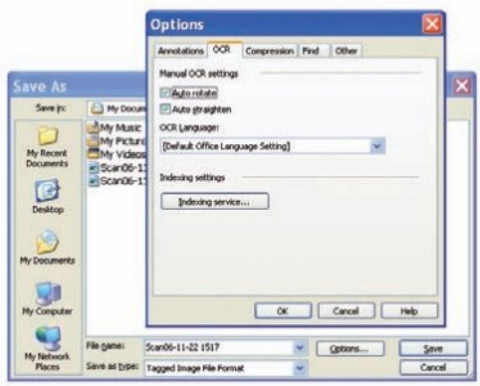


Figure 5.34 Saving scanned data in different forms

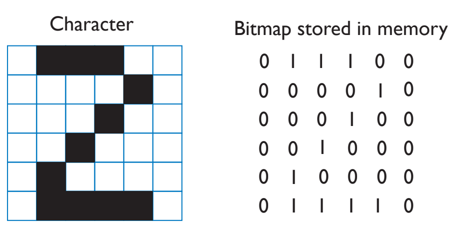


Figure 5.35 A graphic shown as pixels and the corresponding bitmap

varying electrical current by the sensor. Scanners 'read' images by determining the level of laser light absorbed by each dot on the paper as the scan passes over the surface. This data is then interpreted by the software. If the light is totally absorbed by the paper then the small dot on the page is stored as black (0). If the light is completely reflected by the paper then the small dot on the paper is stored as white (1). Colours are stored as various combinations of 0s and 1s depending on the light intensity of the three basic colours of red, blue and green.

The digital data can be saved as a file, which is then available to be manipulated and saved in various formats for further processing.

There are a lot of different types of scanners, from barcode readers to document readers. Most scanners use software standards called TWAIN (technology without an interesting name) to allow the digital data to be saved and used in different applications.

## Bitmapping

**Bitmapping** stores images in memory as a matrix of individual pixels or picture elements. Each pixel can be ON (white), stored as the digital number 1, OFF (black) stored as the digital number 0, or it can represent varying shades of colour from 4-bit monochrome to over 16 million colours. As an example, consider the bitmap of a simple black and white image of a cross on a screen that is 5 pixels wide and 5 pixels high. Only one bit is needed to store each pixel as there are only two possible outputs for each pixel – on or off. This can be shown as $2^1$ (2^1). 1 is the power of 2 and is known as the *bit depth*.

To store a colour image as digital data it is necessary to store each colour as a power of the base 2 system. So, if there are 4 possible colours, the pixel can be stored as $2^2$ (2^2), that is, a bit depth of 2. Similarly, 256 possible colours would be stored as $2^8$ (2^8) or a bit depth of 8.

**Bitmapping** storing images in memory as a matrix of individual pixels or picture elements.

## Optical character recognition (OCR)

Optical character recognition is a type of scanning that requires specialised software. OCR translates optically scanned bitmaps of printed or written text characters into character codes so that hard-copy materials are digitised and can be edited and otherwise manipulated on a computer. It operates in a similar way to a scanner, but its objective is to read text from a page and translate it to separate characters. It digitises the single items of data it 'reads' from documents by analysing the image of the data, comparing it to the character

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images it has stored and selecting the correct match by pattern recognition. This allows the data to be input as separate digital characters or ASCII codes. These individual characters can then be organised and analysed in the same way as data input by more conventional methods, such as keyboards.

OCR systems work best with typed or word-processed documents. They save a considerable amount of time and reduce some of the problems that occur for human typists who may get repetitive strain injury from constant data input. OCR systems save space in libraries, government archives and business offices.

**Table 5.8** Problems with the digitisation process

| Data type | Description of problem | Explanation |
|---|---|---|
| All data types | Digital data will never be an exact representation of analogue data. | Many states reduced to two states is never the same. However, the use of different methods helps to achieve a very good approximation, and human senses are limited so that people are often unable to tell the difference. |
| Video | A high frame rate results in very large files but improves quality. | Large files take up much more storage space and take longer to download and display. |
| Bitmapped graphics | Aliasing results from resizing a bitmapped graphic. Enlarging the image reduces the resolution of the image and creates a jagged effect on the edges. | Methods used to reduce this effect, called anti-aliasing, blend the image into the background using intermediate pixels. However, this increases rather than solves the major problem of bitmapped graphics, that is, the large storage they require. |
| Text read by an OCR | Handwritten text is harder to translate than typed text. | More errors are made, and users need to do more proofreading as handwriting is too different from one person to another. |

## EXERCISE 5.7

1 Unjumble the following words and then explain the meaning of each word.
  a ACIIS
  b AACCEHRRT
  c ADGIIIINOSTT
  d ACGINNNS
  e AINTW

2 Why doesn't the digitisation of data produce exactly the same data as the original analogue data?

3 Why is digital data able to be used if some of the data elements are lost?

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exercise 5.7 continued

4 How does a scanner work?

5 Name TWO common types of scanners.

6 Draw a black and white bitmapped representation of the letter A.

7 How does bit depth help to store a colour graphic?

8 What process is used by optical character recognition to read text?

## Factors affecting file size

Digital media often need lots of fast-access primary and secondary storage, powerful processing and a variety of human expertise for their development. Some of the factors that will influence the amount of storage required include the type of media, the resolution and the amount of colour used in the image.

### Memory size

Memory refers to the amount of data that can be stored. Primary and secondary storage requirements include RAM (random access memory) and the ability to use hard disk space or other devices. It is essential to have sufficient RAM to hold the data while the system is operating. Because of the number of media types and their often simultaneous delivery, the higher the RAM the faster and more smoothly the digital media will be delivered to the user. Because digital media need to be stored for future use they need large secondary storage devices. These can include CD (compact disk), DVD (digital versatile disk), zip disks for limited productions (100 to 250 MB), flash drives and hard disks where space is available.

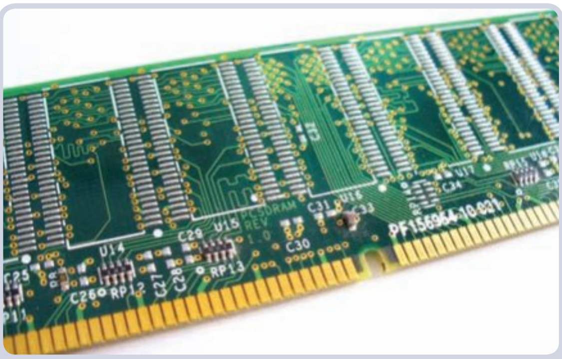

Figure 5.36 RAM hardware

### Processing speed

Processing speed refers to the number of operations that can be carried out by the CPU in any set period of time – the faster the processor the more operations that can be performed. This is most important for large digital media files such as video.

### Colour palette

Colour considerably increases the storage requirements of media as both the number of the pixels on the screen and the bit depth of each pixel is increased. The rule is: the larger the number of colours used the larger the size of the storage required. A graphic is a good example of file storage needs increasing as more colour is used. Each pixel in the graphic is stored

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as one or more bits – that is, bit depth or the number of bits per pixel. To calculate the file size of a black and white graphic 5 pixels wide and 5 pixels high we use the formula:

pixels high x pixels wide x bit depth

The number of bits in a byte is 8.

The size of the file in bytes would be (5 x 5 x 1)/8 = 25/8 or 3.125 bytes for storage.

Colour images require at least 3 bits per pixel, but they can use a lot more bits per pixel if tones are used. Combinations of red, green and blue are used to create a minimum of 8 basic colours (black, white, red, green, blue, cyan, yellow and magenta). It takes 8 bits per pixel to display 256 colours on a screen ($2^8$ or 2^8). A colour image using 256 colours created on an 800 x 600 screen would need 800 x 600 x 8 bits. This means 3 840 000 bits or 480 000 bytes to store the image, many times the number of bytes required to store a black and white image of the same graphic. The calculation can be shown as:

| Screen | Multiplied by | Screen height | Multiplied by | No. of bits per pixel | Equals | Size of graphics file in bits | Divided by | Equals | Size of width graphics file in bytes |
|---|---|---|---|---|---|---|---|---|---|
| (800 | * | 600) | * | 8 or 2^3 | = | 3 840 000 | /8 | = | 480 000 |

## Compression

Compression is the process of reducing the physical size of data. *Decompression* is the process of converting the data back to its original form during retrieval of the data. Digital media uses compression to reduce storage space and allow file numbers to be maximised on media such as CD-ROMs and DVDs. Compression also reduces the retrieval time of files over a network (downloading) and the cost of electronic transfer (less bandwidth is needed). Many files have a standard compression formula e.g. JPG.

Compression is the process of reducing the physical size of data.

Most compression is carried out by software. A *codec* is a coder-decoder program used to compress and decompress data. Different codecs use different algorithms (solutions) to carry out compression and decompression. A number of such codes are in common use. Decoders are needed to use the resulting files.

### COMPRESSION TECHNIQUES

Compression works on the fact that most data has in it much that is redundant, that is, repetitive. Redundancy can be explained by a photograph that has a large number of background pixels of the same or similar colour.

There are two methods of compressing data: lossy and lossless. With *lossless* decompression, the data is identical to original data. This takes more space but gives better data quality. Using lossy decompression, some

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data is removed and decompressed so that the data is different from the original data – usually in insignificant ways. This saves on space.

**Table 5.9** Compression techniques

| Technique | Description | Use | Compression |
|---|---|---|---|
| Lossless | Repetitive patterns are coded into a summary and data retrieved is the same as data stored. | Most text files where it is vital that no data is lost | File may be reduced to 30% of original size |
| Lossy | Data is discarded during compression e.g. shades of colour in a graphic or soft sounds in a sound file. Some data is irretrievably lost. | Sound, images and video files where lost data can be masked by other data | File may be reduced to 5% of original size |

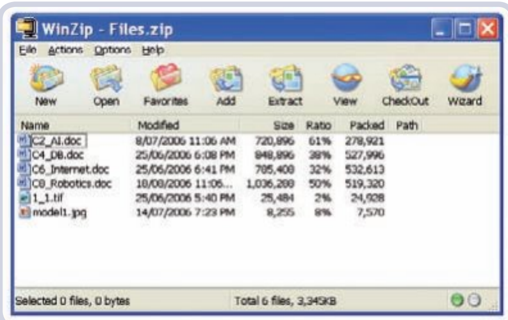

**Figure 5.37** WinZip compression software

### EXAMPLES OF COMPRESSION STANDARDS FOR DIFFERENT DIGITAL MEDIA

MPEG (.mpg) standard is a lossy type of video and sound file devised by the Moving Picture Expert's Group to remove repetitive images in a stream of video. A complete, detailed image of the key frame (first frame) in a video is stored. For the following frames only the image sections that change are stored. Every so many frames, another key frame is stored. This can reduce the storage space needed for a video by 95 per cent.

GIF (graphics interchange format) or Compuservegif is primarily used for drawings and illustrations and it supports transparency and interlacing. Transparency means that the background of the graphic can be transparent and take on the colour of the screen background. Interlacing means that each line of the graphic can be refreshed when the graphic is displayed on the screen. GIF file format also supports animated graphics, but images saved in .gif are restricted to 256 colours.

JPG or JPEG (Joint Photographic Experts Group – a standard of the International Standards Organisation) is a lossy method mainly used for photographs and medical imaging. This method discards repetitive pixels within an image, such as large areas of the same colour in the background. It allows very high compression ratios and thus speeds up the download of such images. The advantage of .jpg is that it allows files to be stored using up to 24-bit colour – well over 16 million different colours.

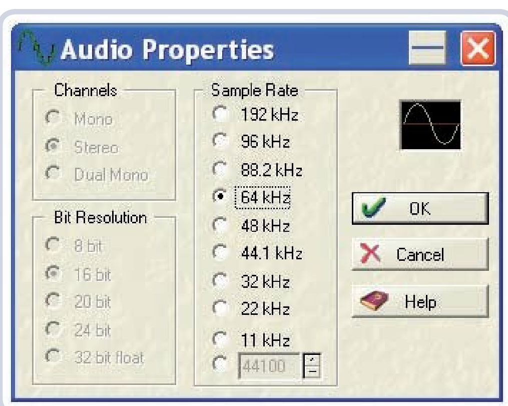

**Figure 5.38** Sampling properties of an audio file

## Sampling rate

Sampling rate, along with sample size, decides how big a file will be. In an audio example, the number of sound channels

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in the signal also determines the size of an audio file. Mono sound contains 1 channel; stereo 2 and quad sound 4 channels. Each increase in bit rate doubles the size of the data file, as does each increase in the sample rate.

**Table 5.10** Storage required for one minute of uncompressed audio at common sample and bit rates

| Sample rate | Bit rate | Stereo | Mono |
|---|---|---|---|
| 48 kHz | 16 bit | 11.346 MB | 5.673 MB |
| 32 kHz | 16 bit | 7.564 MB | 3.782 MB |
| 11.025 kHz | 8 bit | 1.269 MB | 648 KB |

Like graphics and video, sound files can become extremely large. Consider a CD holding a music file that takes four minutes to display. To calculate the size of the file the following formula is used.

sampling rate x sample size x display time in seconds x number of channels

On a CD using stereo sound this would mean

44 100 x 16 x (4 x 60) x 2

and result in a file of 338 688 000 bits or 41 343.75 kilobytes or 40.375 megabytes (MB), a very large file indeed.

This file would be in WAV (waveform) format. Using MP3 compression it could be reduced to a much smaller file, around 3.8 MB – still considerably larger than a text file.

## Frames per second

Digital media such as animation and video that use frames needs an enormous amount of storage space and very fast processing speed. Each picture or frame has to be stored, and many hundreds of frames will be needed for even a simple moving image. A small animated series may need 20 frames per second. This would need around 20 megabytes of storage (with no compression). For these reasons, animation on personal computers needs a computer with a lot of RAM.

The speed at which video is displayed is known as the *frame rate*, that is, the number of frames per second that can be displayed. The larger the number of frames per second the better the quality of the video display. One video frame using 24-bit colour display takes about 1 MB of storage, which means around 30 frames or a second of video needs 30 MB. This can be calculated by

number of frames x file size of each frame

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For a 1-minute video
number of frames = frame rate x time
= 30 x 60 seconds
= 1800 frames
File size of frame = (size of frame in pixels) x bit depth
= 800 x 600 x 24
= 11 520 000 bits
File size of a 1-minute video = 1800 x 11 520 000 bits

**Table 5.11** Equivalent file sizes for 1 minute of video

| Calculation | Result |
|---|---|
| 1800 x 11 520 000 bits | 20 736 000 000 bits |
| 20 736 000 000 bits /8 | 2 592 000 000 bytes |
| 2 592 000 000 bytes /1024 | 2 531 250 kB |
| 2 531 250 kB /1024 | 2471.9 MB approximately |
| 2471.9 MB /1024 | 2.41 GB |

## Display and distribution

**Display** refers to the presentation of digital media.

**Distribution** is the sharing of digital media with other people.

**Display** refers to the presentation of digital media. **Distribution** is the sharing of digital media with other people. The appropriateness of some digital media will vary with the mode of delivery, that is, its type of display and/or distribution.

Hard copy – media printed on paper – will be suitable for graphical data. The type of printer may also determine the suitability of certain types of graphical data – photographs will need colour laser printing and a good resolution to achieve the best output, plotters will be more suitable for CAD or vector drawings.

Soft copy or media displayed electronically will handle a much wider range of digital media but will depend on the storage capacity chosen and the display available.

**Figure 5.39** Optical media stack

### Types of media used for distribution

Optical media is where digital media is 'burned' on to the surface of an optical disk using a laser. CDs and DVDs are two appropriate distribution methods. CDs hold around 700 MB of data and DVDs can hold around 4.7 GB. The DVD would be suited for the distribution of video and the CD more suited to distributing audio.

Magnetic media, including large capacity floppy disks such as zip disks and hard disks, are appropriate media for digital data requiring large storage. Floppy disks holding 1.44 MB of data are suitable for text and limited types of small graphics.

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Internet distribution is popular, as the potential audience is global and the method is relatively cheap. Users can download digital media from many internet sites but need to be aware of copyright as the item remains the property of the creator at all times.

**Table 5.12** Methods used in display and distribution

| Method | Explanation | Use |
|---|---|---|
| Streaming | The process of sending media in packets so that the first packet plays as it arrives and while other packets are still coming | Enables audio and video files to be displayed as quickly as possible and avoids the user having to wait long periods for the full file to download. |
| Buffering | The process of temporarily storing streaming media as it is downloaded | Packets of data may arrive at a faster rate than they can be played. The packets can be accessed from the temporary store as they are needed and the stream of video or audio can be controlled. |
| Broadcasting | Wide distribution of the media to any with the means to receive it | Webcast is the live broadcast of streaming content over the internet allowing for access to news and other data in real time, that is, as events occur or through delayed transmissions. They can be in the form of text, images, sound and video and require special software to view them. |
| Caching | Temporary storage of frequently used files | Allows fast access to such media without repetitive downloads. |

## Factors that influence electronic display and distribution

*Bandwidth* is the amount of data that can be transmitted in a fixed amount of time and is measured in bits per second (bps) or bytes per second. Digital media uses either:

- broadband where several channels can be transmitted at once, or
- baseband where only one signal transmits at a time.

Some media can only be sent by broadband if they are to be effective, for example, video.

*Resolution* refers to the quality of the display of digital media. High resolution refers to use of a large number of pixels or sounds in a given area or time of the display. If the media clip is intended to be displayed at a particular resolution and the resolution is increased, this may result in distortion of the media. Low resolution reduces the amount of time required to download the media, but also reduces the quality of the output.

*Availability* of programs or executable players can result in digital media that is not usable by the user when such software doesn't exist on their system. For example, to show a PowerPoint slide show, the PowerPoint player is needed. Developers of digital media should always try to include

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Figure 5.40 Computer system display intended to detect eye movement in a disabled user

such players in their product or direct users to where to locate them.

*Hardware* such as processors and RAM will be important to the user. Digital media creators should label their products clearly so that users are aware of these requirements.

The intended *audience* is a major factor in electronic display and distribution. The experience of the audience and the age level and interests will always be important. For example, children with little experience and few skills need simple digital media products that are easy to use.

## Evaluation of digital media products

Judging the suitability of a digital media product might involve considering the product against a set of criteria.

Table 5.13 Criteria for evaluating digital media products

| Criterion | Description |
|---|---|
| Display | Appropriate appearance of the final product including the interface and objects used |
| Distribution | Appropriate mode of delivery |
| Purpose | The intention of the product is met e.g. entertainment |
| Audience | People who will use the product are catered for e.g. disabled, children, those with limited computer skills |
| Storage | Appropriateness of file sizes, downloading and transmitting times for the purpose |
| Design | The use of good design principles (these are covered in chapter 3) |

### EXERCISE 5.8

1 Copy and complete the following table to summarise the factors affecting the size of digital media files. One example is provided to help you.

| Factor | Explanation | Detail |
|---|---|---|
| Memory | The amount of data that can be used and stored. | Primary memory: RAM Secondary memory: CD, DVD, zip and hard disks |
| Processing speed | | |
| Colours used | | |
| Compression | | |
| Sampling rate | | |
| Frames per second | | |

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exercise 5.8 continued

2 Calculate the size of the file in bytes required to store each of the following media. No compression is involved.
   a a GIF file of 256 colours with a pixel width/height of 50*20
   b a JPG file with a width/height of 100*50
   c a 2-minute stereo audio file with a sample rate of 32 and a bit rate of 16
   d a video display of 50*50 pixels taking 5 seconds, using 24-bit colour and 30 frames per second

3 Recalculate the size of the audio and video files in question 2 so that they are expressed in megabytes and gigabytes.

   Note: You do not need to do the full calculation to be correct. The correct formula using the figures given is as good an answer as the result of the calculation.

4 Explain the difference between the following terms used in digital media:
   a Display and distribution
   b Hard copy and soft copy
   c Optical and magnetic storage
   d Streaming and buffering
   e Baseband and broadband
   f High and low resolution

5 Select two digital media products available to you. Use the evaluation table (table 5.13) and add an additional column in which you rate the products for each factor against a scale of 1 for very poor to 10 for excellent, and write a simple comment for each factor.

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# Digital media

## Multiple choice questions

Select the best answer to each of the following questions.

1 Digitising is the process of converting data from
- A Digital to analogue code
- B Analogue to digital code
- C Binary to hexadecimal code
- D Serial to parallel code

2 Paint programs used in graphic design allow
- A Sound files to be digitised
- B Primitive shapes to be resized in one operation
- C Vectors to be used for line drawings
- D Individual pixels to be edited

3 The resolution of an image taken with a digital camera is a measure of the
- A Image shape
- B Image quality
- C Image compression
- D Sensor cost

4 Compared to analogue data, digital data is more easily made
- A Interactive and current
- B Colourful and accurate
- C Objective and interesting
- D Structured and grouped

5 Background sound used in a digital product is called the
- A Voice effect
- B Underscore
- C Ambient noise
- D Sound wave

6 A sprite used in animation is a
- A Single frame in a series
- B Cel or cell
- C Lively change in colour
- D Small movable image

7 A .TIF file extension indicates that the file type is
- A Text
- B Image
- C Audio
- D Video

8 The sampling rate of an audio file determines the
- A Sample size of an audio file
- B Sound volume of an audio file
- C Closeness of the digitised sound to the original
- D Ability to edit the sound

9 What is the minimum number of pixels required to store a colour image?
- A 3
- B 8
- C 124
- D 256

10 The measurement of the amount of digital data that may be transmitted in a fixed amount of time is called
- A Baseband
- B Bandwidth
- C Resolution
- D Distribution



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## Extended answer questions

Figure 5.41 covers some of the important characteristics of digital media.

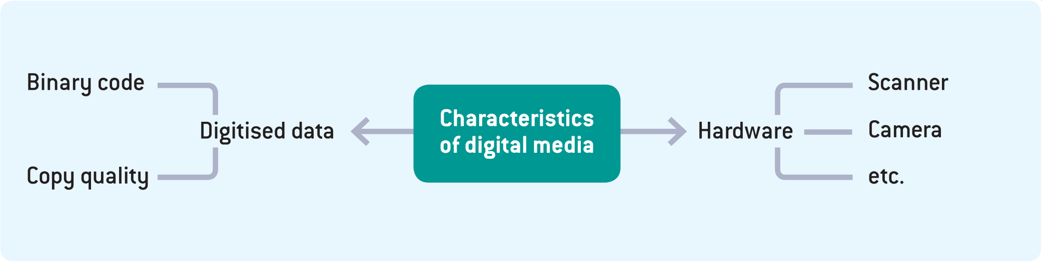


Figure 5.41

Write answers to each of the following questions.

1. What is binary code?
2. How is data digitised?
3. Why is copying digitised data a major advantage?
4. Define the term ‘input hardware’.
5. Hardware digitising devices include scanners. Name TWO different types of scanner.
6. Give TWO examples of pointing devices that digitise data.
7. Explain the TWO major factors that are important to the choice of hardware for digital media.
8. Redraw Figure 5.41 and expand the hardware section to include more examples.
9. Digital data can be manipulated, transmitted and displayed. Briefly explain the meaning of ‘transmission’ and ‘display’.
10. Draw and label TWO examples of manipulation techniques that may be used with images.

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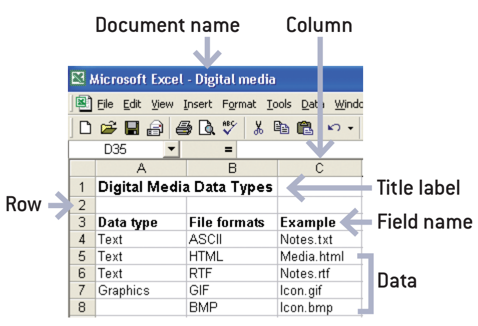


Figure 5.42 Spreadsheet parts

# PROJECT 1: DIGITAL MEDIA DATABASE

## Define the problem

A simple database is needed to hold records of data types and to sort, search and obtain data and information for the user.

## Analyse the problem

A spreadsheet program will function as a simple database. The spreadsheet is a grid of cells. Into the rows and columns, labels (text), values (numbers) and formulas (calculations) are added.

A spreadsheet needs to be organised so that it best provides the information needed. For more information on spreadsheets see Chapter 2.

## Design a solution

### Decide how data is to be organised

Data is entered in rows. Each row is a record, that is, all the data related to one unit in the database. If text was one record in a database called Media, then the related data might be file formats and examples. This related data is called fields.

Rather than enter data directly into the cells of the worksheet, a fill-in-the-blanks form may make it easier to enter the data.

### Collect the data

For each media type we need to know its name, the range of file formats and collect one small file to illustrate each media type. Where possible, save the file in each of the file formats given for that media type. The files should be stored together in a folder on the hard disk, CD or other storage media. Some information that will be useful is in table 5.6.

## Produce the solution

1 **Open** a new worksheet in a spreadsheet program. **Save** the spreadsheet as DigMedia using the **File** menu, the **Save** icon on the toolbar or Ctrl+S on the keyboard.

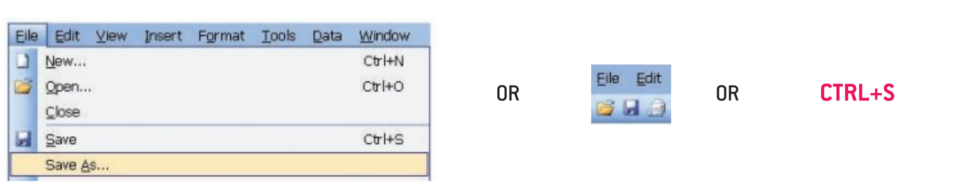


Figure 5.43 Find/Save menu and icon

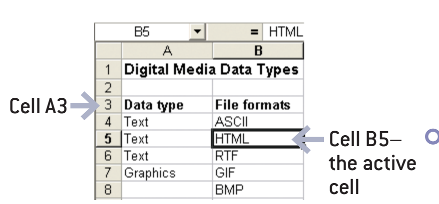


Figure 5.44 Cell locations on a worksheet

Note that each spreadsheet column is identified by a letter and each row by a number. These allow cells to be easily found. For example, cell A3 is in column A, row 3.

2 Name the worksheet by right-clicking the Sheet1 tab (at the bottom of the document), choosing **Rename**, and overtyping Tools on the tab.

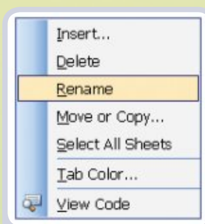


Figure 5.45 Right-click menu



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3 Enter the labels given on Figure 5.46 into the cells shown on the diagram. Press the Tab key to move to the cell to the right, the Enter key to move to the cell below.

These labels are known as fields as they contain data about one aspect of a record.

| A | B | C |
|---|---|---|
| 1 Digital Media Data Types | | |
| 2 | | |
| 3 Data type | File formats | Examples |

**Figure 5.46** Entering data

4 Click on cell **A1** and make the label a larger Arial font, 14 pt size. Press the **Bold** icon on the program toolbar or use the keyboard shortcut (Ctrl+B) to make the labels bold.

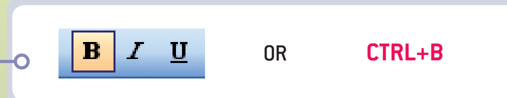


**Figure 5.47** Formatting cell labels as bold

5 Place the cursor into cell **A3** and drag the mouse across to cell **D3**. This will select the range of cells. Make these field name labels bold. Where necessary, widen the columns of each field to show the labels clearly.

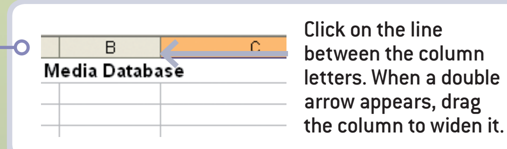


**Figure 5.48** Widening columns

6 Either:

- Enter data into columns A and B under the labels using information from figure 5.42

  or
- Create a form for your database to make data entry easier.
  - Click cell **A4**.
  - From the **Data** menu, select **Form**.

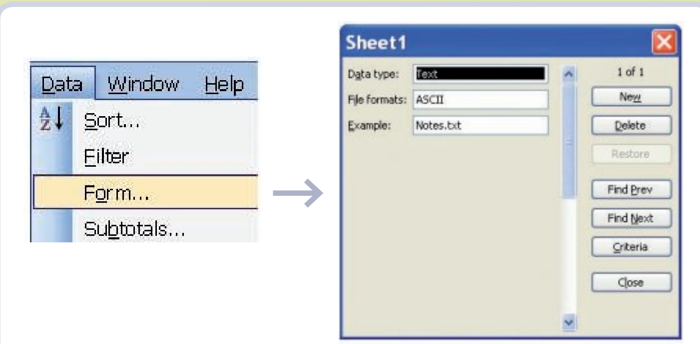


**Figure 5.49** Choosing Form from the data menu

7 Click **New** and use the form to add the records.

8 Click **Close** to close the form when you are finished.

9 **Save** the file.

## Modify the document

1 Click on cell **C3**.

2 From the **Insert** menu, choose **Columns**.

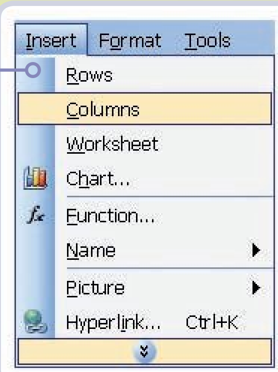


**Figure 5.50** Adding a column

3 In the new cell **C3**, add the field name **Best use**.

4 Press **Enter**.

5 Add data to the records in this field. Keep the data to a minimum. For example, ASCII text is best used for unformatted data.

6 **Save** the file.

## Evaluate the solution

Evaluation may be done by testing the solution to obtain information using sorting, searching and formulas.

Sorting organises data alphabetically or numerically.

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**Figure 5.51** Using Sort

1 Click cell **A3**.
2 Select **Sort** from the **Data** menu.

In the dialogue box, the field name should be shown in **Sort By**.

3 Select the **Ascending** button. This will organise the data types from smallest to largest (A to Z). Note: You may also choose to sort by a second field such as File formats.
4 Check to make sure the Header Row button is selected.
5 Click **OK** to see the sorted data. The column should now be in alphabetical order.

### Searching

Searching allows the user to find records that meet their needs.

1 Click in cell **A4**.
2 Select **Filter** from the **Data** menu.
3 Select **AutoFilter** from the **Filter** submenu.
4 On the field name **Data type**, select the **Arrow** button to show a list of entries in the field.
5 Choose **Graphics** to view only those records that match the criteria of Graphics.
6 Select **Audio** to filter those records that match the Audio criteria.
7 Select **All** to show all records.
8 Stop filtering by selecting **Filter...AutoFilter** again.
9 **Save** the file.

### Evaluate the project

When evaluating the project, you may notice that some examples are difficult to understand. This could be overcome by modifying each example so that it becomes a link to the file containing that example. To do this:

1 Select the cell containing the name of the example. For example, cell A4 may contain the name of a graphic such as Dog.jpg.
2 Choose **Hyperlink** from the **Insert** menu and browse to find the file in the location where you have it stored.
3 Click the file. Check the path name and file name are correct in the hyperlink window and click **OK**.
4 Test the link to make sure the file opens. For example, Dog.jpg may open a file containing a photo of your pet dog.

Any or all of your sample files may be linked in this way.

## PROJECT 2: DIGITAL MEDIA DESIGN

### Define the problem

An engineer needs a simple animation to demonstrate the construction of a bridge.

### Analyse the problem

Animation allows those involved in a construction project (developers, builders and suppliers) to see the overall project before greater involvement is required. The animation would usually be more complex than the solution provided in this project.

The animation software needed must support frames and sprites. Some clip art may also be useful. A microphone and sound software will be needed to record the sound files.



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## Design a solution

For a simple design, all that is required is to outline the supports and panels and rails of the proposed bridge. The setting for the bridge will determine the design chosen. Microsoft Powerpoint is useful for this as it allows you to design the background separately from the sprites. The background can be used for each frame without any extra work.

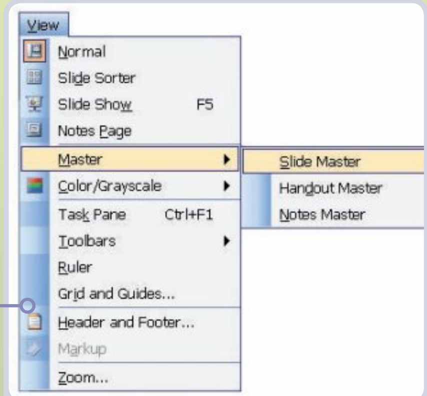


**Figure 5.52** Slide master

## Produce the solution

1 **Open** a new presentation document.
2 Choose a blank presentation and a blank slide for your document.
3 Save the document as Dig_design.
4 From the View menu, choose **Master...Slide Master** to go to the background. All objects created here will appear on each slide of the document.
5 Use the **Draw** tools to create an environment in which a bridge is to be built. The text tool will be useful for adding headings and notes. Keep these headings and notes towards the edges of the slide. If you have some simple clip art that is suitable, you may want to use the **Insert...Picture** menu to import the image into your file. Images may need to be resized to fit the drawing. Figure 5.53 provides a guide to what may be done.

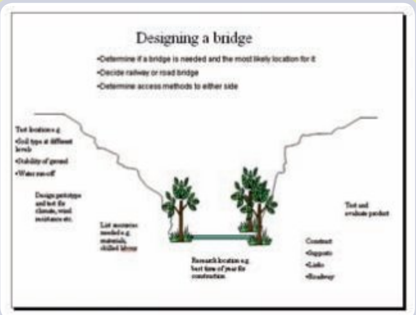


**Figure 5.53** Master slide for bridge design

6 **Save** the file and use the **View** menu to return to normal view.
7 Use the **Insert** menu to insert four new slides into your document. Each slide will have an identical background environment.
8 Go to slide 2.
9 Use the **Draw** tools to draw and fill the solid supports needed to anchor the bridge. These may be shown as a cross section of the site.

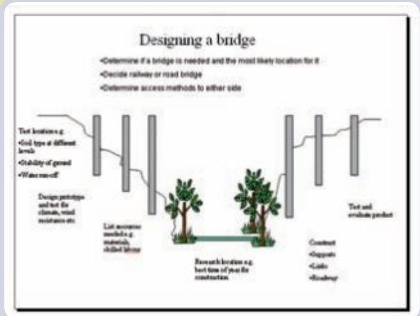


**Figure 5.54** Possible contents for slide 2

10 **Save** the file.
Slides 3, 4 and 5 may progressively add sections of the bridge design to the cross section.

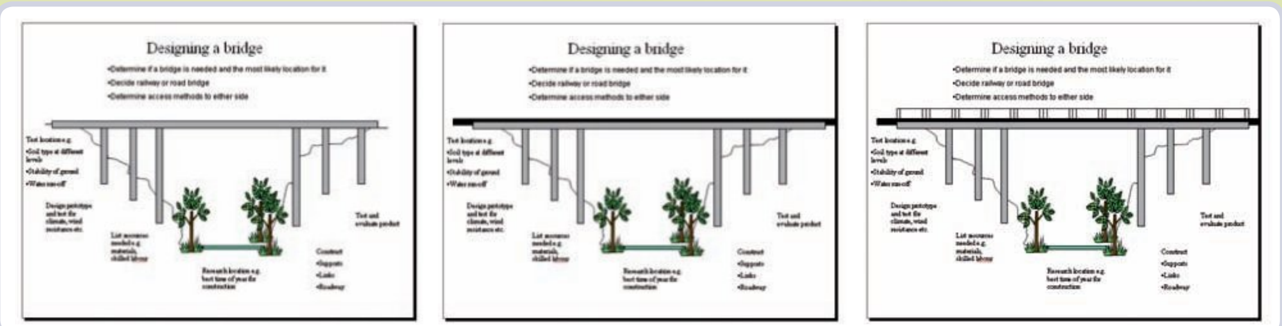


**Figure 5.55** Slides 3, 4 and 5

11 **Save** the file as you complete each slide.

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12 Use the **Slide Show...Slide Transition** menu to set the effects you wish to achieve as each slide is shown. Click **Apply** to **All** to have these options apply to all slides in the document.


**Figure 5.56** Slide transition options

13 **Save** the file.

14 Record a simple explanation of the stages of bridge construction using a microphone and sound software. This may be done as a single file or a series of files, one for each frame/slide. **Save** the sound as **wave** files.

15 From the **Insert** menu, choose **Movies and Sounds... Sound from File** to add the .wav file/s to your animation in an appropriate location. Decide on when and how the sound will be used. These options may be changed using **Custom Animation** in the **Slide Show** menu.

## Evaluate the solution

1 From the **View** menu, choose the **Slide Show** option to view the final product. Make any changes needed by modifying the background master or the foreground of the slides.

2 **Save** your changes.

3 When you are satisfied with the result, use the **Pack and Go** option from the **File** menu to create a self-executing file that will work on machines that do not have Microsoft Powerpoint installed.

4 Provide a copy of the Pack and Go file on a secondary storage device to a peer (person with a similar level of experience to yourself). Ask the peer to provide some positive feedback on your project.

5 Complete the following table related to your experiences with this project. Tick the most appropriate box for each section.

| Knowledge | | | |
|---|---|---|---|
| I know about: | Same as before | Improved | Greatly improved |
| Animation sequences | | | |
| Data types used in digital media | | | |
| Secondary storage examples | | | |
| Skills | | | |
| I can: | Same as before | Improved | Greatly improved |
| Create and use frames and sprites | | | |
| Use techniques to manipulate data | | | |
| Save digital data in a range of file formats | | | |



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CHAPTER 6

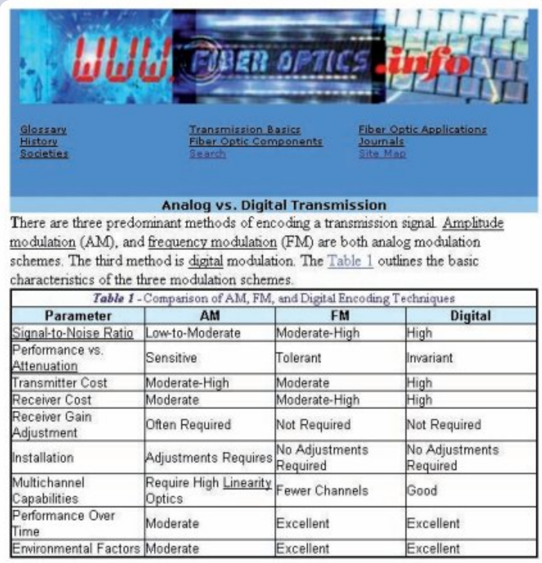
# The internet and website development

The **internet** is a global communication network, that is, a network of computer networks. There is no central control and so sections of the internet can function even when other sections are shut down or damaged. The only controls over the internet in most countries are the addresses assigned to computers, each of which must be unique if the network is to work properly.

The internet is a global communication network.

The internet is set up to let users do many different things, including:

- share documents
- locate information on just about any topic
- send and receive email
- have a real-time (live) conversation using typed text, voice or video
- read electronic magazines and newspapers
- check the weather forecast or the score of a sports game
- play computer games with one or more people at once
- post messages to newsgroups on a common topic
- buy books, CDs, software, wine, or just about anything (called e-commerce).




Analog vs. Digital Transmission

There are three predominant methods of encoding a transmission signal. Amplitude modulation (AM), and frequency modulation (FM) are both analog modulation schemes. The third method is digital modulation. The Table 1 outlines the basic characteristics of the three modulation schemes.

*Table 1* - Comparison of AM, FM, and Digital Encoding Techniques

| Parameter | AM | FM | Digital |
|---|---|---|---|
| Signal-to-Noise Ratio | Low-to-Moderate | Moderate-High | High |
| Performance vs. Attenuation | Sensitive | Tolerant | Invariant |
| Transmitter Cost | Moderate-High | Moderate | High |
| Receiver Cost | Moderate | Moderate-High | High |
| Receiver Gain Adjustment | Often Required | Not Required | Not Required |
| Installation | Adjustments Requires | No Adjustments Required | No Adjustments Required |
| Multichannel Capabilities | Require High Linearity Optics | Fewer Channels | Good |
| Performance Over Time | Moderate | Excellent | Excellent |
| Environmental Factors | Moderate | Excellent | Excellent |

**Figure 6.1** An information site on the internet

The development of the internet brings together the ideas of thousands of humans over many hundreds of years, the development of the hardware and the software to support this exchange, the innovations in networking these together, and the protocols or rules that made it possible for people to talk to each other across the world using vastly different systems.

## The history of the internet

Internet history is very complex, as it is difficult to know where to start. None of the developments covered in this chapter would have been possible if thousands of other developments hadn't taken place previously. Many of these interact with general network concepts and further details can be found in chapter 8.



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The reason for the massive changes in internet technology and use over the last two decades can only be understood if you appreciate that many other things happened earlier to make this easier. For example, in 1945 Vannevar Bush proposed a machine capable of storing vast amounts of information with the idea that users would be able to leave an information trail that they would be able to return to at a future time. It took until 1965 before Thomas Marill and Lawrence Roberts devised linked computer systems over different sites (a wide area network or WAN) and the first steps were taken to make Bush's idea a reality. No one machine would be capable of holding the vast amounts of information Bush contemplated, but many machines could do so.

The first four nodes of ARPANET (what was to eventually become the internet) weren't set up until 1969, and the global concept of information exchange didn't begin until 1973. The internet was almost completely text-based at first, although keys could be used to send the first graphics such as -: and :). In 1985 the Whole Earth 'Lectronic Link was established by Larry Brilliant, possibly the first ISP (internet service provider), but it wasn't until 1989 that Tim Berners-Lee had the idea of the world wide web (WWW) for which he developed software in the following year. The WWW was the key to opening the internet to users without significant computer knowledge, as it was graphically based and used WIMP technology – windows, icons, mouse and pull-down menus. Search tools such as Gopher and Veronica emerged in 1991 and 1992 to make the internet even more usable.

You can consider the development of the internet as a series of linked developments by studying tables 6.1–6.4, which cover only the critical moments in this history. Remember that none of these developments could have happened in isolation and depended heavily on many other developments. For example, without the 1958 development of digital data transmission over telephone lines (as distinct from analogue telephone conversations), few of the ideas, hardware or software would have become what we know today as the internet. Not all such developments were good: viruses and other social issues accompanied the process.

## The history of internet ideas

Ideas came before the development of the actual devices and programs needed for the internet. Many ideas were very important and table 6.1 gives only a few of these. Some ideas were critical. Tim Berners-Lee's idea of a graphical based internet is one such idea. It took two years to come into operation and a few more years to become popular, but, by 1995, packets of data sent by HTTP (internet protocols for hypertext data transfer) were exceeding FTP (the older text-based internet traffic) for the first time. Today the HTTP or world wide web carries most of the traffic on the internet.

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**Table 6.1** Some important ideas in the development of the internet

| Date | Credit | Idea | Importance |
|---|---|---|---|
| 1961 | Leonard Kleinrock | Packet switching networks | Messages could be divided into packets and sent over many different routes to their destination before being rejoined |
| 1965 | Ted Nelson | Hypertext | Text could be used to link to other text |
| 1981 | Ted Nelson | Hypertext database | Linked data could be made accessible through queries |
| 1989 | Tim Berners-Lee | World wide web | Suggested a graphical internet that would be easier to use |
| 1992 | Jean Armour Polly | Surfing the net | Provided a term to explain how users could browse in the internet environment |

## Significant hardware and network developments

Hardware and the idea of connecting hardware (networking) is a basic necessity for the development of the internet. The backbone of the internet consists of cables linking the main connection points, each one called a POP (point of presence). Most internet traffic is carried on fibre optic cables that can handle the routing of many billions of packets (small parts of messages) each day. Only a few of the hardware developments that led to the internet we have today are listed in table 6.2.

**Table 6.2** Hardware developments of importance to the internet

| Date | Inventor or change | Event | Importance |
|---|---|---|---|
| 1942 | John Vincent Atanasoff and Clifford Berry | First electronic digital computer | Computers would become the basic nodes of the future internet |
| 1960 | Echo in use | First communication satellite launched | International communications became faster and more accessible |
| 1963 | Bell 103 modem | First commercial modem | Dial-up connections made possible |
| | Thomas Marill and Lawrence Roberts | Set up of the first WAN (wide area network) | Connecting computers between remote sites was a vital step to the development of a true internet |
| 1966 | Bob Taylor | First steps taken to set up ARPANET | US universities linked to exchange information |
| 1968 | British National Research Lab | First WAN to use packet switching | More efficient use of network links is made possible |
| 1977 | Vint Cerf, Bob Kahn etc. | First widespread use of gateway packet switching technology | Computers of different types could now 'talk' to each other |

continued >

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| | | | |
|---|---|---|---|
| 1977 | First Cray supercomputer developed | 8 MB memory 160 megaflops speed $8.8 million price | Concept of servers required the idea of a major central computer able to handle the traffic |
| 1983 | Paul Mockapetris | DNS server (Jeeves) | Servers now able to handle domain names instead of IP addresses |
| | ARPANET split | Military and civilian sections | First commercial internet possible (took until 1991 to remove military restrictions) |
| 1988 | Fibre optic transatlantic link in use | Europe to North America link | Fast, rapid digital data transfer established |
| 1990 | ARPANET ends | Ceases operation | End of the 'old' internet concepts |

## Software developments

Programs for use on the internet were vital, as the hardware could not operate without the software.

**Table 6.3** A few of the important software developments

| Date | Inventor | Event | Importance |
|---|---|---|---|
| 1956 | John Backus and team | Development of Fortran | First high-level computer language |
| 1972 | Ray Tomlinson | First email software | The beginning of message communication |
| 1979 | Richard Bartle and Roy Trubshaw | First MUD (multi-user domain) | People of similar interests able to confer electronically |
| 1982 | Jarkko Oikarinen | Internet Relay Chat written | Chat sessions now possible |
| 1990 | Tim Berners-Lee | First WWW software | Graphical internet makes it more user-friendly |
| | Peter Deutsch, Alan Emtage and Bill Heelan | Archie released | Concept of a search engine begins |
| | Jim Gosling | Java programming language | A language understood by computers of many different types |
| 1993 | Marc Andreessen | Mosaic search engine | A popular search engine for the WWW |
| | Mosaic Corporation | First version of Netscape released | Free web browser |

**Protocol** a set of rules that governs transmission of data between computers.

## Protocol developments

Protocols are rules that determine how data is handled over the internet. Without such rules, data handling has no standards and will vary from system to system. The development of the internet as one system accessible

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to the world and able to allow communications between machines of many different types depended on the development of these protocols or standard rules.

**Table 6.4** Some important developments in protocols for internet use

| Date | Inventor | Event | Importance |
|---|---|---|---|
| 1968 | | First full version of the ASCII standard published | A standard data code that can be understood by all machines |
| 1970 | Steve Crocker and Network Working Group | First use of the NCP (network control protocol) | Standard rules to link computers |
| 1971 | | FTP introduced | Standard rules to transfer files |
| 1974 | Vint Cerf and Bob Kahn | Introduction of TCP (transmission control protocol) | Rules to control file movement on the internet set standards allowing easy communication |
| 1978 | Vint Cerf, Steve Crocker and Danny Cohen | TCP divided into TCP (error handling and data) and IP (routing) | More complex transfers are possible |
| 1987 | Jeff Case, Mark Fedor, Martin Schoffstall and James Davin | Demonstration of need for internet security – Simple Gateway Monitoring Protocol | Expansion of the internet makes security a priority |

The overall growth of the internet has been phenomenal. From the early beginnings of ARPANET in 1969 with four computers to 2007 when the number of hosts is climbing to more than 350 million, there has been a vast increase in the users and domains registered on the net. It would be almost impossible to know exactly how many users exist today.

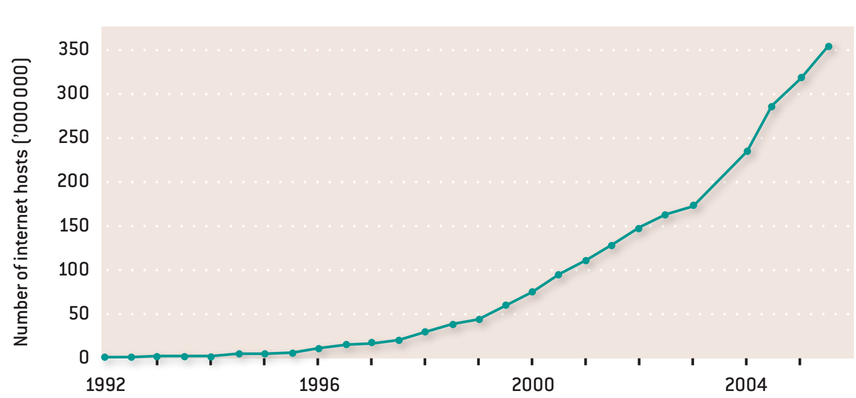


**Figure 6.2** Growth of the internet showing the number of hosts since 1992. The expansion of the world wide web began in 1991.

## Think about this

The larger the internet grows, the more information is being stored. Anybody may publish on the internet. Some information is very reliable, other information is biased, wrong or useless trivia. Should people believe everything they read on the internet? How can you tell what is reliable and what isn't?

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## EXERCISE 6.1

1 True or false? Revise each false statement to be true.
  a The first network underlying internet development was ARPANET.
  b ISP stands for 'internet serial protocol'.
  c FTP was the hypertext component of HTTP.
  d The internet is a global network.
  e The idea of the world wide web came from Tim Berners-Lee.
  f In 1973, ARPANET was also known as the world wide web.
  g The world wide web was the beginning of the rapid expansion of the internet among general users.
  h Packet switching networks allowed data packets to efficiently travel different routes to their destinations.
  i On the internet, MUD stands for multi-user development.
  j Satellites, fibre optics and gateways were essential developments in internet expansion.

2 Match the terms in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| ARPANET | internet relay chat |
| DNS | text capable of linking to other media |
| FTP | cross platform programming language |
| hypertext | rules for data handling on the internet |
| internet | domain name server |
| IRC | file transfer protocol |
| Java | military internet that began in 1969 |
| protocol | graphical component of the internet |
| surfing | largest WAN or wide area network |
| WWW | process of browsing the internet |

3 Why isn't it easy to separate the different components important to internet history?

4 How did ideas precede other internet developments? Use packet switching as an example.

5 Why was gateway hardware important in internet development?

6 What happened to ARPANET between 1983 and 1991 that widened the use of the internet?

## Intranets

**Intranet** a private network that restricts the use of technology and protocols to within an organisation.

Intranets, or private networks, restrict the use of internet technology and protocols to within an organisation. The contents of an intranet are made available only to internal users and are easier to maintain than many other computer-based resources.

An intranet can be set up on a local area network and have no outside access. It may also be set up on the internet, but use password access to restrict the site to authorised users. Users can then access the site away from the organisation.

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Intranets centralise the information system of an organisation in an easily accessible, platform-independent virtual space. An organisation could use its intranet to hold:

- organisational policies
- forms and applications
- literature
- manuals
- contact numbers
- databases

Successful intranets allow:

- participants from across all facets of an organisation to contribute the different skills needed to carry out a particular process
- collaboration between participants by allowing for internal communication and the exchange of ideas
- geographically dispersed participants to work on common projects

The advantages of intranets come with the savings in operating costs and paperwork, improved communication and enhanced community building between those that are part of the system. One of their disadvantages is the problem of security. Such issues are covered later as part of overall internet security.

## The internet model

The internet uses the *client-server* model. Any computer using the internet will be either a client or a server. The **server** is the computer providing access to the data and the **client** is the computer that is accessing and displaying the data.

To improve download speed on the internet, swarming is replacing the traditional client-server process in some instances. The first client connects to the server and starts receiving data. The server breaks the requested file into parts and sends some of those parts to the client. A second client also contacts the server and, rather than wait until the first client has finished, also begins the download process and is sent different pieces of the same file by the server. The first client may also send the second client pieces of the file and vice versa. File transfer becomes like a transfer grid and the overall speed of the download is much faster, particularly with very large files.

**Server** a computer which handles data transfers and programs access across a network.
**Client** a computer that accesses and displays data.

### EXERCISE 6.2

1 What am I?
  a I am a private network using internet software and protocols.
  b I am a protocol for handling linked data called hypertext.

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exercise 6.2 continued

- c I am any machine for accessing and displaying data over the internet.
- d I am the general term for the internet, or any network, where components are not concentrated in one location.
- e I am a term for the opposite of physical space.
- f I am any machine providing data access over the internet.
- g I am the internet protocol that handles the routing of data.
- h I am a supercomputer developed in 1971 and capable of acting as a server on the internet.
- i I am a major problem experienced on intranets.
- j I am the general term for the model or structure of the internet.

2 Answer the following questions in full sentences.
- a List some of the types of data that may be held on intranets.
- b What are the advantages of intranets?
- c Explain TWO different ways in which intranets may be set up.
- d Explain the importance of internet protocols.

# Uses of the internet

The internet can be used for many purposes.

**Table 6.5** Summary of major internet uses

| Use | Examples | Some advantages |
|---|---|---|
| Communication | Electronic mail, mailing lists, newsgroups, chat and messaging systems | Enables users to share ideas, collaborate on projects, ask questions and request information from experts |
| Distribution of information | Websites and web pages from government and health officials | Democratic process makes information available internationally that is current (up to date) and accessible |
| Research | Virtual universities that exist only on the internet | Researchers share resources and collaborate on projects across organisational and national boundaries |
| Marketing | Electronic commerce (selling and buying goods) | Wider potential group of customers and goods |
| Services | Electronic banking | Cheaper than other methods and with 24-hour access |
| Public relations | Information about missions and services of organisations such as charities | Coordination of international aid and wider understanding of problems such as famines |
| Entertainment | Travel, games, newspapers, journals, weather reports, sports and current events | Users may interact with other cultures, widen interests and pursue interests that may otherwise be unavailable |

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## Use of the internet for communication

The internet offers both real-time and delayed means of communicating with others, as well as many services. *Delayed uses* include electronic mail or email, mailing lists, newsgroups and discussion groups. Users can interact with one another without being simultaneously connected to the internet by collecting messages at later times. *Real-time uses* include chatting and instant messaging whereby users may interact simultaneously when they are connected to the internet.

### Email

An email program is required to send and receive email. There are many such programs and they may differ between the sender and the receiver. Most have some specific parts:

- Header: includes all the details related to the receiver or receivers
- To: the email address of the first recipient. This address is essential but the other parts of the header are optional. All email users require an address. For example, if your assigned login name is 'jocelyn' and the name of the computer where your email is stored is 'mycom.uiuc.edu.au' then your email address will be 'jocelyn@mycom.uiuc.edu.au'.
- Cc (carbon copy): the email address of other people who will receive the message. These other people will be seen by all recipients as having received the message. There can be one or more addresses in this box.
- Bcc (blind carbon copy): the email address of other people who will receive the message. These people will not be seen by all recipients as having received the message. This can also contain more than one address.
- Subject: a brief description of the message. This will appear in the recipient's inbox and makes it easier for the recipient to identify the value of the message.
- Body: the message section of the email. The content is usually short.

Some of the processes that form part of email messaging systems include:

- Reply: this option allows users to reply to the sender without having to compose a reply from scratch. The original sender's email address is automatically included.
- Forward: send a message received from one recipient on to another recipient.
- Attach: attach a file (text, graphic, video or sound) to the message. This is very useful when existing data needs to be sent or when the formatting of data is very important.

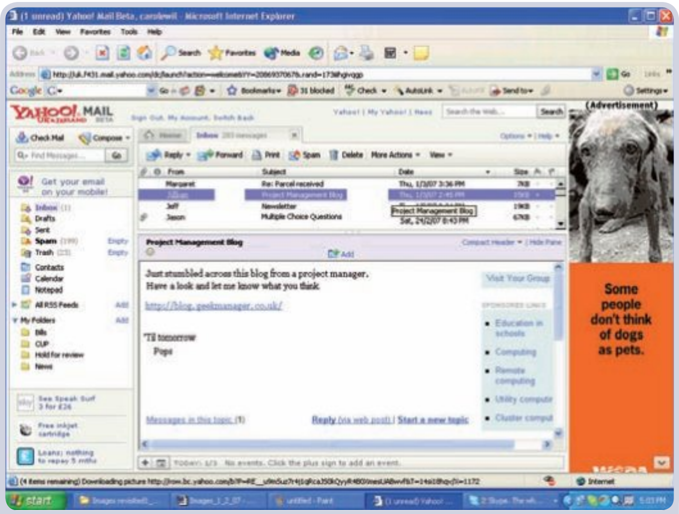


Figure 6.3 Electronic mail software

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- Address book: a file recording the email addresses the sender uses frequently. It is possible to use the address book to broadcast a message to a few or all those in the book. Email addresses may be stored for individuals or linked to groups so that messages can be easily sent to all members of a particular group.
- Signature: an electronic message or graphic attached to the end of each message sent.
- An email message can also contain emoticons (small typed information to convey emotions). Examples include :) for smiling, ;- for winking, :-( for frowning. Emoticons are part of the text of a message.

The advantages of electronic mail are its speed and its capacity to handle video, sound and text data. It is also cheap over long distances as only a local telephone call is usually involved. However, some of the potential problems with the use of electronic mail include:

- the speed and ease with which confidential information can be distributed. This also makes it difficult for the recipient to identify the original sender of a message, that is, the owner of the content.
- the viruses which can be attached to email messages
- the lack of privacy. Electronic mail is available to anybody with the ability to check mail.
- the fact that its speed can be useless unless the mailbox (held by the service provider or on the network) is regularly checked. This can be made easier by setting the email system so that the receiver is automatically notified when they have email waiting for them. However, they must still be logged on to the system to receive such a message.
- flaming – replying to an email message with an angry response. Many people email to others whom they have never met and forget to consider their feelings. Flaming is very bad manners and something to be avoided.
- spam – unwanted email messages.

## Mailing lists

Mailing lists use email to allow groups of people with similar interests – for example veteran car hobbyists – to keep in touch. Anybody who wants to be part of a mailing list must subscribe and then they receive an email each time a message is sent to the group, or they can choose to have a summary sent once a week or so. Some lists are open (anybody may subscribe) and others are limited (only qualified people may subscribe).

## Message boards

Message boards are more public than mailing lists as most can be read by anyone and very few require users to subscribe. They are similar to the whiteboard left on the family fridge for anyone to leave a message for another person to access later.

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## Discussion groups

Discussion groups are a mix of mailing list functions and message boards. They are often open for anybody to read, but usually require people to join the group before they can post messages.

## Newsgroups

Newsgroups are another collection of interest groups, usually in categories such as Sci for science. Some are very specialised such as sci.med.diseases.leukemia.

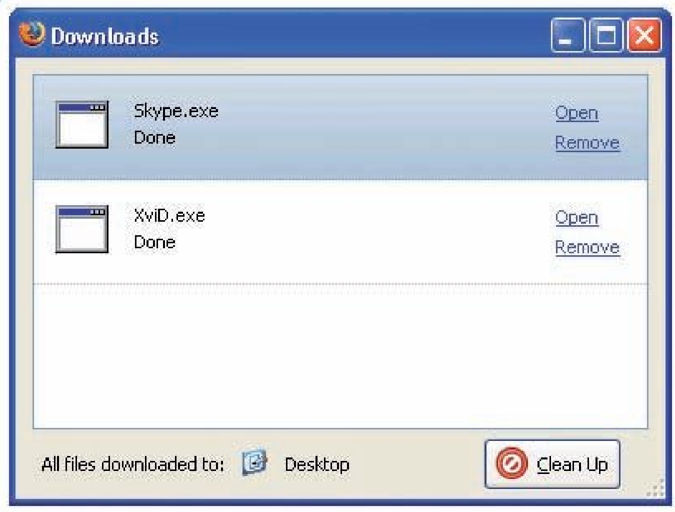


**Figure 6.4** Firefox open source web browser—downloading data

## Chatting

Internet chatting allows real-time interaction between participants using text-based messaging. There are different types of chatting areas including web-based chatting using a browser and IRC or internet relay chatting that connects the user to an IRC server and chat rooms.

To become part of a chat room discussion, the user has an *alias* or nickname (a name other than their own name). They type messages that appear on the screen of all others who are in the chat room at the time and show the alias (handle) of the sender. Chatting etiquette is very important. No user wants to type in capital letters as they would be immediately seen as rude or shouting. Most chat rooms have provision for users to chat exclusively with a few others using a private room rather than staying in an open forum.

## Messaging

Direct chat or instant messaging lets users set up lists of friends and message these directly when both they and their friends are on the internet at the same time. These normally require all those involved to use the same software such as ICQ or Windows/MSN Messenger.

## Use of the internet for e-commerce

Electronic commerce means running a business by using the internet. This may include virtual companies (a company that exists only on the internet) or traditional companies that conduct some of their business across the internet. E-commerce has been made possible because of the vastly increased speed of computer systems and internet connections. Some of the advantages of doing business in this way include access to global markets, lower transaction and advertising costs and the ability to interact with customers in their offices or homes. However, there can be major problems if e-commerce is not carried out correctly.

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Some developments in e-commerce include:

- webskins, that is, establishing a website so that it looks like one company's website when it is actually the website of a company providing e-commerce support to that company
- global shopping and world-wide distribution of products
- virtual private networks between international branches of the one company
- electronic brochures and advertising directly to customers' email addresses
- webcasts, that is, data streaming from a server to a client computer or PDA (personal digital assistant)
- internet job boards listing jobs in most areas of the workplace
- online services, such as, stocks and shares brokerage
- net meetings or conferences between company executives, held across the internet

## EXERCISE 6.3

1 Complete the following sentences to make them true statements.

a Trading or the selling and buying of goods across the internet is called ...

b Collaboration on projects and sharing resources between universities contributes to ...

c Service organisations can use the internet for ...

d Software used to send and receive letters and attachments is ...

e In the address pam66@united.net.au, united is the name of ...

f Sending an email to multiple receivers, all aware of the other recipients, uses ...

g All detail related to receivers of electronic messages is contained in the ...

h Small data units conveying emotions in messages are called ...

i BCC stands for ...

j The major message area of an email window is called the ...

2 Select the correct word from the given list to complete the following paragraph.

| | | |
|---|---|---|
| chatting | delayed | downloads |
| interaction | interactive | locations |
| logoff | newsgroups | one |
| players | purposes | real time |
| simultaneous | users | virtual |

The internet is a (a) ___, non-physical space used for a multitude of (b) ___. (c) ___ uses involve (d) ___ interaction between (e) ___, such as (f) ___. Other uses are (g) ___, that is, (h) ___ occurs but not simultaneously, such as in (i) ___. Entertainment sites on the internet can also be (j) ___ of these

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exercise 6.3 continued

types, such as (k) ___ games involving two or more (l) ___ at very different (m) ___, or sites that allow music (n) ___ so that users can enjoy sound when they later (o) ___.

3 Answer the following questions in full sentences.
   a When would you use reply rather than forward with an email?
   b What is the value of an address book to an email user?
   c Explain how data can be organised in an address book to make it easier for the sender.
   d What is an electronic signature?
   e Compare the advantages and disadvantages of email.
   f How are chatting and instant messaging different from email?

## Research and access to information via search engines

The internet is an amazing tool for research, as it allows scientists from different countries to collaborate on major projects and students to have quality information on just about any topic they need.

So that the internet can be used effectively, **search engines** have been developed to locate specific data from the mass of unstructured data that exists. Collecting data using the internet can waste a great deal of time. There are well over a billion pages on the internet and the number is growing every day, so there needs to be a way of finding what you are looking for relatively quickly and without too much difficulty.

**Search engine** an information retrieval system to locate specific data on the internet.

There are many different search engines, but they all work in much the same way. The user types a *keyword* or keywords into the box and the search engine returns a list of suggestions related to where the information can be found. Not all search engines are the same. Like every tool used for research, no one tool will find all the information you need. Most search engines cover less than one-quarter of the possible sites on the world wide web. Some search engines are better than others, but this can depend on what you are looking for.

*General search engines* enable searches in categories, such as sport, and often use databases to hold details related to large numbers of web pages. These search engines are only as current as the people or the computers used to gather the details can be. They may be months behind on new sites or include old sites that are no longer available. Advanced searching techniques let users find the most specific sites. Some search engines are designed for a particular reason, such as medical searches or searching for data in a particular location. Examples include Google, Yahoo, Ask.com and Search MSN.

*Metasearch sites* are search engines that gather together a number of search engines and provide results from more than one search engine as a single list. Examples include Dogpile, Metacrawler and Mamma.

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## Search engines

Search engines are electronic indexes, similar but on a bigger scale, to the index in the back of a book. They use a database to store details about web pages. A small program called a spider, bot, crawler or intelligent agent travels through the internet searching for new pages. These pages are then analysed by various means, such as:

- keywords in the URL
- keywords in the text on the page
- words in the TITLE tag
- keywords in the source code of the page
- the size of the site, that is, how many other pages link to the page.

Each search engine uses a different method to decide what is important about a page and each updates its data at different intervals. When a user goes to a search engine and types in search words, a list is returned from the database of pages that fit the search criteria. Each search engine will return a different list, some similar and others very different, because of the way they have analysed their collected data and the frequency of their updates.

Such lists are usually provided as links to the websites suggested together with a small abstract of the site contents. Most search engines provide the list in small chunks such as 10 or 20 sites at a time. Sometimes you can decide how many suggestions you wish to see on the list at once.

A search engine may also provide links to popular sites, online newspapers and magazines, newsgroups and chat groups, games groups and other interest groups.

Refining searches in search engines is a way of achieving the best results for the search time available.

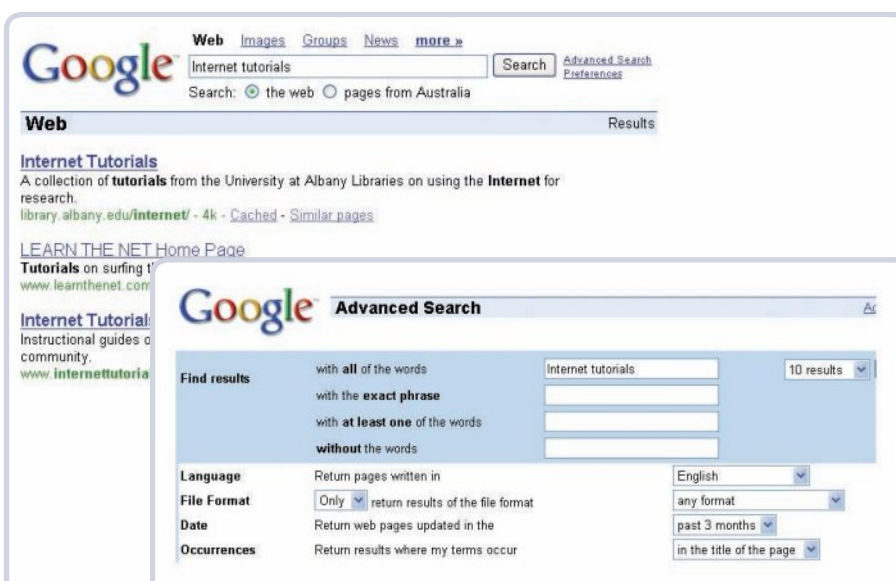


**Figure 6.5** Some results from a simple keyword search

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**Table 6.6** Methods of refining a search

| Methods | Description | Use of the method |
|---|---|---|
| Categories | Domains, groups or types of sites | Specify these in many search engines by using the link to advanced searches.<br>Example: Computers |
| Filters | Software additions | Filters can help to avoid offensive material such as pornography and violence. Some search engines have these available. |
| Links to similar pages | Link (link:) | Links can be useful to find sites like a site you have already located.<br>Example: link: www.shareware.com |
| Small letters | Lower case | Use lower case to increase the number of hits.<br>Example: australian goldfields |
| Plus<br>Minus | Plus (+)<br>Minus (-) | Use these to tell the search engine if you want to include (+) or not include (-) a word or words.<br>Example: Port+Adelaide (no spaces) |
| Quote | Quote (" ") | Use quotes to keep a phrase together if you want the engine to search for words in an exact order.<br>Example: "All that glitters is not gold" |
| Search by keywords | Use specific terms | Where possible, state the exact information you need.<br>Example: 'Dame Nellie Melba' rather than 'Australian women' |
| Star | Star (wildcard) * | The * can be used instead of any letter or group of letters. It is used to find different variations of a word.<br>Example: comp* gives competition, competitor, competencies etc. |
| Title | Title (title) | Use this option to restrict your search to pages with the topic in their title.<br>Example: Running with wolves |

# Internet software

There are many useful software tools for the internet. They can be divided into two major categories: software for the display of internet documents are called browsers, and software for the development of internet documents is known as authoring software.

**Browser** software for displaying internet documents.

## Browser software

To access the internet, particularly the world wide web, you need a web browser or software that supports the navigation and display of HTML files. HTML is a simple markup language that allows display on all computer platforms, that is, all types of hardware. There are two types of browsers.

- Graphical browsers handle text, images, audio, and video and include Mozilla Firefox and Internet Explorer. These browsers are available for

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both Windows-based and Macintosh computers and most of them are free. Navigation is achieved by pointing and clicking with a mouse on hotlinked words and graphics.

- Text browsers allow users to navigate the net using the arrow keys and the enter key to follow a link. Lynx is a browser that provides access to the web in text-only mode.

Software programs called plug-ins can be added to a web browser to give it wider capability. Plug-ins run or display sounds, images and videos. One common plug-in is a PDF (portable document format) reader. HTML documents have hyperlinked files with a .pdf extension and allow large graphics and text files to be displayed easily on a user's machine. Once a plug-in is set to a user's browser, it will automatically open when a file of that type is accessed. ActiveX is now supported by some browsers and allows objects such as animations and videos to be made part of a web page and to be viewed by a user without a plug-in.

Browser software uses a client-server structure and the server component holds web pages in two parts: text and graphics. Browser software controls what you see. All that is sent across the transmission is the information. The client software sends a request to receive the selected page. The server software transfers the information for the page across the internet connection using a protocol called http (hypertext transfer protocol). Many people might be receiving this information at around the same time. The page is displayed by the browser in a set order: text, graphics then sound. The browser decides how to display the information according to the code for the page written in HTML and the browser's available options.

Different browsers have different functions but most offer:

- address lines where the user can type a URL or file location. This will then allow the browser to take you to the site.
- navigation controls: icons and menus that allow the user to go back and forward between pages already downloaded in a session
- access to search facilities, for other pages, for words on the current page
- facilities to save or print the information on the page
- facilities to save the images and graphics as copies
- the ability to refresh or reload the current page
- bookmarks or favourites so that the site address can be stored for future use
- facilities to change the appearance of the text – colour, size and other changes in some browsers. This helps those people who have vision problems.
- directories that connect to many common sites on the internet such as online books, games, chat sessions, online shops, encyclopaedias and dictionaries, even full libraries.

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There are many ways to navigate in a web browser: hyperlinks, menus, toolbar buttons, address box, favourites or bookmarks and keyboard commands, so users have lots of choice.

## Authoring software

Authoring software allows users to create web pages more professionally without a detailed knowledge of HTML, the language of the web.

HTML text editors create HTML documents. For example, many text processors available on most machines will allow tagged code to be written and saved in HTML format.

WYSIWYG (what you see is what you get) HTML editors allow users to create web pages without having to write the HTML code, for example Microsoft FrontPage. Some word processors will also allow this.

Most authoring software needs tools to support its use. For example, graphics programs allowing images to be saved in .gif or .jpg will often allow the user to resize an image or reduce the colour palette so that the physical file size is smaller.

## Types of protocols

Internet protocols are standard rules for internet display and functioning. They allow machines to communicate. Different rules are needed for different operations.

### Transmission control protocol / internet protocol (TCP/IP)

TCP and IP are a suite or group of programs for internet use. They allow computers of different platforms using different operating systems to communicate. TCP carries out the following functions:

- Handshaking, the first contacts between machines on the internet, that is the process of agreeing to the rules that will be used. This involves:
  - determining if the receiver is able to accept a transmission
  - setting up a port connection
  - agreeing to rules such as packet size
- Creating and numbering packets

## Try this

**Using the browser toolbar**

There are many ways to use a browser to get around on a web page: toolbars, keyboard, mouse, favourites (or saved sites) and history. The toolbar is a collection of buttons for frequently used commands.

1 Locate and name the browser on the computer you use.
2 Locate the toolbar of your browser program.
3 Use the mouse to slowly check each navigation tool by moving the mouse across each tool until the tool tip shows.

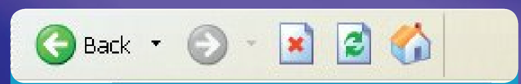


Figure 6.6 Navigation buttons on a standard browser toolbar

4 Write down the description of each navigation tool given in the tool tip box. Explain two different ways to use the Back and Forward buttons.

There is a range of listing options on a toolbar. Each button in the list section opens a list of links in a frame on the left. The list can be closed by clicking the button again.

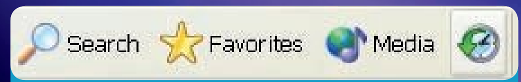


Figure 6.7 Listing option buttons on a browser toolbar

5 Note down how the Search and media options work.
6 Use the web browser help menu and write down the difference between favourites and history lists.
7 Close the browser when you are finished.

Internet protocols are standard rules for internet display and functioning.

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- Handing over control to IP to send the message
- Terminating the connection when IP has finished

IP sends the message by:
- determining the source and receiver address of the packets
- routing or sending packets by different routes to the address
- understanding the machine address in order to send the data to the correct location

Deciding the rules under which data will be sent and turning over control to the data rules is also an IP function.

**Table 6.7** Examples of data rules included in TCP/IP

| Protocol | Abbreviation | Description |
|---|---|---|
| Hypertext transfer protocol | http | Rules for sending data in hypertext form, the protocol of the WWW |
| Simple mail transfer protocol | smtp | Distributes electronic messages and files to one or more electronic mailboxes |
| File transfer protocol | ftp | Rules for sending text data (binary files) between an FTP server and client |

Many other protocols are available on the internet. Telnet (Telnet Protocol) facilitates login to a host computer using terminal emulation. That means the client machine mimics the host machine and acts as a display for the host machine. Text-based commands are typed in to find the wanted information. Telnet is used mainly to access mainframe computers such as large university systems, medical research systems and large libraries. Gradually, telnet systems are being converted to the world wide web.

## Voice over Internet Protocol

Voice over internet protocol is a set of rules that allows for the use of computer capabilities for voice exchange. VoIP uses a personal computer, a microphone and speakers to act like a telephone. Connections may be made across a LAN or WAN or to a computer or telephone system anywhere in the world. Normally, calls are from computer to computer and are free when users have the same software, for example, Skype. It is also possible to call a land-based phone but that requires a small fee. For good sound quality, a broadband connection is needed.

VoIP has many advantages, particularly for businesses: less cabling, less hardware maintenance and the ability to manage different communications needs (phones, internet and text) on the one system. Cost savings come from no longer subscribing to landlines. Companies with offices in more than one location find it easier to connect staff and make inter-office calls.

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## EXERCISE 6.4

1 Unjumble the following words and give a definition of each.
   a EELNTT
   b COOOLPRT
   c AADGHHIKNNS

2 Identify the specific protocol used at each step of the following internet transmission.
   a Handshaking
   b Downloading text data from server to client
   c Routing packets to the client address
   d Downloading hypertext data across the world wide web
   e Sending electronic files to a mailbox
   f Placing a phone call from a computer to a receiver's phone
   g Terminating a connection at the end of a message

3 Answer the following questions in full sentences.
   a How does an individual search engine differ from an index?
   b Explain how search engines locate pages on the web.
   c What is meant by 'refining a search'? In your answer, provide THREE examples of how this can be done.
   d Name TWO types of browser software.
   e Describe the role of a browser plug-in.
   f How does a text editor differ from a WYSIWYG authoring program?

# The world wide web

The world wide web (www) is a system of internet servers that supports hypertext and browsing in a user-friendly way. WWW and the internet are terms that are often used to mean the same thing. However, the world wide web is only a part of the internet—the part that uses hypertext documents. To use the web, a web browser is needed to 'read' these documents on the internet.

The world wide web (www) is a system of internet servers that supports hypertext and browsing.

Hypertext documents are written in HTML (HyperText Markup Language), a coding language that uses English in a special way. However, the web continues to become more complex. Users want to see and hear more and more, faster and faster, and to have more control over what they see. To satisfy these wants, HTML code and extra features like stylesheets and scripting languages keep getting more powerful, and therefore, more complicated. Browsers have also changed in order to use the new features so often older browsers cannot correctly read pages that use new plug-ins or new HTML tags.

## Web services

Web services are interactive extras becoming available on the web that allow tasks to be carried out online, such as software applications like

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**Table 6.8** The web as a medium

| Process | Description | Example |
|---|---|---|
| Information distribution | The web is a broadcast medium transmitting information to a wide audience. | Audio and video over the web is both pre-recorded and live e.g. news sites containing videos shown on the nightly television news. |
| Information retrieval | The use of hypertext as an interactive medium. Hypertext is words that connect one document to other documents. | A single hypertext document will contain word or graphic links to images, video, and sound. Links may or may not follow a logical path, as each connection is programmed by the document designer. |

word processors and sound recording programs. Early web services were the online email websites, such as Yahoo and Hotmail. Such services are independent of operating systems, applications or data on personal computers and allow people to more easily exchange data and to share data with other hardware, such as hand-held devices. They reduce the need for desktop programs and make it easier to use the latest software.

Web developers are constantly developing faster services. One example of this is RSS or Really Simple Syndication, an internet technology that uses filtering and sorting to deliver web services to users. RSS produces information that machines can read and manipulate, making it faster than HTML. One example of how RSS is used is in the delivery of individualised news updates to subscribers' computers or PDAs.

## Solutions to problems on the web

Most solutions require browser plug-ins, extra software and/or higher capacity processing on user machines.

**Table 6.9** Problems and solutions

| Problem | Solution | Example |
|---|---|---|
| Slow download times | Streaming or the playing of files as they are downloaded on to the user's computer | RealPlayer plug in for streaming audio and video |
| Multimedia display | Combination of graphics, animation and sound with text using plug-ins | Shockwave |
| Size of sound files | Sound files for background music in compressed form | MPs file format |
| Real-time display | Live cams or video cameras that link to a web server | Cameras in public and private locations |

continued >

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| | | |
|---|---|---|
| Handling of interactive data | CGI (Common Gateway Interface) allows programs written in CGI script to accept and return data | Completing order forms for an online order |
| Programming complex pages to run on all types of machines | Applets are small platform independent programs that allow the use of calculators, visual displays and interactivity | Java programs called from an HTML page that run on a Java-compatible browser |
| Programming extra functions not handled by HTML | Scripting languages | Visual BASIC script and JavaScript can be used as part of a web page's language |
| Virtual reality or 3D on the web | VRML or Virtual Reality Modelling Language | A user is able to enter a 3D world and control their movements e.g. visit a house on a real estate website |
| Real-time communication using audio and video | Software that allows for collaboration on the internet using video cameras and other equipment connected to machines | CU-SeeMe, Webex and similar software, enables video and audio conferencing |
| Automatic upgrading of user software | Push technology sends data to a program without a program's request | Live updates of antivirus definitions |

## Control of access to information on the web

Most browsers allow the user to set the level of access control when they are using the internet.

### Cookies

A cookie is a small file stored on a user's computer when pages are downloaded from the web. Cookies hold information about a visit to a website, such as a username or password. For example, when you set up an internet banking account the bank stores a cookie on your computer to hold information such as your name and/or your login ID. Next time you log in to the internet bank site the cookie is sent back to the bank website and the information retrieved enables the bank to customise the look of the web page to suit your needs.

Another use of cookies can be for tracking website user habits. For example, a company might want to find out what information is accessed most often, or which web pages are more popular. This can allow them to redesign their website to suit their customers or to customise it for frequent users.

A cookie works because it is given a unique ID so that repeat visitors are easily identified. They are secure in one sense as the information in a cookie is usually only available to the website that created it. For example, if you buy across the internet then your credit card details given for the purchase

**Great idea**

The world wide web until recently has been a read-only system. Web 2.0, or the read/write Web, is an emerging technology where the user controls what they see. Web 2.0 offers online applications and individual control of page content. One example of this is a wiki (what I know is) where users may add and edit content. Using special software, members of a group can collaborate on website content or the web page may be open to anybody to add information. For example, Wikipedia is an encyclopaedia created by users of that site. It may expand to any size and allows users to leave notes or open discussion with the authors. Like the rest of the internet, one drawback is that it is just as easy to publish bad information as it is to publish good information.

A cookie is a small file stored on a user's computer when pages are downloaded from the internet.

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**Figure 6.8** Blocking cookies using browser options

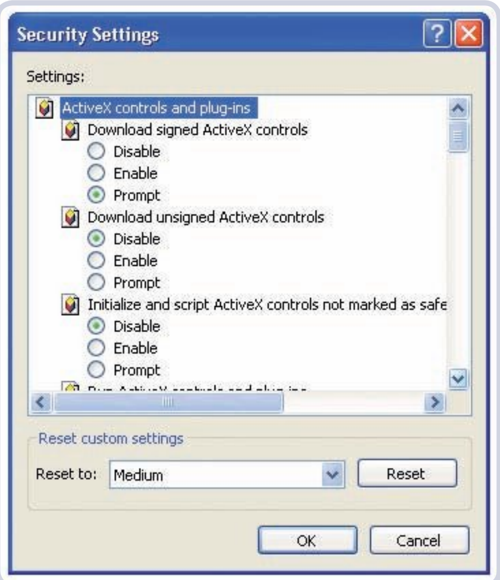


**Figure 6.9** Setting security in a browser

cannot be easily read by another website. However, as they are mostly standard text files, other people can read the cookies on your machine by just opening them on your system.

Privacy issues are very important. If cookies are used by websites, people should be aware of that. They should use their browser to ensure they receive warnings of their use and websites should store private and sensitive information obtained from cookies on their web server and not in the cookies on private machines.

Disabling cookies is possible, but it may not allow users to go to many popular sites on the internet. The better option might be to set the browser so that the user has to authorise a cookie before it is written to the computer.

## Security content

Internet security is threatened in many ways. Programs called *sniffers* can be used to check data packets and copy or catch packets that meet set criteria. The packets can then be opened and their contents checked by those unauthorised to do so. For example, credit card details can be obtained from a packet and then used to commit a crime. Most recent browsers use 128-bit encryption or coding to protect users against sniffing. The encryption used by the browser may not always be supported by the website and the lower value encryption key will be used.

Applets and scripts used in web pages can threaten a machine but only if a hacker gets around the software. Most browsers protect against this by running these little programs inside the browser. They cannot get outside the browser and on to the user's machine, and are wiped when the web page is no longer being used. ActiveX controls are more dangerous, as they can continue after the browser is closed and can also get into the user's machine, but as they only work with Internet Explorer or need special plug-ins, few websites use them. Browsers give users the ability to enable or disable scripts, applets, plug-ins and ActiveX controls.

## Proxies

Proxies are like filters that check all incoming data from the internet. They can be set to protect the user's system against unwanted data or to match those who access a user's system against a previously provided list.

Security protection can be achieved using digital certificates. Legitimate software companies obtain digital certificates to prove that their websites are who they say they are. Verification companies such as VeriSign issue

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these certificates after thorough investigation of each applicant. These digital certificates are downloaded by the site prior to site download and are a way for the browser to check the legitimacy of a web page if the security settings are enabled for this.

To obtain both good security and a functional browser, a balance needs to be achieved when changing security settings. Most internet security experts recommend that users enable applets and scripts, disable ActiveX controls, and only download and use plug-ins from highly trusted sources.

## Firewalls

A firewall is a hardware–software security system that acts as a protective boundary between a network (private) and the outside world (public). It usually sits between the internet and an internal network or intranet. A firewall monitors all aspects of the communications that cross its path and inspects the source and destination address of each message that it handles. To prevent unsolicited traffic from the public side of the connection from entering the private side, the program keeps a table of all traffic coming from the protected computer. All inbound traffic from the internet is compared against the entries in the table. Inbound traffic is only allowed to reach the computers in a network when there is a matching entry in the table that shows that the communication exchange began from an acceptable point.

Firewalls are used to prevent hacking, that is, unauthorised access to data. Hacking can lead to cracking where data is altered, destroyed or damaged. Hacking and cracking are both crimes, and companies protect against them as data is one of their most important possessions.

A **firewall** is a hardware–software security system that acts as a protective boundary between a network (private) and the outside world (public).

**Virus** a program written to alter the contents of a file or another program without the user's permission.

## Virus protection

Computer viruses are programs that are written for the purpose of destroying data or other programs without the agreement of the user. A virus is typically understood to be a software program that can 'infect' other programs by modifying them to include a version of itself. At best, viruses can cause damage that annoys the user; at worst, they can steal or destroy the user's files, or corrupt the user's software (including the operating system). Viruses are not visible on disk directories and so users are often unaware the destruction is taking place until it is too late.

The internet has provided new ways for viruses to transmit themselves, via email, websites and downloaded documents, as well as traditional floppy disk and program-based viruses. New viruses are being written every day.

Figure 6.10 Settings to protect against viruses

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**Table 6.10** Types of computer viruses

| Type | Description |
|---|---|
| Worm | A program that finds its way into either the computer's memory or a disk and alters the data that it accesses. |
| Trojan | A program that attaches itself to another innocent program and causes problems with that program and the data it creates. (ActiveX controls can pretend to be legitimate software and cause damage on a user's machine.) |
| Logic or time bomb | A program that is activated after or during a certain event. (Friday the 13th was the trigger for such a virus to emerge but it caused no trouble until that date.) |
| Boot sector | Hides in the boot sector of a disk or the partition table of a hard disk and takes over control of the computer when the computer starts up. |
| Stealth | A stealth virus works secretly. For example, when it infects a file, the size of that file increases due to the presence of the virus. Such a virus may hide its presence by altering the file size to the size of the original file. |
| Macro | Attached to a word processing or spreadsheet file as a macro. Once the file is accessed, it replaces one of the standard macros with an infected version that can than infect all subsequent documents. |

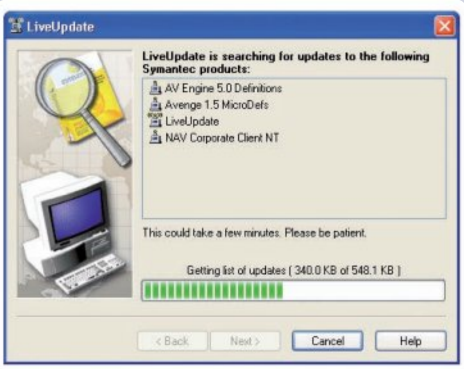


**Figure 6.11** Regular anti-virus updates are internet essentials

There are a number of antivirus programs available such as Norton Anti-virus and Vet Anti-virus. These antivirus programs can be used to scan your disk for the existence of viruses and to destroy the virus. The antivirus program must have constant updates, called definitions, to keep up with the changes. As well, users should never run executable programs obtained from the internet, that is, files with extensions such as .exe, .bat, .com or .dll unless they come from a trusted source. All programs and files should be checked with the antivirus program before they are opened. However, there are always new viruses being written and introduced into the system so users must be ever alert.

## Spyware

Spyware refers to a range of programs designed to take partial control of a computer without the consent of the user. Most are downloaded unknowingly from the internet. Spyware can be very annoying or it can seriously affect computer security, performance and user privacy. Some of the ways that spyware alters a computer include:

- pop-up advertising
- computer slow-downs and/or system crashes
- changed settings such as the browser home page or new toolbars.

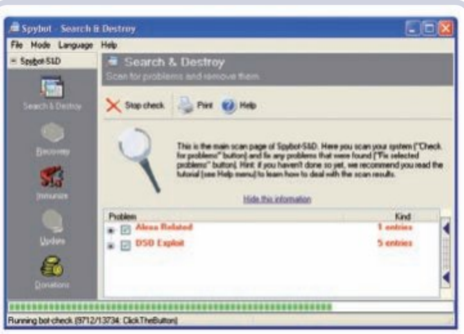


**Figure 6.12** Scanning a system to detect spyware

Spyware can also be used to capture user passwords, collect files, personal information and spread viruses on computer systems. Sometimes the user is unaware that the spyware is on their system.

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Software to prevent spyware being installed on a user's computer is usually part of a security software package and works with anti-virus software.

## EXERCISE 6.5

1 Match the terms in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| applets | internet system supporting hypertext and user-friendly browsing |
| broadcast | ability of users to decide their own pathway through the internet |
| cookie | speeds up download of large files whereby files are displayed as they are being downloaded |
| encryption | small programs written in Java to give extra capability to html documents |
| interactive | an extension of html to handle virtual reality |
| push | small text program stored on a user's machine to hold information on a website visit |
| sniffing | distribution of materials at their request to all users connected to the internet |
| streaming | process of checking data packets sent across the internet in order to match contents with set criteria |
| VRML | technology allowing automatic update of software on user machines without direct user requests |
| WWW | coding of data to disguise its content |

2 Answer the following questions in full sentences.
   a Which is the most dangerous to an internet user?
      i hacking or cracking
      ii applets or ActiveX
   b What are digital certificates?
   c Who would use digital certificates?
   d Why are firewalls used on the internet?
   e What is the best way to prevent your computer programs from getting a virus?
   f Can you see one problem with anti-virus programs ?

3 Carefully study figure 6.13 and answer the questions that follow.

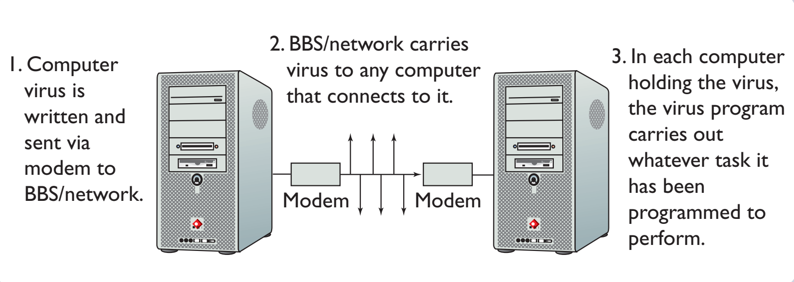


**Figure 6.13** Virus transmission

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exercise 6.5 continued

**a** What is a computer virus?

**b** Use the diagram to explain how a computer virus can be spread from one computer to another by:

- **i** a computer user who uses an internet site that has been infected with a virus
- **ii** a computer user who downloads a game from the internet without using a virus checker
- **iii** a user who opens an unidentified email with a file attachment
- **iv** a computer user who receives an electronic mail message containing a virus and passes the message on to other users by electronic mail

**c** Explain what is meant by each of the following virus types.

- **i** Trojan horse
- **ii** logic bomb
- **iii** boot sector virus

**d** Find the names of THREE recent viruses that have caused major problems on computer systems. Write down the details of the damage caused by each of the viruses you have identified. Remember: The only time a computer is really secure is when it is turned off.

**Great idea**

Podcasting and video casting processes distribute audio and video files, such as radio and television programs, over the internet. Voice, music and video files can be linked to a blog (see glossary) by any person participating in the website and downloaded by subscribers to their mobile phones, PDAs or computers.

**Figure 6.14** Web camera

## Website development

The world wide web consists of files containing information and links to resources throughout the internet. When you are viewing a web resource on the screen using a client or browser you are viewing a web page. Each web page is an individual document.

Hypertext allows text, graphics, audio and video to be integrated on a web page. This can make it very easy to browse and very exciting to view. A single click on any hyperlink allows you to follow the link to the specified resource such as sounds or video clips.

Producing hypertext for the web is done by creating documents with a language called hypertext markup language, or HTML. HTML pages are simple text documents that include the text to be shown on the page and special commands known as *tags*. Tags tell the browser how to display the page. With HTML, tags are placed within the text to achieve document formatting, visual features such as font size, italics and bold, and the creation of hypertext links. Tags are also used to access data held outside the HTML document such as graphics or video. HTML is an evolving language, with new tags being added as each upgrade of the language is developed and released.

For example, if a user wanted text to appear in bold on an HTML page they would surround that text with the needed tags:

```
<b>I want this text to appear bold</b>
```

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results in the display

**I want this text to appear bold**

If the user wanted to link one page to another page, then the text for the link would be surrounded by the tags needed to do this:

```
<a href="http//www.gotothispage.edu.au">My Home Page</a>
```

and it would appear in the browser display as

My Home Page

So that users can see the source code for any web page, most browsers will have a Page source or a View source command.

## Home page (index page)

A web page is sometimes called a **home page**. Home page or index page refers to the starting point for a particular group of pages. For example, the school home page might be the index that contains hyperlinks to all the other pages related to this resource. It can link to student pages, staff pages, history pages, site maps of the various school departments and course pages for the subjects offered by the school. The home page serves as the entry page for the rest of the pages.

**Home page**, also called index page. The storing point for a particular group of web pages.

## Website features

A website is a linked group of pages on a related topic or topics designed and stored as a single unit. The school home page and all its linked pages related to the school makes up the school website.

**Uniform resource locator (URL)** the location, or address, of a website.

### Address

A website has a location or an address known as its **URL**, or **uniform resource locator**. An internet address is a unique address for each computer using the internet and no web pages can be transmitted or received without this address.

There are two important addresses for users of the internet, other than an email address:

- IP or hardware address – the unique identifier or address that is given to each computer and which allows the computer to access the internet and others to locate that computer. Example: 128.190.6.100 is the address of computer 100 on the network called 128 using proxy server 190.6. The proxy server is the computer that connects the internal network to the outside.

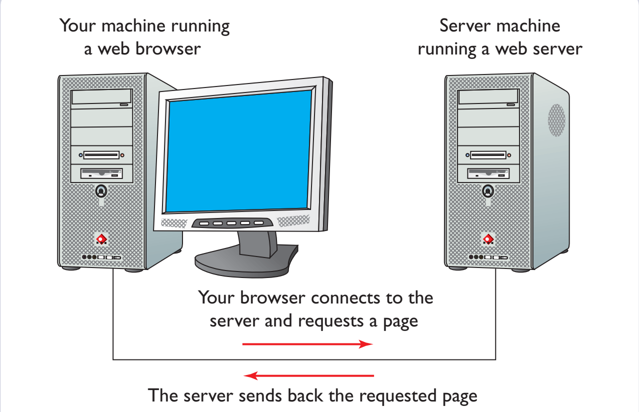


Figure 6.15 Using a URL to retrieve a page from the internet

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- URL (uniform resource locator) – the alphabetic version of the unique IP address given to a page of information on the internet. This makes it easier for the user to type the address in the browser.

Consider the address of the Education Network Australia for example. Its IP address is written as 128.190.6.100 but its URL could be:

| http | :// | www | . | edn | . | edu | . | au |
|---|---|---|---|---|---|---|---|---|
| hypertext transfer protocol | Essential – do not leave out! | The site is part of the world wide web | Spacer | The name of the domain server | Spacer | Type of domain | Spacer | Country – in this case, Australia |

A URL has a protocol (http), host name (www), second-level domain name (edn), top-level domain name (edu), and may also have a country code (au). Under this may come the name of directories and files in the domain, such as /school/students.htm where school is the directory and students is an html file.

Examples of other internet addresses that are not in the WWW could be:
telnet://library.sydney.edu for a telnet site
ftp://ftp.zz.net/images/opera for a file at an ftp site

**Career path**

**Internet consultants help clients use the internet. They introduce business clients to the internet and show them how the business can use the technology to improve its profits, sell more goods or service their customers better. They can also help design websites for e-commerce.**

**Table 6.11** Examples of URL components

| Top level domains | Country codes |
|---|---|
| .com–commercial enterprises | ch – Switzerland |
| .org–nonprofit organisations | de – Germany |
| .net–networks | jp – Japan |
| .edu–educational institutions | uk – United Kingdom |
| .gov–government organisations | sg – Singapore |
| .biz–commercial and personal | au – Australia |

## GUI (graphical user interface) design

Graphical user interface design has the following features:

- a web page displays in a window
- graphics used as illustrations, information and navigation (icons and hot spots)
- links in the form of hot words or hot spots
- tables using rows and columns to hold text, graphics and other media in a simple structure that organises a web page

These features are covered in more detail in chapters 1 and 7 of this book.

## Issues related to the internet

Connecting to the internet requires an ISP or internet service provider. ISPs onsell time on the internet and provide services such as:

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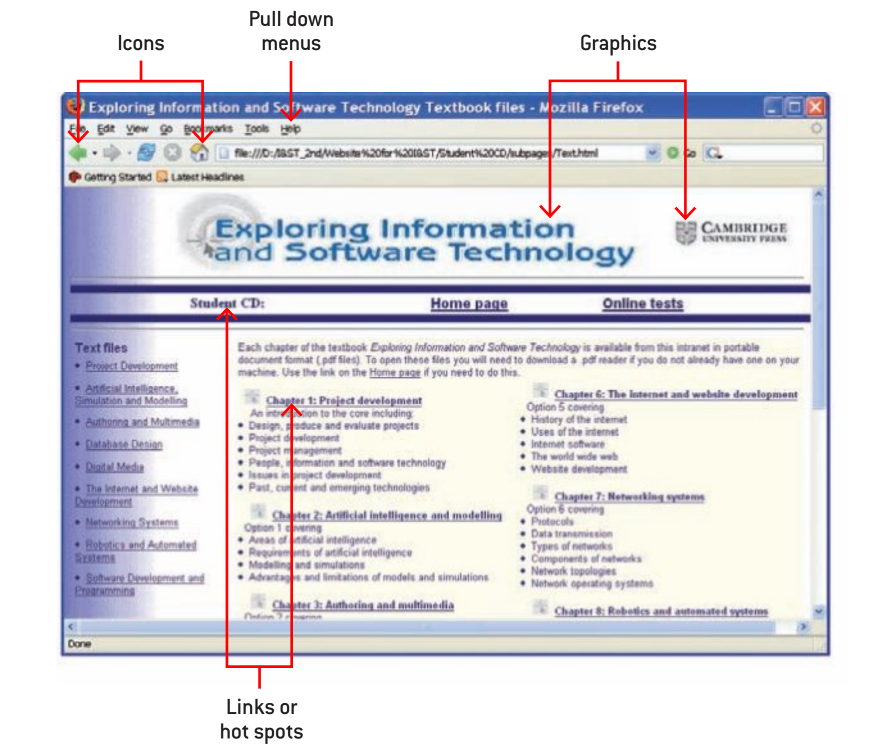


Figure 6.16 Features of web page design

- caching, that is, holding commonly used web pages on their servers to allow users faster access. Pages on the ISP server need to be updated regularly to keep up to date.
- email boxes to hold subscribers mail for collection at their convenience
- technical help to solve common internet problems
- local phone call access in most instances (POP or points of presence)

Factors such as the following determine a good internet connection:

- high bandwidth to suit user needs – this mostly relates to the download speed. High upload is only needed if the user wants to do video conferencing or has a web server.
- network capacity – this will be determined by the performance of the ISPs network during peak traffic periods.
- competitive connection costs
- technical help 24 hours a day
- mailboxes – virtually all internet accounts include a mailbox and some will offer more than one mailbox on the same account.
- web hosting – most internet accounts include space for a website on a web server
- good internet security so that others cannot easily access your computer through the ISP's network

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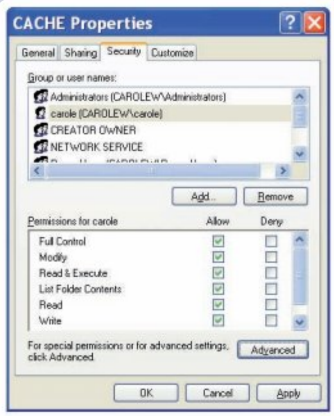


**Figure 6.17** Cache settings

## Caching

On the user's computer, one of the most important issues is the size of the cache. A cache is an area of memory used to temporarily store frequently used files. The browser stores all the internet files it receives in the browser's cache on the hard disk.

When the user returns to the same page, the browser searches the cache to see if this page is stored. If it is, then the browser does not usually have to download the page again, depending on how long it has been stored. This reduces the time waiting for the page to display when the same page is viewed more than once in a short period of time. Depending on the browser settings, a new copy of the page regularly overwrites the page in the cache.

# Issues of importance in internet use

The connection speed of dial-up is limited by the bandwidth of phone lines. However, broadband connections that can handle more data are becoming increasing popular and affordable so web pages are growing in file size. Dial-up connections will struggle to handle this data in download times that are acceptable to the user.

**Table 6.12** Methods of access to the internet

| Connection | Description | Advantages | Disadvantages |
|---|---|---|---|
| DIAL-UP ACCESS | | | |
| Dial-up | An account that allows access across a telephone line using a modem | • Relatively cheap<br>• Many accounts provide unlimited usage in 4-hour blocks | • May disconnect users inactive for set periods of time e.g. 20 minutes<br>• Speed restricted to 53 Kbps (speed of telephone line)<br>• Modem lines may be occupied and dialled a number of times for access |
| BROADBAND ACCESS | | | |
| ISDN (Integrated Services Digital Network) | Uses ISDN adapter and a dedicated line | Bandwidth up to 128 Kbps | Usage fees, access fees are relatively higher than dial-up services |
| ADSL (Asymmetric Digital Subscriber Line) | Uses a dedicated DSL line with a DSL modem and a NIC | High speed connection: 384 Kbps to 32 Mbps download | Must be within a specified distance of a DSL location |
| Cable modem | Use cable television lines for transmission and an NIC | High speed connection up to 30 Mbps | Can be problems with bandwidth if lots of people in an area share the cable |
| DSS (Digital Satellite System) | Dedicated lines with satellite access | High-speed connection | Very expensive |

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Powerline is a relatively new concept in broadband connections. Data is delivered over the standard electricity cables found in most buildings. Devices may also be networked via the electrical wiring in buildings provided the devices are physically connected to power points on a circuit.

The internet is changing rapidly and users need to keep up to date about services and issues related to internet use (see table 6.13).

**Table 6.13** Some current internet issues

| Issue | Description | Example |
|---|---|---|
| Quality | Site content must always be verified to make sure content is reliable | Gov domain is more likely to be accurate and current than a personal website. |
| Internet trading | The exchange of goods and services for money or by barter | Shopping sites on the net from which goods can be ordered and paid for by credit card are vulnerable to fraud. |
| Security | The protection of private data on the internet | Increase in the use of 256-bit encryption on banking sites to protect users' data |
| Taxation | Complexity and global delivery of internet businesses makes it difficult for countries to determine taxation limitations. | Goods purchased and sold in Africa by an Australian business – subject to Australian or African tax laws? |
| Censorship | Global nature of the net and the vast range of laws make censorship of material almost impossible. | A major debate is occurring over the freedom to publish on the internet. |
| Privacy | The invasion of personal space or the use of personal information without the permission of the owner of such information | Spam lists to bombard people with unsolicited email can be banned but this will be difficult to police. |
| Job losses | Internet commerce reduces the need skilled workers | Internet banking is 24-hour access and is user controlled without the need for tellers. |
| Radio and video delivery | Using the internet as the medium for other media, such as radio and video | The ability to download MP3 music files, news and articles from sites on the internet reduces demand for other types of media. |

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## EXERCISE 6.6

The following web page has been downloaded to a client machine connected to the internet.

1 Identify the following:
   a the languages that could have been used to write the document
   b the general term for the clickable text

2 Explain the concept behind creating the following in the source language: bold text, document links.

3 How can you tell that this document is the home page?

4 What differences are there between a web page and a website?

5 If the address line of this document read www.stgeorge.com.au/bank/interest.htm, how could you easily navigate to the home page of this site?

6 What is the full term given to the line beginning http://www?

7 Explain the components of this address line.

8 How is this different from an IP address?

9 Name TWO other domain types not used in this address.

10 List FIVE graphical components used in this design.

11 What technique could have been used to organise this page into parts?

12 Explain the role of an ISP in achieving this page display.

13 Describe THREE different connection types you could use to access this page.

14 Name the criteria you could use to decide if your internet service provider is good.

15 What steps could be taken to determine whether the contents of this page are reliable?

16 What forms of security could be used for this site?

17 Discuss TWO other issues, apart from those mentioned above, that relate to the use of the internet.

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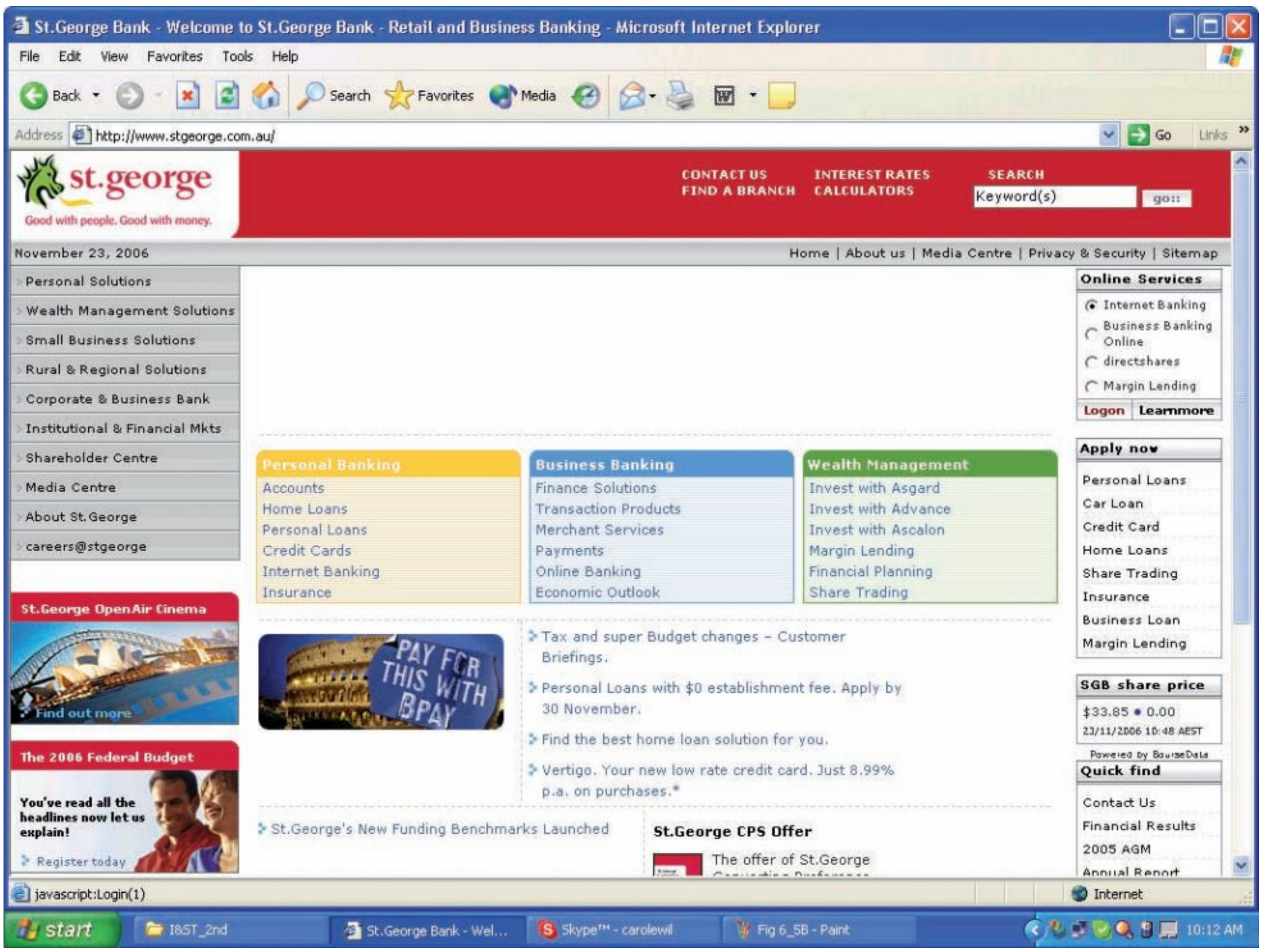


**Figure 6.18** Web page

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## Multiple choice questions

Select the best answer to each of the following questions.

1 The world wide web is
- A A separate network from the internet
- B An alternative name for the internet as all pages are the same
- C A graphical section of the internet
- D A text-based internet

2 HTTP stands for
- A Hardware transfer and television protocol
- B. File transfer protocol
- C. Hypertext technology process
- D. Hypertext transfer protocol

3 Handling data across the internet requires a set of standards or rules called
- A Protocols
- B WWW
- C Cerfs
- D Telnet

4 The most common form of an email address would resemble
- A www.johnlem.net.au
- B http://www.jlem.net.au
- C JOHNLEM@BRIDGEPORT.NET.AU
- D john_lem@bridgeport.net.au

5 An online chat session would normally function by
- A Sending messages via mobile phones
- B Sending emails with attachments
- C Exchanging information in real time over the internet
- D Writing messages on an internet message board

6 Graphical and text-based programs used to navigate and display hypertext documents are known as
- A Browsers
- B Search engines
- C Email systems
- D Plug-ins

7 Search engines store the collected data related to web pages in
- A Keyword accounts
- B A database
- C Data deposits
- D File formats

8 Spyware is used to
- A Protect against viruses
- B Stop the spread of government censorship
- C Prevent pop-up windows when using browsers
- D Take partial control of a computer without the user's consent

9 The term 'URL' can be described as
- A A browser substitute
- B A web page address
- C An internet website and its pages
- D An HTML tag

10 A sniffer is
- A A dog used by the customs department to locate the illegal smuggling of pirated CDs
- B An applet written to give a web page more functionality
- C A cookie downloaded without the knowledge of the computer user
- D Software used to detect data packets that meet set criteria during transmission



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## Extended answer questions

Figure 6.19 gives an outline of some of the issues related to internet use.

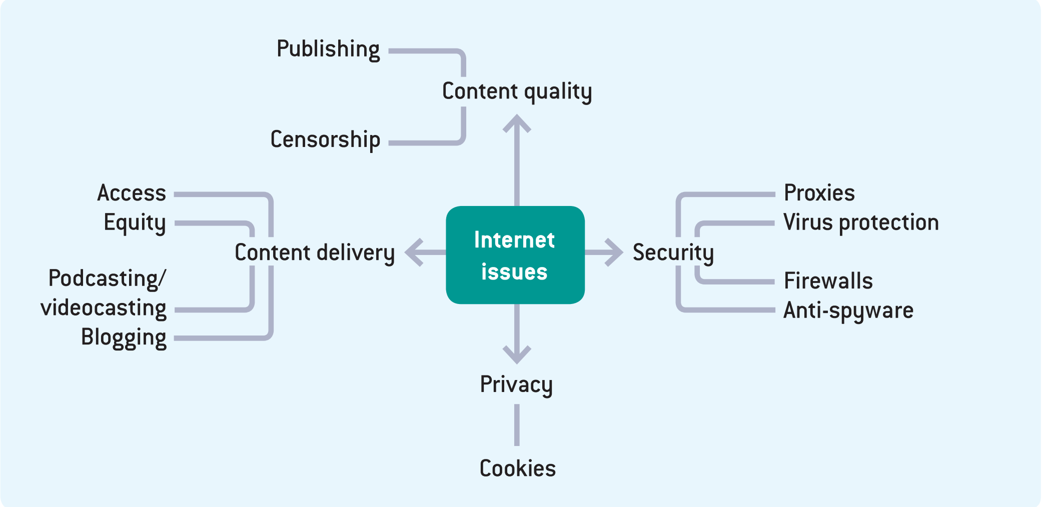


Figure 6.19

Write answers to each of the following questions:

1. What do you understand by the term 'privacy'? In your answer use an example from the internet.
2. How could a cookie invade the personal privacy of an internet user?
3. When and why would you install anti-virus software on a computer?
4. How could a browser be used to provide some security to your machine?
5. What is a proxy?
6. Explain the use of a firewall on a computer system.
7. Draw and label a simple web page to illustrate FIVE of its main components.
8. Describe the difference between access to content and equity of access.
9. Compare podcasting with video casting.
10. Define censorship. Outline why internet censorship would be difficult to achieve.

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# PROJECT 1: BROWSERS AND SEARCH ENGINES ON THE INTERNET

## Define the problem

Investigate and research browser software.

## Analyse the problem

Internet browsers are software programs that are mainly free for non-commercial users. It is possible to make them free as the cost is paid by advertisers. Browsers allow the user to access the internet, including the world wide web. A browser allows the user to connect to the web and to view:

- text
- graphics
- animations
- videos
- other pages via hyperlinks
- extra script to assist HTML

Scripts are programming extensions that add extras to help HTML carry out more complicated tasks. They let the user have access to functions HTML cannot do by itself, such as:

- forms – interactive fill-ins that can provide information
- objects such as clickable buttons and shapes
- message boxes
- live updates while a user is online

Further analyse the problem by using the information in this chapter and on the internet to answer these questions:

1. How is the world wide web different from the internet?
2. What does the browser client do?
3. How is the client different from the server software?
4. Name FOUR items that you might see on a web page in a browser.
5. Why might different browsers show you different views of the same web page?
6. List the steps taken by a browser to open a web page.
7. Name the THREE most important browser functions and explain why each is important.
8. Why do browsers need help from other add-on programs?
9. How is it important to use a browser that recognises extra scripting languages as helpers for HTML?
10. Should browsers have built-in antivirus programs?
11. Why do graphics come to the screen after the text of a web page?
12. How important is it to have a web page tell the user when they need an extra, such as a plug-in, to see the page properly?
13. Compare two different browsers by listing the functions that are supported by each browser.

## Produce a solution

1. Use at least FOUR search engines to search for a specific topic of value in your studies. For example, you might conduct a search for Baltic pine timber. Remember, you don't want to know about travel in the Baltic area or pine cones or other types of timber.

The topic you choose must consist of more than one word.

2. Record your results in a table to show:
   - the name of the search engine
   - any special features or functions used by the search engine



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- the first site located by the search engine using each of the following search methods:
  - Type the topic in without any punctuation.
  - Surround the topic with speech marks.
  - Use + between each word of the topic.
  - Use – to exclude one word of the topic.

An example of such a table could be:

| Search engine | Special features | Special functions | First site located (URL) | | | |
|---|---|---|---|---|---|---|
| | | | Method 1 | Method 2 | Method 3 | Method 4 |
| | | | | | | |

3 Analyse the results and write a conclusion naming the search engine that best suits your search. Consider the information located, the options available to narrow or refine your search and your own preferences.

### Evaluate the solution

Use a table similar to that found at the end of project 2 in chapter 1 to judge what you have learned during this project.

## PROJECT 2: USING HTML AS AN AUTHORING TOOL

### Requirements

- Notepad or similar text processor (important – files must be saved with the extension *.html or *.htm)
- A browser such as Netscape or Internet Explorer

### Define the problem

A simple outline structure is needed for a website that uses basic tools. Greater functionality may be added using JavaScript or advanced HTML tags.

### Analyse the problem

The internet runs on HTML. Advantages of HTML include:

- It is a basic ASCII file with markup tags
- It is cross platform
- It can be created in any text processor or word processor
- It can use standard graphics, sound, video and animations provided they are saved in a usable format e.g. jpeg, gif or mov

HTML can be created in commercial packages such as Home Page or FrontPage but these give the designer very little understanding of how the language works and can best be used once the basic skills are understood.

### Design a solution

The project will create a simple website or intranet. The basic requirement is FOUR web pages, ONE home page and THREE linked sub-pages. Links on sub-pages should return users to the home page.

### Produce a solution

The following basic HTML is provided as a template for page development. It can be copied and

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modified for all pages of the website. Using a template allows the site to be consistent. The HTML tags are written in capitals so that they are more visible, but this is not essential. The tags provided in this section should be supported by the vast majority of browsers.

```
<HTML>
<Tags enclose instructions and do not appear on the display>
<Most tags are used as pairs, that is, begin and end tags>
<The head tag encloses data that identifies the page and any
details for search engines>
<HEAD>
<TITLE>A page template for HTML</TITLE>
</HEAD>
<The body tag starts the data that will form the screen display>
<BODY>
<Center is the tag to centre text>
<CENTER>
<H or font size can be used to alter the size of text>
<The B tag gives bold and the I tag is used for italics>
<H1><B>My Heading in larger print</B></H1>
<A horizontal line on the screen to divide text uses the HR tag>
<HR>
<A new paragraph begins with P. BR gives a blank line>
<P><H2><B>My sub-heading in bold</B></H2></P>
<P>This is the first paragraph of my HTML document</P>
<The A tag creates a link to other pages or to other locations on
the same page>
<A HREF="Subpage.html">Sub Page</A><BR>
<HR>
<P>I'll put my second paragraph here</P>
<A HREF="Subpage1.html">Sub Page</A><BR>
<HR>
<P>Now I'll write a third paragraph</P>
<A HREF="Subpage2.html">Sub Page</A><BR>
<HR>
<P>This is an extra paragraph</P>
<HR>
<The image tag refers to an image stored in the same directory as
the HTML file>
<The file extension needs to be correct as does the name of the
image file>
<Width and height can be changed to suit the image or removed
completely>
<IMG SRC="imagename.jpeg" WIDTH=240 HEIGHT=180>
<User instructions can be provided in many ways>
<P>Click underlined text to select a topic</P>
</CENTER>
</BODY>
</HTML>
```

## More advanced HTML that can be used to alter web page display

*Colour*

Colour can be used to identify links and change the page background.



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```
<Body Text = "#FFFF00" Link = "#003366" VLink = "#DD0000" ALink =
"#AAAAAA" BgColor = "#00CCFF">
```

This creates yellow text on a blue background. Standard links are dark blue, visited links are red and anchor links are grey. Standard colours can also be referred to by name e.g. BgColor="Green"

*Tiling background images*

The image is assumed to be in the same directory as the page using the tag:

```
<Body Text = "#000000" Link = "#1E6BFF" VLink = "#8C2BE3" ALink =
"#D4232B" BgColor = "#8AD9FF" BODY BACKGROUND="nameoffile.gif">
```

The background of the page will be created by tiling a gif file called nameoffile across the available surface. The colour of the text and links will be imposed on this background. The background colour will be used when the gif file is not located.

*Horizontal line sizes and colour*

```
<HR SIZE=4 WIDTH="50%" COLOR="#8AD9FF">
```

This line is 4 pixels wide, occupies 50% of the page and is blue

*Creating lists*

Unnumbered or unordered lists use bullets.

Example 1: Creating a list of links to other web pages

```
<UL>
<LI><A HREF="http://www.cyberhighway.net/~webbuild/album.
html">GORDON ALBUM</a>
<LI><A HREF="http://www.cyberhighway.net/~webbuild/puddy.
html">PUDDY'S PAGE</a>
<LI><A HREF="http://www.cyberhighway.net/~webbuild/help.
html">HTML HELP</a>
</UL>
```

Example 2: Creating a list of items

```
<UL>
<LI>APPLES
<LI>PEARS
<LI>ORANGES
</UL>
```

Numbered lists can be used for any ordered data.

```
<OL>
<LI>APPLES
<LI>PEARS
<LI>ORANGES
</OL>
```

*Hyperlinks within a document*

These links are valuable when the web page is longer than can be displayed on a single screen. They require two tags:

1 The Link (where the link begins):

```
<A HREF="#APD">Another part of this document</A>
```

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2 The Anchor or Tag (where the link jumps to):

```
<H2><A NAME="APD">The link destination</A></H2>
```

*Tables*

Tables are useful when any data needs to be organised or displayed in columns or cells. Most browsers support tables. Tables can have boxes, or lines, around the information or can be without lines so that the items seem to 'float' in organised spaces on the page.

The following example presents a series of information in a vertical table with headers down the side and the information in columns beside it. This information can be anything you like, and the headers can be anything you want. There can be as many headers as you like.

```
<BR>
<TABLE BORDER=4>
<CAPTION ALIGN=TOP><H3>My Table<H3></CAPTION>
<TR><TH BGCOLOR=FFFF33>Heading 1</TH>
    <TD BGCOLOR=FFFFCC>ITEM 1</TD>
    <TD BGCOLOR=FFFFCC>ITEM 2</TD>
    <TD BGCOLOR=FFFFCC>ITEM 3</TD>
<TR><TH BGCOLOR=FFCC33>Heading 2</TH>
    <TD BGCOLOR=FFCC99>ITEM 4</TD>
    <TD BGCOLOR=FFCC99>ITEM 5</TD>
    <TD BGCOLOR=FFCC99>ITEM 6</TD>
<TR><TH BGCOLOR=FF99FF>Heading 3</TH>
    <TD BGCOLOR=FFCCFF>ITEM 7</TD>
    <TD BGCOLOR=FFCCFF>ITEM 8</TD>
    <TD BGCOLOR=FFCCFF>ITEM 9</TD>
</TABLE>
<BR>
```

In the example above, the <TH> </TH> controls the header position. The <TD> </TD> controls the number of columns beside the header. The <TR> is present to indicate each section.

The table border=4 describes the width of the lines around the table. If the code is TABLE BORDER=0, there will be no lines.

A title for the table may or may not be used. In this example, the title is My Table.

Tables could be used to display a series of graphics, a series of anchor links, a series of page links or a series of graphic links.

## Evaluate the solution

Use table 1.7 in Chapter 1 to judge the website you have created. You may wish to extend the number of web pages and to add extra media, tags or extensions. Remember to respect copyright as you expand your design.

Note: Internet html tutorials and books may be useful. There are many of these available.



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CHAPTER 7

# Networking systems

## Networks

A network is a communication system that allows two or more computers and their peripheral devices to be connected in order to exchange data and information. *Communication* is the transfer of data or information within a computer system and within networks. Networks can be small or large, permanently connected through wires or cables, or temporarily connected through phone lines or wireless transmissions. The simplest network is two computers directly connected to each other using a cable, and the most complex network is the internet where many millions of computers can be directly or indirectly connected to each other at any one time.

A network is a communication system that allows two or more computers and their peripheral devices to be connected in order to exchange data and information.

### The nature and role of networks

Networks have basic components: senders, receivers, links or transmission media and data or messages. The components of a network include nodes. *Nodes* are any device attached to the network, such as workstations, terminals, scanners and printers. Terminals send and receive data across a transmission medium.

The aim of networks is to improve the flow of information, to allow for rapid communications between people and to enable the sharing of resources. A network can be relatively *static,* that is, the connections might not change very much. The internet is an example of a *dynamic* network, where many connections are constantly changing as users log on and log off. Regardless of the size, complexity or number of participants, a good network will meet the following criteria:

- data should arrive and be received accurately
- data should arrive quickly
- sending and receiving data should be relatively inexpensive
- it should be easy to obtain and use the hardware and software required to communicate between computers on the system

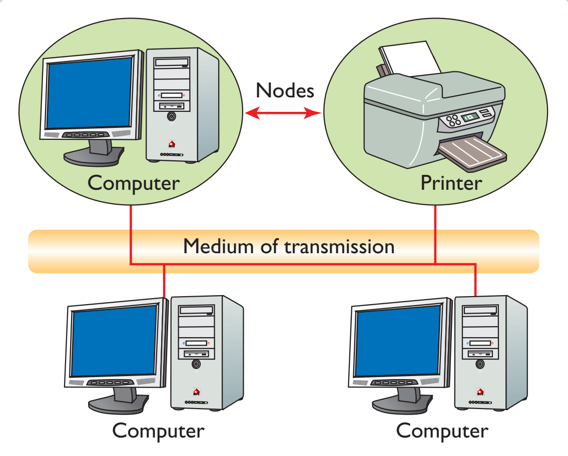

Figure 7.1 A small network



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**Think about this**

Networks make it easy for people to communicate by using a range of technologies including chat programs, short message service (SMS), multimedia messaging service (MMS) and voice mail. Many use wireless connections. Some networks are expensive to set up and to use; some are only available in major population centres. What disadvantages do you know about that have come from these technologies?

- the hardware and software should be reliable
- any data sent should be secure and available only to those people for whom the data is intended

**Table 7.1** Advantages and disadvantages of networks

| Advantages | Disadvantages |
|---|---|
| Shared hardware resources | Security of peripheral devices is important and queues may be needed for their use |
| Shared software resources, particularly applications | Software licensing needs to be controlled |
| Databases can be shared and updated centrally | Data protection and validity checks are most important |
| Improved reliability – a failed peripheral such as a printer can be compensated for by the use of other printers on the network | Backups are more critical than for stand-alone computers |
| Lower costs as software is often cheaper per unit and the hardware nodes may not need to have the fastest processors | Large servers can be very expensive |
| Upgrades can be done incrementally rather than all workstations at once | Central planning is needed |

## Protocols

A protocol is a set of rules that controls the movement of data. There are many of these rules on a network for different purposes and situations. The hardware requires one set of rules, the software a second set of rules and the transfer of data yet another set of rules.

**Handshake** the exchange of agreed rules at the beginning of any connection between nodes.

**Handshaking** is the exchange of agreed rules at the beginning of any connection between nodes. Whenever a network transfers data, the rules must first be checked. Both the sender and the receiver must use the same rules so that they clearly understand the processes they will use to transmit. Compare this to two people from different cultures meeting for the first time: they cannot exchange information in anything but a limited way unless they both speak and understand the same language and have some appreciation of each other's culture. Meaningful communication requires that they establish some protocols before they begin to communicate, that is, they may agree to use rules such as hand signals.

**Table 7.2** Some of the more common network protocols

| Protocol | Description | Function | Value |
|---|---|---|---|
| TCP/IP | Transmission Control Protocol / Internet Protocol | Standard set of rules that splits data into packets for transfer of data across networks | Connects hosts on the internet and is supported even by networks with their own protocols |

continued >

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| | | | |
|---|---|---|---|
| IPX | Internetwork Packet Exchange | Networking protocol used by the Novell NetWare operating systems | Good for non-cable and cable communications |
| SPX | Sequenced Packet Exchange | Sits on top of IPX and provides connection-oriented services between two nodes on the network | Used primarily by client/server applications |
| IPX/SPX | As for IPX and SPX | Provides connection services similar to TCP/IP | Alternative to TCP/IP |
| Netbui or Netbeui | NetBios (Extended) User Interface | LAN (local area network) Manager protocol used by many network operating systems | Used for a wide range of personal computer (PC) networks and network software including Microsoft and Novell |
| AppleTalk | Protocol for all Apple Macintosh computers and laser printers | Supports Apple's local network system as well as Ethernet and Token Ring networks | May connect Macintosh hardware to PCs equipped with special network software |

## EXERCISE 7.1

1 What am I?
- a I am the general term for the sending and receiving of data.
- b I am the exchange of protocols at the start of a connection between nodes.
- c I am a set of standard rules for data transfer.
- d I am the standard set of rules used to split data into packets.
- e I am a general term for any item shared across networks.
- f I am any device connected to a network.

2 Complete these sentences to make them true statements.
- a A network is ...
- b The most complex network is the ...
- c Basic components of a network include ...
- d A node on a network is ...
- e A protocol can be described as a ...

3 Answer these questions.
- a List FOUR advantages of networking.
- b Why must protocols be the same before data can be exchanged?
- c How is TCP/IP similar to IPX/SPX?
- d What is a major advantage of the Appletalk protocol?
- e Compare a dynamic and a static network.

## Data transmission

Data transmission is the process of sending data between and within computer systems. It can take place in different ways as shown in table 7.3.

Data transmission is the process of sending data between and within computer systems.

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**Table 7.3** Transmission modes

| Mode | Description | Examples of use |
|---|---|---|
| Simplex | Data can only be transmitted or sent in one direction | Keyboards, VDU and television connections |
| Half duplex | Data can be sent in both directions, but at different times | Hard disks, CD/DVD storage and intercom communications |
| Full duplex | Data can be sent in both directions at the same time | Telephones, networks and electronic mail |


**Figure 7.2** Simplex transmission

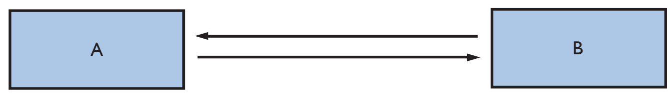


**Figure 7.3** Half duplex transmission


**Figure 7.4** Full duplex transmission

## Data transmission rates

The speed at which data is sent across networks is measured using different criteria.

**Table 7.4** Rates of data transmission

| Rate | Measurement | Example | Issues |
|---|---|---|---|
| Bits per second (bps) | The number of bits of data that are transmitted (or received) in one second is usually written as the maximum number of bits the medium can handle | A modem (modulator-demodulator) can be said to handle 56 Kbps | The real rate may be less than the maximum possible rate as bps depends on medium, receiver and transmitter |
| Baud rate | The number of times per second the medium can change its state, that is, the number of discrete signals per second | Each electrical signal of a 56 Kbps modem sending at 28 000 baud is handling 2 bits | The number of electrical signals measured by the baud rate may be different from the number of bits per second that can be transmitted |

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## Data transmission types

There are two ways to send or transmit data along a communication line or link from one device to another: by parallel or serial transfer.

*Parallel transmission* is where each bit in a byte is transmitted along individual channels or wires so that multiple bits (in bytes or groups of bytes) are sent at the same time. This is often used internally in a computer as it is fast and the distances are short. Over long distances, the bits may get out of order (data skew). Devices that use parallel transmission include disk drives, most printers and joysticks.

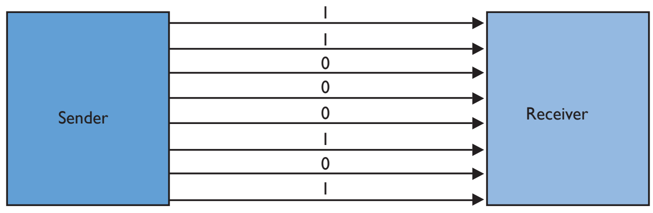


**Figure 7.5** Parallel transmission

*Serial transmission* is where all bits in a byte are transmitted one after the other, as in indian file – the first bit transmitted leaves the sender first and arrives first at the receiver and the last bit leaves the sender last and arrives at the receiver last. This is more usual between a computer and another computer as, although it is slower, it is cheaper. A minimum of two wires are needed for a serial link rather than a minimum of 8 for a parallel link. Serial transfer is usually used for longer distances as it has fewer problems. Devices that use serial transmission include modems, light pens and bar code readers.

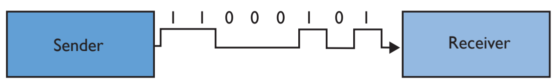


**Figure 7.6** Serial transmission

### Changing the method of data transfer

An RS232 port (a *port* is the connection at the back of an electronic device) is used to convert transmission from parallel to serial and back again. RS232 is a standard arrangement of the pins on the cable and the connection.

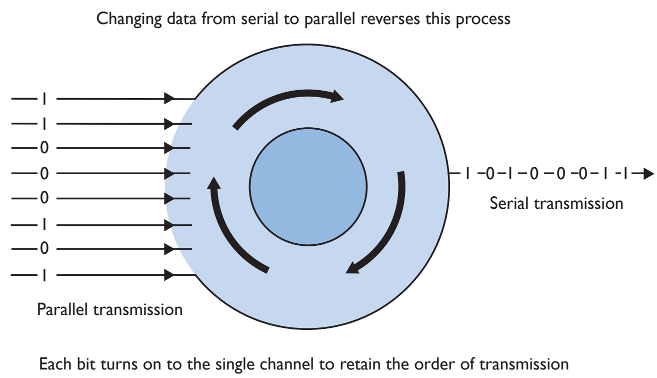


**Figure 7.7** Function of an RS232 port (parallel to serial conversion)

**EXERCISE 7.2**

1 Write one word or phrase to describe each of the following phrases used in computing.
  - a The measurement of data speed in a computer system
  - b Data transferred in sets of 8 bits using 8 buses or transport lines per byte
  - c Data transfer that transmits data one bit at a time using a single communication line
  - d A device used to convert serial and parallel transmissions to their opposites

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exercise 7.2 continued

e The measurement of the speed of data conversion from one state to another

2 Answer the following questions in full sentences.
   a How is serial data transfer changed into parallel data transfer during data communication?
   b Why is serial transfer much slower than parallel transfer?
   c Why is parallel transfer more expensive than serial transfer?
   d What causes data skew?
   e For what reason do serial links need two wires?

A **medium** is the link across which data is sent across a network.

**Bandwidth** is the capacity of the transmission medium to handle a particular amount of data in a given time.

## Data transmission media

A **medium** is the method by which data is sent across a network, that is, the link.

### Bandwidth

**Bandwidth** is the capacity of the transmission medium to handle a particular amount of data in a given time. The higher the bandwidth the more data can be transmitted. Bandwidth is very important for networks that are required to carry a range of different types of data, particularly if video and sound are involved.

*Baseband* is a low-speed connection sending only one signal at a time. It is useful for text.

*Broadband* is a high-speed connection sending many signals at one time, typically at 256 Kbps or faster. Broadband services include ADSL (digital subscriber lines) and cable modems, both of which allow faster connections to the internet than dial-up modems. Broadband is essential for highly demanding data transmissions such as video. More information is provided in table 6.12.


Figure 7.8 Fibre optic cable supports high bandwidth

Primary media can be divided into two categories: wire or cable and wireless or non-cable media.

### Wire media

Wire or cable media links include twisted pair cable, coaxial cable and fibre optics. *Twisted pair cable* consists of pairs of copper wires twisted in a rope fashion to reduce interference. Twisted pair has traditionally been used for telephone lines and for the internal wiring of networks in buildings. It is cheap and easily available, as the telephone network is already in place, but the communication can be interrupted by noise or interference. Better quality twisted pair cable has been produced in an attempt

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to overcome this disadvantage. Category 5 UTP (unshielded twisted pair) is able to handle text, sound, video and graphics data, and is cheaper but slower than other mediums.

*Coaxial cable* is a thick core of copper wire surrounded by insulating material. The insulation is enclosed in a close woven mesh and the conductor is surrounded by a plastic layer for protection. This mesh acts as a shield, and allows the wires to carry electrical signals with very little interference. Coaxial cable can handle more data than twisted pair cable and is more suitable for medium distances, but the cable is heavier and more expensive, and is harder to install.

*Fibre optic cable* is composed of a group of hair-thin glass fibres that permit electrical signals to be transmitted as light pulses. The light that carries the data is transmitted by means of laser pulses and is very fast and secure. Other advantages of optical fibre are its small size, its lightness, the large amount of data it will carry and the long time the cable lasts. It is much more expensive than other cables but most suitable for long distance transmission and high bandwidth.

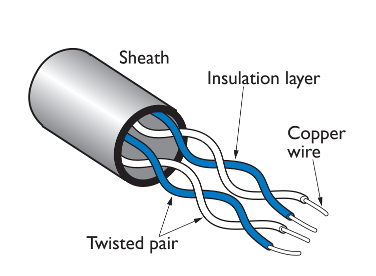


Figure 7.9 Twisted pair cable

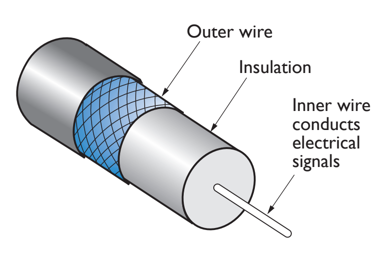


Figure 7.10 Coaxial cable

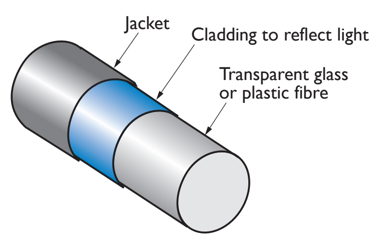


Figure 7.11 Fibre optic cable

## Wireless media

Wireless media uses the atmosphere to create the link across which data is sent. Microwaves and satellites are two examples.

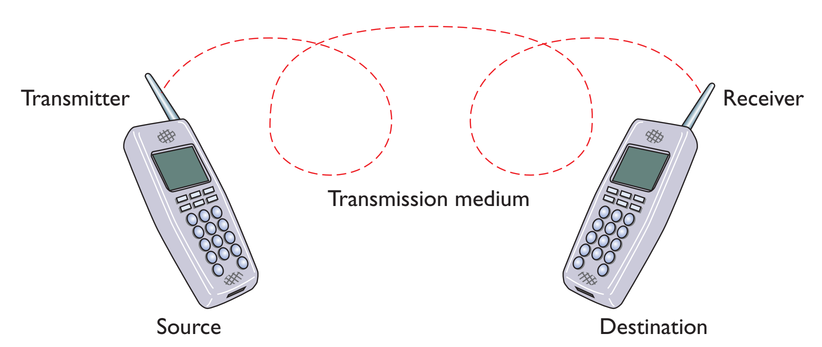


Figure 7.12 Mobile phone network

*Microwaves* transmit large amounts of data over short and long distances at a very fast rate. Microwave transmissions travel in straight lines. Because the Earth curves and obstacles interfere with the transmission, it is necessary to build other hardware such as antennas on high towers, buildings or hills to transmit across line of sight. These act as repeater stations to improve and retransmit the signals and need to be located every 50 km or so. Repeater stations receive a signal and amplify (increase the volume of) the signal before sending it on. Microwave transmission can also be affected by adverse weather such as thunderstorms.

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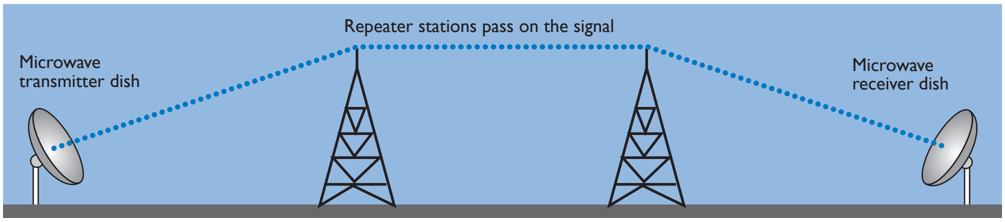


Figure 7.13 Microwave transmission

## Try this

**Sharing files across a network**

Sharing files across a network is a major advantage. More than one person can work on a document or have access to the information they require. Sometimes this may cause problems and the document may need to be protected, either by restricting access or limiting changes that may be made to that document.

1. Open a spreadsheet or word processor document and from the help menu, locate and write down:
   - A list of the different methods that may be used to protect a document from unwanted users or changes
   - The meaning of a document saved as 'read only'
2. Use this information to protect one of your files from change and then share this file with another student.

*Satellites* assisted by satellite dishes and ground stations operate as geostationary relays at a point above the Earth. They are geostationary because they maintain the same position relative to the Earth. They carry large amounts of data. The signal is sent from the satellite dish to the satellite where it is received, improved and sent on to a ground station close to the end receiver. Satellites are very expensive to install but are cost effective and very fast once they are operating, and they offer very high bandwidth.

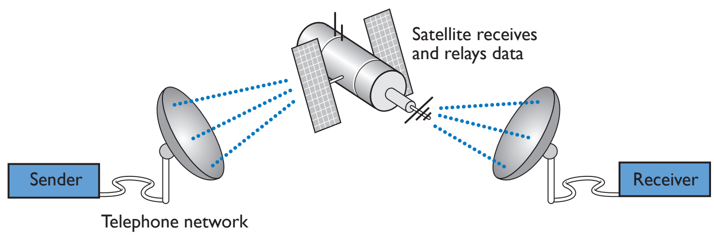


Figure 7.14 Satellite transmission

## Packet switching in networks

*Packet switching* is a method of breaking down a message into smaller groups (packets) to provide an efficient way to transfer data across a network, particularly a large complex network. Each packet can be sent by a different route to its destination and then reassembled into the original message.

A *packet* is a group of binary digits containing data and control characters that form part of a complete digital message. The control characters are used to check and correctly reassemble the message.

Packet switching can be compared to sending a large package via the postal service by dividing it into a number of smaller parcels. Each small parcel has its own address label that can be read to direct the parcel to its correct destination. The parcels can travel on different trucks, buses or other transport to the destination depending on what is available at the time and what method is the quickest. When they arrive, they can then be opened and assembled back into the larger parcel.

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A data packet is composed of the data, a header and a tail. The *header*, or introductory information about the packet, includes the destination, source, number of packets sent, packet identifier and information about the data. The *tail*, or error checking code, will enable the receiver to confirm that there are no errors in the data from transmission.

A PAD (packet assembly/disassembly) facility is used to convert the data transmitted from the computer into the appropriately sized packets at the transmission end, and to reassemble the packets at the receiving end into the correct form for transmission to the receiving computer. Figure 7.15 shows a simple packet-switched network.

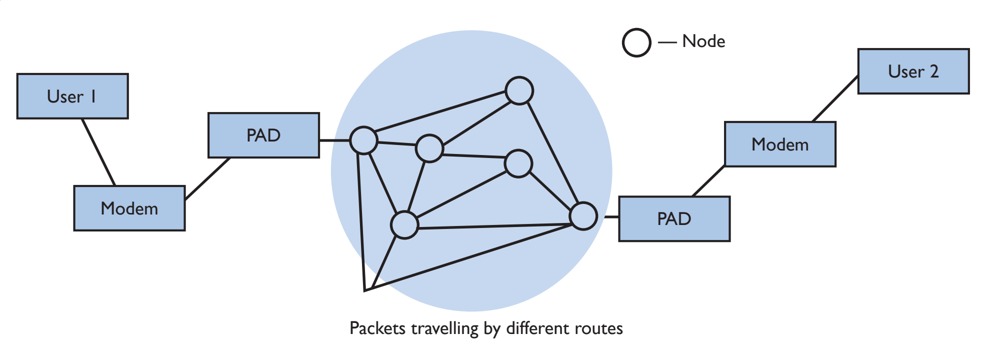


**Figure 7.15** Two users connected to a packet-switched network

A packet switched network has several advantages over conventional networks. Packet switching is more secure as no single link carries the complete message. The costs are lower, as the most efficient route can be used, thus reducing transmission time. There is increased reliability as there are many more links than in other types of networks.

## EXERCISE 7.3

1 Match each term in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| bandwidth | a link that uses laser light to carry data in small glass fibres about the diameter of a human hair |
| coaxial cable | hardware device that can be used as modem and a facsimile |
| fax-modem | a special form of transmission using an antenna suspended above the Earth in a geostationary orbit |

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exercise 7.3 continued

| | |
|---|---|
| fibre optic cable | a small part of a message |
| microwave | a single copper wire insulated and enclosed in a wire mesh or metal sheath |
| modem | the amount of data that can be handled at one time by a data transmission medium |
| packet | a hardware device which allows computers to transmit data over a telephone line |
| satellite | two thin insulated copper wires, twisted to form a spiral |
| twisted-pair cable | a non-cable link that consists of high-frequency radio signals |

2 In what circumstances would it be better to use the following types of links for communications?
  a fibre optic cables
  b coaxial cables
  c twisted pair cables
  d microwaves
  e satellites

3 What am I?
  a A rate of transmission measured in digits sent in a short time frame
  b A method of sending data in two directions simultaneously
  c A means of measuring the number of electronic signals sent by a device on a network in a given time
  d The amount of data that can be handled by a transmission media in any given time
  e High-speed transmission of data sending many signals at a time
  f Any method by which data is sent and received

4 Draw up and complete the following table related to the types of transmission media.

| Media | Type | Description | Advantages |
|---|---|---|---|
| Twisted pair | | | |
| Coaxial | | | |
| Fibre optic | | | |
| Microwave | | | |
| Satellite | | | |

5 Answer the following questions in full sentences.
  a Why is full duplex transmission more useful in networks?
  b What is packet switching?
  c Why is packet switching used with networks?
  d Explain the components of a packet.
  e How are packets assembled and disassembled?

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## Types of networks

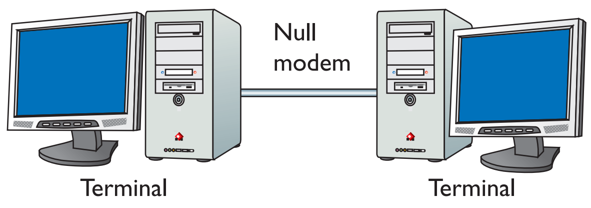


Figure 7.16 Direct connection between computers

Networks are configured – that is, the hardware is connected – in different ways. Figure 7.16 shows the way in which two computers can be networked (joined) so that they can communicate with each other. They are using a cable or null modem to make the connection.

### Local area network (LAN)

A LAN is a network set up in a relatively small area, usually a single site, building or group of buildings close to each other. LANs are able to transmit data at very fast rates over their short distances but are restricted in the size to which they can grow. LAN hardware or physical parts are called nodes. The nodes can be connected by cables, or they can use wireless transmission across radio waves.

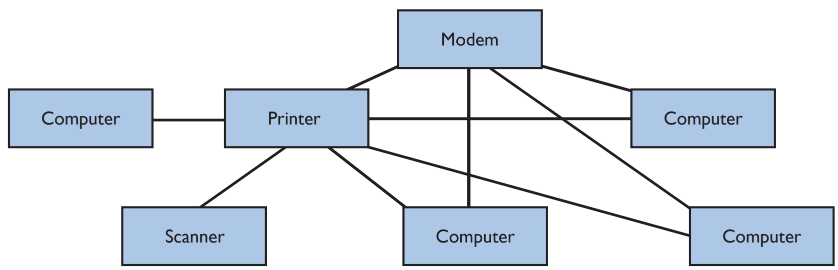


Figure 7.17 A local area network

Normally a LAN would contain nodes such as workstations – personal computers – and peripherals – printers, scanners, facsimile machines. Most LANs would also have a server to provide services to the network.

One LAN will differ from another LAN because of its:

- topology – the way it is arranged
- protocols – the rules it uses
- media – the links between nodes

Wireless LANs or WLANs are becoming a popular type of LAN. A WLAN may stand alone or may be used to extend a cable network. In a WLAN, radio waves transfer the data so the network or devices on the network may be easily moved and changed. Each device needs a transceiver to send and receive data. The speed of a WLAN generally reduces as the distance between the WLAN access point and a connected client increases. Security is a bigger problem than for cable networks so special measures, such as high level encryption (WEP or wireless encryption protocol) are used.

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Voice over Wireless LAN (VoWLAN) is a method used for phone calls over a wireless broadband network.

## Wide area network (WAN)

One LAN can be connected to other LANs over any distance via telephone lines and/or radio waves or satellites. When a network of computers provides facilities for communication beyond a single building or site it is known as a wide area network, or WAN. WANs usually transmit data over links that are owned and serviced by a variety of sources including government or semi-government agencies responsible for the public communications utilities. They also use other hardware to create the links, called bridges, gateways, hubs and routers. These are explained later in this chapter.

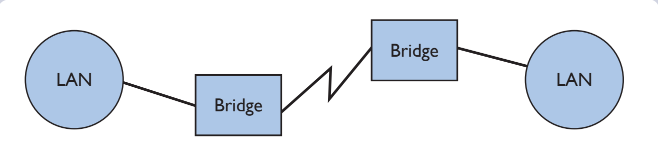


Figure 7.18 A wide area network

Table 7.5 Advantages and disadvantages of WANs

| Advantages | Disadvantages |
|---|---|
| Because of the diversity of the networks the cost is very often spread over many organisations and governments. | High cost involved in installation and maintenance of these networks. |
| Size and coverage allows a wider diversity of inputs available to users, in some cases from overseas or remote geographic locations. | With such a large number of possible users there is an increased security risk. |
| Normally function independently of any single controlling body or government, which means that no single organisation can exercise control of the information presented. | Specialised equipment is necessary for the network to operate effectively. |
| A WAN can give users access to experts and information from wide geographic regions. | Use of satellite communications is almost mandatory for true worldwide coverage and this is expensive. |
| In many of the more recent conflicts in Europe and Asia, people have managed to get news in and out by the use of computer networks when governments have taken control of the radio and television networks. | Problems associated with dealing with so many different organisations and governments on the network. Different languages and standards must be considered, as what can be allowed in one country may not be allowed in another. |
| Many networks carry forums allowing users access to other users with questions and answer sessions possible. | The question of responsibility for what is transmitted is only now being considered from a legal sense. |

## Virtual private network (VPN)

VPNs are private networks that allow secure connections between two or more computers across the internet, for example, between a home

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computer and an office network. They are similar to the public telephone network where a single point-to-point connection creates privacy whereas during a standard internet connection, all links are shared.

VPN devices have special software, encryption tools and user authentication methods to allow a point-to-point connection over what is usually a public link. The technology may also be used to provide extra security to a wireless network or between a wireless device and a cable network by protecting data from the outside world. Data is always protected on a VPN because it is encrypted.

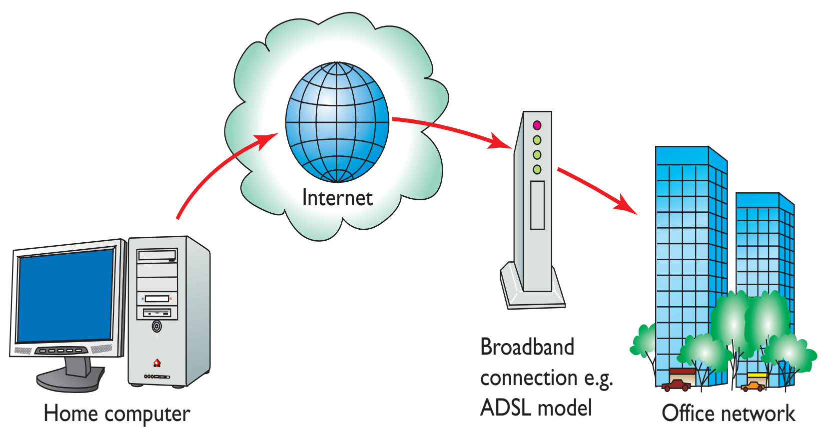


**Figure 7.19** VPNs provide secure links

## Client–server networks

A *client–server network* is made up of clients and servers. Each machine on the network is one of these two types.

Servers are machines that provide services. If there is only one server it provides all the services, such as web services and file transfer services, or there can be servers that specialise in each of these tasks on larger networks. Clients are any machines that connect to, and request, these services.

Client–server networks are very flexible and can offer lots of services. They provide data security and can be centrally managed but they are more expensive to set up, require more skill to manage and are often most suitable for large networks.

On a client–server network the network operating system (NOS) is installed and run on a computer called the network server. A service is provided by a server and accessed by clients. A server continuously monitors incoming service requests. When a service request comes in, the server process reacts to the request, performs the task requested and then returns a response to the workstation making the request.

Network users at workstations request the use of services and resources though client software, which runs on the workstation and talks to the operating system in the server by means of a common protocol. A client makes a request by sending a message to a server containing details of the request and awaits a response. For each server, there are protocols defining the requests that can be made to that server and the responses that can be given. Ultimately it is the client that controls the user interface and the application and the server that controls access to the network.

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Peer-to-peer is a type of network in which a group of computers communicate directly with each other.

## Peer-to-peer networks

Peer-to-peer is a type of network in which a group of computers communicate directly with each other. Resources on one computer are accessible directly from another computer. In peer-to-peer networks, each workstation has similar capabilities and responsibilities. This is different from client-server networks in which some computers are dedicated to serving the others. Peer-to-peer networks are generally simpler. They are fast and so are often used for multiplayer online games, such as Activision's Battlezone, to avoid the expense and delay of handling a lot of traffic at the server. Napster was the first popular peer-to-peer music sharing service on the internet. Music files were not stored centrally but were held on individual user machines and were downloaded from these machines. The service was stopped due to copyright concerns.

Peer-to-peer is normally used for small networks with up to five users. It quick and relatively cheap to set up but there is limited security and sometimes sharing resources can be difficult. All nodes the network are of equal standing, with workstations connected for transfer of data or access to services held on another workstation or peripheral. One workstation will be able to use another workstation to send data to a printer or to access the internet. Files can be copied or moved across. However, a high volume of traffic will slow down the network.

**Table 7.6** Comparison of client-server and peer-to-peer networks

| Peer-to-peer | Client-server |
|---|---|
| Smaller networks | Larger networks |
| Less complex processing | Very complex processing |
| Fast data transfer | Data transfer is a bit slower |
| Less hardware involved | More complex hardware used |
| Simple to install | Difficult to install |
| Cheaper to set up | Expensive to set up |
| Limited network capabilities e.g. sharing software | Almost unlimited network capabilities |

### Example of peer-to-peer networking on the internet

Some organisations have used peer-to-peer networking across the internet to create what is really one huge, scalable, distributed computer system. Figure 7.23 illustrates a distributed system. One such example has been the SETI project (Search for Extraterrestrial Intelligence) at the University of California. The project aims to monitor radio transmissions from the Arecibo radio telescope in Puerto Rico to detect any signs of extraterrestrial life. People volunteer the use of their computers for this, and download a file so that each computer is able to process a small amount of the data. The

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file functions automatically, downloading data from the telescope every few days. When the computer is free, the file then processes the data to detect patterns. The results of the processing are then uploaded to the university computer. Over two million volunteer computers are involved in the processing and this has resulted in the largest single cumulative computer computation undertaken to this time.

## EXERCISE 7.4

1 Complete the following paragraph using the list of words provided.

| | | |
|---|---|---|
| cables | communication | complexity |
| data | gateways | hubs |
| LANs | local area networks | move |
| networks | nodes | one |
| radio frequency | rules | virtual |
| WAN | WANs | WEP |

Computers linked for (a) ___ are called (b) ___. When these links are restricted to (c) ___ they are called LANs or (d) ___. Joining LANs across many sites results in a (e) ___ or wide area network. Connections between (f) ___ on LANs and WANs can use hardware such as (g) ___, bridges, (h) ___ and routers. The cost of (i) ___ is greater than that of (j) ___ as more hardware and (k) ___ is involved. When LANs are composed of nodes that do not use (l) ___ they are known as (m) ___ networks. In such networks nodes can (n) ___ between one associated LAN and another. They use (o) ___ technology to transmit and receive (p) ___ and (q) ___ or wire encryption protocol as standard (r) ___.

2 Answer the following questions in full sentences.
  a Why is the SETI project an example of peer-to-peer networking?
  b Explain the difference between upload and download in this project.
  c What are the advantages of using peer-to-peer networking for this type of task?

3 The XYZ organisation is about to install a new network. Write a report to compare peer-to-peer networking with client-server networking for a company director who has little understanding of computers.

### Great idea

Wi-Fi or wireless fidelity is a type of wireless network. Devices are interoperable, that is, they work with any other Wi-Fi device, regardless of brand as long as they are built to the Wi-Fi standard. Bluetooth is a similar system and is currently cheaper to use and does not require a radio base station for its operation. However, Wi-Fi has a greater range and is faster. Both methods make it easier to use networks in many places where they could not have been used previously and can operate on battery power.

## Components of networks

A network requires a range of hardware (physical devices) and software in order to function.

### Hardware

Hardware is any physical devices associated with the various functions of computers including any device that is part of a network. Hardware outside

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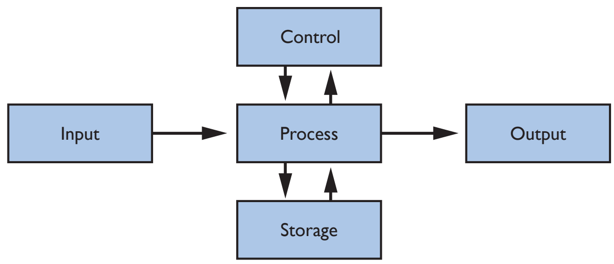


Figure 7.20 Hardware functions

the CPU is called a *peripheral*. Hardware may have several functions, as shown in figure 7.20.

## Classification of hardware by size and power

Computer size is constantly getting smaller whereas computer power is increasing. The figures given in table 7.7 are changing even as this is being written. However, the table does indicate in a general way the difference between each type of computer. It starts at the top with the largest, most expensive and the fastest computer and ends at the bottom with the smaller, cheaper and slower computers available. All these machines are used in networks for different purposes. Mainframes and supercomputers are used for very large, centralised networks where considerable processing power and storage is needed.

Table 7.7 Computer classification

| Type | Speed* | Cost | Use |
|---|---|---|---|
| Supercomputer e.g. Cray | Very fast | Very expensive (many millions of $) | Scientific calculations e.g. mining, government |
| Mainframe | Fast | Expensive (millions of $) | Large businesses, industry and government departments |
| Microcomputer e.g. personal computer (PC) | Fast | Relatively cheap (from < $1000) | Business, home, school |

*Computer speed is measured in MIPS. MIPS stands for millions of instructions per second. The higher the number of instructions per second that a computer can calculate, the higher the speed of the computer.

Figure 7.21 Satellite dish and microwave hardware for WANs

## Servers

Servers perform a number of service functions on a network. Servers allow services to be decentralised and resources to be shared across the network. Because of the services they perform, servers normally have higher processing ability and more RAM than the workstations on the network. They also have larger hard disks to hold the additional data such as large applications, for example, on computers offering database services, or internet tools on computers offering web services. It is most important to protect the data on servers as it is critical data,

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essential for the operation of the organisation running the server.

There are many different types of servers, depending on the type of service required.

Figure 7.22 Network server

### FILE SHARING SERVERS

File servers handle file sharing on a network and are often known as FTP servers because they use the file transfer protocol for many of their operations. File servers can also handle centralised applications, that is, they hold one copy of a database or some other application and share time using the application between those users who need access.

### PRINT SERVERS

Print servers control access to printers on the network and queue data waiting to be printed. They are particularly useful where there are large numbers of printers on a network.

### MAIL SERVERS

Mail servers route email. They store mail coming in from other parts of the network, handle email boxes by storing this mail and distribute the mail to receivers when they are logged on to the network. Mail servers are often combined with web servers.

## Workstations

Workstations are smart or intelligent terminals, that is, they are capable of processing data. Other nodes can be dumb terminals, relying on another node of the network to do their processing.

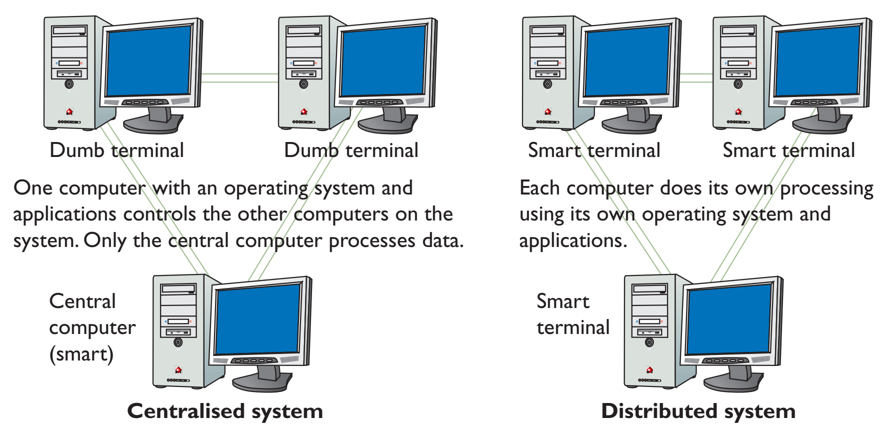


Figure 7.23 Types of terminals

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## Hubs

Hubs are connecting devices. They allow for a single network point to be expanded into multiple points. They are called hubs because they central to the system. There are different kinds of hubs.

Simple hubs just accept a transmission through one cable and pass the transmission to any devices connected to the hub through other cables, that is, they broadcast the signal.

Repeater hubs amplify the received signal and transmit the signal along multiple paths.

Intelligent hubs and carry out their own processing.


Figure 7.24 Switching hub

## Switches

Switches are high performance multi-port devices that connect small sections of LANs and switch traffic directly from the source to the destination. They help to reduce competition for the same bandwidth and decrease collisions between nodes.

Switches are similar to hubs, except that signals are only switched and transmitted to the intended receiver, not to other nodes on the network. In other words, they do not broadcast signals to other connections.

## Routers

Routers direct data traffic. They make their forwarding decisions based on a network address and only look at data that has been forwarded to them for onward transmission. This means that they will not forward local broadcast messages across the network. Routers are protocol dependent, that is, they must understand the network address and routing of any protocol they are to forward. They also need to know the network topology and resources so that they can select the best path through the network and use alternate routing where necessary.

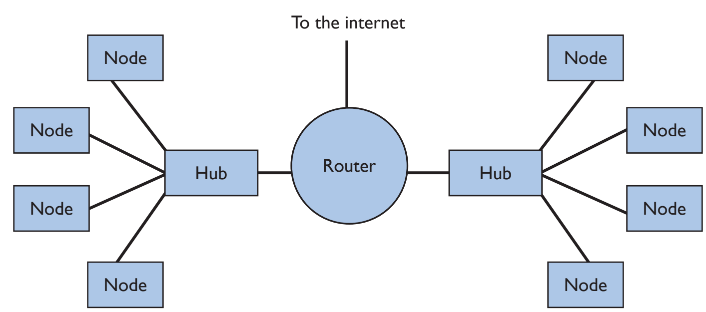


Figure 7.25 Router and hubs in a LAN

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### Bridges

Bridges connect two LANs together in a simple network topology. The bridge enables two devices attached to different LANS that use the same protocol (e.g. TCP/IP to TCP/IP) to communicate. The bridge itself is protocol independent.

### Gateways

Gateways allow one protocol to talk to a different one (protocol conversion) such as TCP/IP to IPX/SPX. They are more complex than bridges, and will translate data in one protocol to another protocol for transmission. For this reason, gateways are very important components of the internet where nodes of many different kinds need to interact.

### Repeaters

Repeaters are amplifiers, that is, hardware that receives data and improves the quality of that data. They do the same job as a loudspeaker at assembly: the data is received, increased in volume and output at the higher volume. Over distance, data signals weaken and repeaters are essential hardware on long distance networks.

### Network interface cards

Often abbreviated to NIC, network interface cards are devices that link the computer processor to the network and must be operating for data to be sent and received. They are often expansion cards that slot into the motherboard and connect to the network using a cable. However, they can also be built into the motherboard and can function by 'reading' a link using infrared waves in the atmosphere. It is usual to have a particular NIC for a specific type of network but some NICs will work with many types of networks.

Figure 7.26 Network interface card

Figure 7.27 Wireless mobile phone

**Great idea**

Many hardware devices on a network are multitasking and use the computer as a tool to assist with only the more complex tasks. A mobile phone using a mobile phone network is a good example. Apart from phone calls, recent models may have:

- Internal memory and flash memory cards
- A 'large' colour screen
- Built-in still and video camera
- A TV output for direct connection to a display
- A document viewer and input via the phone keyboard to read and write files
- Standard applications such as a word processing or presentation programs so that files may be directly downloaded to a network or shown on a TV screen
- Support for playing MP3 music files
- Wireless connectivity to a printer and a network so that hard copies of files and photos may be obtained directly

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## Security of information on networks

Networks store vast amounts of data, some of it critical and very sensitive. This data needs to be protected. Protection can take the form of storage, backup or security of the network.

Figure 7.28 Network connection cables join hardware

### Storage

Data storage refers to the method of keeping data safe for future use. One way of protecting networks is to use multiple copies of the data on different hard disks. This is called RAID or a redundant array of inexpensive drives. *Redundant* refers to the unnecessary repetition of data simply so that a copy of the data will be available should the server fail. To make sure that each copy of the data is identical, the data must be synchronised regularly. RAID is expensive and is normally used only on networks holding critical data, such as banking and government networks.

### Backup

A backup is a copy of data held in a separate location from the original data so that it is available should the original data be lost, damaged or corrupted in some way. The most common method of backup is to copy data each night on to magnetic tape or disks. This process can be automated on networks.

### Security

Security can involve different processes to protect data in different ways. *Physical security* includes locks. These can include door locks or locks on individual hardware.

*Software security* includes passwords, encryption and other structures to restrict access to data to authorised users.

*Passwords* allow only those with user accounts and logon names to access the network resources. The password is a string of case sensitive characters and should be made up of at least two types from letters, numbers and symbols. Passwords should be at least 8 characters long and should never be given to others. It is also important to choose passwords that are not obvious. Birthdays, pet names, or other commonly known information are not good passwords.

*Encryption* codes data in such a way that it is not understood unless it is decrypted or decoded. The decryption key is only available to those who need to use it.

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*Firewalls* are a mix of hardware and software security used to protect networks from those unauthorised to use them, usually from outside. The firewall provides a funnel, forcing all traffic to and from the network to flow through the firewall, a proxy server outside the network. The proxy server decides whether it is safe to let a file into the network. A firewall prevents a direct connection between a network and other networks and protects against spoofing, where another server can connect directly to a network and control that network from outside. A firewall is essential to protect a network server, the network and the data it contains.

*Anti-virus software* protects data. Each workstation can have an independent program for this or it can be controlled from a central location such as a server so that each workstation is checked, virus definitions updated and any maintenance carried out on a regular basis.

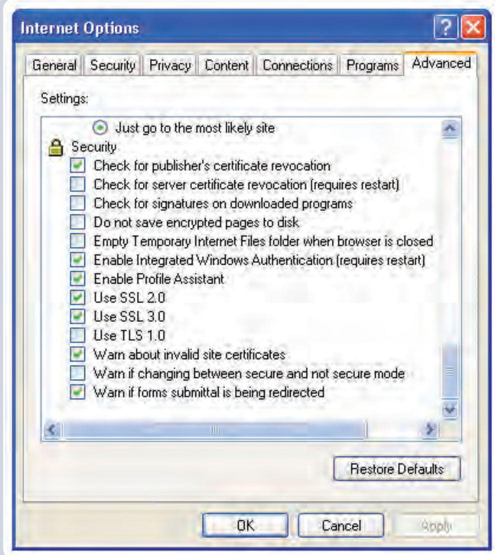


**Figure 7.29** Software security settings

## EXERCISE 7.5

**1** Complete the following sentences to make them correct statements.

- **a** The fastest and most powerful type of computer is a ...
- **b** Any hardware device located outside the CPU is called ...
- **c** Another name for a microcomputer is a ...

**2** Choose the correct type of hardware to use for each of the following situations.

- **a** A terminal on a network required to do its own processing
- **b** A type of hub that will not broadcast signals to all computers on a network
- **c** A central computer to handle use of an application shared between clients on a network
- **d** A device able to analyse data received from terminals and transmit the data along the best available channels
- **e** A computer able to order and organise the use of printers on a network
- **f** A simple device to connect four computers to a network via a single cable

**3** Match each term in column 1 with the best description from column 2.

| Term | Description |
|---|---|
| antivirus | redundant array of inexpensive drives |
| backup | software used to protect data from viruses |
| decryption | common media used for data backups |
| encryption | string of case sensitive characters to allow network access |
| firewall | copy of data to protect against loss or damage |
| magnetic tape | method of encoding data |
| password | security used to funnel all incoming data through a network protection barrier |

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exercise 7.5 continued

| | |
|---|---|
| proxy server | a description of a virus that can infect a machine |
| RAID | the process of converting code into meaningful data |
| virus definition | computer handling traffic coming from outside a network |

4 Answer the following questions using full sentences.
  a What are the requirements for a server on a network?
  b Compare the use of a bridge and a gateway on a network.
  c What is the value of a repeater on a network?
  d Why are NICs important to a network?
  e Compare the different types of security that can be used to protect a network.

**Network topology** the way the nodes of a network are connected.

# Network topologies

**Network topology** refers to the way the nodes of a network are joined together. This can be decided by cables and other hardware and/or by protocols.

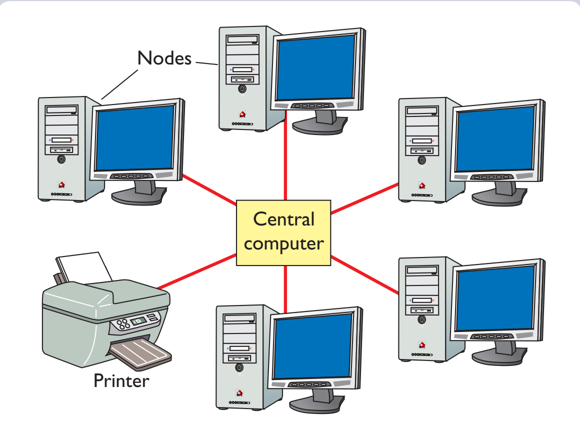

Figure 7.30 Star topology

## Star network

A star network has a central hub to which other nodes are connected. Messages from any node on the network must pass through this central hub. There is no connection between nodes except through the central hub, which is usually a computer. A star network is fast if the central computer is fast, but it will not work if the central computer is not working. A star network is most often used on a large network where speed is important.

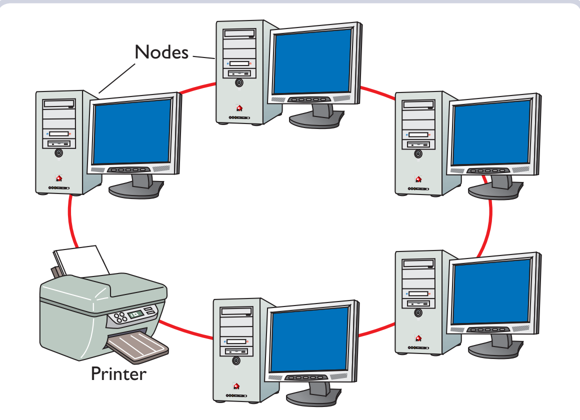

Figure 7.31 Ring topology

## Ring network

A ring network connects all nodes to a closed cable like the circumference of a circle. Each node is connected to two others, one from which it receives data and the other to which it transmits data. Messages are sent around the ring with each node receiving the message and transmitting it to the next node if required. The ring network is fast and is used on large networks where speed is not as important as on a star network. However, if one node on the ring breaks down or a part of the network is disconnected, the network will not work unless special software is used to protect the system when nodes break down. This protection adds to the cost.

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## Bus network

A bus network connects nodes along a single cable called the *bus*. Each end of the cable is terminated or ended. As the data travels along the central cable, each node (computer or peripheral) checks and retrieves data as appropriate. To avoid data collisions, only one computer can transmit messages at a time. This type of network is reliable but slow.

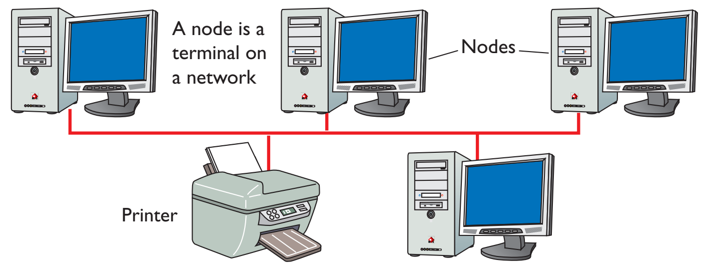


**Figure 7.32** Bus topology

## Mesh network

Mesh topology uses a point-to-point connection to link devices in a network and is most commonly used in WANs. Mesh topologies use routers to determine the best path for data to travel. If one device fails, the data may be sent through any other site connected to the network. This makes them one of the most reliable options for building a network but due to the need to have every device connected to every other device, they are also the most expensive and the most time-consuming network topology to maintain.

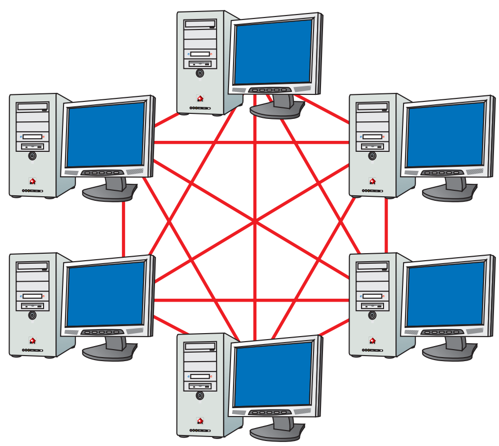

**Figure 7.33** Mesh topology

## Preventing data collisions on networks

Networks constantly transmit data between nodes. This data is always in danger of collision, and methods have been developed to stop this happening. One method is called Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method. This is a protocol used with Ethernet (a standard type of cable) that makes each node wait to transmit until there is no signal on the channel. When a node is sending data, there will be a signal on the channel or carrier. The node must use Carrier Sense to decide if there is a signal. Compare this to a game: people sit around in a circle. They keep very quiet and cannot speak unless nobody else is talking. However, they all have an equal chance to talk if there is nobody else speaking (multiple access). Should more than one person start to talk at exactly the same time they must both stop instantly (carrier sense). The difference between one person starting to speak and another may only be a fraction of a second but the person who started first has priority and the other person must wait.

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A ring network uses a more organised form of avoiding data collisions. A small string of bits called a *token* circulates around the ring continuously in one direction only. A node waiting to transmit waits until the token arrives and 'captures' the token. It sends its data, which is followed immediately by the token. The receiver gets the message, 'captures' the token and sends an acknowledgment back to the sending machine. The token keeps going around the ring so that every node has a chance to send its messages. Compare this to the circle game. People sit around the circle but they cannot speak unless they have been given a token such as a stick. When they have the token, they speak holding the token and pass the token on to the next person in the circle as soon as they have finished speaking. If that person wants to speak they do so, passing the token on as they finish. If they don't wish to speak they just pass the token on.

## EXERCISE 7.6

1 Answer the following questions.
   - a What is the simplest type of network?
   - b Name the THREE topologies of LANs.
   - c Some LANs consist of more than one topology. These are called ...
   - d Explain what type of hardware may be needed to join different network topologies.

2 Use a graphics program to draw and label examples of each of the standard network topologies. Join these diagrams to show how a hybrid network can be created. Be sure to use the correct hardware to connect these networks.

3 Copy and complete the following sentences.
   - a Computers that perform a function for other computers on the network such as sharing hardware resources are called ...
   - b When you disconnect from a host computer on a network you ...
   - c The action of transferring a file from your computer to another computer is called ...
   - d Two advantages of networking computers are ...
   - e The methods of arranging cables and hardware in networks is called ...
   - f Two ways of identifying a bus network include ...

4 Complete the following paragraph using words from the list.

| | | |
|---|---|---|
| capture | carrier sense | Carrier Sense Multiple Access/ Collision Detection |
| colliding | data | first |
| free | listen | network |
| no | one | right |
| ring | sends | token |

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exercise 7.6 continued

Data being transmitted on a (a) ___ needs to be prevented from (b) ___ with other (c) ___. This can be done in different ways. A (d) ___ network uses a (e) ___ to stop collisions. In order to transmit data a node needs to (f) ___ the token as it travels in (g) ___ direction around the ring. (h) ___ node can transmit unless it has the token. When it has the token a node (i) ___ its message (j) ___ followed by the token. Other networks use a standard called CSMA/CD or (k) ___ to prevent collisions. (l) ___ means nodes must (m) ___ for signals on the channel and cannot send unless the channel is (n) ___. The first node to sense a free channel and send has first (o) ___ to transmit.

## Network operating systems

A network cannot work unless it has network software called a network operating system (NOS). This operating system controls the workstations, any peripherals such as a printer, and the data transfer. The main computer on the network, usually called a server, stores the main network operating system but each computer on the network needs workstation software as well.

### Purpose

The network operating system software acts as the command centre, enabling all the network hardware and all other network software to function together as one organised system.

Each computer on a network will have a local operating system called a client to work with the network operating system to allow a variety of processes including file sharing, data sharing, peripheral sharing and remote processing where needed.

Like regular operating systems, network operating systems provide services to the programs that run on top of the operating system. Services are functions provided by the operating system. However, the type of services and the manner in which the services are provided are quite different. The services tend to be much more complex than those provided by regular operating systems. In addition, carrying out these services requires the use of multiple machines, message passing and server processes.

### Network management

A large network is often managed by a network administrator. Some of the jobs of such a person in relation to the NOS can include:

- establishing users – deciding who can use the network and giving them access to network facilities through passwords and IDs

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- establishing groups – deciding how users can be placed into categories e.g. Year 7 and Year 10 may be identified as groups on a school network as they have different network access needs
- allocating security permissions – determining different levels of access for different users and groups according to their needs as members of the network
- setting up policies – documenting users, groups, and security levels so that network users and owners are aware of these and can apply to have their access changed should they wish to show that they should be categorised elsewhere
- setting up profiles – physically organising the rights and privileges of groups and individual users on the networks

The NOS also has other management functions that are built in and automatically operate when selected, such as file compression. This enables the space on the network to be maximised by reducing the size of files stored by users. It can increase the delay experienced by users when opening files, but is balanced by space saving.

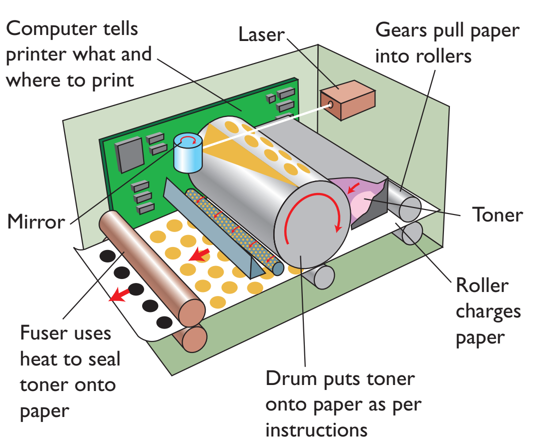


Figure 7.34 Laser printer functions

## Hardware problems

The network administrator is responsible for the maintenance of the hardware on the network. They use their experience as well as hardware manuals, with diagrams such as figure 7.34, to find a solution. Some of the problems encountered with hardware are included in table 7.8.

Table 7.8 Some hardware problems and possible solutions

| Problem | Possible solutions |
|---|---|
| The computer screen is not responding to user commands. | Check connections to the monitor from the system box. |
| | Check the mouse and keyboard connections to the system box. |
| The cursor is not responding to the movements made by the mouse. | Remove the ball from the mouse and clean it. |
| | Check the mouse connections and/or the mouse driver. |
| The computer user cannot access the network. | Check the user is correctly logged in. |
| | Check that the network card is properly installed. |
| Data will not save to a flash drive. | Check that the USB connection to the flash drive is tight. |
| | Check that the driver for the flash drive is correctly installed. |

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| | |
|---|---|
| Screen message says that a file cannot be saved on an external disk. | Check there is a disk in the drive and that the disk is formatted. |
| | Check the hardware connections. |
| The printer keeps printing over the edge of the paper. | Follow the steps suggested by a help wizard to solve the problem. |
| | Make sure the correct page size has been selected. |
| The printer is not responding to print commands. | Make sure the power is on for the printer. |
| | Perform a self-test of the printer. |
| | Check the paper in the printer tray. |
| | Check that the printer being used as the default printer is correct. |
| | If the printer is on a network, check that the user is logged on. |

**Career path**

**Network administrators design, install and maintain computer networks, the hardware and software employed, and provide for network security. They must continually monitor the performance of the network so that it meets the needs of the organisation. They work in large businesses and may have other network technicians to help with their tasks.**

### Users

On a network, users log in to the network server from the workstation. To log in a user enters a login command and gives his or her user name and password. Logon is the process a participant employs to connect to network. If the user name and password are valid, the server logs the user in and allows them access to all services and resources to which they have been granted rights. Logoff is the process the participant employs to disconnect from a network. It is equally important to log off, as an open network may be used by unauthorised users.

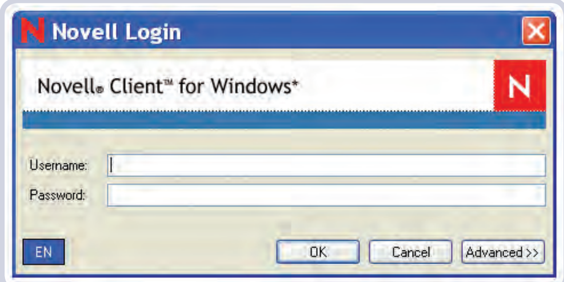


Figure 7.35 Novell Netware® login

## Factors influencing media transmission

When setting up and using a network many factors need to be considered, as shown in table 7.9.

Table 7.9 Factors influencing media transmission

| Factor | Description | Example |
|---|---|---|
| Purpose of the network | The use of the network – a LAN restricts data to a single site; a complex WAN may be global. | A network for gaming between two or three individuals would best use a peer-to-peer set-up. |
| Reason for transmitting | Simple networks may only transmit text data, whereas others need to transmit many data types between thousands of nodes. | Speed could be critical on the Stock Exchange network. |

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| | | |
|---|---|---|
| Cost | Hardware and software requirements become more expensive as networks grow in size and complexity and data transmission costs also increase. | A multinational company may spend many millions setting up and maintaining a WAN. |
| Distance | The closer the network components are to each other the fewer the transmission issues that will result. | Joining two computers needs only a short cable and results in fast transfer and little interference with transmission. |
| Number of nodes possible | Some LAN topologies are restricted to the number of nodes they can efficiently handle. | A bus network gives best results if there are fewer than 20 nodes, whereas star and ring networks can handle many more. |
| Future maintenance or sustainability | It is best not to allow networks to get too large. Instead, smaller networks may be joined by bridges or gateways. | A small network usually restricts problems to the one site e.g. virus issues. |
| Bandwidth | Broadband networks carry considerably more data more rapidly. | ADSL links are more expensive than dial-up modems. |

**Table 7.10** Issues related to networks

| Issue | Description | Example |
|---|---|---|
| Communication | Ideas sent across networks can be rapidly and widely distributed. | Email is sent to all members of a group or all those in an address book. |
| Software licencing | Every copy of software on each server and node needs to be licenced. | Network licensing is available from many software distributors to reduce the cost of multiple copies of programs. |
| Accessibility | Networks should be easy to use. | GUI interfaces and user-friendly software |
| Privacy | Information is more difficult to keep confidential on a network. | Network administrator may have access to an employee's private email. |
| Noise | Noise is any interference with data transmission. | Networks need to have error detection and to retransmit corrupted messages. |
| Security | The network is protected from unauthorised use. | Network logon and logoff procedures– see earlier in this chapter. |

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## EXERCISE 7.7

1 True or false? Rewrite each false statement to be true.
 a Networks will operate without network operating systems of any kind.
 b Network operating systems control peripherals and data transfer.
 c Nodes in a network use client software to contact a server.
 d Network operating systems are simpler than local operating systems.
 e Network administrators manage users and groups on the network.
 f Users are automatically logged off most networks when they are finished a task.
 g Passwords enable an authorised user to use allocated resources on a network.
 h Logoff is the process used to connect a user to a network.

2 As network administrator:
 a How would you check the hardware if you found the characters a user had typed were not appearing on the screen?
 b If the mouse being used did not work when the mouse buttons were pressed, what would be the first step you took to try and find the problem?
 c If the system box light did not come on when the user started the computer, what might be the most obvious problem?
 d The printer doesn't print when a user selects the print command. The control panel switches are on. What else might be wrong?

3 Discuss THREE major factors that will be important in the following situation:

 Telnet Ltd. is about to set up a new network across four divisions of the company: Sales, Marketing, Production and Administration. Each division is located in a different city.

4 Why does Telnet need to consider each of the following issues when establishing its network?
 a security
 b software licensing
 c privacy of personal data
 d noise

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# Networking systems

## Multiple choice questions

Select the best answer to each of the following questions.

1 The link between network hardware and the data or messages sent is called
- A Information
- B Terminals
- C Transmission media
- D Handshaking

2 The rules controlling data movement on a network are known as
- A Peripherals
- B Protocols
- C Signals
- D Tokens

3 Packet splitting software that is used to set rules for internet use is called
- A TCP/IP
- B HTTP
- C Baud
- D Netbeui

4 Large amounts of data transferred across a network at very high speed would most likely use the following type of connection:
- A Baseband
- B Bandwidth
- C Broadband
- D Broadbase

5 Traditional wire or cable media that is cheap and easily available for data transmission is most likely
- A Fibre optic
- B Twisted pair
- C Coaxial cable
- D RS232

6 A group of binary digits containing data and control characters and making up part of a digital message is known as a
- A Packet
- B Split
- C Synchronous symbol
- D Switch

7 A large, spread out network using bridges, gateways, hubs and routers is most likely to be a
- A WAN
- B LINK
- C LAN
- D Terminal

8 Machines on a network that carry out tasks for, and provide software to other machines, are
- A Workstations
- B Peers
- C Clients
- D Servers

9 A network login requires a user name and a
- A Terminal number
- B Emulation key
- C Operating system
- D Password

10 Any type of single hardware unit on a network is a
- A Client
- B Queue
- C Node
- D Terminal



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## Extended answer questions

Figure 7.36 describes some aspects of network topologies.

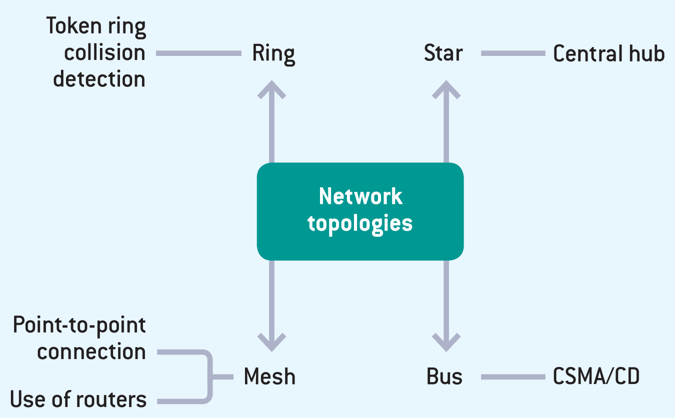


Figure 7.36

Write answers to each of the following questions.

1. Draw simple diagrams to illustrate each of the FOUR network topologies.
2. Name THREE hardware devices used on a network, other than computer terminals.
3. What is meant by 'point-to-point connection'?
4. Why is a bus network slow?
5. Name ONE major problem with a ring network.
6. Explain why a small business might buy a very fast hub for its star network.
7. Why does a mesh network use routers?
8. Describe the way token ring networks prevent data from colliding as it is transferred on the networks.
9. How would a gateway be used on a network? Give an example in your answer.
10. Regardless of the network topology, what are the factors that make a good network?

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# PROJECT 1: WRITING A TECHNICAL MANUAL FOR NETWORK USE

This may be done as an individual or a group project.

## Define the problem

New users often find networks complex and difficult to understand. The aim of this project is to produce a simple manual that will explain networks and their operation.

## Analyse the problem

A network booklet will be produced for the school network. The solution could be used electronically and/or manually according to need. An electronic version could be in the form of a website or a slide show.

## Design a solution

The solution may use any available application: it may be word processed, produced as a multimedia presentation, published as a booklet or magazine or designed as a series of screens or slides. The software chosen will be determined by the outcome required. All solutions should cover the following topics:

- What is a network?
- Why use a network?
- The role of the network administrator
- The network configuration and operating system
- Becoming a network user
- Logging on and off the network
- Network security
- Facilities available on the network: software (custom and off-the-shelf), features of one software package, peripherals and their use, messaging processes

A script and/or a storyboard should be used to show the design of your project.

## Produce the solution

1. Using appropriate software of your choice, follow the outline given in the section on design to produce a solution covering the topics given.
2. Use a graphics package to illustrate the topics with outline drawings, screen captures and/or clip art. There are special software packages available for this but a basic paint or draw program will do the task.
   It is most important to label all network components clearly.

## Evaluate the solution

When the solution is completed, write a report to evaluate the use of the network booklet. This could be done by distributing a questionnaire to new students and asking them to provide feedback on the usefulness of the booklet. Follow the guidelines provided in table 1.7 of chapter 1 to construct your questionnaire.



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# PROJECT 2: WRITING YOUR OWN TEST

## Define the problem

A test is needed to determine if students know the basic terms used in networking.

## Analyse the problem

The subject to test should be simple and the scope of the test should be kept narrow. Ten questions is a good size.

The test should be usable for peer assessment or self-assessment and may be used online or printed out for students to complete. Software will be needed that allows for these options. Microsoft Word is used as the software tool in this example as it allows the designer to use three different types of questions and answers for an online test: text, check boxes and drop-down lists.

## Design a solution

The project will be easier to complete if the form is designed first. The choice of form will depend on the type of answer needed from the test user:

- Text allows the user to enter an answer in alphanumeric form with some flexibility in the way they answer
- Check boxes are good for collecting yes/no or right/wrong type information
- Drop-down lists provide a set of entries from which the answer may be chosen

To design your solution:

1. Decide the inputs and outputs required, that is, what questions will be asked and what answers required.
2. Sketch the form using a storyboard. Label clearly the parts you wish to use e.g. instructions, table, test structure and parts.

## Produce the solution

An example of the steps that may be taken is provided here.

1. Open a new document.
2. Type the heading and instructions. For example, the Tab key will allow users to move from one answer to the next in an online test.
3. Insert a table of two columns and 10 rows.

**Table 7.11** Sample questions and the different answer types

| | |
|---|---|
| 1 A network where connections are constantly changing as users log on and log off is called | Type answer here [text form field] |
| 2 Data transmission in both directions at the same time is | ◯ Duplex [check box form fields]<br>◯ Simplex |
| 3 High speed connections that send many signals at a time are | Broadband [drop-down form field] |

4. Type the questions you wish to ask into column 1.
5. Use column 2 to provide space for the answers. Three different types of answers are given here but you may choose to use only one.

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6 Use the **View** menu, **Toolbars**, **Forms** to open the **Forms** toolbar.

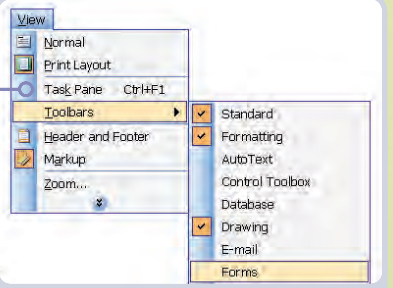


Figure 7.37 Accessing from the View menu

7 Place the cursor into an answer cell of the table (column 2) and use the **Forms** toolbar:
- To create a text form field, click the **Text Form Field** option.
- To create a check box, click the **Check Box Form Field** option.
- To create a drop-down list, click the **Drop-Down Form Field** option.

The inserted choice will appear as a shaded box in the cell. More than one check box will need to be created.

To set up the field and define the information that can be placed in it, you need to use the Form Field options.


Figure 7.38 Forms toolbar

8 Select the shaded box representing the field in the table cell and click **Form Field** options for that type of field.

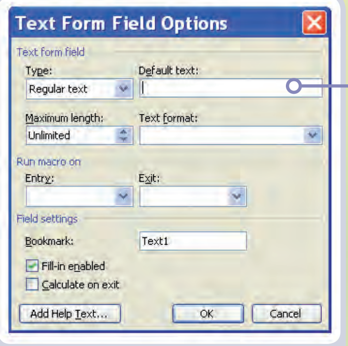


Figure 7.39 Forms options

9 Select the various options you wish to set for the answer to the question.
Text Form Field option examples:
Type: Choose the type of answer that may be given e.g. regular text
Length: Choose the number of characters that you will allow in the answer e.g. 20
Add Help Text (type your own): Choose F1 to display and type 'Your answer may not have more than 20 characters'
Check Box Form Field option examples:
Size: 20 pt
Value: Not checked

Drop-Down Form Field option examples:

Enter items one at a time in the drop-down item box. Click **Add** after each item is entered. To change the order of entered items, select the item and use the up and down arrow keys.

Help text may be added to all form field types.

10 Complete each question by adding the structure for each answer.

11 Protect the form when you have finished by checking the **Protect Form** option on the Forms toolbar (the lock). No changes can be made while the form is locked, except in those cells where answers are required. The Tab key will allow users to move from one answer to the next.

12 Save your work.

## Evaluate the solution

Use table 1.7 in chapter 1 to decide the value of the project for the purpose and note down any changes that could be made to improve the design or content. For example, formatting the answers to a different font and/or size or colour may make the test more user-friendly.

Note: You may like to save the finished project as a template. This will make it easier for you to create further tests in the future by using the same structure and just changing the topic, the questions and the answers.



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CHAPTER 8

# Robotics and automated systems

## Robots and robotics

A *robot* is an electronic device controlled by a program and able to carry out tasks of various kinds – it is a machine made to perform functions that humans might otherwise do. The science and technology related to robots is called *robotics*.

An android or a humanoid is a robot that looks and behaves like a human, and many of us think of robots in that way. However, a typical robot does not look human-like and completes its tasks by following a set of specific instructions that tell it what and how the job is to be done.

Robots range from simple industrial robots that perform a single task, such as spot welding on an assembly line, to complex machinery capable of making many decisions and carrying out a range of tasks including driving trains.

A typical robot has motion, a physical 'body', the ability input data, a power supply to run some type of motor, a computer to control the system and the ability to output data in some form, usually as movement.

**Figure 8.1** Humanoid robot

### Historical perspective on robotics

The word 'robot' was invented by Karel Capek in 1917 in a story called 'Opilek'. In 1920 Capek wrote a play, *Rossum's Universal Robots,* based on this story. Capek gave his machine workers the feelings of humans. Eventually these robots were used to fight wars and they turned on their human creators. Isaac Asimov later used the word robotics in *Runabout,* a science fiction novel, and went on to write more stories about robots as helpful assistants for humans.

Before the term 'robot' came into use, people imagined many machines that would do tasks for humans. Even Leonardo da Vinci drew a design for a mechanical man. Early machines existed that were very similar to robots in that they used precision-engineered gears to move, but they were called automatons. The best known examples of these include 'The Writer', by



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Figure 8.2 Automaton

Pierre Jaques-Druz, a figure of a small boy who could write, and Jacques Vaucarson's mechanical duck that could eat and digest food.

Early robots were non-adaptive – they were machines that simply followed instructions. They carried out a series of operations in a sequence for a set period of time. A human operator was needed to check on any problems in the environment and provide any requirements for the machine. Vaucarson's duck continued the eating and digesting process, even when the operator provided no food.

Real robots were not possible until transistors and integrated circuits had been invented in the 1950s and 1960s. Today, the term robot is more usually applied to adaptive machines that respond to changes in their environment.

**Table 8.1** Some steps in the development of robots

| Date | Development |
|---|---|
| 1969 | Shakey, a robot, showed how a machine could use movement, sight and problem-solving |
| 1973 | Freddy, a Scottish robot, is able to use sight to find parts and assemble models |
| 1989 | ALVINN (an autonomous land vehicle in a neural network) becomes the start of a car that could drive very long distances under computer control |
| 1991–2 | TD-Gammon plays backgammon at championship level against human players |
| 1997 | Robo-Cup soccer begins – 40 teams of interactive robots compete |
| 2000 | Smart toys, or robot pets, are available commercially |
| 2000+ | Nomad robot is used to explore remote areas of Antarctica |
| 2004 | Rover robot explores the surface of Mars |

## Asimov's contribution to the concept of robots

In the 1940s and 1950s, Isaac Asimov believed the time was coming when robots would be so 'human-like' that laws would be necessary to control their behaviour. He wrote a science fiction book called *I, Robot* in which he developed three laws of robotics that are often quoted. The three laws are:

- A robot may not harm a human being, or through inaction allow a human being to come to harm.
- A robot must obey orders given to it by human beings except where such orders would conflict with the first law.
- A robot must protect its own existence as long as such protection does not conflict with the first or second law.

Asimov's belief that machines might one day take control of humans is not new, and continues today in films such as *Terminator* and *The Matrix*.

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The 'smart cruise missiles' that have been used in warfare are technically robots, and have broken Asimov's laws.

## Similarities between robots and human systems

It is easy to understand why people see robots as 'human-like'. Humans and robots have a lot in common. Humans are systems that work within narrow ranges of temperature and pressure and need constant supplies of energy and raw materials to function. Wastes must be output or they will poison the body, causing the system to crash. The human system uses feedback from its environment to make decisions and to change the output based on the feedback received.

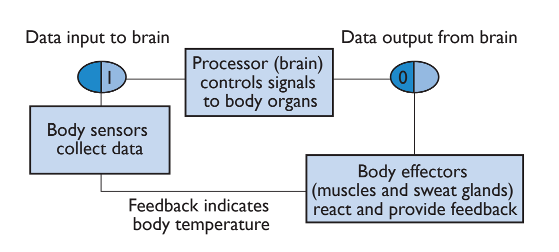


**Figure 8.3** The human temperature system

A robot has the same basic structure as a human, with some differences. For example, the robot temperature system, according to the setting of temperature sensors, is able to work within a much larger range of temperature and pressure. It also needs constant supplies of energy. The robot will not operate if most components are not functioning. A simple robot can function with just a controller and some means of output, but a more complex robot will need to interact with the environment in the same way as a human system. The data in the human system will not need to be converted, as a human is able to accept input, process and output data in analogue form. In the robot system, the data will need to be converted from analogue to digital data and back to analogue data as it is processed and output.

## Data handling

### Data forms

Data can be represented in digital or analogue form. Digital data is data that can only be in one of two states – like a common light switch, the electronic circuits can either be high voltage or low voltage. Analogue data can have many states and measure much smaller units, like the volume control on a television that can be varied continuously.

Humans use analogue data in speech, music and video but computerised robots use digital data as it is simpler to handle. This requires hardware to convert data from one form to another, called ADC (analogue-to-digital converters) or DAC (digital-to-analogue converters). Using just two states, ON or OFF, it is possible for a robot to do many complex tasks.

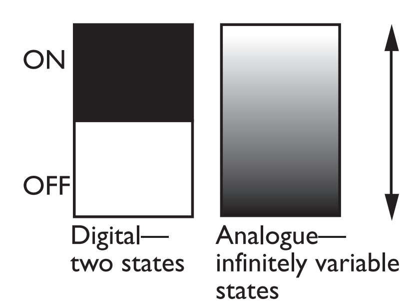


**Figure 8.4** Comparison of digital and analogue data

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## EXERCISE 8.1

1 Define the terms 'robot', 'robotics' and 'android'.

2 Describe a typical robot.

3 Consider the following diagram of a system.

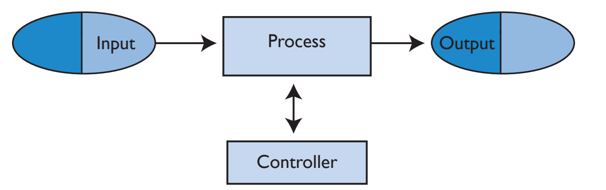


**Figure 8.5** Robot system

a What type of data is the most usual form of input for the robot system?
b Name the general term for output from robots.

4 Complete this table to compare the human system and a robot system.

| System | Input | Output | Process | Feedback |
|---|---|---|---|---|
| Human | | | | |
| Robot | | | | |

5 How were automatons different from our present-day understanding of the term 'robots'?

6 In what way was Freddy the robot an improvement on Shakey the robot?

7 Rewrite each of Asimov's laws in your own words.

8 Asimov's robotic laws are in a hierarchy. Which law is the most important?

9 How might a robot be 'trained' to carry out the first law?

10 Why do you think these laws were written?

11 Might such laws be necessary one day? Explain your answer.

12 Research: Find TWO examples of robots used in film or television (for example, from the Star Wars movies). Explain how such robots differ from the standard industrial robot.

13 Complete the this paragraph using words provided in the list.

| | | |
|---|---|---|
| adaptive | automatons | behaviour |
| controller | feedback | human |
| 1917 | instructions | Karel Capek |
| non-adaptive | robots | task |

Robot is a term first used in (a) ___ by (b) ___ when he wrote about machines with (c) ___ feelings. Before this, machines similar to (d) ___ had been called (e) ___. One of these machines was a mechanical duck that could eat food. These types of robots were (f) ___ as they followed fixed sets of (g) ___ to complete a (h) ___ and humans were the (i) ___. Many current robots are (j) ___, that is, they may adjust their (k) ___ when they receive (l) ___ from their environment.

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## Types of robots

### Non-adaptive robots

A non-adaptive robot would be a machine used to move steel into a blast furnace that would continue to follow its program regardless of the environment. It would collect the steel, move it to the mouth of the furnace and drop it in. Unless a human operator shut it down, the non-adaptive robot would continue its task repetitively, even if the furnace stopped burning or blew up.

Non-adaptive robots do a variety of tasks in areas such as industry, where a robot may be able to both weld and spray, and may also be reprogrammable, that is, able to accept new instructions that alter their purpose. This is only possible if the robot is equipped to carry out the alternative task.

Non-adaptive robots are also called *open-loop systems,* as they receive no feedback from the environment. An industrial welding machine will follow a set of instructions to weld metal components fed into the system by an assembly line. Should the supply of materials to be welded run out, the machine will continue to weld as it has no knowledge of the results of its actions.

### Adaptive robots

Adaptive robots have the greatest potential. They take the output from their systems and use it as feedback to control the behaviour of their systems and so are called *closed-loop systems*. The machine is programmed to make decisions based on feedback from its environment. For example, an adaptive robot in a blast furnace might have heat sensors and touch sensors that would provide input on which to base decisions. If the heat dropped below a set level or the door of the blast furnace was closed, the robot could decide not to continue feeding steel into the furnace. Making such decisions provides the robot with the basics for reasoning and intelligent reaction.

Input in a closed loop system can produce a variety of outputs, depending on the additional input from the feedback. The robot would need to store a knowledge base of all the available outputs. Sensors in the robot input data that 'teaches' the robot about its environment. A touch sensor may 'teach' the robot that there is an obstacle in its path. This feedback from the sensor checks the knowledge base and alters the processing carried out by the robot so that its behaviour changes to avoid the obstacle. In the case of the industrial welding machine, if it were an adaptive robot, it would detect that no welding materials remained and change its behaviour accordingly, that is, stop welding operations.

Figure 8.6 Adaptive robots

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Figure 8.7 Industrial robot

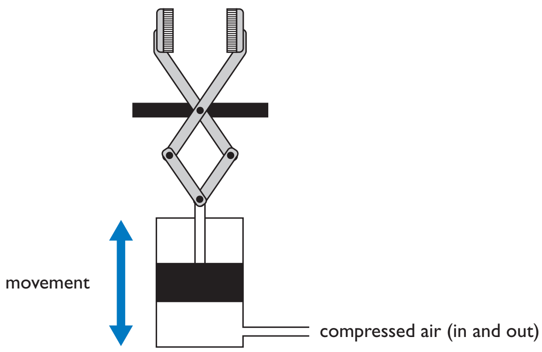


Figure 8.8 Grippers in action

Figure 8.9 Robotic toys

## Industrial robots

Industrial robots are usually non-adaptive and efficiently complete routine tasks such as drilling, welding, assembly, painting and packaging. They are used in manufacturing, electronics assembly, food processing and many other areas of production.

To be useful, an industrial robot needs a means of carrying out its instructions. Such a means is known as an *end effector*. An end effector is a mechanical device on the end of a robot arm used to do some useful work.

End effectors take the form most suitable for the action they perform. A tool of some kind will be needed if the action to be carried out is some form of cutting, drilling or twisting operation. A gripper is needed if any grasping, holding, moving or controlling operation is the objective. When connecting, disconnecting or redirecting an operation is needed, then a switch will be used that can turn an electric current off or on.

## Domestic robots

Domestic robots are increasingly within the realms of possibility. Some computer programs exist to turn air conditioning and cooking appliances on and off at set times or by signal over a mobile phone. Others automatically handle routine tasks such as household alarms, maintenance of swimming pools, vacuuming, and closing roof structures in wet weather. There is even a robotic lawnmower. Robotic pets are available for those who live in units or spaces where real pets are not allowed, or for those who want to avoid feeding, cleaning and vet fees. A number of children's toys are adaptive robots. Remote-controlled vehicles are popular forms of these.

Figure 8.10 Remote controlled vehicle

Figure 8.11 Domestic robot

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## EXERCISE 8.2

1 True or false? Revise each false statement to be true.
  - a A non-adaptive robot can also be called an 'intelligent robot'.
  - b Non-adaptive robots are the same as adaptive robots.
  - c A robot must be designed to look like a human.
  - d A non-adaptive robot must have knowledge to function.
  - e Non-adaptive robots may be used to carry out simple repetitive tasks.

2 Match each concept in column 1 with the correct description from column 2.

| Concept | Description |
| --- | --- |
| end effector | weld, drill, assemble and paint manufactured items |
| gripper | mechanical device used to connect/disconnect the power supply |
| industrial robots | robotic arm device used to do useful work |
| remote controlled car | device used to grasp and hold items |
| switch | automated programmable toy |

3 Study figure 8.12 and write a paragraph explaining the problems it raises about the use of robotic devices in industry. In your paragraph, discuss both the advantages and disadvantages including the displacement of people by robotic devices.

Figure 8.12 Are robots replacing humans?

# Purpose, use and function of robots

## Purpose of robots

A robot is designed for a purpose, depending on whether the task is simple, complex and/or requires the robot to have some degree of 'intelligence'. The purpose of a robot will decide if it is designed to be a smart robot or a dumb robot. *Smart* robots are adaptive robots that operate under programmed control and are able to learn as they carry out their tasks. *Dumb* or non-adaptive robots do repetitive tasks well, but learn nothing from their

**Think about this**

Nanotechnology is the development of different types of miniature machines. Nano, meaning very small, comes from nanometer (nm) or one billionth of a metre. Nanorobots are being explored as miniature solutions for a number of human problems. One use is in medicine where a very small robot may be built to explore the human blood system. Why is nanotechnology seen as such an important development?

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operations. Smart robots are able to investigate volcanoes, go deep into the unknown chasms of oceans, detect active land mines and deactivate bombs left by wars or terrorists, visit other planets and carry out tasks in extreme heat or cold. Dumb robots are more valuable for industrial jobs in dust, heat and cold that would be uncomfortable or hazardous for humans.

### Repetitive or dangerous tasks

Robots are excellent at repetitive, boring and/or dangerous tasks. The vast majority of robots are used for industrial purposes such as these. Automation in industry uses a wide range of robot devices to help reduce the costs of manufacturing, increase productivity and standardise goods to a high quality. Humans are only needed for tasks where initiative or discernment is needed, such as quality control.

The type of repetitive and dangerous tasks that a robot can perform precisely and continuously include spray painting of parts, loading and unloading of materials, cutting, welding, assembly of cars, sorting, cleaning and polishing and detection of faulty components.

### Operating in remote locations

Robots are capable of being programmed to operate in remote locations. Depending on their construction, they may be static or mobile, programmed for one or many tasks, adaptive or non-adaptive.

Robots have long been considered for exploration of areas of Earth where humans and vehicles find it difficult, dangerous or impossible. This has led to considerable research on methods of locomotion for extreme areas such as the very depths of the ocean, investigating deep caverns and high mountains on the surface, or taking measurements in the excessive heat of the desert or the cold of Antarctica. Ambler is one robot developed for very rough locations. It is about twice the height of a human male and has the ability to control its balance, stability and movement. Its legs are not made to bend, but they swing horizontally and lengthen to touch the ground. Each leg is independent of the others and legs can be used in any order. The controller allows the robot to make decisions: which route to take given the destination by a human, how far to stretch each leg, how to avoid legs colliding with each other and what ground is the most stable. The controller also reduces the time needed to send data back to a human operator for decisions. Such stability enables Ambler to protect scientific instruments used to map the terrain over which it passes and to concentrate on sending the data for which it was designed.

## Use of robots

Robots are invaluable in exploration of environments that will not readily accept human beings, in industry and for general maintenance and repair. Hostile environments, even wars, have led to a lot of research into ways

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in which robots can be designed to cope well in such environments and transmit information from such places back to humans. Much of this information has also helped to improve the application of robots in less hostile environments such as manufacturing.


Figure 8.13 Robotic arm used in industry

## Exploration

Space is a hostile environment, and the use of human labour in such places is both costly and complex. This makes robots more appropriate for exploration, transport, maintenance, surveying and scientific collection tasks on other planets. Robots can remain at planetary sites and carry out tasks, enabling humans to monitor their progress in the relatively safe environment of Earth. They are also able to substitute for humans in the actual travel to and study of other planets. Provided they do not malfunction, they are able to travel over many thousand light years and have the potential to journey to planets well beyond our solar system that remains beyond human ability to do so in a single lifetime.

Robots involved in space exploration include a robonaut called Sojourner which travelled on the Pathfinder space ship to Mars in 1997 and was a roving or walking robot similar to a human, with a head, two arms, five-digit hands and two eyes. This robotic astronaut uses an advanced robotic arm to mimic the human arm and was able to handle very delicate items. On its head were two small colour video cameras to collect stereo vision. The robot was controlled by a human astronaut using a data glove to model the movement the robot was to perform. A data glove contains many input devices or sensors to collect data. The robot carries out the exact movement performed by the data glove by responding to over 150 sensors and controllers. This enables the astronaut to remain in relative safety and use the robot to respond rapidly to emergencies or to hazardous situations without the need for preparation, protective clothing and breathing apparatus. A robonaut is also equipped to carry out standard maintenance tasks. Robots were also used for the 2004 Mars expedition.

The Dual-use Mobile Detachable Manipulator, or (DM)2, is a mobile maintenance robot designed for space exploration. (DM)2 has a number of different arms, end effectors or grippers and other hardware and is controlled by Chimera, a real-time operating system. A real-time operating system means that the robot is able to respond to input immediately. The tasks of (DM)2 on the moon surface involved manipulating materials, maintenance of parts and exploration.

Figure 8.14 Space probe

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### Assembly-line robots

Robots are useful for both the assembly of parts and the processes of an assembly line. An assembly line is an automated series of tasks intended to construct or assemble a product in a manufacturing system. It is usual for a robot to be designed for a particular workstation and to have a restricted number of tasks to perform in the assembly process. Each robot is programmed for its specific precise task or tasks. It has specific touch sensors and actuators for the task and can continue to repeat its actions over very long periods of time.

### Maintenance and repair

Robots do maintenance and repair in space but are more than capable of these tasks on earth. Examples include robots used for maintenance of the railway system, a job which can be time consuming, tedious and dangerous for human workers. Robots can be programmed to run along the overhead stanchions or on the rails themselves using the electricity to power themselves. They may be scheduled on lines the same as trains. The robot locates faults, photographs them and feeds locations and statistical data back to base (such as depth of rust or missing parts). An engineer can then access the database containing this information and make decisions about the priority of the problems. Other robots able to take the correct repair steps, such as welding a gap, could be sent to the location. Other robots could be programmed to repair the maintenance and repair robots.

## EXERCISE 8.3

1. What am I?
   - a. I am a robot able to learn as I carry out my tasks.
   - b. I am a robot suitable for repetitive industrial jobs.
   - c. I am a task for which humans are most useful.
   - d. I am the space shuttle that took robots to Mars in 1997.
   - e. I am the input hardware collecting visual images on Mars.
   - f. I am the maintenance robot that went to the Moon.
   - g. I am the term used to describe a robot's ability to immediately respond to input.
   - h. I am an automated series of manufacturing tasks.
2. Answer the following questions.
   - a. Give THREE reasons for the use of robots in industry.
   - b. Name FOUR dangerous jobs a robot is able to do more precisely than a human.
   - c. Explain TWO extreme environments where robots are more suitable than humans.
   - d. What job was given to Ambler, the robot?
   - e. Describe the advantage of having a robotic controller for robots like Ambler.

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exercise 8.3 continued

f Why are robots chosen for space expeditions?
g What did Sojourner do?
h How did the data glove operate?
i How do robots help to maintain and repair railway lines?

## Function of robots

For any effective robotic task, input and output tools are needed.

Degrees of freedom the number of different ways an appendage can pivot.

### Technical aspects of robotics

Robots are designed to carry out movement. The amount of movement is determined by the *degrees of freedom* built into the design. Degrees of freedom are the number of different ways an appendage can pivot. A human arm has seven degrees of freedom as it is able to pivot (rotate) in seven different ways.

Robotic arms used in industry to perform a large range of tasks are a good example of why degrees of freedom are important. They are particularly valuable in the handling of materials such as heavy steel or dangerous chemicals. A standard robotic arm made up of seven metal segments has six joints including a 'shoulder', 'elbow' and 'wrist'. Each joint is pivoted by a separate stepping motor (see further information in Actuators, later in this chapter) or by a hydraulic or pneumatic motor if the joint is large. The stepping motor moves in exact increments so that the arm is moved very precisely. The arm will move with six degrees of freedom, corresponding to the joints:

- the base of the arm can be rotated
- the base of the arm can be pivoted
- the elbow can be bent
- the wrist can move up and down
- the wrist can move left and right
- the wrist can rotate.

Some robotic arms will rotate fully; others will only move in one direction, either horizontally or vertically. Those that move in only one direction have only one degree of freedom.

**Great idea**

**Robot technology has brought many great ideas for people with a disability. These have helped people use technology more easily and include artificial limbs, voice recognition software, the translation of musical, science or maths notation into Braille, virtual pencils, alternative keyboards and mouses for people with limited use of their hands, digitised speech devices, voice amplifiers and simplified programs for the use of email.**

### Hardware to control robots

No computer program to operate a robot will function unless it has the hardware to collect and input and/or output and display the appropriate data. The computer program exercises the control, that is, provides the instructions for the hardware to function.

Figure 8.15 Degrees of freedom in a robotic hand

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## Input hardware

There are many ways of inputting data into a robotic system.

**Table 8.2** Some general hardware input devices used in robotics

| Device | Main Features | Advantages | Disadvantages |
|---|---|---|---|
| Digital camera | Digitises photographs | Easy to use; photographs can be edited | Expensive compared to using a scanner |
| Keyboard | Layouts available include QWERTY, Dvorak, Maltron | Commonly available: most people are trained to use the QWERTY layout | Relatively slow; may cause RSI (repetitive strain injury) with repeated use |
| Light pen | Laser point contacts screen | No typing skills are needed and easy to use | Needs special programs for operation |
| Mouse | Point, drag and click to control an on-screen cursor | No typing skills are needed; easy to use; common; may be wireless | Requires a graphical interface and a driver |
| Microphone | Very user-friendly input | No hands needed and no training; works for music and speech | Dialect problems for speech but these are being overcome; specialised software needed |

### SENSORS

**Sensors** a device that converts input from the environment into a signal that can be communicated to a control system.

**Sensors** are specialised input devices that measure data from the environment. The most common types of sensors measure temperature, light, touch, magnetism, sound, and position, but there are also sensors that can recognise images, speed, pressure, flow and many others types of input. Each form of data input requires a different type of sensor.

*Temperature sensors* are used for temperature control. Thermostats are the simplest form of temperature control. A bi-metal strip can work as a thermostat. Two different metals expand by different amounts, causing the strip to bend when it is heated. When cold, the switch is open. When the temperature rises, the switch closes.

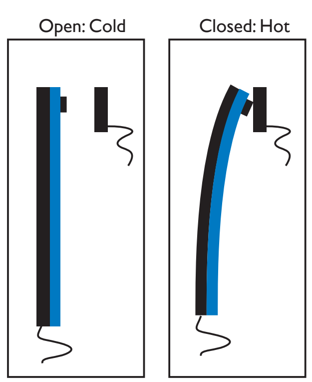


**Figure 8.16** Bi-metal strip

**Table 8.3** Types of temperature sensors

| Name | Description | Examples of use | Issues |
|---|---|---|---|
| Thermostat | Switch that opens at a set temperature and stays open while the temperature remains at that level or higher: when the temperature falls below that level, the switch will close | Ovens, hot-water services | Not as accurate or as quick to respond as other sensors but they are cheap |
| Thermistor | Measures temperature continually as resistance: when the temperature increases, resistance drops | Microwave ovens, air conditioners | Similar to thermostat and also cheap |

continued >

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| | | | |
|---|---|---|---|
| Thermocouple | Uses semiconductors* to measure temperature | VCR (video cassette recorders) | Accurate and faster than other types, but more expensive and also needs a power source to operate |

*Semiconductors are sensor materials with electrical properties that are not as good as those of good electrical conductors such as copper wire but not as poor as non-electrical conductors such as the plastic sheath around the wire. Silicon has only partial resistance to electricity and can be used as a semiconductor. When a good electrical conductor like metal is overlaid on a silicon base (the semiconductor), an integrated circuit (or silicon chip) can be created.

*Light sensors* detect changes in the level of light. It is relatively easy to construct such a sensor to read barcodes, as they collect data as simple changes between black and white. These changes can then be converted into digital form. Image sensors are also forms of light sensors. It is much harder to use light sensors to convert more complicated images into digital form. It is possible to teach some pattern and shape recognition (image recognition) but the more complicated the image, the poorer the light sensor will perform.

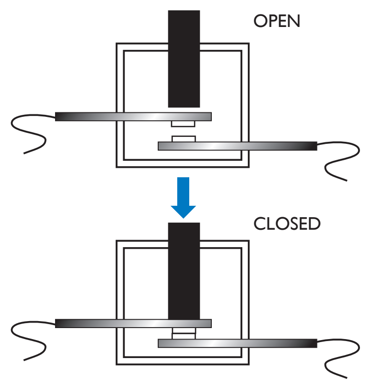


Figure 8.17 Simple contact sensor

*Position sensors* can also range from the simple to very complex. A simple position sensor would be a contact sensor – a switch that could be either on or off. When the machine came into contact with an object the switch would close.

A more complex position sensor could decide how far away an object was from a machine. This could involve the use of light projected ahead of the machine, and the level of light reflection could be measured by a light sensor. The reflected light would increase as the machine was closer to the object. When the light intensity reached a certain level, a switch could be turned on. This type of position sensor could be used as part of a security system in a building.

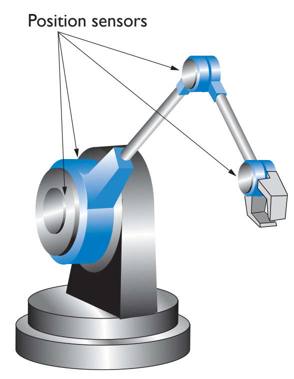


Figure 8.18 Position sensors used to control a robotic arm

*Potentiometers* are sensors that can be used to determine rotation. They work on electrical resistance and the meter shows the amount of voltage at a particular point. This gives a fairly accurate reading of the amount of rotation.

*Sonar sensors* use sound to determine position. High-frequency sound waves 'bounce' off objects and enable a robot to find its way around.

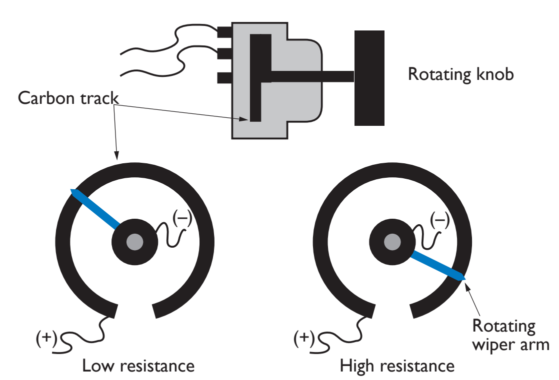


Figure 8.19 Potentiometer

## Output hardware

Output devices provide data in a form that can be understood outside the robotic system.

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**Table 8.4** Examples of general hardware output devices used in robotics

| Device | Main features | Advantages | Disadvantages |
|---|---|---|---|
| Speakers | Speakers Volume control; available to a wide range of people | Normal speech rather than synthesised speech is possible | Require extra hardware e.g. sound cards |
| Monitor/VDU (visual display unit) | CRT and LCD displays available for many applications | No waste of paper; can be interactive or display animations | No hard copy (i.e. no printed page) |

**Actuator** a specialised hardware device which, under control, comes out mechanical actions.

## ACTUATORS

**Actuators** are specialised hardware devices that do the work of the system, that is, they output a response. Each actuator does a different task, so most robots will have many different actuators. The simplest may just switch a device on or off. Actuators work on power: electrical, hydraulic (oil under pressure) or pneumatic (air under pressure). Forms of actuators include solenoids, stepping motors and pneumatics.

*Solenoids* use an electromagnet to move an arm or plunger through a small movement. The electromagnet moves when an electric current passes through it. This can be used to push or pull an object. In the starter motor of a car, a small solenoid is used to push a rod to connect the starter motor drive gear when the ignition key is turned to start the car.

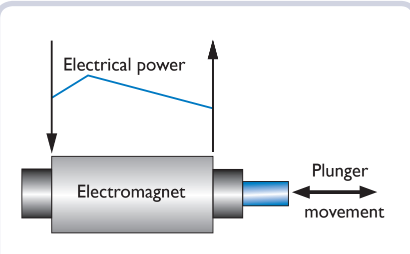

Figure 8.20 Solenoid

*Stepping motors* also use electromagnets. They can accurately count the rotations of a motor around a spindle to measure position. The shaft of the motor turns in small precise steps. A hard disk drive can use a stepping motor to position the read-write head at the correct spot on the platter and track of the disk.

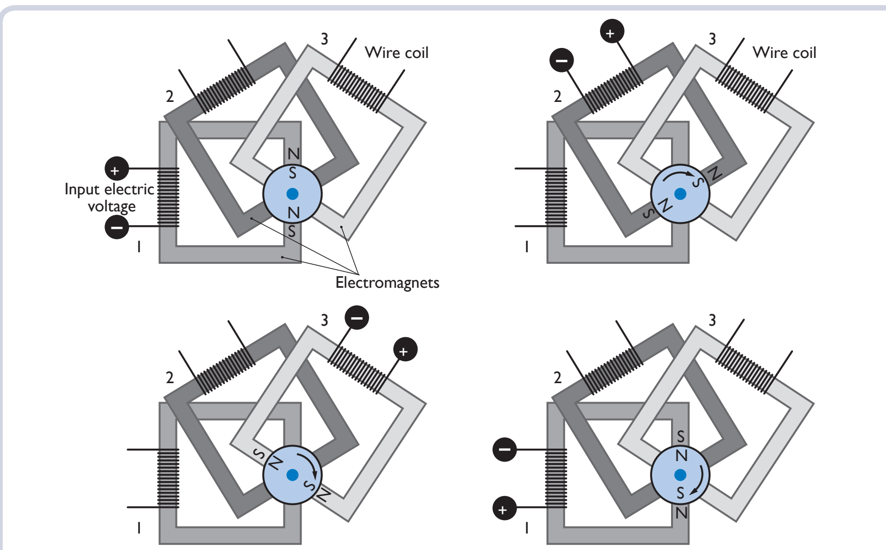

Figure 8.21 Stepping motors are used to control degrees of freedom in robotic limbs

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# Storage and processing devices

Storage devices, or memory, hold data for later output or processing by the robotic system. Processing devices convert data into forms required by the system.

**Table 8.5** Storage devices

| Device | Components | Main features |
|---|---|---|
| Primary storage | ROM | Permanent storage |
| | RAM | Temporary or volatile storage |
| Secondary storage | Wide range: see table 5.5 | Holds data for future use |

## The motherboard

The motherboard is the printed circuit board that holds, controls or supports primary storage and processing devices. It is found in all computer systems including robots.

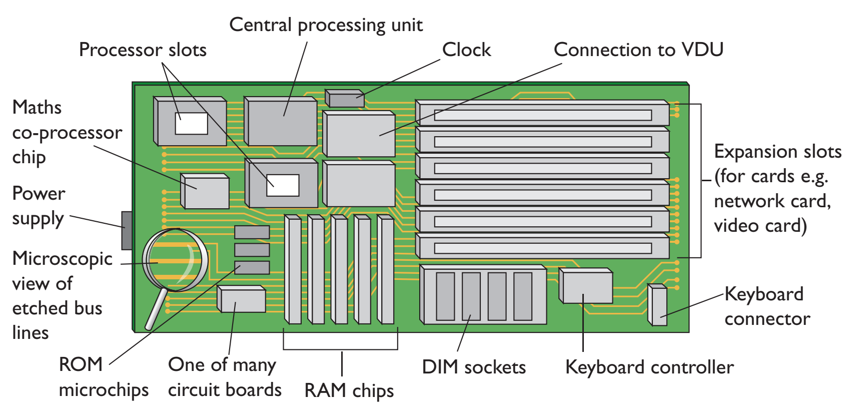


**Figure 8.22** An example of motherboard configuration

## Primary storage

**Primary storage** holds data for processing, processed data waiting for output and instructions for processing. Primary storage is found on the motherboard where it is linked directly to the processing parts of the computer so that instructions can be completed very quickly.

Primary storage can be either permanent storage or temporary storage. *Permanent* storage is read-only memory or ROM. Data can be read or accessed from ROM but cannot easily be changed. The data in ROM includes the program that reads the operating system from secondary storage into RAM before the operating system is executed. This process is called bootstrapping or *booting*.

### Career path

Technicians create, develop and maintain hardware parts. For example, a semiconductor technician produces and tests microchips, monitors their manufacturing process, maintains equipment and manages workflow. Emerging technology has created new jobs such as a nanotechnician—a technician who works with microscopic controls and parts.

**Primary storage** the main memory of a computer, composed of RAM and ROM.

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Figure 8.23 Primary memory

## Temporary storage

Temporary storage is random-access memory or RAM. Data can be read or accessed from RAM and changed by the user. The data in RAM is volatile, that is, it depends on the electrical supply and can be kept for future use by writing RAM contents to secondary storage.

The ability of primary storage to store temporary data depends on the size of the RAM. Data in RAM during robotic operation could include the operating system, the application that the user has loaded into the computer for current use e.g. a program to operate a robot on an assembly line and any current files.

Temporary storage is random-access memory or RAM.

## Secondary storage

Secondary storage is any storage outside the central processing unit (CPU). The size of the secondary storage determines the ability of the system to store data for future use. Examples of secondary storage include hard disks, DVDs and portable flash drives.


Figure 8.24 Memory card

### Great idea

Robotics benefited from the change to portable memory. Not only could removable cards hold data for digital cameras, phones, ATMs and other devices but battery power could be used as well as standard electricity. Smart cards were able to hold a range of data for purposes such as knowledge bases and the data store could be changed or updated when needed, as when the functions of a robot have to be adjusted.

## EXERCISE 8.4

1 Match each term in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| back-up | storage that is not held on the computer motherboard |
| booting | permanent memory that stores data imprinted by the manufacturer |
| bus | manipulation and organisation of data to achieve a purpose |
| cache | a copy of data, on disk or tape, made to guard against accidental loss |
| microprocessor | the first storage areas accessed on booting and located on the motherboard |
| primary storage | etched lines or wires for data transport |
| processing | temporary storage spaces on the hard disk to increase data access speeds |
| RAM | a computer with one silicon chip |
| ROM | the process of starting a computer |
| secondary storage | volatile memory that holds data while it is being used |

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exercise 8.4 continued

2 Write answers to each of the following. Some research may be needed.
  a How is primary storage different from secondary storage?
  b What are the TWO main components of primary storage?
  c Why is the amount of primary storage important in determining the capabilities of a robot?
  d What type of programs are contained in ROM?
  e Why do robots need secondary storage?
  f What is the difference between reading and writing data?

3 Sketch and label the components of a motherboard available for you to study, or use figure 8.22. Against the labels, state the function of each component. Add extra labels where appropriate to show expansion cards and co-processors.

## Processing hardware

Processing changes data into another form that humans may use as information. Robots require considerable processing power. The two computer processors available are the CPU and co-processor chips.

The CPU is the part of the computer that performs the *processing* and *control* functions. In a microcomputer, the CPU is usually on one chip. *Microprocessor* refers to any system using a single silicon chip. There are a wide range of such devices today including cameras, digital watches and monitoring devices such as security systems, as well as robots and personal computers.

*Co-processor* chips are integrated circuits that assist the CPU with specific processing tasks. One well-known example is the maths co-processor that helps with mathematical computations.

**Processing** changing data into another form that humans may use as information.

### Parts of the CPU

There are a number of different parts in the CPU, each with a particular function (see tables 8.6 and 8.7).

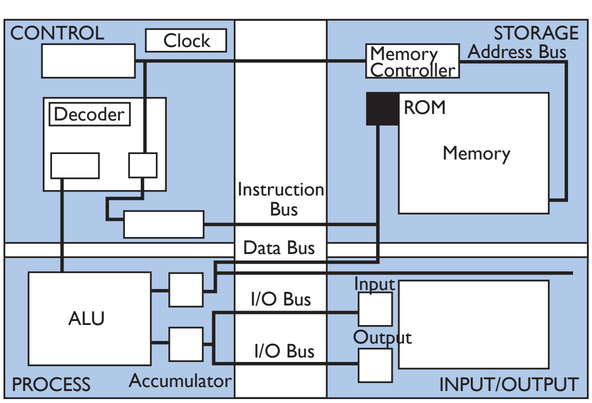


**Figure 8.25** Parts of the CPU

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**Table 8.6** Functions of CPU components

| Component | Description | Function/s |
|---|---|---|
| Register | An electronic circuit capable of temporarily storing binary digits | Stores the next instruction, temporary results, memory addresses and data to be processed |
| Arithmetic logic unit (ALU) | A collection of electronic circuits used to perform arithmetic and logical functions | • Arithmetic functions: +, -, *, /<br>• Logical functions: AND, OR, NOT<br>• Compares numbers so the program can make decisions, (for example = > <) |
| System clock | An accurate, very fast electronic timer | Synchronisation transfers data at a particular clock pulse. The faster the system clock, the more instructions per second that can be executed by the CPU. |
| Control unit | Controls all operations in the CPU | Sends data along the correct buses and controls the fetch-execute cycle |
| Buses | Wires or metallic strips etched into circuit boards along which signals are transferred from one component to another | Each bus line (data line) has a set number of paths along which bits travel equivalent to the number of bits in the computer's wordlength. The 'wider' the bus the quicker data can be transferred from one location to another. |

**Table 8.7** Functioning of the CPU

| Process | Explanation | Function |
|---|---|---|
| Data input from the keyboard or other peripheral | Each key on the keyboard is connected to sensors that connect to the CPU. | As a key is pressed a series of pulses/non-pulses is sent to the CPU. |
| Data processing | Inside the CPU there are thousands of electronic switches. | Each switch is opened or closed by electrical pulses that carry the binary data around the computer. |
| | The machine begins a cycle (fetch-execute) that has four steps. The process will continue until each instruction in a program goes through this cycle. | • Fetch – control unit fetches one instruction from memory<br>• Decode – control unit decodes the instruction (decides what it means) and sends instructions to get the data needed<br>• Execute – control unit directs the ALU to execute the instruction<br>• Store – control unit stores the result of this operation in primary storage (either RAM or a register) |
| Data output | The CPU is connected to the graphics card and other peripherals by buses. | Data that has completed the cycles in the CPU is sent to the screen. |

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## Computer control

Control is needed to determine how input data from sensors is passed to processors and then sent on to actuators so that output is achieved in a robotic system. Control is exercised by the CPU and the program delivering instructions.

Programmable logic controllers or PLCs are specialised controllers that are part of many automated systems such as assembly lines. PLCs are microprocessors attached to sensors and actuators. The PLC follows programmed steps to do its task. For example, imagine an assembly line filling soft-drink bottles that fills different size bottles of the same drink. One machine on the line receives the small bottles from a source at a fixed speed. The counter records the number of each bottle. Each bottle is fed along a guide to the next machine in line. The bottle is filled and passes to the next machine where it is capped. The assembly line continues on the basis that if the timing is right, all bottles should be filled to the same level. A set number of bottles are filled and capped before the run is completed. The programmable logic controller controls each step and each process, times and schedules the assembly line, and stops when the counter indicates that the run is finished. It can then be reprogrammed to fill larger size bottles, that is, a program is installed that has changed timings. The assembly line begins again.

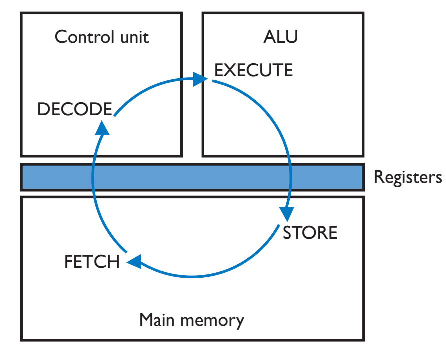


**Figure 8.26** The fetch-execute cycle

### EXERCISE 8.5

1 Complete the following paragraph by choosing the correct words from the list.

| | | |
|---|---|---|
| ALU | arithmetic operations | buses |
| control unit | CPU | data |
| electrical | integrated circuit | motherboard |
| operations | output | process |
| registers | silicon | storage |
| system clock | | |

Robots use computer systems to input, (a) ___, store, control and (b) ___ the data they require. The main board of the computer containing the CPU is called the (c) ___. On this board is a silicon chip known as the (d) ___ or central processing unit. A (e) ___ chip is an (f) ___ containing many pathways and layers for (g) ___ conduction. The CPU has a number of different components including temporary (h) ___ areas for data or instructions known as (i) ___, pathways or (j) ___ linking components of the motherboard, an electronic timing device or (k) ___ that keeps all computer (l) ___ in step, a unit called the (m) ___ that carries out calculations or (n) ___ and determines relationships between (o) ___ elements and a unit that handles the overall direction of instructions known as the (p) ___.

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exercise 8.5 continued

2 Complete the following sentences to make them correct statements.
   a The five functions of a robotic computer system are ...
   b The computer component used for processing and control is the ...
   c Any hardware device located outside the CPU is called ...
   d Another name for a microcomputer is a ...
   e Co-processors in robotic systems assist the ... with ...
   f Apart from personal computers, microprocessors are used in ...

3 Match the terms in column 1 with the correct description from column 2.

| Term | Description |
|---|---|
| actuators | the number of different ways arms or legs may rotate or pivot |
| degrees of freedom | normal movement of the human arm has this flexibility |
| microprocessor | a standard robotic arm has this amount of flexibility |
| PLC | input hardware measuring data from the environment |
| sensors | output hardware that responds to control signals |
| seven degrees of freedom | an actuator using an electromagnet to control movement |
| six degrees of freedom | an actuator using incremental movement to rotate objects |
| solenoid | specialised controller used in automated systems |
| sonar | computer controller with only one silicon chip |
| stepping motor | sound detecting sensor |

## Software programs to control robots

Robots are controlled by their stored sets of instructions called *software*. It is these programs that allow robots to operate by remote control. Most robots that 'think' do so using large databases of stored knowledge. They are able to compare data they 'see', 'feel' or are given with what is in their knowledge base, but they are restricted by the rules and data they store. Some robots are able to learn or 'reason' using this stored knowledge and add to it as they encounter similar situations.

Another method of giving robots some degree of 'intelligence' is through the use of neural networks – hardware and software modelled like the human brain. These software programs learn from experience and are trained to respond to specific types of input.

Machines can already help doctors in surgery. The human surgeon remains in control but is able to carry out tasks with greater precision and have much greater visual control of the patient with the robotic machines available. Robots are more consistent and reliable than humans in such situations.

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The Zeus system being used in Europe has a computer workstation, video display and hand controls. These allow the surgeon to manipulate table-mounted surgical instruments using a robot called AESOP (Automated Endoscopic System for Optimal Positioning). AESOP is a mechanical arm that carries out the task of inserting a surgical camera in a patient. The surgeon can use foot pedals or voice instructions to position the camera so that hands remain free.

The da Vinci robot was developed in 1999 to assist surgeons with open heart surgery. The robot actually carries out the operation under the direction of the surgeon who sits at a computer and controls its procedures. The computer uses a set of miniature cameras to enable the surgeon to see a 3D image of the patient's body and guide the robot to make precise cuts and movements.

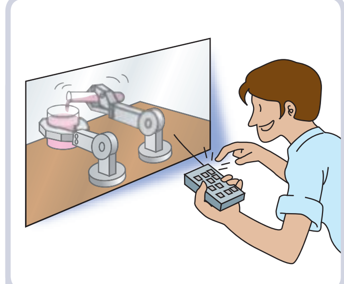

**Figure 8.27** Human control of robotic arms

Robots are also revolutionising prosthetics, that is, the science of developing artificial parts for use by humans. One such development has changed the standard artificial leg into a system that is able to adapt to the user. The knee joint is able to detect the unique movements of its user through a microprocessor and adapt its programmed movements to suit the user so that each artificial knee learns to walk in the way its user prefers.

In the future, surgeons will be able to operate using programs such as Zeus from a remote location. The surgeon might sit at the computer console and remotely control the robotic arms operating on the patient. Very long operations would not tire the surgeon as much as they do at present, there would be fewer patient complications as robotic surgery needs much smaller openings in the human body to carry out the tasks needed, particularly for heart surgery, and people in remote locations could have the best specialist care. At the same time, the computer robot in the operating room would be programmed to analyse the patient and develop the necessary spare parts customised to the patient's needs.

## EXERCISE 8.6

1 From the list provided, choose the best type of hardware or software for the task given.

| | | |
|---|---|---|
| bi-metal strip | PLC | potentiometer |
| thermostat | light sensor | position sensor |
| solenoid | thermocouple | thermistor |
| gripper | | |

- **a** A simple switch is needed to turn temperature off and on.
- **b** An accurate but cheap measure of temperature is needed.
- **c** A cheap but slow switch is needed to respond to temperature change.
- **d** A surgeon needs to use a robotic extension to pick up forceps.

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exercise 8.6 continued

- e Barcodes need to be read from books.
- f A semiconductor is needed to very accurately measure temperature.
- g Some form of contact sensor has to detect a human walking on a mat.
- h A rotation metre is needed to determine circular movement.
- i An electromagnet is used to move an arm through a small vertical movement.
- j An assembly line needs a control program and hardware.

2 Name TWO different types of sensors used in robotic operations.

3 Explain the use of actuators.

4 What are the advantages of using robotic actuators?

5 Compare the da Vinci system with the Zeus system. In your answer make sure you refer to the role of the controller (human and machine) in the systems described.

6 Why would an artificial knee need to have the same degrees of freedom as the human knee?

7 Name THREE future possibilities that may develop in robotic surgery.

8 The following description is provided of a robotic car wash system:

As I drove up to the wash bay I noticed two huge signs among many others. The first sign read 'Wait until wash bay is clear before driving forward'. The second sign said 'Drive forward until front wheel is on the pressure plate and a red light comes on'. From this information I realised that the robotic car wash included the two major types of control systems.

- a What did the first sign read?
- b How was this an indicator that the car wash at this point was a non-adaptive system?
- c What did the second sign read?
- d How was it possible to know that this part of the car wash was an adaptive system?
- e Why was the pressure plate needed?
- f What name is given to the hardware devices that send signals from the environment back to the control system so that it can change its way of operating?

## Automated control

Automated control the mechanised command of a task or tasks.

Automated control is the mechanised command of a task or tasks. The machines controlling the operations are most often computers using programs that provide instructions or step-by-step details of how to produce the needed output. Humans may design and maintain the programs but the machine has control, not the human.

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## Historical perspective of automated control

For many hundreds of years, humans had ideas about how machines could be made to control themselves, but until recently, the technology was not available to do this. When the computer became portable and cheaper, the first major steps could be taken.

In 1973, Stanford University demonstrated the first independent, computer-controlled vehicle, the Stanford Cart. It was able to navigate a room full of chairs. Since then, most applications of automated control have been in industrial situations but some examples of the common use of sensing and actuator devices are given here.

### Traffic-light sensing devices

Traffic-light systems use computer tracking devices to automate their operation. SCATS, the Sydney Coordinated Adaptive Traffic System, monitors traffic signals. Input comes from sensors installed under the road surface.

Vehicles travelling over the sensors are counted and the traffic signals changed to meet changing traffic patterns. The sensors are wire loops containing a magnetic field. A vehicle travelling over them disturbs this field.

Maintenance and repair is ongoing, as the road surface distorts due to temperature and other changes, and this may damage the loop. The maintenance system needs to respond quickly, and this is the role of SCATS. When a sensor is found to be faulty, SCATS dials into the system and checks if the problem still exists. For example, a car parked on a sensor for a long time might send a faulty signal but the sensor is okay as soon as the car is moved. If the problem persists, SCATS loads FMAN or the fault management system. A technician responds and goes to the site to check out the problem and repair it if possible. If further attention is needed the FMAN database is upgraded to include the fault and the priority for repair (set by the technician). Next, the road is inspected by an inspector who decides whether the road surface needs to be opened. If so, a contractor is contacted to carry out the work of installing new sensor loops.

### Navigation systems in cars

Cars use automated geographical positioning systems (GPS) to help the driver to find destinations. The GPS uses satellite technology to keep an accurate record of the car's position on the globe. From that latitude and longitude it is able to calculate the best route to take to the destination input by the driver. This is done using electronic maps of cities and large towns and current data on road closures or road works downloaded using the satellite link to the main roads offices. These systems use voice feedback to reduce distractions for the driver and are able to respond rapidly to any problems such as accidents or breakdowns so that they can divert the driver to an alternative road where necessary.

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### Security system sensing devices

Home and business security systems can also use automated monitoring to track movement or change in their vicinity. Once they are activated, they use infra-red beams to cover the space to be protected. These beams are continuous and react immediately if the beam is broken by movement large enough to cause a major disruption. This then responds with an alarm and/or a back-to-base signal. A back-to-base signal transmits directly to a security monitoring station that tracks the systems in many houses and businesses. The alarm is given at the base and the base may then respond in a number of ways: by ringing the property and asking for security identification of the person answering the call, by alerting the local police to a possible problem and/or by ringing a contact number and alerting the contact to the situation.

Figure 8.28 Security camera

### Actuators and sensors to open and close doors

Automatic opening and closing of doors is now common. This requires both sensors to detect movement and actuators to operate the doors, that is, motors to carry out the tasks. There are a range of sensors depending on the cost of the system: motion sensors use infra-red beams and detect when the beam is broken, pressure sensors are used under mats and activate a switch when weight is applied to the mat located either side of the door. The doors will then respond when movement occurs using actuators such as pneumatic motors driven by compressed air that spin at a very fast rate and respond quickly.

## Innovations in robotics

### Chipification

Chipification is an off-shoot of robot development. It is the use of microchip communications to collect data and assist with identification and location. Products may contain microchip records so that their contents, shipping instructions, current whereabouts and other details can easily be read by a scanner. Robotic machines may be monitored in warehouses and their movements tracked to see how they may be reprogrammed to be more effective. Embedding microchips under the skin of animals is widespread, that is, a dog or cat may have a microchip implanted so that if the animal is lost, it can be scanned and identified. A few countries now allow microchips to be used in humans for storing personal medical records. Radio Frequency Identification Technology (RFID), that is, tracker tags may be used to find the location of criminals on home release, foreign visitors, elderly people and children. Some RFID are currently being embedded in clothing for

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marketing surveys, for example, how often jeans are worn, for how long and where they are purchased. Many of these uses may be seen as an invasion of personal privacy.

## Intelligent robotic systems

An intelligent robot is still a dream, but scientists are working to make it real. R2D2 and C-3PO in the *Star Wars* movies may be possible in the future, with human behaviour, personality and the ability to think and reason. Scientists in this area are working with artificial intelligence as well as robotics.

To achieve an intelligent robot, scientists need to considerably extend the problem-solving abilities of computers. This involves expanding the data stores so that facts are supplemented with rules that determine how facts may be used. When a computer has to make decisions it will need to go through all the possible actions or processes and decide what choice or choices will be best based on this knowledge base. The computer would be limited to the problems it is designed to solve rather than having the more generalised intelligence of human beings.

## How an intelligent robot works

An intelligent robot can recognise objects in its environment. This is done using a vision system that involves pattern recognition and tactile sensors to input touch. Pattern recognition provides the robot with a knowledge base of possible images and these are then matched with the scenes the robot encounters during its tasks. The robot can then plan actions based on recognised patterns and touch to achieve a goal. For example, work has been done in Australia on a robot that is able to shear sheep automatically. The robot has a vision system to carry out a study of the shape and size of the sheep. It is then able to build a 'model' of the sheep's body and to develop a plan for shearing that particular sheep by matching the pattern of the model to task lists that need to be done. Sensors enable the shearing head on the electronic clippers to continuously change to meet any changes in the model of the sheep's body as shearing takes place.

Learning is a very complex process and there are a number of ways a robot can be taught to learn using pattern recognition:

- imitation – a robot uses pattern recognition ability or special hardware (such as the data glove) to repeat the actions of a human
- voice recognition – inflection in a voice is seen as a pattern. Tone and voice can then be repeated by the robot.

**Intelligent robot** a robot that recognises objects in its environment.

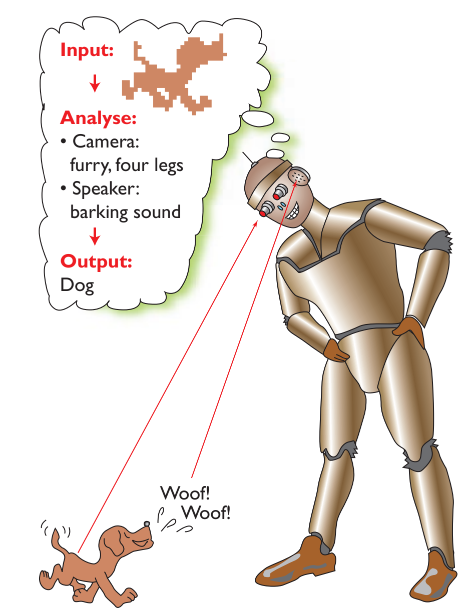


Figure 8.29 Teaching a robot

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## Try this

**Designing a robot**

Use a graphics program to design a robot to carry out a simple task such as washing up. You may consider manipulating appropriate clip art as the basis of your design. On your design or in a separate report include each of the following:

- What input hardware would be needed? (Make sure you state why each device is required.)
- What output hardware would be needed?
- Write a list of the data that would need to be included in the knowledge base stored by the robot so that it can use pattern recognition to carry out its task.

Creating an intelligent robot isn't simple. Our intelligence comes from our brain, and scientists know very little about how it functions. They know the brain has billions of nerve cells called neurones that store and learn data through electrical connections but how this works is unknown. Human-like robots are the result of constant experiments, trial and error and many failures. We still have a very long way to go.

## EXERCISE 8.7

1 What am I?
   - a I am machine control of a task or tasks.
   - b I am the first independent automated vehicle.
   - c I am the automated traffic light system used in Sydney.
   - d I am the hardware used to detect traffic movement.
   - e I am the full term for a GPS.
   - f I am the hardware used to keep car navigation systems up to date.
   - g I am a non-cable link that is broken when movement is detected in a security system.
   - h I am the process of matching stored data to data collected by sensors.

2 True or false? Rewrite each false statement to be true.
   - a Most automated control systems are used in industry.
   - b Even the repair and maintenance of SCATS is automated.
   - c Car navigation systems use technology called GPS.
   - d Voice feedback in car navigation systems reduces driver distraction.
   - e Back-to-base security systems are wired into their owner's laptop.
   - f Automatic door systems need sensors but not actuators to function.
   - g R2D2 was the first really intelligent robot.
   - h Androids are commonly used in industry.

3 Answer these questions.
   - a Name TWO sensors used to collect data for intelligent robotic systems.
   - b How does pattern recognition work?
   - c List TWO areas in which pattern recognition is being used to help a robot to 'learn'.
   - d Why does the sheep shearing robot need a vision system?
   - e How does the 'model' of the sheep help the robot know what to do?
   - f How is feedback provided as the shearing progresses?

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## Multiple choice questions

Select the best answer to each of the following questions.

1 An android is most likely to be an
A Analogue machine
B Industrial robot
C Adaptive robot
D Non-adaptive robot

2 Robots collect data from the environment using hardware known as
A Actuators
B Sensors
C Extensors
D Divisors

3 An adaptive robot is most likely to be used when there is a need to do
A Repetitive industrial tasks
B Simple exploration tasks
C Complex tasks using feedback
D Tasks requiring no feedback

4 Sets of instructions by which robots are controlled are called
A Hardware
B Arrays
C Lists
D Software

5 Possible movements a robotic limb may perform are called
A Degrees of freedom
B Repetitive actions
C Actuator functions
D Stepping rotations

6 Hardware that processes data for a robotic system is the
A Keyboard
B Screen display
C CPU
D Microphone

7 One type of actuator using electromagnets to control rotations of hardware parts is a
A Stepping motor
B Potentiometer
C Position sensor
D Solenoid

8 RAM is part of
A Co-processor chips
B Display hardware
C Primary storage
D Secondary storage

9 Specialised controllers built into many automated robotic systems are
A ALUs
B PLCs
C DPCs
D HTPs

10 One important process that works with a knowledge base to give a robotic system some degree of 'intelligence' is
A Navigation
B Programming
C Automated control
D Pattern recognition



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## Extended answer questions

Figure 8.30 covers some of the aspects of robotic systems.

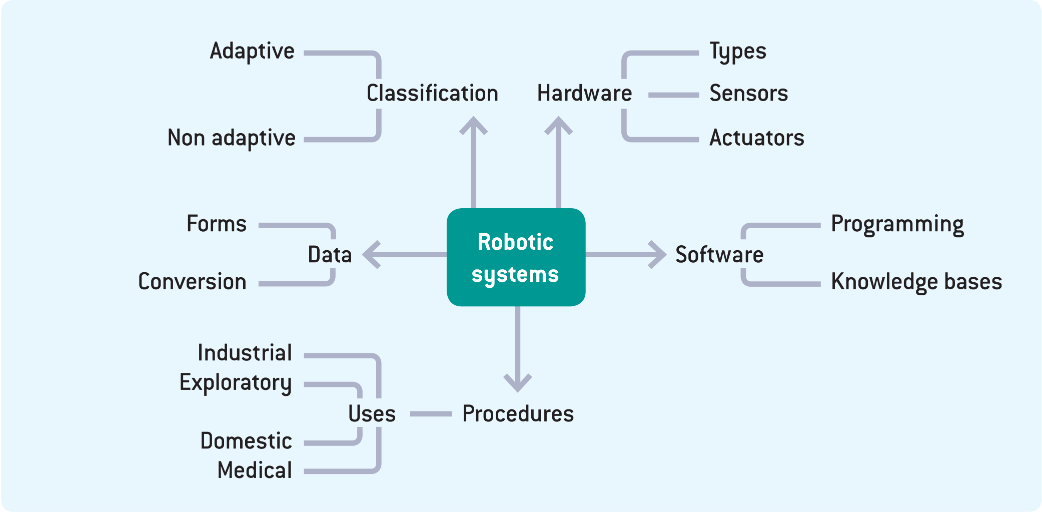


Figure 8.30

Write answers to each of the following questions:

1. List THREE types of sensors used by robotic systems.
2. Name the FIVE main parts of the CPU.
3. Which types of robotic systems need actuators?
4. How would you classify the robotic system shown in figure 8.31?
5. Redraw figure 8.31 so that it represents the other classification of robotic system.
6. When would a robotic system handle analogue data?
7. How is analogue data converted for use in a robotic system?
8. How does the fetch/execute cycle of the CPU function?
9. Provide ONE example of the industrial use of a robot.
10. Describe how intelligent robotic systems are able to learn.

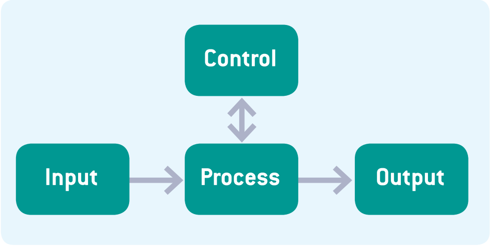


Figure 8.31

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# PROJECT 1: CREATE A BROCHURE AND/OR A WEB PAGE

## Define the problem

A number of businesses produce robotic kits. A brochure or a web page is needed to help market these kits.

## Analyse the problem

The marketing product should explain the basic concepts of robotics such as 'What is a robot?' and 'What is robotics?', and the tasks performed by robots including their ability to go where humans cannot, to do repetitious and boring tasks, to do quick and accurate assembly tasks, and their application in hobbies and toys. The marketing material should also briefly describe the design of robots including looks, sensing, movement, manipulation, energy and intelligence, and include an example of one kit available from robotic kit manufacturers such as Lego, Fischertechnik etc.

Illustrations may be drawn, scanned or gathered. Sources need to be acknowledged by the authors of the brochure or web page.

## Design a solution

The product will be produced by a team in which each team member will have one or more responsibilities in production such as authoring, editing, video, animation, photography, music and sound etc.

The team should begin the design with the following steps:

1. Write a product proposal outlining what result they wish to achieve.
2. Do market research using internet, catalogues, magazines, books, etc. and gather data.
3. Organise data into groups, for example, text, illustrations etc. Save the data in a suitable format if necessary: graphics for the web should be saved as .GIF (for animations), .JPG (for photographs) or .PNG. Graphics for publishing are usually saved as .TIF.
4. Decide on a name and a purpose for their product.

## Produce the solution

The following steps are provided to assist in developing one solution.

1. **Open** a new word processing document.
2. From the **Insert** menu, select **Table** and set the columns at 1 and the rows at 12.
3. Set up the content like this:
   a. In Row 1 of the table, type *Robots and robotics with* [insert the name of the company that makes the robot kits you are marketing].
   b. In Row 2, type *A robot is*
   c. In Row 3, type *Robotics is*
   d. Leave Row 4 empty for the moment.
   e. In Row 5, type *Tasks done by robots*
   f. In Row 6, list the tasks performed by robots.
   g. In Row 7, type *Design of robots*
   h. In Row 8, list the components of robot design.
   i. In Row 9, type *Examples of* [Business name] *kits*
   j. In Row 10, list some of the kits available.
   k. Leave Rows 11 and 12 empty for the moment.
4. Return to Rows 2, 3, 5, 8 and 10 and provide the extra information you have found from your research.
5. Highlight the text in Row 1 and format the text as **Heading 1** from the **Style** menu.
6. Highlight the text in Rows 5, 7 and 9 and format this text as **Heading 2** from the **Style** menu.



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7 **Save** the file as a Word document.
8 Select Row 4 and from the **Table** menu choose **Split Cells** and change the number of columns to 2. Also change the number of columns in Rows 11 and 12 to 2.
9 In each of the cells in Rows 4, 11 and 12, use the **Insert** menu to select **Picture...From File** and locate an appropriate illustration for each section of the document from those collected earlier.
10 **Save** the file.
11 Use the **Format** menu and select **Background...Fill Effects** to add a texture or **Gradient** fill to the background of the document. Choose a background that will not prevent the text from being easily read. Change the colour of all or some of the text by highlighting the text to be changed and using the **Font Color** palette from the toolbar or use the **Format** menu... **Font** to change the font colour.
12 **Save** the file.

**To create a brochure from your file:**

1 From the **Edit** menu, choose **Select All** to highlight the entire table.
2 From the **Format** menu, choose Borders and Shading and select the Borders setting of None. Click OK.
3 Add page numbers, author/s and document titles using headers and footers (View menu).
4 Use colour to highlight headings and key words in the brochure.
5 From the AutoShapes menu on the **Drawing** toolbar, choose **Callouts**, select a suitable callout and drag it to an appropriate position. Type text into the callout box to draw attention to the particular key concept related to robots that is appropriate in that position.

**To create a web page:**

1 Add any additional material to the file that you have collected. This may include animation, video or sound. Note: If there is any problem installing or using this additional material, please check that your machine has the necessary software installed. Some methods of adding media include:
   - Animated text (may not work in all browsers)
     - Highlight the text to be animated.
     - From the **Format** menu, select **Font**, and click the **Text Effects** tab. Choose the effect required. Be careful not to overdo this.
   - Background sound
     - Use the **View** menu...**Toolbars** to show the **Web Tools** toolbar.
     - Select the **Sound** icon. In the window for the sound, browse to find the sound file needed.
     - In the **Loop** box, enter the number of times the background sound is to repeat.
     - **Close** the Sound window.
   - Video
     - Use the **View** menu...**Toolbars** to show the **Web Tools** toolbar.
     - Select the **Movie** icon and browse to find the file.
     - You can use the **Alternate Image** box to set up a graphics file that you want to use as a substitute when the user's browser doesn't support video and/or the **Alternate Text** box to enter the alternate text that you want to appear in place of the video or alternate image.
2 From the **Start** list, select **Open** to play the video when the user downloads the web page or **Mouse-over** to play the video when the user moves the mouse pointer over the movie or **Both** to play the video either way.
3 Use the **Loop** box to enter the number of times you want the movie to repeat.
4 To check the video while you are authoring the web page, right-click the image representing the video, and then click **Play**.
5 **Save** the file as a Word document.
6 Save a copy of the file using the **Save As** command but choosing the web page or html option for the file type.



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## Evaluate the solution

Test the web page file by double-clicking the file name and launching the file in a browser. Use table 1.7 from chapter 1 to decide the value of the solution produced by the team.

# PROJECT 2: ROBOT DESIGN

## Define the problem

A simple prototype (working model) to demonstrate the function of a robot needs to be produced from a basic robot design.

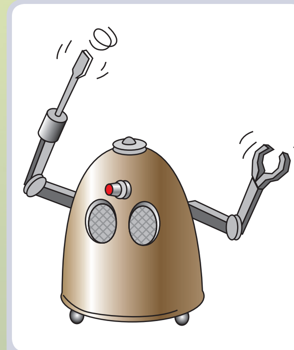

Figure 8.32 An atypical robot

## Analyse the problem

Any presentation program that has draw tools, slide timings and transition settings could be used to draw the basic outline. The model could then be turned into a working model by copying, modifying and animating the basic outline.

It is important to note that a robot does not necessarily have to resemble a human in any way. Most robots are developed for industrial use and are machines without human attributes.

## Design the solution

A storyboard (see chapter 1) should be drawn to show the basic outline of the robot. Frames, such as those in figure 8.35, could be labelled to show the changes that will take place and the linear links between the frames.

## Produce the solution

Microsoft PowerPoint is used here for the example.

1 **Open** a new presentation program.
2 Choose **Blank** slide.
3 Save the file as 'Robot Design'.
   Note: The examples given here will show a human-like robot but your robot may be very different.
4 On the first slide, use the **Draw** tools to create a robot design of your own. Restrict your drawing to an area no larger than one quarter of the slide as shown by the darker area in figure 8.33. Fill tools, 3D tools and general drawing tools will all help you give your robot some detail.

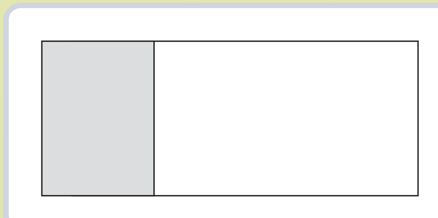

Figure 8.33 Drawing area of slide

5 Save the file regularly.
   When the robot design is completed, select all the objects on the slide by using the **Edit** menu or the keys Ctrl+A. Use the Draw menu to group the objects on the slide. This will give you one object to duplicate on the following slides.
6 Use the **Insert** menu to insert nine new blank slides.
7 Return to slide 1. Select the drawing and copy to slides 2 to 10.
8 Return to slide 2. Use a range of tools to change the position of the robot design on each slide from slide 2 to slide 10. Some suggestions include:
   - Drag to a new position slightly to the right of the last position.
   - Rotate the design using the **Rotate** tool.
   - Use the **Rotate** menu to rotate and flip the design in different ways.
   - Make sure that each change on a slide is to the right of the change on the previous slide.
9 If you are very clever, you may select the design and use the Draw menu to ungroup the objects. Each object may then be moved as shown in figure 8.34.

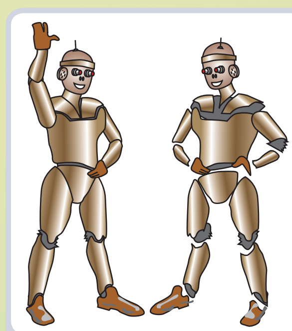

Figure 8.34 Group and ungroup objects

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The result would be a series of robot images that have various changes made to each image.

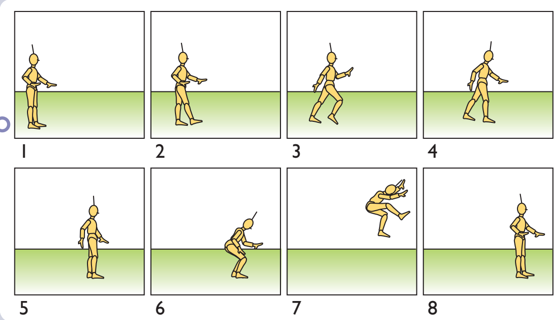

**Figure 8.35** Series of slides

10 Once the slides are completed, make sure you save the file.

A prototype is a working model of the design. This can be created using animation effects available in a presentation program.

First, set the timing and other components for the slides.

11 On the **Slide Show** menu, select **Slide Transition**. Click to select **Advance Slide Automatically** after box and type 00:01 into the time box. From the **Sound** drop-down box, choose a suitable sound such as Drum Roll. Click **Apply to All** to use these timings for every slide.

12 Use the **Slide Show** option from the **View** menu to check the timings. If you wish you can change the timings. You can also set animation options for each of the different objects on different slides using the **Slide Show** menu and the **Custom Animation** settings. **View Show** on the **Slide Show** menu will allow you to view the individual slides without a complete slide show.

When you have finished, your teacher may allow you to demonstrate your robot design and the prototype or working model of your design to others in the class.

## Evaluate the solution

A table is provided to assist individuals and class members with the criteria that they may consider using when evaluating the robot design and prototype. The marks or judgement of each category may be decided by the team members or judges. Some other evaluation criteria may be found in chapter 1.

**Table 8.8** Evaluating the robot design

| | Criteria to evaluate | Explanation |
|---|---|---|
| Robot design | Function or utility | Fitness for task or tasks<br>Ability to manufacture in suitable materials |
| | Quality | Good features, completeness |
| | Originality | Use of actuators, sensors, etc. |
| | Simplicity | No unnecessary extras |
| Prototype | Presentation | Appearance and functioning of the model |
| | Technical | Animation techniques e.g. changing images, timings etc |
| | Additional features | Innovation or differences that add to the model's functions |



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CHAPTER 9

# Software development and programming

Computers solve problems. They do so through programs written in programming languages. Like human languages, programming languages use rules that computers understand so that they can carry out the tasks set by the programs. Programs are sets of coded instructions that can be either directly understood by the computer or translated into code that can be directly understood. Each different set of coded instructions is a programming language. The only programming language that is directly understood by a computer is machine code, that is, high and low voltages that communicate instructions through electric pulses. All codes except machine code slow down the execution or running of a program as they require translation into machine code before they may be understood by the computer.

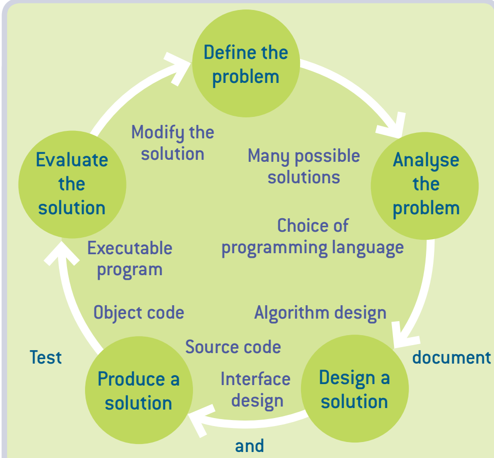

Figure 9.1 Steps in software development

## Software systems

Software is the programs or sets of instructions that perform tasks in a computer system. There are many of these sets in any computer. For example, starting the computer requires a boot or start-up program, working with programs needs an operating system and an application for the task. The software for each task may be different but the computer remains the same.

Although some software is very flexible, it is wrong to imagine that one program will do everything. That is the same as expecting a screwdriver to cut a large hole in the wall – you may be able to do some of the job with the wrong tool but it won't be done well, nor will it be easy. The computer must have the right equipment if it is to achieve its purpose, and this means a combination of the right software.

**Programs** a sequence of instructions written in a programming language, that directs a computer's actions.

### Types and examples of software

Software is of two main types: system software and application software. Most computer users treat the software as a 'black box', that is, as long as it does its job they do not need to understand how it operates. Software students have to understand how programs work – they need to treat software as a 'white box'.



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The skin or appearance of the program may be changed

**Figure 9.2** Customising software

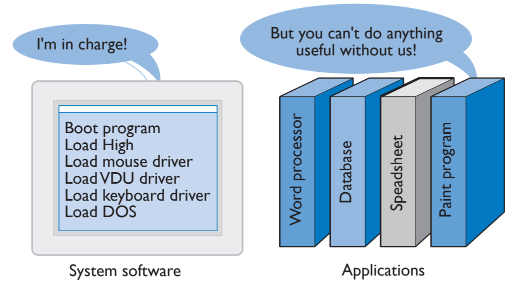


**Figure 9.3** Software for computer systems

**System software** files, utilities and resources that the computer needs to run properly.

### Great idea

Once, software came in one form and people could change very little. A great idea was to add the ability for users to customise software, that is, to actively control the way technology looks or behaves. This may be as simple as choosing the 'skin' or appearance of a monitor display or the tune played by a mobile phone when it rings, or as important as adapting a program to better meet the needs of a disabled user.

**Figure 9.4** Microsoft Windows® Vista operating system

## System software

**System software** manages or controls a computer's resources. It is essential for the computer to operate. System software provides the interface between the hardware and application software. The more the user is removed from the workings of the hardware that the system software handles, the easier or more user-friendly the program is.

**Table 9.1** Functions of system software

| Function | Description | Examples |
|---|---|---|
| Hardware support | Allows use of peripheral hardware such as printers and scanners | Programs to scan or read a hard disk to find files |
| Data access control | Allows creation, editing and recording of file locations | Programs to handle directory and folder manipulation and storage |
| Usage records | Billing programs recording users, dates, times, files | Programs to view documents by type, date or size |
| Resource management | Allocates time between tasks by switching from one task to another and back to the first task | Programs to cater for simultaneous multiple tasks such as background printing while the user works on another document |
| Security and access | Protection of system resources | Programs to control password access to files or hardware |

**Table 9.2** Types of system software

| OPERATING SYSTEMS<br>Control the operations of the computer | | UTILITIES<br>Assist the operating system in system management | |
|---|---|---|---|
| Command interface– the operating system works when the user types commands into the system | GUI – the operating system works through Windows, icons, a mouse and menus that allow the user to interact with the system | Drivers – programs that control the operation of specific peripheral devices e.g. the video card, printer etc | Specialised utilities – perform specific jobs e.g. the disk defragmenter that checks and reorganises the file saving structure on a disk to make it more efficient |

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## EXERCISE 9.1

1 Match each term in column 1 with the best description from column 2.

| Term | Description |
|---|---|
| black box | instructions that control processing |
| hierarchy | the means of carrying out operations or instructions |
| resources | software not fully understood by most users |
| interface | users of a system |
| processors | individual facts input into a system |
| procedures | programs or sets of instructions |
| hardware | general term for components needed to perform a task |
| software | diagram where the most important level of a system is at the top |
| data | physical units that make up a system |
| people | meeting point between parts of a system |

2 True or false? Rewrite each false statement to be true.
- a Computer hardware can work without software.
- b Software is often called programs.
- c Programs that start up the computer and control its operations are systems software.
- d Operating systems consist of one program.
- e Operating systems manage hardware devices.
- f An application program is the same as an operating system.
- g Application programs consist mainly of utility programs.
- h Application programs do not need operating systems in order to work.

3 Answer the following questions in full sentences.
- a Name THREE jobs done by systems software.
- b List FOUR peripheral devices that require a driver.
- c Provide TWO specific examples of utility software.
- d Name TWO different types of operating systems.

### Application software

Application software is written to solve users' problems by carrying out specific tasks, for example, word processors, computer games, spreadsheets and databases. An application program will only work if it has hardware to carry out its task and an operating system to carry out instructions for many of its commands and to boot up or start the system. The information created from an application is usually stored in a file. Each different application has its own file types, for example, a word-processor application creates and changes word-processor files. Files can sometimes be shared with other programs.

Application software software that performs a specialised task.

Custom software and off-the-shelf software are two main types of applications. *Off-the-shelf* software is ready-made general programs purchased

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**Figure 9.5** Drafting applications used by architects

to solve various common problems such as a database shell. There are a wide range of such programs available. Many of them can be customised to meet the specific needs of a user.

### Application standards

In the past, each computer platform was mainly independent of other platforms. For example, Apple Macintosh software worked on a Macintosh and not on other computers that used Microsoft Windows. Standards developed so that software and data created by a particular type of software could be easily moved to other computers or devices. One standard used for software has been SGML or Standard Generalised Markup Language. SGML is the international standard for setting out the structure and content of electronic documents, such as those used on the internet. It is compatible with almost any computer system.

**Open source** software for which the creators have made the source code of the program available to users and those who wish to collaborate to improve the software function.

### Open source software

**Open source** software creators make the source code of the program available to users and those who wish to collaborate to improve the software functions. It is not always free software but the licence fees for its use are often much cheaper than other types of software on the market. Open source is seen as a challenge to established multinational software companies. Some examples of open source programs include OpenOffice Writer (word processor), OpenOffice Calc (spreadsheet), OpenOffice Base (database), OpenOffice Impress (multimedia), OpenOffice Draw (graphics), Firefox (web browser) and OpenOffice 2.

For example, Firefox is a free open source internet browser. It is multi-tasking, protects the system against viruses, spyware and pop-ups, and works well with blogging software (see the glossary and chapter 6). Firefox lets the user keep track of several pages or sites at once and view them in a single browser window. Open source software collaboration often introduces new ideas that are then taken up by multinational software companies.

#### Great idea

**A web application is software accessed with a web browser over the internet or intranets. Web applications are easy to update and maintain as individual copies of software do not need to be distributed and installed on numerous computers. They may be used for email, online commerce, wikis, discussion boards, blogs and many other purposes. Yahoo mail and Hotmail are two examples.**

## Data handling

Data is the raw material of all programs and their code. All software handles data in binary code, that is, digital data.

### Bits and bytes

Binary code is a series of 1s and 0s, each called a bit. Most measures of storage capacity and transmission rates between computers are in terms of bits or multiples of bits:

| | | |
|---|---|---|
| 8 bits | = | 1 byte |
| 1 kilobyte (K) | = | 1024 bytes |

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| | | |
|---|---|---|
| 1 megabyte (MB) | = | 1024 kilobytes |
| 1 gigabyte (GB) | = | 1024 megabytes |
| 1 terabyte (TB) | = | 1024 gigabytes |

The calculation of computer data is very different from the way in which we normally use terms such as 'kilo'. When we discuss a kilogram as a measurement of weight or a kilometre as a measurement of distance we are using the base 10 number system. Calculations using a base 10 number system give us results such as 1000 grams = 1 kilogram or 1000 centimetres = 1 kilometre. Because there are only two possibilities (0 and 1), computers use a *base* 2 number system to measure all data storage. This gives a different result when storage calculations are made, because $2^{10}$ = 1024, that is, 1024 bytes are needed to store 1 kilobyte. We must be very careful not to confuse computer storage with the terms used for other types of measurement.

Complex combinations of 1 and 0 are used to represent characters. Each character is a series of 1s and 0s called a *byte*. A byte is usually made up of 8 bits (eight 0s or 1s). Bytes are grouped together to form words. A computer *word* is defined as the number of bits that make up a common unit of information, that is, the number of bits that can be processed in one operation by the CPU that moves bits around the system one word at a time. The larger the number of bits in a word the faster a computer can operate. Very slow PCs may have only 8 bits in a word, but faster computers will have 128-bit words or larger.

Figure 9.6 A digital video camera captures analogue data and converts it to digital forms.

## Data coding

To store and then use data, a computer needs to convert the data into a binary number or code. So that computers use data in a common form, sets of rules or codes for converting data have been accepted in most countries. The most common standard code used to represent characters as binary data is called ASCII – American Standard Code for Information Interchange.

In ASCII, each character is coded as one byte. Standard ASCII represents characters as a series of 7 bits. For example, the 7-bit ASCII code for the letter D is 1000100, that is, 1000100 = ON OFF OFF OFF ON OFF OFF. Using a 7-bit code allows standard ASCII to represent 128 characters ($2^7$).

If ASCII is expanded to 8 bits it is known as Extended ASCII and it can represent 256 ($2^8$) characters including symbols and foreign language letters. ASCII can also be expanded to 8 bits to check for errors. The extra bit is called a *parity bit*.

Normally the smallest amount of data that the computer can use is the byte (8 bits). Each ASCII character code requires one byte of storage. For example, a name such as JUNE contains 4 characters, and each character

**Binary code** a base 2 number system which is used to represent the two states of data in a digital computer, commonly referred to as ON or OFF.

**ASCII** the standard protocol used to code text in a personal computer.

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requires one ASCII code or one byte of storage. The name JUNE would need 4 bytes.

- Codes 0 to 31 are reserved for use by the computer
- Code 32 is a space
- Codes 33 to 128 are common characters: letters, numbers and symbols

With Extended ASCII, when the code has 256 rather than 128 characters, the codes from 129+ are often different from system to system

Another code, mostly used on mainframe computers is EBCDIC or Extended Binary Coded Decimal Interchange. EBCDIC is an 8-bit code.

**Table 9.3** ASCII chart (8-bit code) for letters

| Character | Binary code | Character | Binary code |
|---|---|---|---|
| A | 01000001 | a | 01100001 |
| B | 01000010 | b | 01100010 |
| C | 01000011 | c | 01100011 |
| D | 01000100 | d | 01100100 |
| E | 01000101 | e | 01100101 |
| F | 01000110 | f | 01100110 |
| G | 01000111 | g | 01100111 |
| H | 01001000 | h | 01101000 |
| I | 01001001 | i | 01101001 |
| J | 01001010 | j | 01101010 |
| K | 01001011 | k | 01101011 |
| L | 01001100 | l | 01101100 |
| M | 01001101 | m | 01101101 |
| N | 01001110 | n | 01101110 |
| O | 01001111 | o | 01101111 |
| P | 01010000 | p | 01110000 |
| Q | 01010001 | q | 01110001 |
| R | 01010010 | r | 01110010 |
| S | 01010011 | s | 01110011 |
| T | 01010100 | t | 01110100 |
| U | 01010101 | u | 01110101 |
| V | 01010110 | v | 01110110 |
| W | 01010111 | w | 01110111 |
| X | 01011000 | x | 01111000 |
| Y | 01011001 | y | 01111001 |
| Z | 01011010 | z | 01111010 |

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**Table 9.4** ASCII code for numbers and other characters

| Character | Binary code | Character | Binary code |
|---|---|---|---|
| 0 | 00110000 | space | 00100000 |
| 1 | 00110001 | ? | 00111111 |
| 2 | 00110010 | + | 00101011 |
| 3 | 00110011 | * | 00101010 |
| 4 | 00110100 | = | 00111101 |
| 5 | 00110101 | ! | 00100001 |
| 6 | 00110110 | . | 00101110 |
| 7 | 00110111 | | |
| 8 | 00111000 | | |
| 9 | 00111001 | | |

## EXERCISE 9.2

1 What am I?
   a I am off-the-shelf and customised programs written to perform a task for the user.
   b I am a set of instructions written to manipulate numerical data.
   c I am the paperback that usually comes with a program to explain how it works.
   d I am the meeting point between system components.
   e I am any set of instructions written to perform a task in the computer.
   f I am the physical devices without which a program will not operate.

2 How many bytes are required to store each of the following?
   a HOWARD
   b Howard
   c Jennifer
   d 3
   e You are here.

3 Decode the following from 8-bit ASCII to text. (Note that in this, spaces have been included between the bytes for your convenience. In the computer the string of digits would be continuous, perhaps with a parity bit – to detect errors – also included.)

   01001101 01010010 00100000 01000011 01001000 01000101 01001100 01000101 01010011 01001011 01001001 00100000 01010100 01000101 01000001 01000011 01001000 01000101 01010011 00100000 01000011 01001111 01001101 01010000 01010101 01010100 01001001 01001110 01000111

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exercise 9.2 continued

4 True or false? Rewrite each false statement to be true.
  a The binary digits 0 and 1 are each called a bit.
  b A group of 8 bits is known as a gigabyte.
  c A group of 1024 bytes is called a terabyte.
  d A group of 1024 kilobytes is called a megabyte.
  e A group of 1024 megabytes is called a byte.

5 Explain the difference between 7-bit ASCII and 8-bit ASCII.

6 Give the full name of the most common code used to represent binary code in the computer system.

## Converting binary code to decimal

The most common number system used by people is the decimal number system – a base 10 number system. As computers use the binary number system (base 2) it is necessary to convert binary data from decimal to binary so that it can be used and from binary to decimal so that data can be decoded for output to the screen or other device so that users find it easy to read.

Binary numbers are converted to decimal numbers in the following way. Each binary digit in a binary number represents ascending powers of 2 as we move from right to left.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1024 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| $2^{10}$ | $2^9$ | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |

Using this table, a binary number can be converted to its decimal equivalent:

*Example:* Binary number – 10011001

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1024 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| $2^{10}$ | $2^9$ | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| | | | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |

1 indicates that we include that power of 2 in our total
0 indicates that we don't include that power of 2 in the total
Thus: 10011001=128 + 0 + 0 + 16 + 8 + 0 + 0 + 1 = 153

## Using the hexadecimal number system

Binary numbers are valuable for computer use, but people find them very difficult to work with as long strings of 1s and 0s are hard to follow. Programmers writing code for computers to use find it very difficult to work with huge print-outs of hundreds of thousands of 1s and 0s. The hexadecimal number system makes this process a little easier and improves the storage of data in the computer.

The hexadecimal number system is a base 16 number system made up of sixteen digits – 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F. To represent

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a byte, the 8 bits of a byte are divided into two groups, each called a *nibble*. Each group of 4 bits or nibble is then represented by a hexadecimal digit. This means that the 8 digits in a binary number can be reduced to 2 digits in hexadecimal.

**Table 9.5** Examples of binary and hexadecimal numbers

| Character | Binary code | Hexadecimal | Character | Binary code | Hexadecimal |
|---|---|---|---|---|---|
| A | 1000001 | 41 | 1 | 0110001 | 31 |
| C | 1000011 | 43 | 2 | 0110010 | 32 |
| J | 1001010 | 4A | 3 | 0110011 | 33 |
| m | 1101101 | 6D | 4 | 0110100 | 34 |
| s | 1110011 | 73 | 5 | 0110101 | 35 |

## EXERCISE 9.3

1 Convert the following binary numbers into decimal numbers. Each binary number is a nibble (half a byte or 4 bits).

Binary numbers

| 8 | 4 | 2 | 1 | These are the column values for the binary numbers |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | |
| 0 | 0 | 1 | 0 | |
| 0 | 0 | 1 | 1 | |
| 0 | 1 | 0 | 0 | |
| 0 | 1 | 0 | 1 | |

2 Convert the following binary numbers to decimal numbers. Each binary number is in 7-bit ASCII code.
   - a 1001010
   - b 1010111
   - c 0101110
   - d 1000110
   - e 1001111

3 What is a nibble?

4 True or false? Rewrite each false statement to be true.
   - a The smallest unit for storing data, either a 0 or a 1, is called a byte.
   - b A bit generally consists of eight bytes.
   - c A bit is smaller than a byte.
   - d A word is the number of bits that can be processed by the CPU at one time.
   - e A 32-bit word size is larger than a 64-bit word size.
   - f ASCII is the standard coding method used by personal computers.
   - g Mainframes use a code call EBCDIC.
   - h ASCII stands for Australian Code for Information Interchange.
   - i 7-bit ASCII code can represent 128 characters.
   - j No personal computer uses more than the 7-bit ASCII code for data.

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exercise 9.3 continued

5 Users may have a number of problems with software. Match the problem in column 1 with the most likely solution from column 2.

| Problem | Possible solutions |
|---|---|
| A file does not open with the programs you have. | At the operating system level view by date to list documents most recently used. |
| The hard disk is full when you try to save a file. | Become familiar with file extensions or icons and view files by type to find the file for which you are looking e.g. wps or .doc for word processing files, .gif and .jpg for graphics |
| You can't remember the name of the document you created when you last used the computer. | Delete old, unwanted or temporary files and try again. |
| You have been losing saved documents or files on a regular basis. Your programs are behaving in an unusual manner. | Put the file on a portable disk and take it to a machine that has the program you need. |
| You have a large number of files on your hard disk and cannot tell their content. | Obtain recent anti-virus definitions (from the internet if possible) and scan the disk. |
| The large number of files on your hard disk is making it difficult to find files. | Organise your files into a hierarchy of folders with appropriate labels. |
| You need to locate a particular type of file. | Rename the files according to their topics. |

## Basic programming concepts

A problem definition is an exact statement of the problem and a knowledge of the way in which a computer can help solve the problem.

All computer programs start with a problem that needs to be solved. A problem definition is an exact statement of the problem and a knowledge of the way in which a computer can help solve the problem.

### Input, process, output

To understand any problem, it is necessary to analyse or study input, processing and output.

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**Table 9.6** Components of a problem solution

| Component | Description | Example |
|---|---|---|
| Input | An exact list of data to be input into the computer | Input can include the kind of data (such as numbers, letters) and/or the way in which the data will be put into the computer, such as a keyboard or DVD. |
| Process | The change or conversion of input into meaningful data | Processing rules may be decisions such as the number of chances a user should be given in a game or whether to add numbers rather than subtract them. |
| Output | An exact list of the output needed and the way it is to be presented | Data can be displayed on the screen (soft copy), on paper (hard copy) or in the movement of devices such as robots or computer controlled machinery. The human interprets the data as information. |

The problem definition is most important – if it is not exact then planning a solution to the problem will be impossible. Techniques can be used to make sure the problem is clearly understood.

**Refinement** is the process of dividing a problem into its sub-problems. The hierarchy, or the levels of the problem, helps to make the components of the problem clearer. For example, a small program is needed by a bookstore to store the title and publisher of each book sold and to produce a weekly report sorted by publisher with the total of each title sold. This problem can be refined by drawing a hierarchy, as shown in figure 9.7.

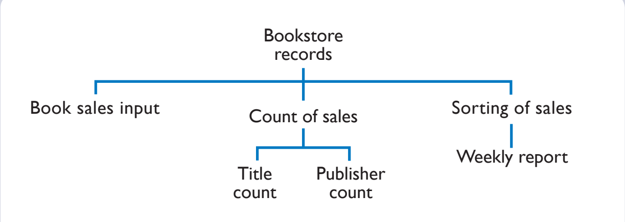


Figure 9.7 The bookstore problem

**Prototyping** is the development of a working model of the solution to the problem. The model will have inputs and outputs, but will be a simplified version of the solution. It will help users both to understand the problem more fully and to develop a solution that solves the problem.

It is also important to know the various tools that will help to solve a problem.

**Refinement** is the process of dividing a problem into its sub-problems.

**Prototyping** developing of a working model of the solution to the problem.

**Table 9.7** Tools used in programming

| Tool | Description | Example |
|---|---|---|
| Reserved words | Words that perform tasks in a programming language and cannot be used for other purposes | In BASIC language the word PRINTdisplays the following data on the same line: e.g. PRINT "A" displays A |
| Functions | Functions perform specific tasks. They are either built into the programming language or user specified. | A function to capitalise every word in a line of text |

continued >

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| | | |
|---|---|---|
| Assignment statements | Methods of giving a value to an item in a program, that is, producing a result of some kind | X:=Y where X is the item and Y is the value assigned to X |
| Variables | Holders of values that change during the execution of a program | N=V allows N to take the value of whatever data is held in V at that point in the program |
| Constants | Holders of values that remain the same during the execution of a program | N=5 means that N will always take the value of 5 in that program |

## EXERCISE 9.4

1 What am I?
   a I am a working model of a solution to a problem.
   b I am a string of binary digits carrying out a task in a computer.
   c I am the term used for the way data is to be presented.
   d I am a process used to divide a large problem into smaller problems.
   e I am the only language understood by a computer.
   f I am used in programming to carry out a specific task in a program.
   g I hold values that will change as the program is run.
   h I am another way of saying 'run a program' or make a program operate.
   i I am used to give a value to an item in a program.
   j I hold data that will not be changed as the program runs.

2 Refine the following problem by writing and numbering each step needed to communicate to another person the way to draw a two-dimensional basic house exactly like the one drawn here. The instructions below will help you.

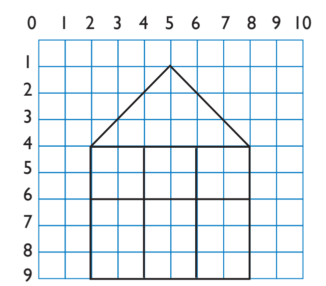

Figure 9.8 House grid

   a Refine the problem by breaking it up into steps. Three possible steps are: roof, walls and windows and door.
   b Write a set of procedures to complete each step. One procedure for Roof could be: place pencil on coordinate (2, 4), draw straight line from coordinate (2, 4) to coordinate (5,1), draw straight line from coordinate (5,1) to coordinate (8, 4), lift pencil.
   c Complete the other procedures.
   d Join your procedures together to solve the whole problem.
   e Test your solution by giving the instructions to at least two other people who are not in your class. Check the results from each person. If the results from each person are not identical to the original drawing, revise the steps you took to solve the problem until each solution is exactly the same.

Note: There may be many different solutions to the same problem. The only criteria for success is whether the solution SOLVES the problem.

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## GUI layout

GUI or graphical user interface is the user-friendly display standard that allows functions to be accessed through windows, icons and menus by using a mouse. Many programming language environments use GUIs to enable the creation of GUI programs. This has the following advantages:

- simpler and easier to use
- faster program development
- more complex program development by 'novice' programmers

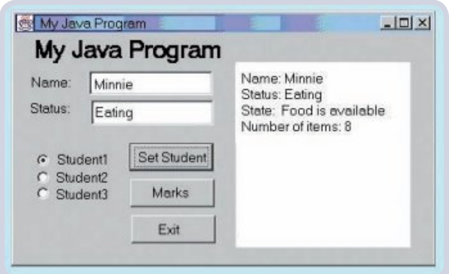


**Figure 9.9** Java programming language—GUI development window

## Graphics tools

Graphics tools in GUI programming environments enable the easy and rapid creation of graphic objects on a screen. Objects in a GUI programming environment can be inserted in a program under development to save time and make it easier for an inexperienced programmer.

**Table 9.8** Some objects available to programmers in a GUI environment

| Object | Use in programming |
|---|---|
| Command button | A graphic object usually labelled with text to indicate its function. Buttons usually perform an instantaneous action to initiate an action when clicked. |
| Radio button | Choice button to allow one choice from each group of choices |
| Check box | Choice button to allow more than one choice from each group |
| Cursor | Used to indicate the state of the system (watch or hourglass cursors indicate a short pause, for example), or a change in the interactive possibilities offered by the interface (like the window resize arrow cursors that appear at the edges of windows) |
| Dialog box | Special windows that pop up to provide information or choices to the user. Dialogue boxes are usually modal, that is, they must be dismissed (with the 'Cancel' or 'OK' buttons) before further action can take place. Some dialogue boxes provide many buttons, pop-up menus, or other choices; others may just contain a text message with an 'OK' button used to dismiss the dialogue box. |
| Text boxes | Objects that contain text. These may be static or scrollable to hold text off the screen that may be user activated to bring the rest of the text to the display. |
| List boxes | A form of menu in which options are shown as a static or interactive list (hot link to other data) |

## Data types

Programs and interfaces are developed from data or raw facts. Data comes in many different forms.

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**Table 9.9** Data types used by programmers

| Type | Description | Storage | Example |
|---|---|---|---|
| Character | Smallest item of meaningful data – a letter, number, symbol or punctuation mark | Stored as 1 byte (usually 8-bit ASCII) | 9 or S or @ |
| Numeric data | Integer (whole number); can be + or - | Most are stored as 2 bytes (2 x 8 bits). A 16-bit machine can store $2^{16}$ integers (65 536 different combinations). | 2 |
| | Real (floating point or fractional numbers): can also be + or - | Stored as a number of bytes for each part. The integer part is the exponent and the decimal part is the mantissa. | 3.1975 |
| String | A sequence of characters with a single identity | Each character is usually stored as one single byte. Maximum length of a string is usually 255 characters on older systems. | Hello programmer! |
| Boolean | A variable which has only two possible outputs | May be stored as one bit (0 or 1). | + or -, T or F |

*Variables* are among the most important data types and can be characters, numbers, string or Boolean. In a program, each variable needs to be unique so that it is not confused with other variables. As well, meaningful names should be given to variables and other data types so that their purpose can easily be understood from their name. For example, Surname makes sense as a variable name but Variable1 means little. The variable Surname can then be used to hold data that changes during the program. For example, Surname might hold Innes at the start of the program and Zeiger at the end.

## Data operators

Data operators allow data to be manipulated.

Data operators allow data to be manipulated.

### Relational operators

Relational operators allow two values (characters, strings, variables) to be compared and return the result as either true or false.

**Table 9.10** Examples of relational operators

| Relational operator | Meaning | Example | Output |
|---|---|---|---|
| = | Equal to | More_marks=Yes | True or false |
| <> | Not equal to | Total<>Percent | True or false |

continued >

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| | | | |
|---|---|---|---|
| < | Less than | Mark1<Mark2 | True or false |
| > | Greater than | Temperature>30° | True or false |
| <= | Less than or equal to | Lines<=50 | True or false |
| >= | Greater than or equal to | Number>=100 | True or false |

Make sure that you understand the difference between an assignment statement and the equal to operator. The assignment statement is used to assign a value to a variable (Total:=5) whereas the equal sign is used to compare two values or variables (Total=5 determines if the value of total is equal to 5 and returns True if it is and False if it isn't).

## Logical operators

Logical operators are used to compare logical values and return true or false.

**Table 9.11** Examples of logical operators

| Logical operator | Use of operator | Example |
|---|---|---|
| NOT | Changes a value to its opposite | A :=NOT B changes A to false if A is true |
| AND | Both must be true or both false to return true | A:=B AND C returns true if B AND C are both true or both false |
| OR | One value must be true to return true | A:=B OR C returns true if either B or C are true |

## Arithmetic operators

Arithmetic operators are the basics of calculations. The output is always a number. Calculations are carried out in the same order as standard mathematical calculations.

**Table 9.12** Arithmetic operators

| Arithmetic operator | Meaning | Example | Explanation |
|---|---|---|---|
| + | Add | Total:=Mark1+Mark2 | Mark2 is added to Mark1 and the value assigned to the variable Total |
| - | Subtract | AmtOwed:=Balance-Paid | Subtract Paid from Balance to get value of AmtOwed |
| * | Multiply | C:=A*B | Find the value of C by multiplying A times B |
| / | Divide | Percent:=(2/4)*100 | The value of Percent is equal to 2 divided by 4 and the result multiplied by 100 |

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| | | | |
|---|---|---|---|
| ( ) | Group | Convert Fahrenheit degrees to Celsius degrees: TempC:=(TempF-32)/1.8 | Subtracts 32 from the value in the variable TempF, divides the result by 1.8, and then stores the result in the variable TempC |

## EXERCISE 9.5

1 Name FIVE objects from the following menu that are available for use in a GUI programming language and explain the use of each of the named objects.

Figure 9.10 GUI objects

Note: Microsoft Word...View menu...Toolbars will allow you to investigate this type of GUI environment further.

2 Complete the following paragraph with the best choice of words from the list.

| | | |
|---|---|---|
| Boolean | character | cursors |
| data | graphical user interface | integers |
| novice | objects | real numbers |
| string | text | user friendly |

GUI or (a) ___ is a (b) ___ programming environment which is simple and easy to use for (c) ___ or beginning programmers. This type of programming allows the programmer to place (d) ___ into their programs such as buttons, (e) ___ boxes and (f) ___. They also allow the use of a wide range of (g) ___ types. The smallest item of meaningful data used in any program is a (h) ___. Numeric data may be either (i) ___ or (j) ___, also called decimals. Any series of characters is known as a (k) ___ with a special use of variables called the (l) ___ data type used to hold only two possible outputs, such as Yes and No.

3 Copy the table below. Complete the table with a unique name to identify the item in the first column and the data type you would use to store the data. An example is given in the first row.

| Data to be handled | Unique identifier (Variable name) | Data type |
|---|---|---|
| Example: Your first name | Example: FirstName | Example: String |
| Number of students | | |
| Your birthday | | |
| Test results | | |
| Your gender | | |

An **algorithm** is a series of detailed instructions or steps that will solve a problem in a set amount of time.

## Algorithms

Once you have some understanding of the basic components of program development, it is time to consider how problems are solved. An **algorithm** is a

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series of detailed instructions or steps that will solve a problem in a set amount of time. Algorithms are used to solve problems in a logical way. Designing a solution using an algorithm is a way of avoiding vague solutions.

All algorithms have the following characteristics:

- They are finite, that is, they always have an end.
- They solve problems using standard constructs or methods.
- They use precise steps.
- They are designed to describe a problem in a way that will always be understood to mean the same thing.

## Examples of algorithms

Algorithms are commonly used in our daily life.

**Table 9.13** Common uses of algorithms

| Use | Description | Example |
|---|---|---|
| Appliance instructions | A logical set of steps to operate a machine | Microwave instructions |
| Recipes | A logical set of steps to cook an item | Cake recipe |
| Directions | A logical set of steps to arrive at a location | Map coordinates |
| Repair manuals | A logical set of steps to repair an item | Car maintenance manuals |

### EXERCISE 9.6

1 An algorithm written to use a microwave has the following statements. Place these statements into logical order.
Close microwave door
Open microwave door
Place the food into the microwave
Plug the microwave into the power
Press Start
Remove food when timer rings
Select time

2 Describe the problem in understanding the following sentence:
'Go to the table where the telephone is ringing and pick it up.'
Rewrite the sentence so that the meaning is clearly understood

3 Why is the following sentence vague?
'Bake the cake until the cake is cooked.'
Use basic English to write a better algorithm for the problem by following these steps:
What are the inputs?
What processing has to be carried out?
What are the outputs?

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## Representing algorithms

There are accepted methods or standards of representing algorithms so that problem solutions are easily understood by all who use them. One method is *pseudocode*, a precise way of using the English language to write solutions to problems in text. Another method is to use diagrams such as flowcharts to graphically describe the steps needed to solve a problem.

### Pseudocode

Pseudocode a precise form of English that uses keywords and rules of structure.

Pseudocode is a very precise form of English. There are keywords and rules of structure that must be used.

**Table 9.14** Common pseudocode keywords

| Keyword | Meaning |
|---|---|
| BEGIN<br>END | To start a program<br>To finish a program |
| INITIALISATION<br>END INITIALISATION | To set any values at the start of a program<br>To end the values section |
| BEGIN SUBPROGRAM<br>END SUBPROGRAM | To start a subprogram<br>To end a subprogram |
| IF <condition> THEN<br>ELSE<br>ENDIF | To allow selection or choice<br>For another choice (may not be needed)<br>To end the choice |
| CASEWHERE <condition> OTHERWISE<br>ENDCASE | To allow for many choices<br>To end the choices |
| WHILE <condition><br>ENDWHILE | To begin a loop at the start of a sequence |
| REPEAT<br>UNTIL <condition> | To begin a loop at the end of a sequence |

The rules for using pseudocode include:

- Keywords are written in capitals.
- Basic keywords come in pairs, for example, for every BEGIN there is an END, for every IF there is an ENDIF.
- Indenting is used to show the structure in the algorithm.
- The names of subprograms are underlined.

### Flowcharts

Flowcharts a pictorial method of describing algorithms using a set of symbols, connecting lines and arrows.

Flowcharts are a pictorial method of describing algorithms using a set of symbols, connecting lines and arrows.

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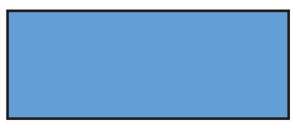
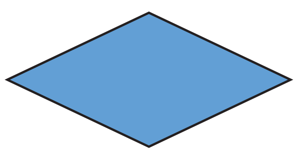
Terminator

A terminator (begin or end)



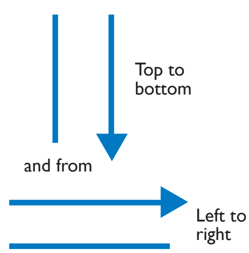
Process box

A process (an action to be performed)



Decision diamond

A decision (choice to be made)




Flowlines

The flow of control is shown by connecting lines along which the flow normally passes, from top to bottom and from left to right, unless otherwise shown by arrowheads on the lines.

Subprogram

A subprogram (a minor program that forms part of the main program but which is developed separately)

**Figure 9.11** Common flowchart symbols

The rules for flowcharts are:

- There is only ever one way into a flowchart structure and one way out.
- A single flowchart should fit on one page. If the flowchart doesn't fit on one page, then subprograms should be used.

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## EXERCISE 9.7

1 Write answers to the following questions.
  a What is an algorithm?
  b How is pseudocode different from flowcharts?
  c When would an arrow be used in a flowchart?

2 Draw up a table using the structure given. Complete the table to show the different rules used by pseudocode and flowcharts.

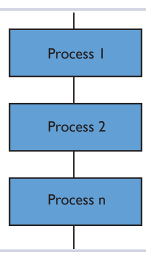
| Meaning to be shown | Pseudocode keyword | Flowchart symbol |
| --- | --- | --- |
| Begin a problem solution | | |
| Make a simple choice | | |
| Start a subprogram | | |
| Make a choice from many choices | | |
| End a problem solution | | |

3 True or false? Rewrite each false statement to be true.
  a Algorithms are a never-ending series of steps to solve a problem.
  b The steps to solving a problem can be carried out in any order.
  c Algorithms are only written to solve computer problems.
  d 'Good' algorithms are produced when the problem to be solved is thoroughly understood.
  e There is only one correct solution to every problem.
  f Once a problem is solved there is no need to modify the solution.

**Control structures** standard structures that control the logic flow of an algorithm or program.

**Pseudocode sequencing** | **Flowchart sequencing**

```
BEGIN
    Process 1
    Process 2
    ...
    Process N
END
```




Example of making a pot of tea

```
BEGIN
    Fill a kettle with water
    Boil the water in the kettle
    Place tea leaves in the pot
    Pour boiling water into
        the pot
END
```

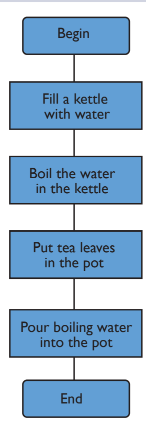



**Figure 9.12** Writing sequences

## Control structures

**Control structures** are standard structures used in an algorithm to show the order in which statements are carried out. There are three basic control structures:

- Sequencing (or steps)
- Selection (or choice)
- Repetition (or loops)

### Sequencing

Sequencing is the most common form of control structure. Each step of the algorithm is carried out in order of its position. Each step is done only once. A simple way of writing sequencing is:

```
Do this
Do that
Do the next thing...
```

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## EXERCISE 9.8

1 A pseudocode algorithm is provided which will allow the user to input two whole numbers and output the sum of the two numbers.

```
BEGIN
   Get 2 numbers
   Store in num1 & num2
   Calculate sum (num1 + num2)
   Output sum
END
```

Write the flowchart algorithm to solve the same problem.

2 Figure 9.13 shows a sequence of steps involved in buttering and eating a slice of bread. Write the pseudocode algorithm to solve the same problem.

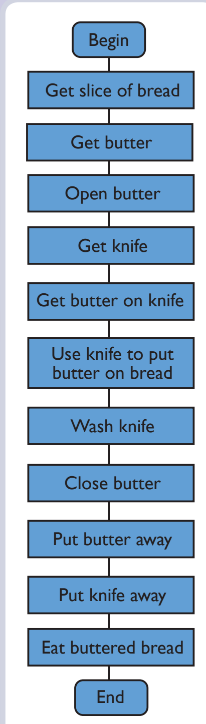



**Figure 9.13**
Flowchart algorithm

## Selection control structures

Selection allows a choice to be made in an algorithm. Selection decides which particular answer from a set of available answers is to be carried out next. There are two types of selection control structures:

- binary selection – where there is a choice between two possible answers
- case selection (also called multiple selection) – where there is a choice between many possible answers

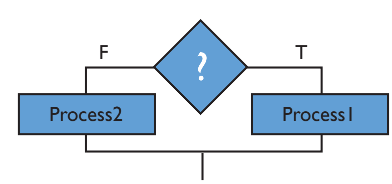
### BINARY SELECTION

Binary selection allows the choice between two possible paths. If the condition is met then one path is taken, otherwise the other possible path is taken.

**Pseudocode binary selection**

```
IF <condition> THEN
   Do this (Process1)
   ELSE
   Do that (Process2)
ENDIF
```

**Flowchart binary selection**




The condition is checked and if the result is TRUE then process1 is carried out. If the result is FALSE then Process2 is carried out.

**Figure 9.14** Writing binary selection

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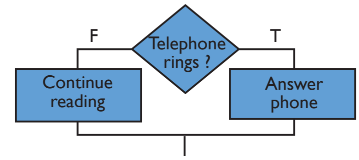
**Pseudocode binary selection** | **Flowchart binary selection**

```
IF the telephone rings THEN
   Answer the phone
   ELSE
   Continue reading
ENDIF
```




The condition (is the telephone ringing?) is checked and if the result is TRUE (yes) then Process1 (answer the phone) is carried out. If the condition is FALSE (no) then Process2 (continue reading) is carried out.

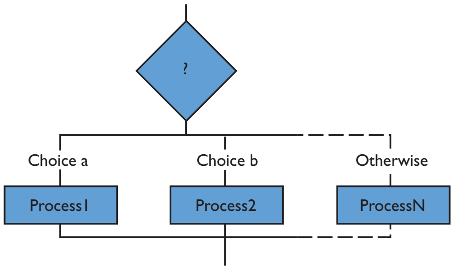
**Figure 9.15** Example of binary selection for answering the phone

## CASE SELECTION

Case or multiple selection allows choice between three or more possible paths when solving a problem. If the condition is met (TRUE) then one path is taken, otherwise one of the other possible paths is taken. (Note: only one process is carried out.)

**Pseudocode algorithm** | **Flowchart algorithm**

```
CASEWHERE <condition> OF
   Choice a: Process1 (Do this)
   Choice b: Process2 (Do that)
   ............ (Do the other)
   OTHERWISE: ProcessN (Do something else)
ENDCASE
```

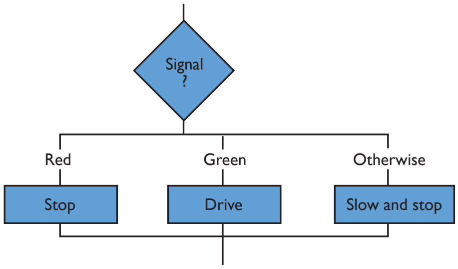



The condition is checked and if the first choice (choice a) is TRUE (Yes) then Process1 is carried out. If the condition is FALSE (No) then choice b is checked against the condition. If no choice is found to be TRUE then the otherwise process will be carried out.

**Figure 9.16** Writing case selection

**Pseudocode algorithm** | **Flowchart algorithm**

```
CASEWHERE traffic light is
   Red: Process1 (Do this)
   Green: Process2 (Do that)
   OTHERWISE: Slow down and prepare to stop
ENDCASE
```




The condition (the colour of the traffic light) is checked and if choice a (red) is TRUE (Yes) then Process1 (Stop the vehicle) is carried out. If the condition is FALSE (No) then choice b (Green) is checked against the condition. If the condition is TRUE then Process2 is carried out (Drive through intersection). If no choice is found to be TRUE then ProcessN (slow down and prepare to stop) will be carried out.

**Figure 9.17** Example of case selection (traffic signals)

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## EXERCISE 9.9

1 Complete these algorithms using binary selection.

a A set of instructions to follow when driving toward a set of traffic control lights. Pseudocode algorithm:

```
IF lights are green THEN
   drive through the intersection
   ELSE
   ________________________
ENDIF
```

b Flowchart algorithm for the same problem (use figure 9.18):

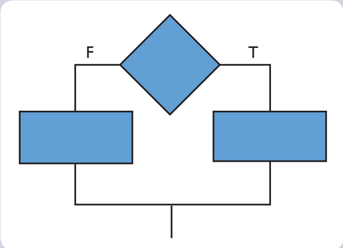


Figure 9.18

2 A test situation exists which will assign pass or fail results to test marks. A score of 50 marks or over will be a pass. The flowchart algorithm in figure 9.19 is almost finished. Complete the algorithm and then write the pseudocode algorithm to solve the same problem.

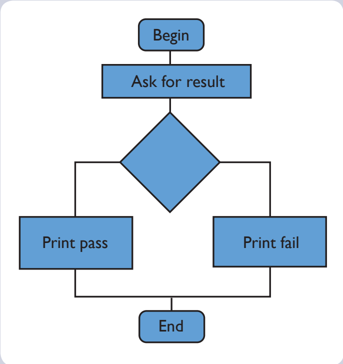


Figure 9.19

3 Complete this algorithm involving case selection.

A test situation gives grades to a student based on knowledge of a subject.

less than 50 marks: grade 3
51 to 70 marks: grade 2
71 to 100 marks: grade 1

The flowchart algorithm in figure 9.20 has been partly completed. Redraw the design and finish the chart.

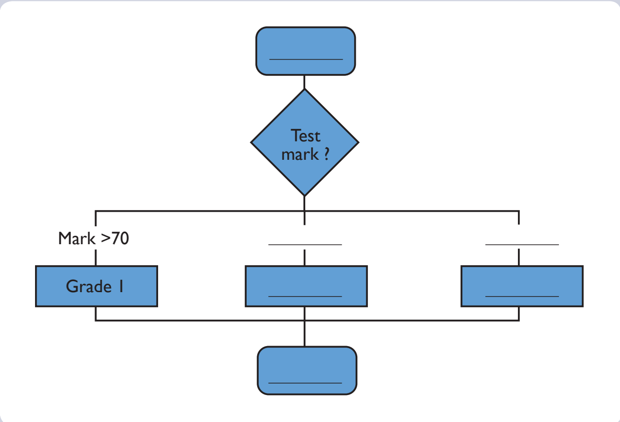


Figure 9.20

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## Repetition and/or iteration such as pre-test and post-test

A repetition control structure carries out a particular action any number of times until a condition is met. In order to do this, a loop is created to return the program to a point where the repetition starts for the number of times needed until the condition is met.

A loop must have a terminating (ending) condition. The terminating condition must be:

- tested at some time during each repetition
- updated during each repetition

It is essential in designing a 'good' algorithm to ensure that any loop will end. The algorithm must say under what conditions the loop will end.

There are two ways of testing to see if the end condition is met: pre-test loops and post-test loops: In *pre-test loops* the condition is tested at the start of the loop. If the condition is false the first time, the processes will NEVER be carried out. Pre-test loops end when the condition is false.

In *post-test loops* the condition is tested at the end of the loop. The body of the loop will be executed the first time through, whether the condition is true or false, as the body of the loop is executed before the condition is tested. Post-test loops end when the condition is true but they always do the loop at least once.

Remember: the post-test loop requires only one read statement but the pre-test loop requires two. A very general rule is to use pre-test loops when the number of loops is not known and post-test loops when the number of loops is known.

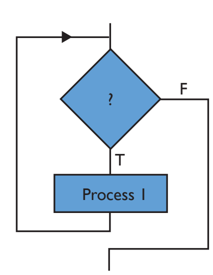
### PRE-TEST LOOPS

Pre-test loops are also known as guarded loops because the loop is only operated when the condition is met.

**Pre-test loops in pseudocode**

```
WHILE <condition> is true
   Do this (Process1)
   ......
ENDWHILE
```

**Pre-test loops in flowcharts**




The condition has to be met at the beginning of the loop or the loop is not carried out. If the condition is met, the loop is carried out repeatedly while the condition remains true.

**Figure 9.21** Pre-test repetition structures

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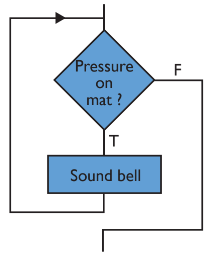
| Pre-test loops in pseudocode | Pre-test loops in flowcharts |
|---|---|

```
WHILE there is pressure on the mat
   Sound the bell
ENDWHILE
```




The bell continues to ring while there is pressure on the mat. No bell rings if there is no pressure on the mat.

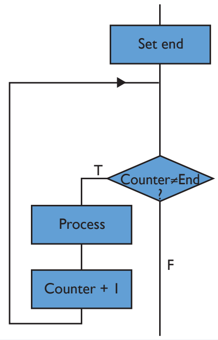
Figure 9.22 Example of pre-test repetition (shop bell)

## COUNTED LOOPS

Counted loops are special types of pre-test loops. They are used when a known number of repetitions will occur.

| Counted loops in pseudocode | Counted loops in flowcharts |
|---|---|

```
BEGIN Counting
   set end
   FOR counter from 1 to end
      Do process
   NEXT counter
END Counting
```




The condition has to be met at the beginning of the loop or the loop is not carried out. If the condition is met, the loop is carried out the set number of times given in the condition.

Figure 9.23 Counted repetition structures

| Counted loops in pseudocode | Counted loops in flowcharts |
|---|---|

```
BEGIN Timing
   End=60
   FOR counter from 1 to End
      Display time in seconds
   NEXT counter
END Timing
```

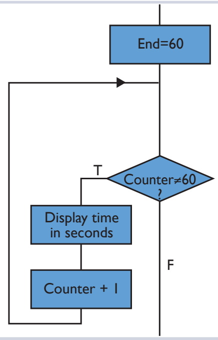



Figure 9.24 Example of counted repetition (timer)

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## EXERCISE 9.10

1 The pseudocode algorithm for a particular problem is given as:

```
BEGIN
   Input the numbers 10 to 0 (in that order)
   Read 2 numbers
   WHILE both numbers ≠ 0
      Calculate mean
      Print mean
      Read 2 numbers
   ENDWHILE
   Print end message
END
```

- **a** Write an explanation of this loop in general English.
- **b** Explain why there are two read statements in a pre-test loop.
- **c** When does the loop end?
- **d** Draw and complete the flowchart algorithm for the same problem.

2 Explain, giving an example, when you would use a fixed or counted loop to solve a problem.

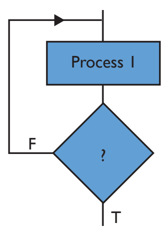
### POST-TEST LOOPS

In post-test or unguarded repetition the body of the loop is carried out before testing the condition. The loop is repeated until the condition is true. The loop always has to be carried out at least once even if the end condition is originally true.

**Post-test loops in pseudocode**

```
REPEAT
   Do this (Process1)
   ....
UNTIL <condition> is true
```

**Post-test loops in flowcharts**




A post-test loop is called an unguarded loop because no check is made before the algorithm begins the loop structure.

Figure 9.25 Post-test repetition structures

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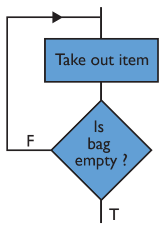
| Post-test loop in pseudocode | Post-test loop in flowcharts |
|---|---|
| REPEAT<br>Take out one item<br>UNTIL bag is empty |  |



**Figure 9.26** Example of post-test repetition (unpacking a school bag)

## EXERCISE 9.11

1 The flowchart algorithm for a particular problem is given in figure 9.27.

Write down and complete the missing sections in the pseudocode algorithm for the same problem.

```
Program Number
    __________
    ____________
    ____________
        Read 2 numbers
        __________________
        Print mean
        __________both numbers = 0
        Print __________
    END
```

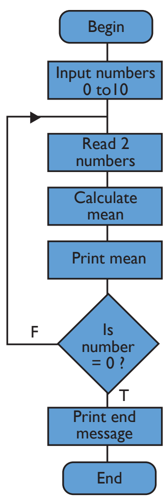



**Figure 9.27** Flowchart

2 Explain the difference between a pre-test and a post-test loop.

3 A flowchart algorithm is provided in figure 9.28 for the problem 'Making a telephone call' but there are errors. Correct the solution and then write the pseudocode for the problem.

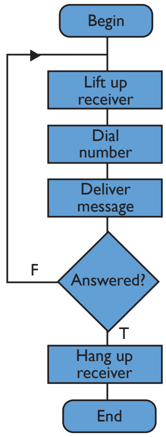



**Figure 9.28** Flowchart

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## Subprograms

Subprograms are part programs that are called from within the main program. They allow the process of breaking a problem down into small steps to be further refined. The solution to the problem is then easier to follow. Each section of the solution is developed and presented in understandable chunks.

In pseudocode, the statement in the main program that is expanded in a subprogram is underlined to indicate a further breakdown of the problem. In flowcharts a branch to a subprogram is shown by additional vertical lines each side of the process box.

**Subprograms in pseudocode**

```
BEGIN MAINPROGRAM
   Process 1
   Process 2
   Process 3
   Process 4
END MAINPROGRAM

BEGIN SUBPROGRAM Process 2
   Do this
   Do that
END SUBPROGRAM Process 2
```

**Subprograms in flowcharts**

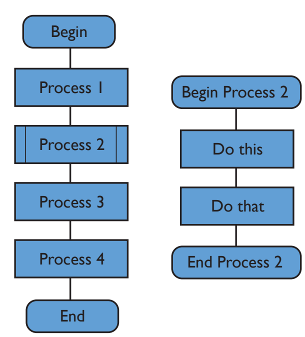


Figure 9.29 Writing subprograms

**Subprograms in pseudocode**

```
BEGIN MAINPROGRAM
   Set counter to 0
   Record_Marks
   Print report
END MAINPROGRAM

BEGIN SUBPROGRAM Record_Marks
   Get number of marks
   REPEAT
       Ask for mark
       Record mark
       Counter=Counter+1
   UNTIL Number of marks=Counter
END SUBPROGRAM Record_Marks
```

**Subprograms in flowcharts**

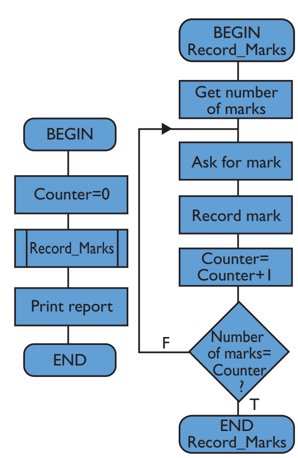


Figure 9.30 Examples of the use of subprograms (recording and printing results)

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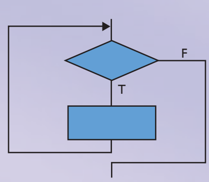
## EXERCISE 9.12

1 Match each term in column 1 with the best description from column 2.

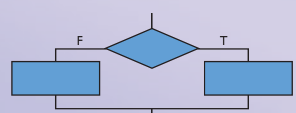
| Term | Description |
|---|---|
| algorithm | a loop which is always carried out at least once |
| binary selection | a control structure in which each step is carried out in order of its position |
| flowchart | an algorithm where choice is made between 2 alternatives |
| IF...THEN...ENDIF | selection statement involving more than 2 choices |
| case selection | a loop which may not be carried out if the condition is met on first being tested |
| post-test loop | keywords written in English for solving problems |
| pre-test loop | binary selection keywords in pseudocode |
| pseudocode | set of steps to solve a problem |
| sequence | a visual way of presenting an algorithm |

2 Name the control structure being used in each of the following algorithm segments:

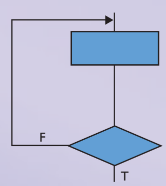
**a**




**b**




**c**




**d**

```
IF
<condition>THEN
  Process1
  ELSE
  Process2
ENDIF
```

**e**

```
CASEWHERE <condition>
OF
  1: Process1
  2: Process2
  OTHERWISE: ProcessN
ENDCASE
```

**f**

```
BEGIN
  Process1
  Process2
END
```

3 This program is given in a flowchart in figure 9.31.
Write the equivalent algorithm in pseudocode.

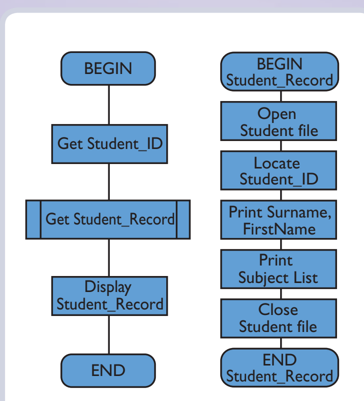



Figure 9.31

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## Desk checking

Desk checking is a simple manual tracing of the steps of an algorithm in order to make sure the solution is free of errors. It aims to check a program's logic before it is coded, that is, errors that may not stop a program from working but will give the wrong result.

Desk checking uses test data in a table to check all input and output. Test data should include all the expected inputs and some unexpected input as well. Input test data is used that will produce known results. The test data should include: (1) typical data, which will test the commonly used program paths; (2) unusual but valid data, which will test the program paths used to process exceptions; and (3) incorrect, incomplete, or inappropriate data, which will test the program's error routines.

A 'walk through' of the design to find any errors is best if test data also covers the boundary values of a problem (the limits).

### Example of desk checking

An algorithm has been written to count the numbers from 1 to 5 and display them on the screen. Test data for this problem needs no inputs but should show the expected outputs.

**Table 9.15** Test data for desk checking

| Algorithm | Desk check output | | | | | Expected output |
|---|---|---|---|---|---|---|
| BEGIN Counting | Count | | | | Display | The screen display should show 12345 |
| Count=1 | 1 | | | | | |
| REPEAT | | | | | | |
| Count=Count+1 | 2 | 3 | 4 | 5 | | |
| Display Count | | | | | 2345 | |
| UNTIL Count=5 | X | X | X | ✓ | | |
| END Counting | | | | | | |

When the output does not match the expected output, there are one or more errors. In this case, setting count to 0 at the start would solve the error. Another desk check should be carried out to make sure.

**EXERCISE 9.13**

1 The following tables are provided to desk check the given algorithms. Complete the tables.

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exercise 9.13 continued

**Table 9.16** Desk check of Sums algorithm

| Algorithm | Desk check output | | Expected output |
|---|---|---|---|
| | Count | Display | |
| BEGIN Sums | | | |
| Count=4 | | | |
| WHILE COUNT ≠ 0 | | | |
| Count=Count–1 | | | |
| Display Count | | | |
| ENDWHILE | | | |
| END Sums | | | |

**Table 9.17** Desk check of Write algorithm

| Algorithm | Desk check output | | Expected output |
|---|---|---|---|
| | Total | Display | |
| BEGIN Write | | | |
| Total=6 | | | |
| REPEAT | | | |
| Total=Total+4 | | | |
| Go to new line | | | |
| Display Total | | | |
| UNTIL Total=22 | | | |
| END Write | | | |

**2** Input data for table 9.18 is 5, Johann; 0, Helen; 2107, Mantine; 2108 Lilith

**Table 9.18** Desk check of Decision algorithm

| Algorithm | Desk check output | | | | | Expected output |
|---|---|---|---|---|---|---|
| | Input | | | | Print | |
| BEGIN Decision | 5 | 0 | 2107 | 2108 | | |
| Get Student_ID | | | | | | |
| IF Student_ID<2107 | | | | | | |
| Print Name | | | | | | |
| ELSE | | | | | | |
| Print "NK" | | | | | | |
| ENDIF | | | | | | |
| END Decision | | | | | | |

**a** Complete the desk check.
**b** What boundary values are included here?

# Programming languages

The function of a programming language is to allow the user to write a program or a set of step-by-step instructions that tell a computer how to carry out a task.

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Machine code is directly understood by the machine, it can be executed or carried out rapidly and no translation is needed. However, it is very difficult to write and most people find it very hard to work with long strings of unstructured binary data or bit streams such as ...000110110111000101100100001110 11...

To overcome these problems, many different programming languages have developed, each with its advantages and disadvantages. They are divided into low-level and high-level languages.

**Table 9.19** Main types of programming languages

| Lower level languages | | Higher level languages | | |
|---|---|---|---|---|
| Machine specific language | Assembly language | Instructions written in a more easily understood form | | |
| Generation 1 | Generation 2 | Generation 3 | Generation 4 | Generation 5 |
| Code is usable by only one type of processor | Use shortened instructions called mnemonics that are more easily understood by the user | Code is written as instructions detailing how a task is to be done | Most are non-procedural languages where users define only what they want the computer to do | Advanced types of 4GLs |

**Table 9.20** Advantages and disadvantages of different levels of programming languages

| Level | Advantages | Disadvantages |
|---|---|---|
| Machine specific language | • Restricted to one type of processor<br>• Executes very quickly as machine directly understands instructions | • Many million machine instructions may be needed for the computer to perform a useful task<br>• Very hard to write code in machine language |
| Assembly language | • Reduced code by using abbreviations. For example, ADD X, 100 means use addition to increase the value at address X by 100 | • Still needs thousands of instructions to perform one useful task<br>• An assembler program is needed to convert assembly language into machine language for the computer to use |
| Higher level languages | • More portable between different processors<br>• Programs are written in language closer to the language we understand | • Needs some form of translation as the computer can only understand machine language<br>• Requires the programmer to learn the language in order to write code<br>• Different languages use different syntax (rules)<br>• Some languages are harder to learn than others<br>• Different languages are suitable for different purposes |

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## Translating higher level languages

To translate higher level language into machine language, the translation can be carried out by a translator. Different types of translators function in different ways.

An *interpreter* takes one instruction at a time and finds, from its instruction library, the equivalent machine code instructions that it then obeys. Each time the program is run, each instruction is translated into machine code making program execution slow.

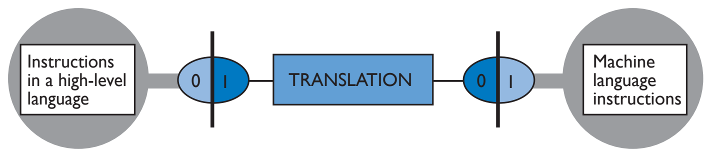


**Figure 9.32** The process of translation

An *incremental compiler* is another type of interpreter that uses an interpreter for the mainline of the program and compiles the modules as they are written. This helps to speed up program execution.

A *compiler* changes the complete program from a high-level language into machine code but does not execute the program until required. The translated program, which is the one the computer understands, is kept for future use. This makes the process quicker than when using an interpreter.

## Examples of programming languages

There are thousands of computer languages written for many different purposes and new ones are created continually. Table 9.21 shows just a few.

**Table 9.21** Programming languages

| Language | Level/Type | Use | Example |
|---|---|---|---|
| Machine | Low | BIOS (Basic Input-Output System) and booting programs needing quick execution | `00000000000110000011101110100111000111000011110101010111100 ... (binary representation of machine code)` |
| Assembly | Low – 2G | Autoexec.bat file | `MOV AX,C (Move C to memory address AX)` |
| BASIC | High – 3G | Beginners All-purpose Symbolic Instruction code | `QuickBASIC`<br>`  PRINT 6^2+2`<br>`  END` |
| FORTRAN | High – 3G | Language used by scientists and engineers | `IF (NUMBER .EQ. 999) GOTO 2`<br>`SUM=SUM+NUMBER`<br>`COUNT=COUNT+1`<br>`WRITE (6,70)`<br>`READ (5,40) NUMBER`<br>`GOTO 1` |
| COBOL | High – 3G | Common Business Oriented Language | `MOVE CALCULATED-DATE TO`<br>`TODAYS-DATE`<br>`READ IN-FILE` |

continued >

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| | | | |
|---|---|---|---|
| C++ | High – 4G | A development from the C language for business use | `TABLE FILE SALES`<br>`SUM UNITS BY MONTH BY`<br>`CUSTOMER BY PRODUCT`<br>`ON CUSTOMER SUBTOTAL PAGE`<br>`BREAK`<br>`END` |
| Prolog | High – 5G | Artificial intelligence | `dog(A) = name(Y) and`<br>`name(Y) = "fox terrier"` |

Considerably more code is needed to deliver output in a low-level language. Both of these examples in table 9.22 output the same data, that is, they display 'My Program' on the screen.

**Table 9.22** Comparing a low-level and a high-level language

| Low-level language | High-level language |
|---|---|
| Example: Assembler | Example: Pascal |
| `MY Message;Set up MY code and data section`<br>`  ASSUME CS:MY,DS:MY;Tell assembler about`<br>`conditions at entry`<br>`  ORG 100H ;`<br>`MAIN: JMP BEGIN;Control must start here`<br>`MSG DB 'My, Program.$' ;Put data first`<br>`BEGIN: MOV DX,OFFSET MSG;Let DX -> message.`<br>`  MOV AH,9;Set DOS function code for printing a message`<br>`  INT 21H ; Invoke DOS`<br>`  RET ;Return to system`<br>`MY ENDS ;End of code and data section`<br>`  END MAIN;Terminate assembler and specify entry point` | `BEGIN`<br>`Print "My Program" /*`<br>`Output data */`<br>`END` |

## EXERCISE 9.14

1 Match each term in column 1 with the closest definition from column 2.

| Term | Definition |
|---|---|
| high-level language | second-generation language using mnemonics |
| assembly language | program to convert higher language to machine language |
| machine language | software or sets of instructions for the computer to carry out |
| software | procedural languages that use 3 basic control structures |

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exercise 9.14 continued

| | |
|---|---|
| systems software | only language understood by a computer |
| translator | coding and rules are more user friendly |
| program | software that will run on many different types of processors |
| processor independent | programs that run a computer system |
| assembler | code to abbreviate machine language |
| third-generation language | programs to manage computer operations |

2 Explain the difference between:
   a low-level and high-level language
   b interpreter and compiler

3 Answer these questions using full sentences.
   a What is the advantage of using a low-level language to solve a computing problem?
   b Why is a translator needed for high-level languages?
   c What is the advantage of the most recent high-level languages?

4 Identify whether each of the following small fragments of code are from a high-level or a low-level language.
   a REPEAT X:=X+1 UNTIL X>20
   b MOV AH,9
   c brother (a,b) := male (a), parent (a,z), parent (b,z)
   d 0001100101001110001110001010

## Career path

**Engineers design and test the operation and performance of hardware and software. Their work may involve developing new hardware designs as well as maintaining existing systems. An experienced electronic engineer can specialise in industrial robot control systems. With software knowledge as a computer programmer, they can also write code to create or maintain computer programs.**

## Data structures

**Data structures** organise data. They make it easier to store related data by using a single name for a data collection so the data can be easily retrieved when it is needed.

*Files* are data structures holding all the data related to a particular topic. The data can be of any data type. Application programs allow data to be saved as files, for example, a spreadsheet stores data as a spreadsheet file.

*Records* organise related data into *fields*, that is, they are separate data items that stay together. They can be seen as a group of cells, each cell containing one item about the data, organised into a row that holds all the data in the fields in the row as one unit, that is, a record. Records are used in databases.

*Arrays* organise related data into grids. They are a variable that holds a group of data items. A simple array or one-dimensional array can be called a *list* and the list can be given a single name. For example, one set of data items might be the days of the week. They can be given a single name Day. Each day of the week can then be identified by its location or subscript, such as Sunday as Day(7), Monday as Day(1) etc. Thus there are two parts to an array: its name and the identifier for each location in the array.

**Data structure** a way of organising data, making it easier to store related data by using a single name for a data collection so the data can be easily retrieved when it is needed.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY | SUNDAY |

Figure 9.33 Array of days of the week

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## Try this

**Studying the code of others**

Studying other programmers' code lets you see how code works and, although some of this may not make sense to begin with, it still allows you to understand how computer code works in a very general way. Studying HTML code (see chapter 6 for further information) is one of the easiest ways to do this. HTML source code (the code understood by the programmer) may be viewed by using a browser.

1 To do this, open a web page on the internet or one available from your hard disk. Look at the components of the page and then use the **View... Source** option from the browser menu to show the basic features of the HTML document. Notice that there is usually a lot more code than the product seen by the user.
2 Some code can be identified as performing a task on the user's screen e.g. tags such as <p> </p>which start and end a new paragraph. Note down TWO examples of this.
3 Some code does not seem to do anything. Write down ONE example of code that carries out tasks hidden from the web page user.
4 Some code must be used for every document written in that code e.g. <body> </body>. Give another example of such code.
5 Some code may have attributes. For example, <font size="+3" color="#FF0000">Welcome</font> shows the font code and the attributes of font size, colour etc. Attributes may also have values e.g. +3 is the value of size. Write down another example of code with attributes and values.

Arrays save a lot of time when programming. For example, consider a theatre booking system where each seat in the theatre is stored separately. This may mean many hundreds of separate data entries. Instead the seats can be stored in an array and the seats located according to their position or subscript. Writing code to store and retrieve data from the array is then simpler. In Quick BASIC, storing data in the array could be done in code as:

```
DIM Seats array(N)
    Position=1
WHILE position <=N
    Input "Enter a seat number";Seat_
array(position)
    Position=position + 1
ENDWHILE
```

To retrieve data from the array the code would look like:

```
Position=1
WHILE position <=N
    Print "The seat number is ";Seat_
array(position)
    Position=Position + 1
ENDWHILE
```

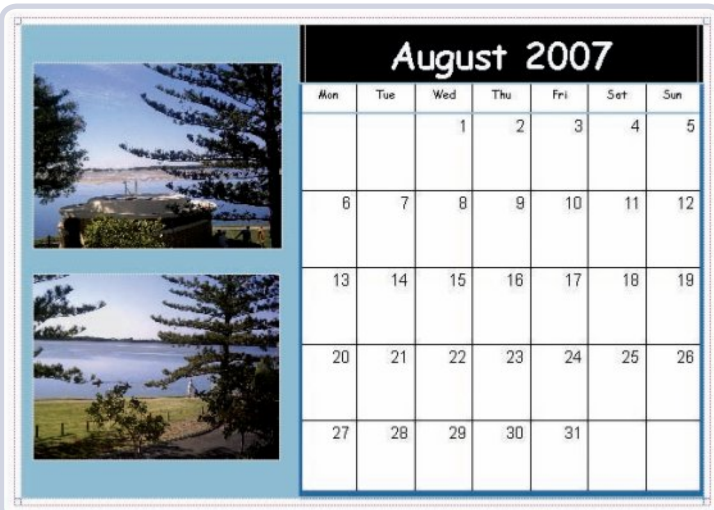


Figure 9.34 Calendar array

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## Testing

All algorithms and programs should be tested to make sure that they solve the problem. Testing should be carried out at all stages by running a program or by checking the program manually. Tracing the errors in a program and fixing them is called debugging.

**Debug** to find and remove logic and syntax errors in a program or algorithm.

Testing by running a program uses test data. This involves trying the program and using different types of data to see if the results are what is expected. Test data can be the same data used for desk checking and should also test boundaries or limits reached by the program.

Manual testing or a walkthrough involves using a paper and pencil to go through each program instruction and record the output to see if it is as expected. This could also involve using another programmer or group of programmers to check the code that is peer checking.

Clear and correct algorithms help to avoid bugs in the first place and make testing easier.

### EXERCISE 9.15

1 Arrays are very useful for storing related data in an efficient way. They are also useful when it comes to sorting and searching groups of data. The following algorithm has been written to search for an item in a list of items. Read the algorithm and then answer the questions related to it.

```
BEGIN Find_Friends
  Enter Name_of_Friend
  N=1
  Found=0
  REPEAT
    IF Find_Friends_Array(N) = Name_of_Friend THEN
      PRINT FirstName(N), Birthday(N), Favourites(N)
      Found=1
    ELSE
      N=N+1
    END IF
  UNTIL Found = 1
  IF found = 0 THEN
    Print "There is no friend with this name."
  END IF
END Find_Friends
```

a What is the algorithm searching for?
b List TWO types of constructs (control structures) used in the algorithm.
c Name TWO variables used in the search.

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exercise 9.15 continued

- d Give the name of the array term for N.
- e Explain what happens if the search of the array is successful.

2 Answer the following questions in full sentences.
- a What is meant by testing a solution?
- b Why is it important to understand what the output of a program or algorithm should be?
- c For what reasons is it important to use a range of test data, including unexpected data?

3 True or false? Rewrite each false statement to be true.
- a Testing a solution occurs only when the problem has been solved.
- b Running a program is one way of testing the solution to that problem.
- c Debugging is the process of writing test data.
- d A bug is an error in an algorithm or program.
- e Expected output should match with the actual output from a program.
- f Test data should only cover one or two areas of the problem solution.
- g The best way to avoid problems is to write the program before writing the algorithm.
- h Having another programmer check your code for errors is called peer checking.
- i Manual testing is done using pencil and paper.
- j Test data is not necessary until you have solved the problem.

## Error detection

Finding code errors can be done using peer check, desk check and software debugging tools.

**Table 9.23** Types of errors found in programs

| Error | Description | Example |
|---|---|---|
| Syntax | An error in the use of the programming language rules such as a typing mistake in a reserved word | From C++: Reading( ): //error: illegal character ':' |
| Logical | An error in the program structure that results in incorrect output | Output expected to be in real numbers but integers given instead |
| Run-time | Error resulting from the translator or machine's inability to handle a task | Overflow error where not enough memory is available to store data or where there is an attempt to divide by 0 |

Software debugging tools usually detect syntax errors. Logical errors can be detected by the translator if they are errors such as the wrong data

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type but are often only picked up by peer checking and desk checking. Run-time errors cause the program to stop during execution and the translator may help to identify the error and provide a line number for the location of the error.

### Think about this

Software solutions often have many bugs, that is, errors. Often users need to download many fixes for programs to repair such errors. How can software developers best avoid these problems?

### Error correction

Error correction is more difficult than locating the errors. Most translators have tools to help make this easier.

Most translators locate and display syntax errors in 'red' text. Syntax errors include typing mistakes in reserved words, missing or wrong punctuation, variable names that do not conform to the language rules and failing to complete groupings, e.g. IF but no END IF.

For logic errors not detected by desk checking, most programming languages have a debugger which allows the setting of breakpoints, watch expressions to observe variables or single line step routines (execute one line at a time).

With *watch and trace*, it is possible to tell the computer to display (or watch) certain variables in a program. The programmer can then step through the program line-by-line (or trace through the program) watching the variables as they change. This is like doing a dry run on paper. This tool, however, is very powerful when used with the breakpoint tool described below.

*Breakpoints* let the programmer stop the program execution at a set point and then single-step to find the problem. Programmers can also add temporary output statements to observe what is happening.

Run-time errors that crash the program are often hard to find. Testing using test data may help to locate the problem such as an array declared as 5 elements needing 6 storage locations.

## Documentation of programming code

Documentation is vital for good programming. Programs always need to be fixed or maintained and this is often done by others outside the original team. There are a number of ways in which a program can be documented.

**Intrinsic documentation** is built into the code. This is the use of meaningful variable names such as Total or Text_array. Programmers know from the name what they are meant to do.

**Comments** in code are non-executable lines of text that explain what is happening. Commenting code is always good practice. It is very important when using variables, functions, expressions, and scripts. When changes are needed after a week or two or there is a need to fix errors or debug code, the purpose of a variable or an expression may not be immediately clear but a comment saves time working out the meaning.

**Intrinsic documentation** the use of meaningful variable names in the code to indicate to the programmer what to do.

**Comments** in code are non-executable lines of text that explain what is happening.

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**Table 9.24** The use of comments

| Documentation of the program itself | Documentation of the code |
|---|---|
| In Java<br>`/**`<br>`* Title: My Little Program`<br>`* Description: A program to`<br>`introduce some basic skills`<br>`* Copyright: Copyright (c) 2004`<br>`* Company: Novices Ltd`<br>`* @author Carole Wilson`<br>`* @version 1.0`<br>`*/` | In Java<br>`/**Set a button on the screen*/`<br>`MarksBtn.setText("Marks");`<br>`MarksBtn.setBounds(new`<br>`Rectangle(100, 142, 84, 28));` |
| In C++<br>`/* Title: Introduction to languages */`<br>`/* Object oriented languages */`<br>`/* May 2004 */` | In C++<br>`/* Class body follows */`<br>`main() {`<br>`cout << "hello, new users\n";`<br>`}` |
| In Quick BASIC<br>`REM written by A Programmer`<br>`REM Program to load a file`<br>`PRINT "FileA", "July", "2004"` | In Quick BASIC<br>`REM Function returns a value`<br>`for X` |

Comments are usually displayed in green or another colour text to distinguish them from executable code (in black) or errors (in red). They will have a symbol to distinguish them from code. For example, in C++ any text between /*... and */ is identified by the translator as a comment and stripped from the code when it is executed.

User support documentation can include hard copy and soft copy materials to help the user of the program. This could include hardware requirements, manuals, trouble shooting guides, wizards and online help to guide the user through a task.

## Project development

Project development can include modifying an existing program to suit the new tasks or user needs or it may involve creating a new program to solve a problem.

Modification can be as simple as using the available tools in a program to suit a task, for example, writing a macro. A macro automates an often performed task. Creating a new software solution is used when a problem cannot be solved by existing programs.

One of the requirements of project development is an understanding of random and sequential files.

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## Random and sequential files

Direct or random files are stored or written randomly and given an address so that they can be found again. This is like people who move into houses on a street in any order and have an address where they can be located. Files on magnetic and optical disks are stored this way. Recording a random file address is done by the FAT (file allocation table) on a disk. The disk locations are held for the file or parts of the file where the file has been split to store it across more than one location. When a file is needed the address is looked up and the file can be read directly from its location. It is a quick method of locating data.

Sequential files are stored or written in order. On magnetic tape, each file is stored in the order it is received. To find a file each file is checked from the beginning of the tape until the required file is found. This is a very slow method of locating data.

## Object-oriented software development

In an object-oriented programming language such as Java, classes, objects and encapsulation are used to store and process data. For example, if we were to write a program about cars, cars could be our class. Cars would store data as attributes such as cars have wheels. Objects are then the operations of the class, that is, a sedan car has a front and rear seat and a boot. Encapsulation lets the details about the data and operation of the objects remain hidden from the user, so the user operates the cars but doesn't need to know how that happens.

The advantages of object-oriented software include:

- objects are flexible as they can be developed separately and joined when needed
- when changes need to be made only one object needs to be changed
- each object can be tested separately so it is easier to find bugs
- objects can be reused in other programs
- objects may inherit features from other objects so features need to be programmed only once

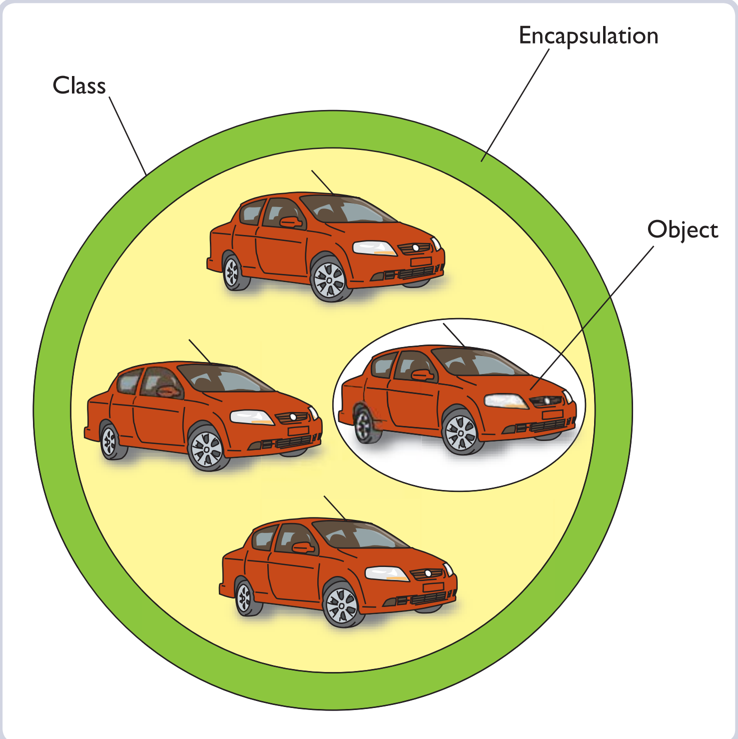


**Figure 9.35** Object-oriented concepts

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## EXERCISE 9.16

1 A small Pascal program is given here. It contains comments to help the programmer understand the code.

```
PROCEDURE swap_sort_elements(VAR one, two :
sort_elements);
VAR
  temp : sort_elements; {Use temp to hold data
  during the swap}
BEGIN
temp := one; {Put the first element into the temp
store}
one := two; {Put the second element into the place of the
first element}
two := temp; {Put the element in temp into the place of the
second element}
END; {swap_sort_elements}
```

a If VAR is the syntax for variable, what is the name of the variables used?
b What code is used to start and finish this section of code?
c Why is the temp (temporary) store needed?
d How does the programmer explain the purpose of the program and the way it works?

2 The following extracts of programming code contain errors. Identify as many errors as you can and say what type of error they are.

a
```
N=2 *(I+J))
```
b
```
Number=5
WHILE Number<3 DO
Display Number
ENDWHILE
```
c
```
'Program to calculate average
SUM:=Average/Counter
Display Average
```
d
```
IF Total>5
Total:=Total/0
ENDIF
```
e
```
Set Array to 6 elements
DOWHILE N<9
Array[N]:=Array[N+1]
Store Array[N]
```
f
```
LOOOP
```

3 It is intended to use object-oriented programming for an interactive program on Animals. To help the designers, match the concepts in column 1 with the best description from column 2.

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exercise 9.16 continued

| Concept | Description |
|---|---|
| attribute | group of objects with some similar behaviours |
| bug | ability of all objects in a class to receive attributes from belonging to that class |
| class | process to hide the operation of objects from the user |
| encapsulation | behaviour of an object |
| inheritance | data that will change as a program executes |
| object | syntax or rules to control the use of code for a program |
| programming language | error in program code |
| variable | one category of items in a class |

4 Mammals is suggested as one class in a OOP program on Animals.
  - a Name TWO behaviours or attributes that mammals have in common that allows them to become a class in the program.
  - b Dogs and Cats are two objects in the Mammal class. What will they inherit from the Mammal class? How is inheritance an advantage?
  - c Why could Dogs be a separate class?
  - d Name THREE objects that could be included in the Dogs class?
  - e What are the advantages if we decide to move the Alsatian from the Dog class to the Wolf class?

5 A button is an object in some programming languages. Describe FOUR different events that a button could be programmed to carry out.

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# Software development and programming

## Multiple choice questions

Select the best answer to each of the following questions.

1 A line of programming code reads: WHILE X=1. This is an example of
- A Machine language
- B Assembly language
- C Third generation language
- D Fourth generation language

2 The process of an operating system loading its instructions into RAM is started by
- A A word processor
- B A boot-strapping program
- C ROM
- D A jump drive

3 A GUI desktop is an example of the interface of a
- A Operating system
- B Hardware device
- C Command system
- D Mouse

4 A series of instructions written to solve a problem in a finite time is a
- A Program
- B Icon
- C Algorithm
- D Operating system

5 Programming code written in different languages is always
- A Identical for all programs
- B Different for similar types of programs
- C Usable in any program
- D Unusable for any other purpose

6 Refinement is the process of
- A Listing the ways in which a problem may be solved
- B Sorting a problem into order
- C Modelling a solution to a problem
- D Dividing a problem into smaller parts to work towards a solution

7 The control structure used to correctly order the steps of a program is
- A Stringing
- B Sequence
- C Selection
- D Repetition

8 A post-test loop always does the loop at least
- A Four times
- B Three times
- C Twice
- D Once

9 A pseudocode solution differs from a flowchart because
- A No text is used
- B Text and symbols are used
- C Text only is used
- D Symbols only are used

10 Manually tracing the steps of an algorithm to locate errors is known as
- A Testing
- B Coding
- C Translating
- D Deskchecking



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## Extended answer questions

Figure 9.36 outlines some aspects of software systems.

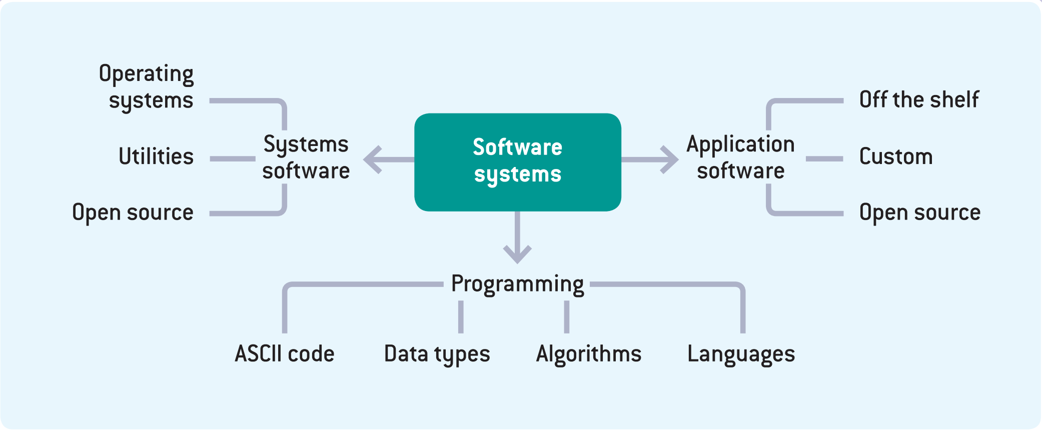


Figure 9.36

Write answers to each of the following questions by using the guidelines provided.

1. Name THREE examples of off-the-shelf software.
2. Explain how custom software is different from open source applications.
3. Write the full term for 'ASCII'.
4. Compare operating systems with utility software.
5. Describe FOUR simple data types used in programming.
6. Contrast an arithmetic operator with a relational operator and a logical operator.
7. What is the value of an array in programming?
8. Draw a simple diagram to show the control structures used to represent algorithms.
9. Explain the different levels of programming languages. Why do so many different languages exist?
10. How may a programmer debug their written code?

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# PROJECT 1: PROGRAMMING OFF-THE-SHELF SOFTWARE

## Define the problem

This project aims to introduce some very simple examples of coding a Microsoft Excel spreadsheet to produce an array of random numbers and validate data entries.

## Analyse the problem

Users can adapt an existing software package to suit their own needs. This is an informal programming approach that is used to solve small problems for which software already exists. Much off-the-shelf software uses fourth generation programming languages, such as those associated with databases, word processors or spreadsheets, and allows a number of simple procedures to be included in a program.

## Design a solution

The most easily used of the programming tools in off-the-shelf software is often the macro. However, there are a number of ways to program applications other than the macro. One of these is a programming language known as Visual Basic for Applications which is valuable for this project as it may be used to easily code a spreadsheet.

The project design will provide separate examples to demonstrate the generation of random numbers, the use of random numbers in a game format and a simple example of data validation. Each example will use a separate worksheet.

## Produce the solution

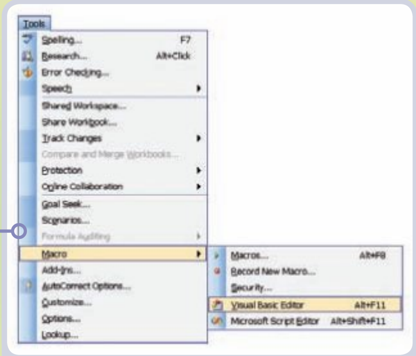

**Figure 9.37** Tools menu

1. Open a new spreadsheet.
2. Rename Sheet 1 as Array (use the right mouse button menu).
3. Open the **Visual Basic** editor from the **Tools... Macros** menu.
4. Use the **View...Code** menu in the **Projects** window if the code window is not open.
5. In the editor type the following code:

```
Sub MyArray()
Dim List, Marks, x As Variant
List = Array("Student1", "Student2", "Student3", "Student4",
"Student5")
Marks = Array("Test1", "Test2", "Test3", "Test4")
x = Application.Transpose(Marks)
Range("B1:F1") = List
Range("A2:A5") = x
End Sub
```

The code generates a two-dimensional array in the open worksheet.

6. Press F5 in the middle of the code to have it execute the subprogram.
7. Check the worksheet to make sure this has occurred.
8. Save the spreadsheet as Programming.



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**To generate a random list of numbers:**

1 Go to Sheet 2 and rename it Random Numbers.
2 Open the Visual Basic editor from the **Tools** menu.
3 Open the editor window (**View...Code**) if it is not open.
4 In the editor type the following code:

```
Sub Numbers_Game()
Dim NextNum(10) As Integer
NextNum(1) = Int(100 * Rnd())
NextNum(2) = Int(100 * Rnd())
NextNum(3) = Int(100 * Rnd())
NextNum(4) = Int(100 * Rnd())
NextNum(5) = Int(100 * Rnd())
NextNum(6) = Int(100 * Rnd())
NextNum(7) = Int(100 * Rnd())
NextNum(8) = Int(100 * Rnd())
NextNum(9) = Int(100 * Rnd())
NextNum(10) = Int(100 * Rnd())
MsgBox “Random Numbers: “ & NextNum(1) & “, “ & NextNum(2) & “,
“ & NextNum(3) & “, “ & NextNum(4) & “, “ & NextNum(5) & “, “
& NextNum(6) & “, “ & NextNum(7) & “, “ & NextNum(8) & “, “ &
NextNum(9) & “, “ & NextNum(10), vbExclamation, “Guess the numbers”
End Sub
```

5 Press **F5** in the middle of the code to have it execute the subprogram or click the **Run** button.
6 Evaluate the result. If it is not correct, recheck the code.
7 **Save** the file.
8 Move to Sheet 3.
9 Type in the following data in the block A1:B8

| Information and Software Technology | |
|---|---|
| **Class 10** | **Marks** |
| Ann | |
| John | |
| Liesel | |
| Marco | |
| Vin | |

10 Highlight the cells B4:B8. Select **Data...Validation** from the menu. Make the following choices in the Data Validation window.

11 Click **OK** and then try a range of data types to see if they are allowed: decimals, values outside the boundaries (minus values, values >50) etc.
12 Save the file.

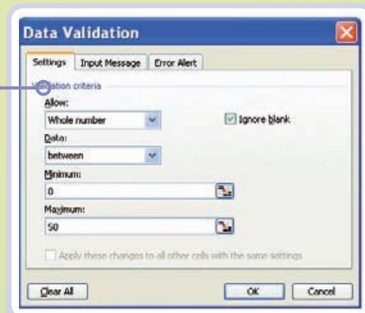


Figure 9.38 Data validation choices

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## Evaluate the solution

Answering the following questions should help you evaluate the solution to this project by discovering what you have learned from completing the task.

1 Refer to sheet 1: what does transpose mean in this context?
2 Explain the use of constants and variables using the code you typed into the editor window.
3 What is data validation?
4 Why are boundaries needed for computer programs and testing of program code?
5 How does data validation protect the program user from entering data outside the accepted boundaries?
6 Try some programming for yourself, for example, in sheet 1 you could extend the code to fill the block of cells from B2:F5 with values. (Hint: You may find this easier to do using row ranges.)

# PROJECT 2: PROGRAMMING IN A GUI ENVIRONMENT

## Define the problem

Random generation of data by programming languages is a useful tool in many programs. In this project, randomisation will be used to create graphics of some kind.

## Analyse the problem

Programmers use modules to assemble some programs. These modules are pre-existing sections of code that carry out a specific function. Graphics may be modules used in many other programs and there would be a number of standard graphics for this purpose.

## Design a solution

This project will use Visual Basic V6 but similar processes are possible in other programming languages. The choice of graphic is a star burst.

## Produce the solution

1 Use a new standard.exe project form and create one command button. On the Properties list, name the button CmdStar and give it the Caption=Star Burst.
2 Code the program as follows by typing this code into the code window. The first line of code is typed into the General Declarations area:

```
Dim I, CCode As Integer
```

3 Code the button as:

```
Private Sub cmdStar_Click()
Dim Col, Row As Single
WindowState = 2
Randomize
Scale (-245, 134)-(245, -134)
For I = 1 To 100
Col = 245 * Rnd(1)
If Rnd(1) < 0.5 Then Col = -Col
Row = 134 * Rnd(1)
If Rnd(1) < 0.5 Then Row = -Row
CCode = 15 * Rnd(1)
```



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```
Line (0, 0)-(Col, Row), QBColor(CCode)
Next I
End Sub
```

4 Create a second button named CmdClear (Caption=Clear Screen) to clear the screen when each demonstration is finished and code the button:

```
Private Sub cmdClear_Click()
Form1.Cls
End Sub
```

## Evaluate the solution

1 Run, test and debug the program.
2 Use table 1.7 from chapter 1 to decide the value of the solution produced. Remember that this module would be one small section of code in a large program.

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# Glossary

**Actuator** A specialised hardware device which, under control, carries out mechanical actions, for example, cause a robotic arm to move

**Adaptive robot** a robot that 'learns' from its environment and is able to 'adapt' to changes

**Algorithm** A series of detailed instructions or steps that will solve a problem in a set amount of time

**Alphanumeric** Data made up of letters or numbers

**Alphanumeric spreadsheets** Spreadsheets with letters for column identifiers and numbers for row identifiers

**AML** A manufacturing language used for programming robotic tasks

**Analogue** Data that can have many states and be measured on a continuum, such as the volume on a television

**Analogue-to-digital converter (ADC)** changes analogue data to digital data

**Analysis** The investigation or study of a problem, particularly its components or parts

**Analyst** someone who develops a design to meet a new need or solves a problem in an existing situation

**Animation** The process of making graphics appear or move as if alive, as in an animated cartoon

**Application software** Software that performs a specialised task

**Applications** Programs that perform a specialised task for the user

**Arithmetic logic unit (ALU)** the part of the CPU capable of mathematical and logical operations

**Array** A data structure in which a collection of data items of the same type can be treated as a single entity

**Artificial intelligence (AI)** Machines that mimic human behaviour

**ASCII** American Standard Code for Information Interchange; the standard protocol used to code text in a personal computer

**Assembler** Also assembly language; translator which changes a program written in assembly language into machine language

**Audio sequence** A continuous series of digitised sounds or waveforms

**Authoring systems** Software applications that are specially designed to create programs or files that combine data types for multimedia output

**Automated control** The mechanised command of a task or tasks

**Automatic teller machine (ATM)** a terminal on a banking network specially modified to allow a user to carry out basic banking operations

**Backup** A copy made by the user, on disk or tape, of software or data, to guard against accidental loss

**Backward chaining** Backward chaining inference engines move backwards from the conclusion to be proven towards the known facts by searching the rules

**Bandwidth** The capacity of the transmission medium to handle a particular amount of data in a given time

**Barchart** A series chart which uses columns to show values

**Barcode reader** Input scanning device which reads barcodes

**Baud rate** The number of times per second that a data connection changes state

**Binary code** A base 2 number system which is used to represent the two states of data in a digital computer: commonly referred to as ON or OFF



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**Binary search** An algorithm used to search structured data that must be ordered in either ascending or descending order. The data to be searched is repeatedly divided into two parts: one part is discarded and the other is searched until the search item is found or it is decided that the search item is not in the data

**Bit** The smallest representation of data in a computer, commonly written as a 0 or a 1

**Bit depth** The number of bits used to represent the colour value of each pixel

**Bitmap** A section of memory consisting of a series of 0s and 1s corresponding to pixels on the screen

**Bitmapping** Storing images in memory as a matrix of individual pixels or picture elements

**Bits per second (bps or bit/s)** the number of bits that are conveyed or processed per unit of time

**Block** A range of spreadsheet cells in adjacent rows and columns

**Blog** A web log or web page journal, maintained by one person or a group

**Bluetooth** Technology used to connect mobile phones, mobile PCs, hand-held computers and other devices with short-range radio links

**Boundary** The delineation between a system and its environment, the limits of a system

**Browser** Software for displaying internet documents

**Bug** An error in a program

**Bus** Communications line over which data is transferred to and from the control unit

**Byte** The smallest representation of information in a computer, usually a group of 8 bits

**Cable** Physical medium by which data may be transmitted

**Calculation** Process of using a formula to find a result

**Cathode ray tube (CRT)** picture tube in a monitor or VDU

**Cell address** Coordinates of a cell or row and column location

**Central processing unit (CPU)** hardware which retrieves, decodes, interprets and executes instructions

**Character** A single letter, number or symbol

**Chart** Numeric data represented graphically in a variety of ways: bar, column, line and pie charts

**Client** A computer that accesses and displays data

**Clipboard** Usually a temporary file to hold a piece of text or graphics to allow easy transfer between documents or applications

**Closed database** A database to which no more data entries may be added but in which data may be manipulated

**Coaxial cable** A cable made up of two or more insulated wires that run inside one another which can carry electrical signals with very little interference

**Collaboration** The ability of the people in a team to work together

**Column** A series of text items arranged vertically on a page, such as a series of cells in a table

**Comments** Non-executable lines of text in computer code that explain what is happening

**Communication** The exchange of data, files and commands within a computer system and with other computers

**Compiler** Translator that converts the entire source code, written in a high-level language, into machine language

**Compression** The process of reducing the physical size of data

**Computer-aided design (CAD)** The process of using a computer system to assist in the development of engineering and/or architectural drawings

**Computer-assisted manufacture (CAM)** The process of using a computer system to assist in the manufacture of products

**Constant** Data type that does not change during the execution of a program

**Consultant** Someone with expertise who is contracted by a business to give advice

**Control** The management of operations within a system

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**Control structures** Standard structures that control the logic flow of an algorithm or program
**Controller** Person, mechanical or electrical device that controls a system
**Cookie** A small file stored on a user's computer when pages are downloaded from the internet
**Copy** The process of creating a second version of a document or text without altering the original version
**Copyright** The sole legal right to produce or reproduce software
**Current technologies** Technologies in common use now
**Cursor** A movable symbol on a screen that indicates where the next action will occur
**Data** Raw facts that can be input, stored, processed, output and retrieved from a computer
**Data compression** Techniques for reducing the size of files
**Data dictionary** A description of each field in a database, including field name, field width, data type and description of purpose
**Data operators** Allow data to be manipulated. Can be relational, logical, arithmetic
**Data structure** A way of organising data, making it easier to store related data by using a single name for a data collection so the data can be retrieved when it is needed
**Data transmission** The process of sending data between and within computer systems
**Data types** Also called media types. The methods used to save and store particular types of data
**Data validation** A check to ensure that the data entered into a database is accurate and error free
**Data verification** The check made on the data once it is in the system to ensure it is correct
**Database** A collection of related records organised and stored so that information can be obtained by the user
**Database management system (DBMS)** A database that consists of several linked files called tables
**Debug** To find and remove logic and syntax errors in a program or algorithm
**Decision** The outcome from a range of inputs
**Degrees of freedom** The number of different ways an appendage can pivot
**Designers** People who plan and build a new system or change an old system
**Desktop publishing** The electronic production of documents using text and graphics in a more flexible manner than in general word processing
**Digital** Any system where data is processed and stored as binary code, that is, two possible states
**Digital media** Any method of storing, transmitting, receiving or manipulating data in digital form
**Digital-to-analogue converter (DAC)** Hardware and processes that convert digital to analogue data
**Digitisation** The process of converting data from analogue to digital form
**Direct access** Data is stored randomly and given an address so that it can be found again; also known as random access
**Directory** Storage area on a disk that holds files or programs. A directory may also be called a folder
**Disk** A circular piece of metal or plastic, coated with a thin layer of magnetic material on which electronically transmitted data may be stored
**Disk drive** Hardware device which writes to and reads from a magnetic disk
**Display** To show computer output on a screen: [Page 6] the method of presenting a project [Page 158] refers to the presentation of digital media
**Display hardware** The physical components that visually present data to the user, i.e. screens
**Distribution** The sharing of digital media with other people
**Document** A file or block of data stored under a unique name
**Documentation** Written description of a program or the statements within the program to assist others to use the program
**Draw programs** Use objects to create vector graphics
**Dumb terminal** A terminal on a network that carries out no local processing; it sends characters input at the keyboard and displays information received on the screen
**Edit** To delete or alter data in a file

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**Effector** A mechanical device used to do some useful work on the end of a robot arm

**Electron beam** A ray of light generated by an electron gun, used to illuminate pixels on a screen

**Electronic book (ebook or e-book)** The term may refer to the software (the book text) and/or the hardware reader

**Electronic commerce (e-commerce)** The conduct of business over the internet

**Electronic funds transfer at point of sale (EFTPOS)** the use of data communications to transfer money from the customer's account to the firm's account using a personal identification number and a magnetic-striped plastic card containing account details

**Email** Electronic mail; the use of data communication to send letters, documents and messages between users

**Emerging technologies** Technologies that are available but which are not yet being used widely

**Emulation** The process of pretending to be something else, that is, copying something else

**Engineers** People who design and invent the parts of the computer system

**Environment** The elements outside a computer system which affect that system

**Ergonomics** The study of the relationship between people and their working environment

**Evaluation** Judging a solution

**Expert system** a computer program that consists of knowledge in the form of facts and educated guesses

**Expert system shell** A tool for building expert systems

**Fast processor** A processor which handles data at a rapid rate using various methods, for example, a clock speed of 3 GHz

**Feedback** The return of some part of output to be used as input in a closed loop computer-controlled system

**Fibre optic** The transmission of digital data as a series of light pulses through an optical fibre

**Field** A subdivision of a record containing a specified piece of data

**File** A block of related data written to a storage device

**File format** The organisation of a file or document to meet user specifications

**Filter** A process that translates the form of the data in the database during a query to display the output from the query

**Firewall** A hardware–software security system that acts as a protective boundary between a network (private) and the outside world (public)

**Firewire** A serial bus standard that allows for the high-speed exchange of data in a computer system.

**Firmware** Instructions, often part of the operating system of the computer, that are stored in ROM

**Flash drive** Portable secondary storage device using a USB connection, with a large capacity to hold data. Also known as flash memory

**Flowchart** A pictorial method of describing algorithms by using a set of symbols, connecting lines and arrows

**Font** A typeface, or set of letters and numbers of similar design and size, for example, Times New Roman

**Form** Usually a database layout in which a single record is displayed

**Format** (1) The process by which a disk is prepared to receive data, involving the division of the disk surface into tracks and sectors. (2) The appearance of text or graphics on a page

**Fortran** A computer language used for scientific calculations

**Forward chaining** Forward chaining inference engines consider the known facts and move forward to reach a decision by attempting to match each rule with the known and inferred facts

**Frame** A single screen display stored as a unit in the frame buffer

**Freedom of Information Act** A federal law that allows citizens access to information related to themselves, and to other information after set time frames

**Function** An inbuilt formula which is part of the spreadsheet's commands

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**Geographic information system (GIS)** An electronic map system storing location data in a database
**Gigabyte** A measure of data storage 1 gigabyte (GB)=1024 megabytes
**Global positioning system (GPS)** A method of fixing the location of items using satellite technology
**Graph** A diagram or chart representing the relationship between two or more things using lines or bars
**Graphic** A pictorial representation of data used in computer systems, i.e. in digital form
**Graphical user interface (GUI)** A screen interface which uses windows, icons, mouse and pull-down menus
**Graphics tablet** A digitising input device used for precise drawings
**Handshake** The exchange of agreed rules at the beginning of any connection between nodes
**Hard disk** A type of disk in which the platters are made from metal and the mechanism is sealed inside a container to prevent dust contamination
**Hardware** The physical components of a computer system
**Hexadecimal** A base sixteen number system made up of sixteen digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F; used for data storage
**Home page** Also called index page. The starting point for a particular group of web pages
**Hyperlink** A 'hot link' which allows text to be used for navigation; when clicked the text moves the focus to another part of the document or to another document
**Hypertext** Text that supports links to other forms of data e.g. text, files, images and video
**Hypertext markup language (HTML)** A text-based language that uses tags to control the display of data in a web page
**Icon** A picture on a computer screen representing an instruction or menu option
**Index** The location of individual data items in an array; can also be called a subscript
**Industry** Any large-scale business activity, particularly in trade and manufacture
**Inference engine** The software in which new facts are inferred from the existing facts in the system
**Information** Data that has been organised in a way that is meaningful to the user
**Input** The process of transferring data or instructions from the environment into the computer's memory using a peripheral device
**Instructions** Coded commands to a computer to perform a certain task
**Integrated software** A software package that contains two or more application programs; each program can be used separately but is able to exchange data with the others
**Intelligence** Solving problems independently, learning by experience and reasoning
**Intelligent robot** A robot that recognises objects in its environment
**Intelligent system** A system that receives data from the environment through one of a range of input devices, reacts to that data and produces what the human user would consider an intelligent response
**Interface** The meeting point between any two parts of a system
**Internet** A global communication network
**Internet protocols** The standard rules for internet display and functioning e.g. TCP/IP
**Internet relay chat (IRC)** Software or the process that supports online chat rooms
**Interpreter** Translator which converts source code written in a high-level language line by line of code into machine language
**Intranet** A private network that restricts the use of technology and protocols to within an organisation
**Intrinsic documentation** The use of meaningful variable names in the code to indicate to the programmer what to do
**Intrinsic naming** The use of meaningful names for objects and data types
**Input-process-output (IPO)** the components of a system
**iPod** Apple's portable media player, storage device and PDA

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**Joystick** An analogue input device able to detect relative movements in two dimensions and transmit appropriate signals to the computer
**Keyboard** An input device for converting keystrokes into electrical signals
**Kilobyte** A measure of data storage 1 kilobyte (KB)=1024 bytes
**Knowledge bases** Collections of facts and rules related to a particular topic, held in a database, as the basis of reasoning
**Label** Text used as row and column headings to identify data
**Laser** An optical input or output method used by printers and CD-ROM devices to store or generate data by means of light
**Learn** The process of reacting to feedback from the environment by altering behaviour
**Light pen** A photo-electric device used with a CRT screen to create, manipulate and modify images
**Link** Hardware used to make a connection between computers on a network
**Local area network (LAN)** A network restricted to a single site
**Logic** The correct sequence of instructions in a program or algorithm which lead to correct output
**Loop** To repeat an action one or more times
**Macro** A set of routine instructions stored so they can be carried out by the user, who begins the process by selecting a few keys from the keyboard
**Mail merge** A process by which the contents of one document are combined with information from another document to produce form letters
**Mainframe** A large computer capable of handling a large number of users and/or programs simultaneously, processing very large amounts of data at very fast speeds
**Manipulation** The alteration of data items by editing, sorting, searching or some other method
**Media** The physical material on which data is represented
**Medium** The link across which data is sent in a network
**Megabyte** A measure of data storage 1 megabyte (MB)=1024 kilobytes
**Megahertz** MHz; one million cycles per second; usually used to measure the clock speed of the CPU
**Memory** The amount of storage space available in the computer
**Menu** A list of choices available to the user of a program
**Microcomputer** A self-contained computer which uses a microprocessor as its CPU
**Microprocessor** A single silicon chip which contains some memory and which can be programmed to perform a range of basic logical processes
**Microrobot** A very small multi-function device which uses a computer, sensors and actuators to carry out some predefined task with minimal human intervention
**Microwave** A non-cable media used for data transmission
**Model** An image or representation, sometimes in miniature, to show the construction or serve as a copy of something
**Modelling** The process of emulating or copying some aspect of the real world
**Modem** Modulator-demodulator; a device enabling the transmission of data from one computer to another across a telephone line
**Monitor** A hardware device used to display text and images generated by the computer
**Morphing** The organisation of graphical and audio data so that, across a series of frames, one image or sound changes to another by blending into the next one
**Mouse** A mechanical or optical input device used to move a pointer on a screen
**MP3** Standard compressed format for audio files
**Multimedia messaging service (MMS)** A store-and-forward method of transmitting graphics, video clips, sound files and short text messages over wireless networks using the WAP protocol
**Multimedia system** An information system that combines at least two types of media
**Multitasking** The ability of an operating system to allow the user to carry out more than one task at any given time

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**Network** A communication system that allows two or more computers and their peripheral devices to be connected in order to exchange data and information

**Network topology** The way the nodes of a network are connected e.g. star, ring, bus, mesh

**Neural networks** Formed when hardware and software are joined so that a type of machine thinking can occur

**Nibble** Each group of 4 bits in a byte is called a nibble

**Noise** General term given to interference during data transmission

**Non-procedural languages** Programming languages given problems to be solved and given what has to be done to solve them; the non-procedural language then has rules which allow the system to decide how best to solve the problems

**Numeric field** A field containing only numbers

**Numeric spreadsheet** Spreadsheet using numbers for both column and row identifiers

**Optical character recognition (OCR)** Involves scanning text from paper and translating it into a form that can be manipulated, e.g. in a word processor

**Online** The user's computer is under the control of an external computer located at a far distance, for example, the user is using the internet

**Open database** A database in which data may be added, edited and altered to suit the user

**Open source** Software for which the creators have made the source code available to users and those who wish to collaborate to improve the software function

**Operating system** Software that supervises and controls system resources and manages the flow of data

**Operators** People who control the day to day functioning of computer systems, including the daily set up of the system, purchase of equipment, daily maintenance and fixing minor problems

**Output** The process of transferring data or instructions from the computer's memory into the environment using a peripheral device

**Packet switching** The process of routing and transferring data in packets

**Paint programs** create raster or bitmap graphics in which individual pixels can be manipulated

**Parallel processor** A processor working with one or more additional processors to run a program. More data can be processed simultaneously so the processing speed is very fast

**Parallel transmission** Where all bits in a byte are transmitted simultaneously in groups of 8 bits/1 byte

**Parity** An extra bit added to a byte to check for errors in transmission

**Past technologies** Tools such as hardware, software and procedures no longer in common use

**Peer-to-peer** A type of network where computers communicate directly with each other

**Peripheral** Any input/output device connected to the CPU of a computer

**Personal computer** A microcomputer which has a single silicon chip as its processor

**Personal digital assistant (PDA)** Portable handheld devices such as iPod used for personal tasks, for example, email and appointment schedules, and/or for entertainment, such as music players storing MP3 files

**Pie graph** Circle graph showing sections or sectors of a total

**Piracy** Theft of intellectual property by the copying or use of software to which the user has no legal right

**Pixel** Picture element: the smallest part of the screen, the appearance of which can be controlled by the computer

**Plotter** An output device which uses pens to draw an image

**Plug-and-play** Software standard that allows for the automatic connection and recognition of peripherals added to an operating computer without the need to restart the system

**Podcasting** A method of publishing audio files via the internet, allowing users to subscribe to a feed to receive new files automatically

**Portable document format (PDF)** A data format used to compress and store files in a fixed resolution and device-independent format

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**POST** Point-of-sale-terminal; a dumb terminal in a retail outlet which transmits and receives data but does no processing

**Potentiometer** a sensor used to determine rotation

**Powerline** Term used for delivering broadband over electricity cables. Devices may also be networked via the electrical wiring in buildings provided they are physically connected to power points on a circuit.

**Prediction** The use of a spreadsheet or other computer program to see the possible outcome of making changes to data or other structures; allows the impact of changes to be seen on the computer before a decision is made to carry them out

**Primary sources** provide data direct from the origin

**Primary storage** The main memory of the computer, composed of RAM and ROM

**Printer** An output device capable of converting electrical signals to physical impressions on paper

**Privacy** The right to keep information related to oneself away from the knowledge of others

**Problem definition** An exact statement of the problem and a knowledge of the way a computer can help solve the problem

**Process** To carry out an instruction, or a series of instructions, usually related to the manipulation of data

**Processing** Changing data into another form that humans may use as information

**Program** A sequence of instructions written in a programming language that directs a computer's actions

**Programmer** Person who writes the software or programs for the computer system

**Programming** The process of writing the code or sequence of instructions which will result in a program

**Programming language** A set of instructions in which a program is written for a computer system

**Project management** The use of knowledge, skills, tools and techniques to meet the requirements of a project

**Projects** the planning, design and production of solutions to problems

**Protocol** A set of rules that govern transmission of data between computers

**Prototype** A working model of a project built in order to further understanding

**Prototyping** Developing a working model of the solution to the problem

**Pseudocode** A precise form of English that uses keywords and rules of structure

**Query** A question asked of a database using a structured query language specific to the database

**Queue** A line of data items waiting to be processed

**QWERTY** The 'standard' keyboard named after the first six letters of the second row

**Random access memory (RAM)** Volatile primary storage

**Range** A group of cells in adjacent rows or columns

**Raster** An image formed from a pattern of pixels, that is, a bitmap graphic

**Read** Process of loading instructions or data into primary memory or to a peripheral, such as a screen

**Readability** The ability to present a document using fonts, typefaces and other processes to increase the ease of reading the document

**Really simple syndication (RSS)** Uses filtering and sorting to deliver web services, such as the news, to internet users. A browser with support for RSS e.g. Firefox or Safari, is needed

**Reasoning** The ability to follow logical rules in order to arrive at a conclusion based on those rules

**Record** A collection of facts about an entity in a database, made up of one or more related fields

**Refinement** The process of dividing a problem into its sub-problems

**Register** A group of fast access memory cells within the CPU used for the temporary storage of data

**Report** A collection of data and statistics gathered from an analysis of the data in the database

**Resolution** A measurement of the clarity of an image

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**Resource** A resource is any part of a system which is used by the processor to perform its task

**RGB** A method of colour representation using the levels of the three primary colours of red, green and blue required to produce a particular colour

**Robot** A computer-controlled device which uses sensors and actuators to carry out some pre-defined task

**Read only memory (ROM)** Permanent primary storage

**Row** Cells in a horizontal arrangement

**Satellite** A non-cable media used for data transmission using a satellite dish to send and receive data from the earth's surface

**Scanning** The process of reading data from paper documents and converting it to digital form

**Scroll** A method of moving within a document in the direction desired by the user

**Searching** Examining data to find all elements which meet a set criteria

**Search engine** An information retrieval system to locate specific data on the internet

**Secondary sources** Sources that provide data indirectly

**Secondary storage** Permanent storage provided on a peripheral device, such as a hard disk, DVD or CD

**Semiconductor** An accurate, fast sensor used in devices like video cassette recorders. Its conductivity rises with the rise in temperature

**Sensor** A device that converts input from the environment into a signal which can be communicated to a control program

**Sequential** Data access which reads data in the order in which it was stored

**Serial transmission** Where all bits in a byte are transmitted one after the other in single file

**Server** A computer which handles data transfer and program access across a network

**Short message service (SMS)** Uses a mobile phone or the internet to send and receive text messages of up to 160 characters

**Simple data types** The basics of data – numbers and letters

**Simulation** Using a computer to represent a physical system, that is, to pretend to be something else

**Simulators** Hardware devices that use a computer model as the basis for an experiment or simulation of a situation in the real world

**Skype** An example of a peer-to-peer internet telephone (VoIP) network that uses free software and allows a PC to operate as a telephone when a microphone is attached

**Smart terminal** A computer which has the capacity to process data

**Software** A sequence of instructions used to direct the operation of a computer. Also known as programs.

**Solenoid** An electromechanical device in which an electrical current creates a magnetic field

**Sort** The arrangement of data in a particular order, such as ascending or descending

**Spreadsheet** Programs which organise data into columns and rows so that mathematical calculations may be carried out on the data

**Spyware** A range of programs, mostly downloaded unknowingly from the internet and designed to take partial control of a computer without the consent of the user

**Storage** Any device which can save and retain data over a period of time and allow it to be retrieved when needed

**Storyboard** The visual presentation of a project, drawn as a panel or series of panels that show consecutive changes between screens in a planned multimedia program, and the navigation between them

**Style** A style is a group of formatting structures which work together

**Syntax** The rules of a programming language

**Synthesis** The process of combining small systems or sub-systems into a larger, more complex system

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**System** A collection of interacting parts working together to achieve a particular function
**System software** Files, utilities and resources that the computer needs to run properly
**Table** A design layout which displays data in columns and rows
**Tape** A sequential storage media
**Technician** Person who installs, repairs and maintains computer systems
**Template** A document created for repeated use
**Temporary storage** Random-access memory (RAM)
**Terabyte** A measure of data storage 1 terabyte (TB) =1024 gigabytes
**Text** Data which consists of strings of printable characters separated by white space characters
**Thermistor** A sensor which controls temperature using resistance; measures temperature continually: when the temperature increases, resistance drops
**Thermocoupler** Accurate, fast and widely used temperature sensors They need fairly complicated electronic circuitry in order to work
**Thermostat** The simplest sensor used for controlling temperature. It is a switch which opens at a set temperature and stays open while the temperature remains at that level or higher
**Trainer** Person who teaches those who will use the computer system to operate different programs
**Transfer** Data transfer is moving data within a computer or between different parts of the computer system using a sender, a receiver and a link
**Translator** A general term for a program which converts high level language into machine code
**Twisted pair** A cable medium which consists of twisted wires and is subject to noise interference
**Typeface** The design of a set of characters
**Uniform resource locator (URL)** The location, or address, of a website
**Universal serial bus (USB)** A standard software/hardware format for high-speed communication between a computer and other devices
**Users** General term for the people for whom a computer system is designed
**Utility** A program that performs file management functions
**Validity** The ability of data to meet rules of currency and accuracy
**Value** A decimal or whole number used in a spreadsheet
**Variable** A data type which changes value during the execution of a program
**Vector** The coordinates of objects, such as the starting and finishing points of a line. Draw graphics are also known as vector graphics
**Virtual private network (VPN)** A local computer network set up for an organisation or community that uses a secure internet access
**Virtual reality** A computer-generated three-dimensional model with which people interact
**Virus** A program written to alter the contents of a file or another program without the user's permission
**Visual display unit (VDU)** Computer monitor
**Vlogging** Also called video logging, that is, a blog that includes video, text images and links
**VodCast** Video on demand received from the internet and including vlogging
**Voice over internet protocol (VoIP)** A standard format used for phone calls made over the internet
**Voice over Wireless LAN (VoWLAN)** A method used for phone calls over a wireless broadband network
**Volatile** Temporary memory present only while power is on
**Wiki** A website that allows users to add and edit content
**Wireless** Wireless refers to communications in which data is sent using infrared, radio or other electromagnetic waves rather than some form of wire
**Wireless LAN (WLAN)** A local area network using wireless technology set up on a single site
**Word** A computer word is the number of bits that make up a common unit of information, that is, the number of bits which can be processed in one operation by the CPU, which moves bits around the system one word at a time

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**Word processor** A program written for the creation, editing and manipulation of text

**World wide web (WWW)** A system of internet servers that supports hypertext and browsing

**Write** Process of loading instructions or data into secondary memory or output to a peripheral, such as a printer

**WYSIWYG** What you see is what you get

**XML** eXtensible Markup Language used to add functions to HTML

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