Introduction

Aims

This book has been written to provide the knowledge, understanding and practical skills that you'll learn through studying the Cambridge International Level 1/Level 2 course in Information and Communication Technology, also known as Cambridge IGCSE ICT. This book, together with the accompanying CD provides:

- practice tasks which offer guidance on how to answer questions for the practical parts of the course
- activities which allow students practice in answering questions for the practical parts of the course
- source data files for the tasks and activities
- advice for the practical parts of the course
- suggestions for possible teaching methods.

Although it has been written with the Cambridge syllabus in mind, it can also be used as reference text for other practical ICT qualifications at GCSE and other equivalent Level 2 courses.

Using the book

The text is in 21 chapters. Although some elements of the practical chapters may be examined in the theory question papers, and vice versa, the sections for the theory work are in Chapters 1–10 and the sections for the practical work in Chapters 11–21. Answers on the Teacher's CD include some marking guidance.

Examination questions

The practical section contains examination-style questions.

Colour codes and symbols used

Throughout the book there are a number of colours and symbols used. Key presses are shown as <Enter>, but be careful with Chapter 21, where html codes are also shown in angled brackets, like this <html>. Different sections of text are in the following styles.

Tasks

These are examination-style questions in the practical section (which often include the use of source files from the CD for the practical tasks) that are answered within the chapter. The text demonstrates the techniques used to solve the task and gives some example answers. These provide easy-to-follow step-by-step instructions, so that practical skills are developed alongside the knowledge and understanding.

Activities

These are examination-style questions in the practical section, usually at the end of a chapter or section for the students to answer. These often include the use of source files from the CD.

Exercises
In the theory section, these are short exercises for the students to complete in order to confirm their understanding of the concepts covered in a section or chapter.

HTML markup

```
All html markup appears in a blue proportionally spaced font
with a blue dotted border.
```

Cascading stylesheets

```
All cascading stylesheets appear in a cerise proportionally
spaced font with a cerise dotted border.
```

Advice
These give advice and shortcuts for improving your ICT skills.

Text colours

Some words or phrases within the text are printed in **red**. Definitions of these terms can be found in the glossary on the CD.

In the practical section, words that appear in **blue** indicate an action or location found within the software package, for example 'Select the **HOME** tab.'

In the database sections of the book, words in **orange** show fieldnames.

Words in **green** show the functions or formulae entered into the cell of a spreadsheet, for example a cell may contain the function **=SUM(B2:B12)**.

Hardware and software used

The practical elements of the examinations can be undertaken on any hardware platform and using any appropriate software packages. For the purposes of this book, we have needed to choose specific software packages, but the functionality of many other packages is very similar. Many of the skills demonstrated in Chapters 11 to 21 are transferable and can be adapted for other hardware and software platforms.

All the tasks and activities within the practical chapters have therefore been created using a PC platform with *Microsoft Windows 8.1* operating system and include the use of *Notepad*. Independent packages used for the practical sections include packages from *Microsoft Office Professional Edition 2013*, including *Word*, *Excel*, *Access* and *PowerPoint*. *Internet Explorer* has been used as the web browser, although we would recommend testing all web pages in at least three different web browsers.

For the website authoring section of the book (Chapter 21), all work has been produced in html code without the use of a WYSIWYG package. Although you may have a WYSIWYG package, it is important to realise that you are expected to have knowledge of underlying HTML and cascading stylesheet code. All html written within this chapter is written in HTML version 5, and is W3C validated (at the time of going to print). All cascading stylesheets used have been W3C validated.

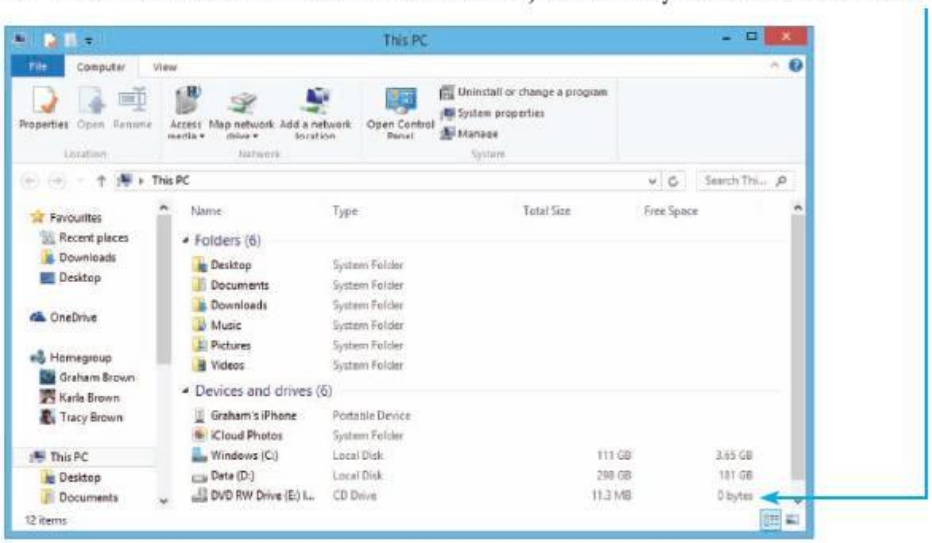
Using source files

Source files can be found on the CD and will need to be copied onto your local machine or network drive in order to use them. Copy them and give them read/write access. This is essential to ensure that you can use some of the file

types included on the CD. For example, you cannot create queries or reports in *Access* when working from the CD. The CD will contain all source files in a series of sub-folders, one for each of the practical chapters.

PC users

On the keyboard press <Windows> and <E>. The Windows Explorer window opens for This PC. Locate the CD or DVD drive, which may be called drive D: or E:



For the purposes of this section, we will assume that it is called drive E:. If your machine has a different drive for the CD letter, adapt these instructions accordingly. Locate the **Chapter source files** folder, which can be found at **E:\Resources\Chapter source files**. To locate an individual file, such as the image snowball.jpg used in Chapter 12, use the path **E:\Resources\Chapter source files\Chapter 12\snowball.jpg**.

It may be better to copy the contents of this folder into a new folder on your local machine or network drive. To copy an entire folder, drag its contents from the source CD into a new folder. To copy a single file, open the file that you wish to use. Select the **VIEW** tab, then **Edit Document** to change the document from Read only and allow you to save it. Select **FILE** and then **Save As** to save a new copy with an amended filename. You may need to change the file permissions of these files to read/write to enable you work on them; however, check with your network administrator before attempting to make these changes.

MAC users

Double-click on the CD icon on the desktop. Use Finder to navigate to the location for the new folder, then create a new folder (<Apple>+<Shift> +<N>). With Finder, choose the CD and select all files (<Apple>+<A>) and copy them (<Apple>+<C>). Go to the new folder using Finder and paste the files (<Apple>+<V>).

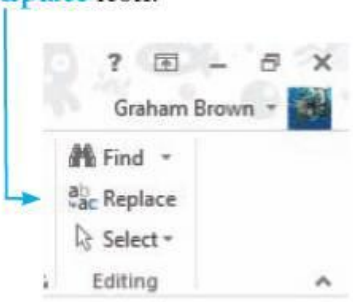
Changing the source files to match your regional settings

Before attempting any of these processes, back up all source files. The source .csv (comma separated value) files supplied on the CD have commas as separators between fields and full stops within currency values. If your regional settings for these values are different to these (for example, if you use commas within

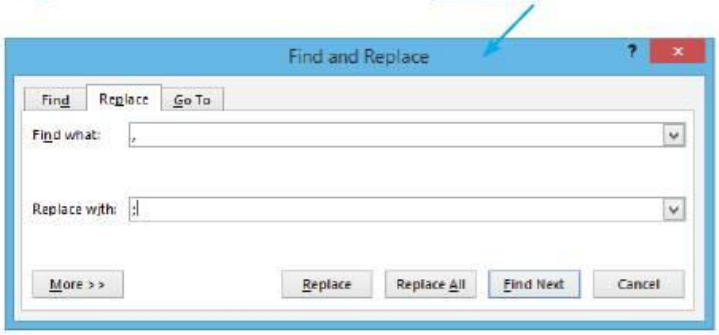
currency values rather than full stops and your software settings require you to use semicolons for separators between fields), then the source data files will need to be edited for use with the regional settings for your software. This process may be required to convert the source data files before the start of the practical examinations. You can do this process in many packages, but the easiest (at this level) is *Word*. Open the .csv file in *Word* using **FILE** and **Open**. Select the file from the list to open the file, which will look similar to this.

```
Who manufactured the car?,Model,Colour,Price that we bought the car
for,Price that we will sell the car for,Year,Extras,Does the car need
cleaning?
TVR,Tuscan,Black,18000,20305,2006,Alloy Wheels   Air Conditioning,N
Mercedes,C200,Silver,4995,5995,2003,Air Conditioning,N
Toyota,MR2 roadster,Electric blue,13995,15895,2005,Leather Seats   Air
Conditioning,N
```

Select the **VIEW** tab, then **Edit Document** to change the document from Read only. Select the **HOME** tab, then the **Editing** section followed by the **Replace** icon.



Enter a , (comma) into the **Find what:** box and a ; (semicolon) into the **Replace with:** box, then click on [Replace All].



Repeat this process, replacing a . (full stop) with a , (comma). All the characters will have been replaced within the file like this.

```
Who manufactured the car?;Model;Colour;Price that we bought the car
for;Price that we will sell the car for;Year;Extras;Does the car need
cleaning?
TVR;Tuscan;Black;18000;20305;2006;Alloy Wheels   Air Conditioning;N
Mercedes;C200;Silver;4995;5995;2003;Air Conditioning;N
Toyota;MR2 roadster;Electric blue;13995;15895;2005;Leather Seats   Air
Conditioning;N
```

Save the file with the same file name using the **HOME** tab and **Save**. This will ensure that the file is saved in .csv format.

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Section 1

ICT Theory

Chapters

1 Types and components of a computer system

In this chapter you will learn about:

- hardware
- software
- the main components of a computer system
- operating systems
- different types of computer systems
- the impact of emerging technologies.

Computer systems are now commonplace in every part of our daily life. This first chapter introduces the basic components that make up these computer systems, most of which will be described in much greater depth in later chapters. Basic components, including hardware (both external and internal) and software (both application and system) are all briefly introduced in the following sections.

A good analogy is to compare computers with books: the actual pages and ink used on the pages of a book are equivalent to the hardware used to make up computers; the words written on the pages are equivalent to the software. Without the words, the book is useless. Similarly, without software, computers would be of little use to any of us.

1.1 Hardware and software

Hardware is a general term for the physical components that make up a computer system: the keyboard, mouse, monitor, printer and so on. Hardware can be either external or internal.

Software is a general term for the programs that control the computer system. There are two types of software: **application** and **system**. Examples of each are shown on the following pages.

Figures 1.1 and 1.2 on pages 3–4 describe some of the features of both application and system software. Further details about software can be found in the later chapters of this book.

Hardware falls into two categories: external and internal. External hardware (input, output and storage devices) is covered extensively in the following chapters of this book.

Figure 1.3 on page 5 considers the following internal hardware devices:

- the motherboard
- random access memory (RAM)
- read-only memory (ROM)
- video cards
- sound cards
- internal storage devices: hard disk drive (HDD) and solid state drive (SSD).

Since it isn't always possible to see the internal hardware devices, the photographs in Figure 1.4 on page 6 give you some idea of the physical appearance of the components described in Figure 1.3.

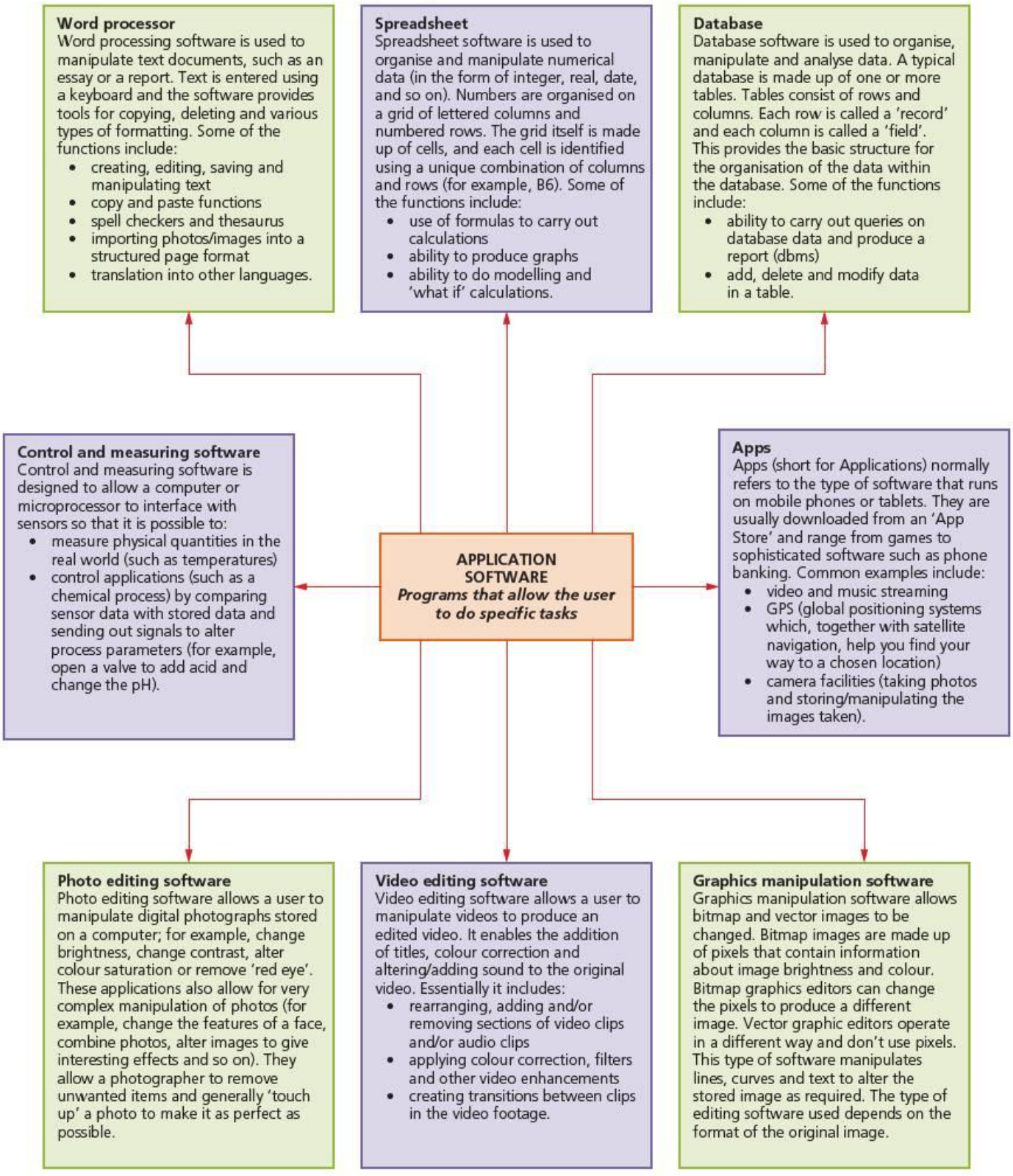


Figure 1.1 Application software

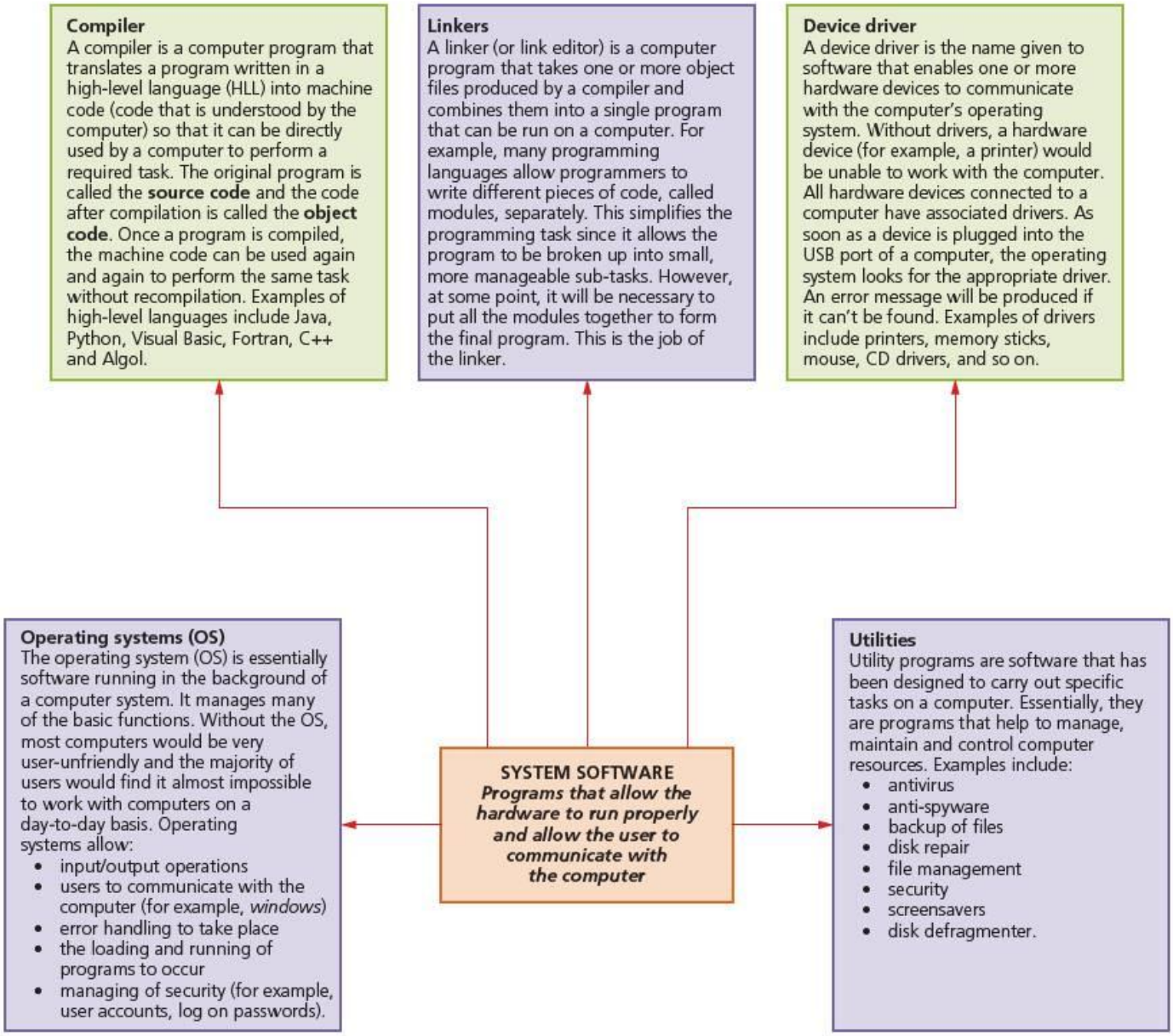


Figure 1.2 System software

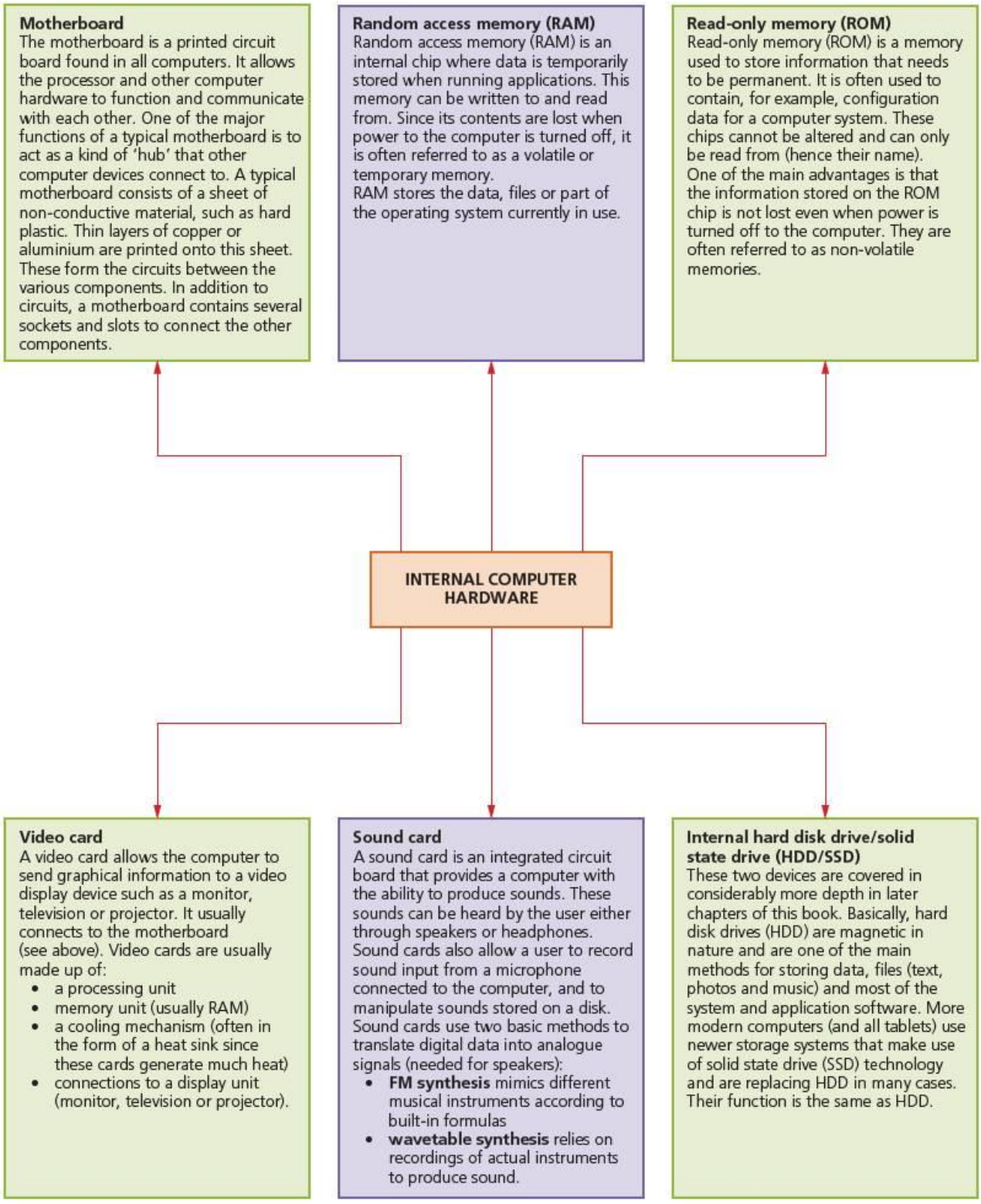
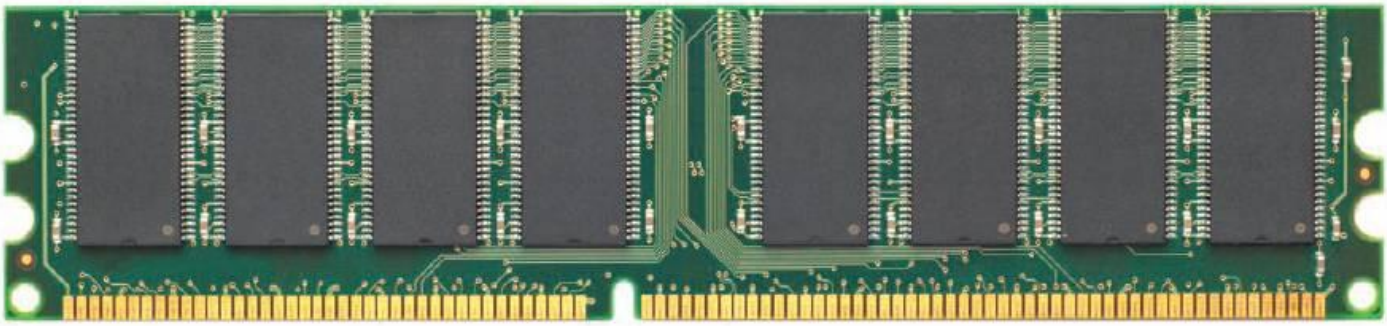


Figure 1.3 Internal computer hardware

RAM



ROM

Video card

Sound card

SSD

Motherboard

HDD

Figure 1.4 Internal hardware images

1.2 Main components of a computer system

As already mentioned in Section 1.1, a typical computer system is made up of hardware and software. Figure 1.5 shows an example of a computer system consisting of input devices, output devices and secondary storage. These will be discussed in more detail in Chapter 2, but examples are given in Table 1.1.

Table 1.1 Examples of input, output and secondary storage devices

Device	Examples
Input devices	keyboard, mouse
Output devices	monitor, printer
Secondary storage devices	DVD R/W drive, removable hard disk drive

Internal hardware devices were discussed in Figure 1.3 – these consist of four key components:

- the **central processing unit (CPU)**, contained on the motherboard
- **internal hard disk drive**
- **random access memory (RAM)**
- **read-only memory (ROM)**.

The **central processing unit (CPU)** is the part of the computer that interprets and executes the commands from the computer hardware and software. It is normally part of the computer motherboard.

CPUs used to be made up of discrete components and numerous small integrated circuits; these were combined together on one or more circuit board(s). However, due to modern manufacturing techniques, the CPU is now referred to as a **microprocessor**. This is a single integrated circuit which is at the heart of most PCs and is also found in many household devices and equipment where some control or monitoring is needed (for example, the engine management system in a car).

The CPU is made up of a control unit, which controls the input and output devices; an arithmetic and logic unit (ALU), which carries out calculations and makes logical decisions; and the immediate access store (RAM).

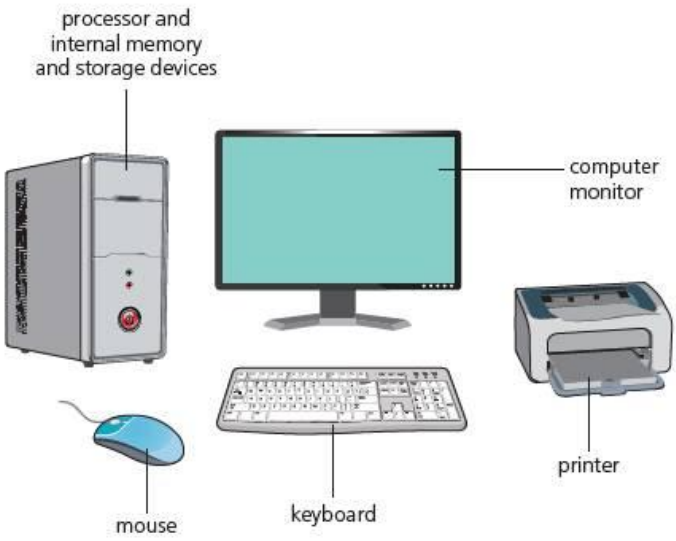


Figure 1.5 A typical computer system

The **internal hard disk drive (HDD)** or **solid state drive (SSD)** is the computer's main internal storage; this is where the applications software, disk operating system and files (for example, text, photos or music) are stored. The main advantage of these storage devices is the fast data transfer/access times and their large capacity to store data (see Chapter 3 for further discussion).

Random access memory (RAM) is an internal chip where data is temporarily stored when running applications. This memory can be written to and read from. Since its contents are lost when power to the computer is turned off, it is often referred to as a volatile or temporary memory. This was fully defined in Figure 1.3.

Read-only memory (ROM) is a memory used to store information that needs to be permanent. It is often used to contain, for example, configuration data for a computer system. These chips cannot be altered and can only be read from (hence their name). One of the main advantages is that the information stored on

the ROM chip is not lost even when power to the computer is turned off. It is often referred to as non-volatile memory. This was fully defined in Figure 1.3.

It is worth noting that ROM also contains some coding known as the **boot file**. This code tells the computer what to do when it first starts up; it is often referred to as the **BIOS (basic input/output system)**.

When the computer is turned on, the BIOS carries out a hardware check to find out if all the devices are present and whether they are functional. Then it loads the **operating system** into the RAM.

The BIOS stores the date, time and system configuration in a non-volatile chip called a **CMOS (complementary metal oxide semiconductor)** – this is usually battery powered.

1.3 Operating systems

Operating systems have already been referred to earlier on in this chapter (see Figure 1.2).

To enable computer systems to function and to allow users to communicate with computer systems, special software known as **operating systems (OS)** has been developed. The general tasks for a typical operating system include:

- control of the operation of the input, output and backing storage devices
- supervising the loading, running and storage of applications programs
- dealing with errors that occur in application programs
- maintaining security of the whole computer system
- maintaining a computer log (which details computer usage)
- allowing communication between the user and the computer system (user interface).

1.3.1 User interfaces

Command line interface (CLI)

Command line interface (CLI) requires a user to type in instructions to choose options from menus, open software and so on. There are often a number of commands that need to be typed in, for example, to save or load a file. The user therefore has to learn a number of commands just to carry out basic operations. Having to key in these commands every time an operation has to be carried out is also slow. However, the advantage of CLI is that the user is in direct communication with the computer and is not restricted to a number of predetermined options.

The section of CLI shown in Figure 1.6 imports data from table A into table B.

The statements in Figure 1.6 show how complex it is just to carry out a fairly straightforward operation using CLI.

```
1. SQLPrepare(hStmt,
2. ? (SQLCHAR *) "INSERT INTO tableB SELECT * FROM
   tableA",
3. ? SQL_NTS):
4. ? SQLExecute(hStmt);
```

Figure 1.6 CLI code

Graphical user interface (GUI)

Graphical user interface (GUI) allows the user to interact with a computer (or MP3 player, gaming device, mobile phone, and so on) using pictures or *icons* (symbols) rather than having to type in a number of commands. For example, the whole of the CLI code in Figure 1.6 could have been replaced by a single icon.

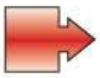


Table update

Simply selecting this icon would automatically execute all of the steps shown in Figure 1.6 without the need to type them in each time.

GUIs use various technologies and devices to provide the user interface. One of the most common is **WIMP (windows icons menu and pointing device)**, which was developed for use on personal computers (PCs). Here a mouse is used to control a cursor and icons are selected to open/run windows. Each window contains an application, and modern computer systems allow several windows to be open at the same time. An example is shown in Figure 1.7 (here a number of icons can be seen on the left-hand side and at the bottom of the screen).

A windows manager looks after the interaction between windows, the applications and windowing system (which handles the pointing devices and the cursor's position).

In recent years, devices such as **touch-screen** phones use **post-WIMP** interaction, where fingers are in contact with the screen allowing actions such as *pinching* and *rotating*, which would be difficult to do using a single pointer and device such as a mouse.

Figure 1.7 Windows screen showing icons

Summary of the main differences between CLI and GUI

Table 1.2 The main differences between CLI and GUI

Interface	Advantages	Disadvantages
Command line interface (CLI)	• The user is in direct communication with the computer. • The user is not restricted to a number of predetermined options. • It is possible to alter computer configuration settings.	• The user needs to learn a number of commands to carry out basic operations. • All commands need to be typed in, which takes time and can be error-prone. • Each command must be typed in using the correct format, spelling, and so on. • It is more difficult to edit once commands are entered.
Graphical user interface (GUI)	• The user doesn't need to learn any commands. • It is more user-friendly; icons are used to represent applications. • A pointing device (such as a mouse) is used to click on an icon to launch the application – this is simpler than typing in commands.	• It uses up considerably more computer memory than a CLI interface. • The user is limited to the icons provided on the screen. • It needs an operating system, such as *Windows*, to operate, which uses up considerable memory.

Who would use each type of interface?

- CLI: a programmer, analyst or technician; basically somebody who needs to have direct communication with a computer to develop new software, locate errors and remove them, initiate memory dumps (contents of the computer memory at some moment in time), and so on.
- GUI: the end-user who doesn't have (or doesn't need) any great knowledge of how the computer works; a person who uses the computer to run software or play games or store/manipulate photographs, for example.

1.4 Types of computer

There are many types of computer systems in existence. The following sections summarise some of the more common types currently available.

1.4.1 PC/desktop computers

PC/desktop usually refers to a general-purpose computer that is made up of a separate monitor, keyboard, mouse and processor unit.

The term PC (personal computer) usually refers to computer systems that are IBM-compatible, thus distinguishing them from, for example, Macintosh/Apple systems.

It is worth making a comparison here with laptop computers.

The advantages of desktop computers over laptop computers are as follows.

- Spare parts and connections tend to be standardised, which usually results in lower costs.
- The desktop tends to have a better specification (for example, a faster processor) for a given price (often due to size and construction constraints in laptops).
- Power consumption is not critical since they usually plug straight into a wall socket and the larger casings allow a better dissipation of any heat build-up.
- Because they are usually fixed in one location, there is less likelihood of them being damaged.
- Internet access is also more stable since they are not moved around (the user will always have the same data transfer rate).

They do also have disadvantages when compared to laptop computers.

- The most obvious is that they are not particularly portable since they are made up of separate components.
- Because they are not particularly portable, it is necessary to copy files, etc. when you want to do some work elsewhere (for example, at home) – with a laptop you simply take the whole computer with you.
- They tend to be more complicated since all the components (for example, keyboard, mouse) need to be carried round with you and then connected to the computer by wires or wireless connections, which also clutters up the desk space.

1.4.2 Laptop computers

Laptop (or **notebook**) refers to a type of computer where the monitor, keyboard, pointing device and processor are all together in one single unit. This makes them extremely portable.

Key features you would expect to find in a laptop:

- lightweight (to aid portability)
- low power consumption (and also long battery life)
- the processor shouldn't generate too much heat (cooling is very important).

The advantages of laptop computers compared to desktop computers:

- the most obvious is their portability; they can be taken anywhere since the monitor, pointing device, keyboard, processor and backing store units are all together in one single unit
- because everything is in one single unit, there are no trailing wires, etc.
- they can take full advantage of Wi-Fi
- since they are portable, they can link into any multimedia system.

Laptop computers do have disadvantages when compared to desktop computers, however:

- since they are easily portable, they are also easier to steal
- they have limited battery life, so the user may need to carry a heavy adaptor
- the keyboards and pointing devices can sometimes be awkward to use.

1.4.3 Tablets

Tablets are a relatively new internet-enabled portable computer. They work in a similar way to a smartphone. Tablets use touch-screen technology and don't usually have a conventional keyboard (although some tablets that are a cross between tablet and laptop do exist). The keyboard is part of the touch screen and keys are simply touched by the finger or a stylus. Internet access is usually through Wi-Fi or 3G/4G/5G (mobile phone) connectivity. Tablets are equipped with a series of sensors including cameras, microphones, accelerometers and touch screens.

Some of the typical features of tablets include:

- high-definition, anti-glare displays
- front- and back-facing cameras (which are used to take photos and videos, or act as a webcam when doing video calls over the internet)
- lower weight and longer battery life than laptops
- Bluetooth connection to printers and other devices
- flash (solid state) memory and cloud storage facilities to back up and synchronise (often just referred to as 'sync') data sources
- sensors to carry out the following functions:
  - proximity sensors to detect if the device is close to, for example, the ear (which allows it to block unintended 'touches')
  - accelerometer, which detects movement and orientation of the device (for example, moving the display from portrait to landscape to view videos, or to allow it to be used as a 'steering wheel' in car-racing games)
  - can use sophisticated speech-recognitions systems (such as *Siri*) to enable the user to ask the device to look for things (for example, search the address book).

Some of the latest tablet devices have been designed as a hybrid between tablet and smartphone – sometimes referred to as a phablet – which have slightly smaller screens than tablets (typically between 12 cm and 15 cm display size). All of the features of a normal phone are available with some of the features of a tablet (notably they have a larger screen size than a phone; larger memories – typically 32 GB (or more) memory as standard; use quad core processors; allow multiple windows to be open and so on).

Advantages of tablets compared to laptops:

- very fast to switch on (no time delay waiting for the 'windows' system to load up)
- fully portable – they are so lightweight that they can be carried anywhere
- touch-screen technology means they are simple to use and don't need any other input devices
- can use several Apps as standard (such as built-in camera, MP3/4 players and so on)
- don't generate any heat – they use solid state technology
- battery life of a tablet is a lot longer
- when the power button is pressed it goes into standby but remains connected to the internet, so the user still hears alerts when emails or other 'events' are received.

Disadvantages of tablets compared to laptops:

- they often have limited memory or storage compared to a laptop
- they can be expensive to run if the internet is being accessed frequently via 3G/4G/5G mobile phone networks
- typing on a touch screen can be slow and error-prone compared to a standard keyboard
- transferring of files often has to be done through an 'Apps store'; the lack of an App 'drag and drop' facility can prove irritating for users
- laptops tend to support more types of file format than tablets, and are also better equipped to run different types of software.

1.4.4 Smartphones

Smartphones allow normal phone calls to be made but also have an operating system (such as iOS, Android or Windows), allowing them to run a number of computer applications. They allow users to send/receive emails, use a number of Apps, use a camera feature (to take photos or videos), MP3/4 players (for music and videos), and so on.

Smartphones communicate with the internet either by using Wi-Fi hot spots or by using 3G/4G/5G mobile phone networks. They make use of a number of Apps that allow the following functions, among many others:

- send/receive emails
- surf the net (for example, so you can order goods on the move)
- global positioning system (use of maps to navigate to a location)
- calendar functions
- telephone banking (send and receive money using banking Apps)
- Voice over Internet Protocol (VoIP) – telephone network using the internet, which also allows video calling
- streaming of videos
- streaming of music (from radio stations, for example)
- instant access to social networks (social contact with friends no matter where you are in the world)
- instant messaging.

The next generation of smartphones will use touch screens with OLED (organic light-emitting diode) technology. The touch screens are coated with a crystalline layer that allows the phones to be partially solar powered, but this also allows them to use Li-Fi (similar to Wi-Fi except communication uses visible light rather than radio waves). Communication using Li-Fi is considerably faster than Wi-Fi (it has a much higher data transfer rate); it is also more secure (it stops internet 'piggybacking', unauthorised use of the internet connection) and can also be used on flights since it doesn't use radio waves.

The technology works by switching LED bulbs off and on in nanoseconds (10^{-9} of a second) which is too quick for the human eye to detect. Light on represents the binary value 1, while light off represents the value 0. This is the basis behind the method used for communication.

Advantages of smartphones:

- they are very small in size and lightweight – therefore very easy to carry round and have on your person at all times (this is more difficult with laptops since they are much bulkier and also much heavier)
- can use them to make phone calls as well as connect to the internet while on the move
- because they use Wi-Fi and mobile phone networks, they can be used almost anywhere (this is not the case with laptops or PCs, although tablets also use the same technology)
- they have hundreds of Apps (such as camera facility, MP3/4 players, and so on) – again this is similar to tablets, but it is an advantage compared to laptops
- they have a reasonable battery life compared to laptops.

Disadvantages of smartphones:

- the small screens make pages difficult to read and small keyboards make typing things in more difficult and slower (laptops and PCs have much bigger screens and much larger keyboards) – this disadvantage is becoming less of a problem as smartphone screens get larger on newer phablets
- web browsing and photography can drain the battery quickly
- memory size in most phones isn't very large when compared to laptops and PCs – although it is comparable with tablets
- not all website features are compatible with smartphone operating systems
- because of their small size, it is much easier to lose a smartphone (or for it to be stolen) than laptops or PCs
- the data transfer rate using mobile phone networks is slower than with Wi-Fi – this makes streaming of video or music, for example, less than satisfactory at times.

1.4.5 Smartwatches

Smartwatches essentially allow users to wear a mini-computer on their wrists. They offer the same functions as a smartphone and make use of OLED technology (see Chapter 2). As with smartphones, they use touch-screen technology but also have the ability to link to smartphones using Bluetooth technology.

Smartwatches have the following functions:

- internet connectivity (browsing, searches, sending emails and so on)
- ability to make and take phone calls
- messaging via text or video
- weather forecasts
- fitness and health-monitoring capability
- GPS (finding your location and, using satnav, directions to other locations).

These are just a few of the functions; essentially whatever is available on a smartphone is available on a smartwatch. Many of the advantages and disadvantages of smartphones also apply to smartwatches, but the following are additional points to be considered.

Additional advantages:

- they are even more convenient than smartphones since the technology delivers notifications straight to the user's wrist
- they are very easy to use for monitoring fitness and health regimes.

Additional disadvantages:

- smartwatches are relatively large and bulky (so that the display can show the Apps clearly and also permit the use of a battery, which gives an acceptable usage time before recharging), which can make them uncomfortable to wear
- they tend to be rather unattractive in design, which means there is still some reluctance for the technology to be adopted.

1.4.6 Mainframe computers

Mainframe computer is a term used for a large, very powerful, computer system. The name comes from the days when the individual components were housed in large (often room-sized) frames.

Their main purpose is to run commercial applications, such as banking and insurance, where huge amounts of data need to be processed every day.

The main features of mainframe computers are:

- they can have several CPUs
- they have very fast processor speeds
- they can support multiple operating systems
- they have huge amounts of storage capacity
- they have huge internal memories (for example, several hundred gigabytes of RAM)
- they often operate using time sharing or batch processing.

1.5 Impact of emerging technologies

Some of the latest technologies were mentioned in Section 1.4. This section reviews briefly the impact of the following new technologies:

- artificial intelligence (AI) biometrics
- vision enhancement
- robotics
- quantum cryptography
- computer-assisted translation (CAT)
- 3-D and holographic imaging
- virtual reality.

New technologies are being developed at a remarkable rate, so the reader is advised that the above list could be out of date very quickly. A quick review on the internet is advised every six months or so to ensure that the reader is up to date with all the latest technologies.

1.5.1 Artificial intelligence (AI) biometrics

A known problem with biometric technology is that many fingerprint identification systems falsely reject a person's fingerprints – when the scanned fingerprints are checked against the database no matches are found.

Artificial intelligence (AI) biometrics overcomes this problem using **dynamic profiling** – the system learns by using AI about a person's fingerprints on every scan. This means a person doesn't have to worry about getting their finger in exactly the right place every time on the scanner. The system learns from the different alignments and is therefore still able to match the fingerprints to those stored on a database.

Facial-recognition systems have the same problem. A human being is still able to recognise a face even if the person has grown facial hair, now wears glasses or has aged. Computerised facial-recognition systems are confused by such **soft biometric** changes. New systems use AI to learn from scanning a number of faces and can pick out these soft biometric features. This means the system can still recognise faces and cross-reference these attributes with corresponding images stored on the database.

Other AI biometric technologies are being developed, so these security systems become increasingly more reliable.

1.5.2 Vision enhancement

Low-vision enhancement systems (LVES) use video technology through a headset connected to a computer. The system allows images to be projected inside the headset in front of the eyes. This effectively brings the objects closer for examination by the user of the system.

Night vision enhancement (NVE) amplifies infrared light and visible light so that an image can still be seen in apparent darkness. For example, the military use this technology to carry out surveillance at night. The dim light source is captured and passed through an **image intensifier tube**, which converts the light into electrons. These electrons pass through another tube where they are amplified to produce several times the original number of electrons. A screen at the end of the tube is coated in phosphor dots that glow when electrons collide with them – this results in an image that is considerably clearer than the original.

1.5.3 Robotics

Robotics has been around for many years, mostly in the manufacturing industry. They are used in car factories to weld car bodies, spray body panels and fit items such as windscreens. No human intervention is required. However, there are areas outside manufacturing where robotics is evolving rapidly, and we could see robots appearing in many areas of our lives in a relatively short space of time.

One application is the use of **drones**. These are unmanned flying devices that are used by both the military and civilians. The military have used drones in reconnaissance missions for a number of years. Civilian uses include surveying the landscape in 3-D for use with GPS, investigating weather phenomena (for example, flying into hurricanes or other weather conditions that would be dangerous for manned surveillance), or search and rescue/fire fighting in natural disasters. All of these are currently under evaluation and many more applications could evolve over the coming years.

Another application is the use of robots in surgical procedures. Robotic surgery allows surgeons to perform complex procedures with more precision, flexibility and control than standard surgical techniques. With this technique, surgeons use robotics equipped with a camera arm and several interactive mechanical arms – these have joints that work like a human's wrist.

1.5.4 Quantum cryptography

Cryptography is the science of making a message unintelligible to any unauthorised user (a hacker). This technique is often referred to as **encryption**. There are many methods of cryptography in existence but all of them have a limited life as computers become faster and faster at number crunching. A consequence of this is that, over the next few years, a hacker is increasingly likely to decipher encrypted messages unless computer designers can further strengthen security systems.

Quantum cryptography is based on the use of photons (light) and their physical quantum properties to produce a virtually unbreakable cryptography system. This helps protect the security of data being transmitted over fibre-optic cables. The technology relies on the fact that photons oscillate in various directions and produce a sequence of random bits (0s and 1s) across the optical network. It is based on the laws of physics rather than mathematics (which is how current cryptography methods work). How this works in detail is beyond the scope of this book.

1.5.5 Computer-assisted translation (CAT)

Existing online language translators have a very limited use.

Consider the insect called a fruit fly, which particularly enjoys eating bananas. What if we typed in the phrase: 'fruit flies like a banana'. This could be translated into German using a free online translator as '*fruchtfliegen wie eine banane*'. The statement in German only refers to the banana-shaped flight path of a piece of fruit thrown through the air! Imagine a whole page being translated that is full of such double meanings of words and phrases.

Computer-assisted translation (CAT) goes some way to overcome these issues. CAT is a type of language translator that uses specific software to help in the translation process. In particular, CAT uses two tools:

- terminology databases – linguistic databases that grow and 'learn' from translations being carried out
- translation memories – these automatically insert known translations for certain words, phrases or sentences.

All CAT software needs some post-editing by the user to remove errors from the translation process. While not perfect, they are certainly more accurate than existing free online translators.

1.5.6 3-D and holographic imaging

Holography is a technology that allows 3-D images (known as holograms) to be produced. The technology involves the use of:

- a source of laser light
- interference of light
- light diffraction, and
- light intensity recording.

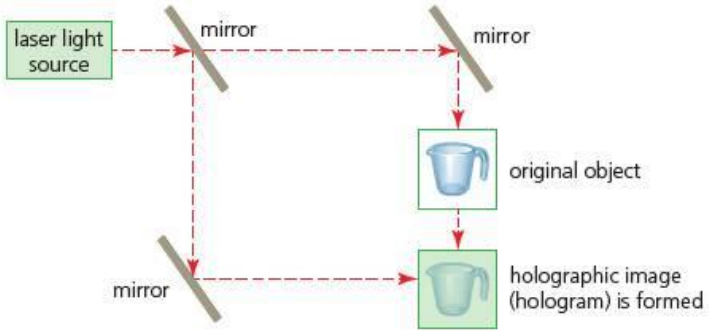


Figure 1.8 Formation of a hologram

As a holographic image is rotated, it appears to move in the same way as the original object, thus appearing to be in three dimensions (3-D). The hologram is produced by first splitting a laser beam. Half of the light (known as the **object beam**) is reflected off the object on to a photographic plate. The other half of the light (known as the **reference beam**) is reflected off a mirror and on to the same photographic plate. The holographic image is produced where the two light beams meet on the photographic plate.

Holograms have the following applications:

- engineering design (CAD)
- architecture (ability to rotate design through 360 degrees)
- simulations
- medical imaging (see inside organs in 3-D – links into tomography, which is the same technology behind 3-D printers)
- cinema (special effects)
- gaming (special effects)
- advertising
- holographic televisions (expected by around 2025, these should give a full 3-D experience without the need for special glasses)
- holographic computer memories (a new type of optical storage – a crystal the size of a sugar cube can hold up to 1 TB of data)
- optical computers (these will operate at speeds that are trillions of times faster than-current technology computers).

1.5.7 Virtual reality

Virtual reality is an artificial environment created by software. The user makes use of data goggles, sensor suits, data gloves or helmets to get a feeling of reality (that is, the feeling of 'being there'). The technology is used in training (for example, in a nuclear reactor where the user can see all the walls, pipes, vessels and valves as if they were inside the reactor, so that they can be trained safely to deal with certain events), education (for example, to explore the inside of a building such as a castle in a history lesson) or in games (where the user can interact as if they were there, such as a driving simulator where the road ahead is output on to a visor in a helmet strapped to the user's head).

Virtual reality is used in all of the following areas:

- military applications (for example, training to use a new tank)
- education (for example, looking inside an ancient building as part of a history lesson)
- healthcare (for example, as a diagnostic tool)
- entertainment (for example, games where gloves, goggles or helmets are worn to give realism to the scenario and even to give images or sound to make it seem very real)
- fashion (for example, to do fashion shows before doing the real thing to see the clothes on people, check out the venue and so on)
- heritage (for example, showing monuments such as Stonehenge)
- business (for example, training courses and role-playing scenarios for staff)
- real estate (for example, allowing people to 'look around' houses that are for sale)
- engineering (for example, seeing how new designs will look)
- sport (for example, a golfer trying to improve their swing can use this technology and get feedback to improve their game)
- media (for example, special effects in films such as *The Matrix*)
- scientific visualisation (for example, looking at molecular structures in chemistry).

2 Input and output devices

In this chapter you will learn about:

- input devices
  - uses of each device
  - advantages of each device
  - disadvantages of each device
- direct data entry (DDE) devices
- output devices
  - uses of each device
  - advantages of each device
  - disadvantages of each device.

2.1 Input devices and their uses

As the name suggests, these are hardware devices that allow data to be input into a computer. Many such devices exist, ranging from the more common ones, such as the keyboard, through to the more specialist devices, such as barcode readers. A number are described in this section.

2.1.1 Keyboards

These are the most common input devices and are used to input text, numbers and instructions into the computer. Most use the **QWERTY** layout (this name comes from the keys on the top row, which spell out 'QWERTY').

Ergonomic keyboards are designed to reduce the health-related problems associated with standard keyboards, such as carpal tunnel syndrome and repetitive strain injury (RSI).

Uses

- Input of data into applications software (for example, text into word processors, numbers into spreadsheets, etc.).
- Typing in commands to the computer (for example, Prnt Scrn, Ctrl+P to print out etc.).

Advantages

- Fast entry of new text into a document.
- Easy to use for most people.
- Easier to do verification checks as the data is entered (can immediately compare the source document with typed data on the screen).

Disadvantages

- Can be difficult to use if the user has limited arm/wrist use.
- Slow method when compared to direct data entry (for example, optical mark recognition).
- Fairly large device that uses up valuable desk space.

Exercise 2a

Find out about a number of applications that use input/output devices and discuss the reasons why they were chosen (that is, their advantages and disadvantages).

Concept keyboard

The **concept keyboard** uses icons or phrases instead of standard letters. These are often used in fast-food restaurants, where a single key represents one item, for example an ice cream. The person serving only needs to touch this key to order the ice cream and bring up its price on a screen.

- This allows for fast data entry (no need to type in whole commands).
- The keyboards are waterproof (useful in a restaurant environment).
- Also, in certain applications (for example, at unmanned airport information kiosks), these keyboards are tamper resistant, preventing people from keying in information that could potentially corrupt the computer system.

Numeric keypads

A **numeric keypad** is used to enter numbers only (although some have a function key to allow alphabetic characters to be input).

Uses

- **Automatic teller machines (ATMs)**, where the customer can key in their PIN, amount of money, etc.
- Mobile phones, to allow phone numbers, etc., to be keyed in.
- **Point-of-sale (POS) terminals** in case the barcode reader fails to read the barcode – the number has to be keyed in manually by the operator.
- Chip and PIN devices when paying by credit/debit cards (key in PIN, amount of money, etc.).
- Fast entry of numeric data into a spreadsheet.

Advantages

- Faster than standard keyboards when entering numeric data.
- Since many are small devices (for example, mobile phones) they are very easy to carry around.

Disadvantages

- Sometimes have small keys which can make input more difficult.
- Sometimes the order of the numbers on the keypad isn't intuitive.

2.1.2 Pointing devices

Mouse

The **mouse** is an example of a **pointing device**. The user controls the position of a pointer on the screen by moving the mouse around. There are usually two buttons, which have different functions: the left button is usually used to select items by double clicking, while the right button brings up drop-down menus.

Many also have a scroll button, which speeds up the process of moving through a document.

Recent developments have produced the **optical mouse** (where movement is detected by reflected light rather than the position of a moving ball) and the **cordless** or **wireless mouse** (which transmits signals to a USB wireless receiver plugged into the computer). The advantage of an optical mouse is it has no

Figure 2.1 Example of a drop-down menu

moving parts and it also doesn't pick up any dirt. This makes it more robust and improves its performance since the older type of mouse can 'skid' on certain surfaces, reducing the control of the pointer.

Uses

- Opening, closing and minimising software.
- Grouping, moving and deleting files.
- Image editing, for example controlling the size and position of a drawing pasted into a document.
- Controlling the position of a pointer on the screen to allow selection from a menu or selecting an icon, and for scrolling up and down/left and right.

Advantages

- Faster way to choose an option than using a keyboard.
- Very quick way to navigate through applications and the internet.
- Doesn't need a large desk area when compared to a keyboard.

Disadvantages

- Can be more difficult for people with restricted hand/wrist movement than using a keyboard data entry.
- Easy to damage, and the older type of mouse quickly becomes clogged up with dirt.
- Difficult to use if no flat surface is readily available (for example, on an aeroplane).

Exercise 2b

Try out as many input devices as possible and write down your own views on their ease of use, advantages and disadvantages.

Touchpad

Touchpads are used as a pointing device in many laptop computers. The pointer is controlled by the user moving their finger on the touchpad and then gently tapping it to simulate the left button of a mouse (i.e. selection). They also have buttons under the touchpad which serve the same function as the left and right buttons on a mouse. Their uses are the same as those of a mouse.

Advantages

- Same as the mouse (faster than a keyboard for choosing options, used to navigate applications and the internet, etc.).
- Since the touchpad is integrated into the laptop computer there is no need for a separate mouse – this aids the portability and is also a big advantage if there are no flat surfaces available.

Disadvantages

- People with limited hand/wrist movement find the device difficult to use.
- Can be more difficult to control the pointer when compared to a mouse.
- More difficult to use when doing certain operations such as *drag and drop*.

Trackerball

Trackerballs are similar to a mouse except that the ball is on the top or the side of the device; the user controls the pointer on the screen by rotating the ball with their hand. It is easier to use for people with limited hand/wrist movement. Some trackerballs have two buttons, which have the same function as the left and right mouse buttons. If they have a third button, it is the equivalent to a *double click*. Since trackerballs don't physically move, there is no need for desk space.

Uses

- Used in applications where the user has a disability (such as RSI).
- Used in a control room environment where it is faster than a mouse to navigate through process screens.
- Used in some luxury cars to select functions such as radio, telephone, music, satnav and so on.

Figure 2.2 Trackerballs are used in some luxury cars to select functions such as radio, telephone, music and satnav

Advantages

- Doesn't need the same fine control as a mouse.
- Easier to use than a mouse if the operator is disabled.
- More accurate positioning of the pointer on screen than a mouse.
- They are more robust than a mouse.
- Needs less desk space than a mouse or a keyboard.

Disadvantages

- Not supplied with computers as standard, therefore more costly.
- User may need training since it isn't standard equipment.

2.1.3 Remote control

A **remote control** is used to control the operation of other devices remotely using infrared signals. The buttons on the keypad are used to select options (such as television channels, sound levels on a hi-fi, timings on a DVD recorder, etc.)

Uses

- Televisions, satellite systems, DVD players and hi-fi systems all use remote controls to alter functions such as sound volume, on/off, change channels open the disc drawer, and so on.
- Used to control multimedia systems.
- Used in industrial applications to remotely control processes, stop and start machinery, etc.

Advantages

- Can be operated from any reasonable distance, unlike, for example, a corded mouse which is restricted by the length of cord (useful for disabled people).
- Some chemical processes are hazardous, so it is a big advantage to be able to select operations from a distance.

Disadvantages

- Difficult to use if the operator has limited hand/wrist movement.
- It is easier to block the signal if, for example, the walls in the building are very thick.

2.1.4 Joysticks

Joysticks have similar functions to a mouse and a trackerball. By gripping the stick, a pointer on the screen can be controlled. Buttons are used to make selections. Often they have another button on the top of the stick that is used for gaming purposes, for example to fire a weapon.

Uses

- Used in video/computer games.
- Used in **simulators** (for example, flight simulators) to mimic actual controls.

Advantages

- Easier than a keyboard to navigate the screen.
- Control is more realistic than using a mouse, for example.

Disadvantages

- More difficult to control the on-screen pointer than with other devices, such as a mouse.

Driving wheel

A **driving** (steering) **wheel** is an example of an input device that is similar to a joystick in many ways. It connects to a computer (or games machine), usually through a USB port. The wheel allows you to simulate the turning of a steering wheel, and there are associated devices (such as buttons or pedals) which allow you to accelerate and brake. Sensors are used to pick up left/right movement so that the user gets the sensation of steering a car around a circuit or on the road.

Uses

- Used in video/computer games (for example, car-racing games).
- Used in **simulators** (for example, car-driving simulators) to mimic actual vehicle controls.

Advantages

- Easier than a keyboard or joystick to control steering movements; it is more natural.
- The 'driving experience' is nearer to how an actual steering wheel and other controls operate in real life.

Disadvantages

- It can be a rather expensive input device compared to mouse or joystick.
- Movements in the steering can be too sensitive, giving an unrealistic 'feel'.
- Unless it is an expensive simulator, feedback to the driving wheel is non-existent.

2.1.5 Touch screens

With a **touch screen** the user can choose an option by simply touching a button/icon on the screen. The selection is automatically made without the need for any pointing device.

Uses

- Self-service tills, for example at petrol stations, where the user just touches the screen to select the fuel grade and payment method.
- Automatic teller machines (ATMs) to choose from on-screen options.
- Point-of-sale terminals at, for example, restaurants.
- Public information systems at airports, railway stations, tourist offices, etc.
- Personal digital assistants (PDAs), mobile phones and satellite navigation systems.
- Interactive white boards in education.
- Computer-based training (CBT) where answers are selected during on-screen testing.
- They can obviously also be used as an output device, since they still work as a flat-screen monitor.

Advantages

- Faster entry of options than using keyboard or mouse.
- Very easy method for choosing options.
- User-friendly – no training necessary in its use.

Disadvantages

- Limited number of options available.
- Can lead to problems if an operator has to use the system frequently (straining of arm muscles, RSI, etc., are all possible).
- The screen can get very dirty with constant touching; this can reduce its responsiveness and can also make it more difficult to read in strong light.

2.1.6 Scanners

Scanners are used to enter information from hard copy (for example, text documents, photographs) into a computer. The most common type is the flatbed scanner (shown on the right), which is made up of a glass panel and lid. The hard copy document or photo is scanned by a light source and produces a computer-readable image.

The subsequent image can then be manipulated using a drawing package. Images can also be used with optical character recognition (OCR) software to allow the information to used in a word processor, desktop publishing, presentation software, etc. (see Section 2.2.5). Specialist scanners exist that are designed to carry out a specific task, for example barcode scanners (see later).

Uses

- Scan in documents and convert into a format for use in various software packages.
- Scan in old/valuable documents/books, thus protecting the originals, as well as producing records in case the paper copies are lost/destroyed (this is also known as archiving).
- Scan in photographs (not all cameras are digital, so some photographs are still printed on paper requiring conversion to computer format for storage).
- Scan in barcodes at POS terminals.

Advantages

- Images can be stored for editing at a later date.
- Much faster and more accurate (i.e. no typing errors) than typing in documents again.
- It is possible to recover damaged documents and photographs by scanning in and then using appropriate software to produce an acceptable copy.

Disadvantages

- Quality can be limited depending on how good a resolution the scanner is capable of (since most scanners have a range of resolutions you can choose from).
- They can be fairly slow at scanning, especially if the colour scanning mode is chosen or if the chosen scanning resolution is high.

2.1.7 Digital cameras

Digital cameras have largely replaced traditional film-based cameras. The images are stored on a memory card (solid state memory) and can be transferred to a computer by:

- directly reading the memory card (by slotting it into a card reader attached to a computer or a printer)
- connecting the camera to the computer using a USB port
- using wireless data transfer (Wi-Fi or Bluetooth).

The images are uploaded from the camera and stored in a file on the computer; the user can select which photos to upload and which to ignore. The images are then available for printing out as photos, to be used in a 'slide show', imported into software such as a word processor, or for upoading on to the internet.

Advantages

- Easier to produce better-quality photographs than with a traditional camera.
- Easier and faster to upload photographs to a computer rather than having to scan in hard copies when using traditional methods.
- No need to develop film and print out photographs anymore – this saves money and is also environmentally more acceptable (saves paper and reduces the use of the chemicals used in developing traditional film).
- Memory cards can store several hundred photographs.

Disadvantages

- Need to be computer literate in using the cameras properly; also, the transferring, storing and manipulating of the images via a computer requires some understanding of how computers work.
- There is some artistry lost since clever software now corrects errors in the photographs (for example, incorrect exposure, removal of red eye, etc.).
- The resolution still isn't as good as many expensive traditional cameras (this is improving all the time however; the quality of photographs depends on the number of pixels (many cameras now offer more than 20 mega pixels per image), quality of lens, etc.).
- Images often need to be compressed to reduce the amount of memory used (a single image can use more than 4 MB of memory, for example).

Many smartphones and tablets are now capable of taking photographs of a very high quality. Some of the latest smartphones are essentially making cameras almost obsolete for the casual photographer. Because the quality of the lens is an important feature, professional photographers will continue to use digital cameras for a number of years. However, it is now possible to get special attachments for many smartphones to allow special effects, zooming functions and even light filters.

Video cameras

Although specialist video cameras (as shown in the photo) exist, many digital cameras are capable of taking moving images. Since the video footage is simply a number of still photos 'stitched' together, this allows a digital camera to take reasonable video.

These cameras are often referred to as **DV (digital video) cameras**; they store compressed photo frames at a speed of 25 MB per second – this is known as **Motion jpeg**.

In both digital and video versions, the camera picks up the light from the image and this is turned into an electronic signal using light-sensitive sensors. In the case of the DV cameras, these signals are automatically converted into a compressed digital file format.

The advantages of using DV cameras compared to traditional video cameras (that use film) are:

- it is much easier to manipulate video footage using specialist software (for example, remove all the colour except one colour to give dramatic effects, etc.)
- DV format gives a very high quality of image which lends itself to effective editing.

The only real drawback is cost (it is possible to store 20 minutes of video footage on a 1 GB memory card costing about $20; while a video tape costing only $5 would allow a 60-minute video to be taken). But costs of memory cards will no doubt continue to fall, reducing this drawback with time.

2.1.8 Microphones

Microphones can be connected directly to a computer. Sounds can be inputted and then manipulated. The input sound is converted to an analogue signal and then converted into a digital signal. The computer's sound card usually does this automatically, that is, it acts as an analogue to digital converter (ADC).

Uses

- To input speech/sounds to be used in various applications, for example in presentations, sampling (in films, music, etc.) and special effects (films).
- Input in voice-recognition software:
  - the software converts the speech into text that can be used in, for example, a word processor or to input commands into a computer
  - to recognise commands; for example, some cars now have voice-activated systems to switch on the lights, turn the radio volume up, etc.
- Microphones can also be used as a sensor to pick up sound (for example, in a burglar alarm system).
- Used in video conferencing or Voice over Internet Protocol (VoIP) applications.

Advantages

- Faster to read text than to type it in using a keyboard.
- It is possible to manipulate sound in real time using special software rather than work on a recording done at some earlier stage.
- If used in a voice-activation system, it has the advantage of improving safety (since the car driver, for example, doesn't need to take their hands off the wheel to operate a switch or alter the radio station, etc.).

Disadvantages

- Sound files can use up a lot of computer memory.
- Voice-recognition software isn't as accurate as typing in manually (for example, software can't distinguish the difference between '*their*' and '*there*'.

2.1.9 Sensors

This section deals with **analogue sensors**. A sensor is a device that inputs data to a computer; the data is a measurement of some physical quantity that is continuously changing (for example, temperature, light, moisture, etc.). These physical quantities are analogue in nature. Since computers only understand digital data (1s and 0s), the information from the sensors needs to be converted; this is done using an **analogue to digital converter (ADC)**.

Sensors are used in both monitoring and control applications – various types of sensors are used depending on the application (see the table below). When monitoring, the data sent to the computer is often transferred directly to a spreadsheet package (for example, taking measurements in a scientific experiment, measuring atmospheric pollution, etc.).

Table 2.1 Uses of sensors

Type of sensor	Applications
Temperature	used in automatic washing machines, central heating systems, automatic glasshouses, ovens
Pressure	used in burglar alarm systems, washing machines, robotics, environmental monitoring
Light	used in automatic glasshouses, automatic doors, burglar alarm systems, street lighting control
Sound/acoustic	used in burglar alarm systems, monitoring liquid and powder flow in pipes
Humidity/moisture	used in automatic glasshouses, environmental monitoring, used in factories where moisture levels are crucial (for example, manufacture of microchips, paint spraying)
pH	used in automatic glasshouses, chemical processes, environmental monitoring

Advantages

- More accurate readings taken when compared to human operators.
- Readings are continuous – no break in the monitoring.
- Because it is a continuous process, any necessary action (control system) or warning (monitoring system) will be initiated immediately.
- Systems can be automatic, removing the need for human intervention (very important if the process is hazardous or needs precise control/monitoring).

Disadvantages

- Faulty sensors can give spurious results (for example, sensors on the rear bumper of a car that monitors obstacles; if these become dirty, they may either not identify an obstacle or give a continuous alarm).

2.1.10 Graphics tablet

A **graphics tablet** is used with a stylus to produce freehand drawings. The images produced can then be stored in a file on a computer.

Uses

- Used to produce drawings, computer graphics, etc.
- In countries where the written language uses complex characters (for example, China and Japan) graphics tablets are used as a form of input as it is faster than typing in the characters with a keyboard.
- Used in computer-aided design (CAD) work.

Advantages

- It is possible to modify drawings before they are input.
- They offer a very accurate method of drawing (better than using a mouse or trackerball).
- They can record levels of pressure, unlike other point-and-click devices.

Disadvantages

- They are more expensive than other pointing devices (such as a mouse).
- It takes longer to produce a drawing using this equipment than doing it with pen and paper.
- Menus are often not very user-friendly.
- Larger drawings (such as A4) are expensive to produce.
- The touch screens are damaged easily.

2.1.11 Webcams

Webcams are similar to digital video cameras; however, they are connected directly to the computer (through a USB port) and they don't have a memory. Whatever information the webcam picks up is transmitted directly to the computer. Many computer systems now have webcams built in to their monitors as standard.

Uses

- Many people use webcams as a more personal way of having a conversation while chatting online.
- They are used to enable video conferencing to take place.

Advantages

- They can be left on constantly, only being activated as required; this means it is possible to have an immediate face-to-face video chat much like instant messageing with images.
- They allow people to keep in contact with each other without the need to travel (very useful for elderly or disabled people).

Disadvantages

- They have very limited features and are often of poor quality.
- They need to be connected to the computer (although this is less of an issue with laptop computers when the webcam is usually built in to the monitor lid).

2.1.12 Light pens

Light pens are used with computers as an input device. They contain sensors that send signals to a computer whenever light changes are detected. The devices only work with CRT monitors (see output devices section) as they rely on the screen image being built up row by row by an electron beam. The screen is refreshed 50 times every second; because of this, the computer is able to determine the pen's position by noting exactly when the device detected the electron beam passing its tip. Systems to allow light pens to operate with LCD monitors are still at the development stage.

Uses

- Selecting objects on CRT screens.
- Drawing on screen (for example, with CAD packages).

Advantages

- Greater accuracy than touch screens.
- Small (can be used where space is an issue).
- Easy-to-use technology.

Disadvantages

- Problems with lag when drawing on screen.
- Only works with CRT monitors (at the moment).
- Not that accurate when drawing.
- Rather dated technology.

2.2 Direct data entry (DDE) devices

2.2.1 Devices for reading information from cards

Magnetic stripe readers

These are used to read information on the magnetic stripe found on, for example, the back of a credit or debit card.

The stripe contains useful information, for example: account number, sort code, expiry date and start date.

Uses

- On credit/debit cards for use at ATMs or EFTPOS (electronic funds transfer at point of sale) terminals.
- Security devices to allow entry to buildings, hotel rooms, etc.

Advantages

- Fast data entry compared with keying in with a keyboard or keypad.
- Error free (since no typing is involved).
- Secure (information not in human readable form and, since there is no typing, removes the risk of somebody observing your key strokes).
- Prevents access to restricted/secure areas.
- Not affected by oil, water, moisture etc.
- No moving parts – so physically very robust.

Disadvantages

- If the magnetic stripe gets damaged (for example, due to exposure to a strong magnetic field) the data is lost.
- Doesn't work at a distance (card needs to be in close contact with the reader).
- Since the information is not human readable, this can be a disadvantage in some applications.

Contactless card readers

Contactless debit or credit cards allow customers to pay for items worth up to $25 without entering their PIN. All contactless cards have a small chip that emits radio waves embedded in them. The card is held within a few centimetres of the payment terminal to pay for an item; the terminal picks up the signal from the chip and allows the transaction to be processed.

The steps taken are:

1. Customers look out for the contactless symbol on the payment terminal.
2. The shop assistant enters the amount for payment.
3. The card reader informs the customer to present their contactless card.
4. The customer holds their card in front of the card reader.
5. The terminal display will indicate that the card has been read.

Advantages

- Faster transaction (typical transaction takes 15 seconds as opposed to 30 seconds using a magnetic stripe reader).
- The system uses 128-bit encryption to protect data.
- Customers do not have to worry about typing errors (such as incorrectly typing in a PIN).
- Retailers no longer have access to the customer's credit/debit card information.
- The chip in the contactless credit card responds to the payment terminal reader with a unique number used for that transaction only; it does not simply transmit the consumer's account number; this number is also encrypted.

Disadvantages

- They are more expensive than normal credit/debit cards.
- A thief with a suitable reader could monitor your contactless card transaction while standing at the counter with you, or just behind you (the third point above reduces this risk considerably however: because you don't have to type in a PIN, somebody standing behind you couldn't steal your PIN and use it).
- Can take money twice if the customer uses it as a chip and PIN card (one is contactless and the other is chip and PIN).
- Transactions are usually limited to a small maximum value (e.g. $25).
- Transactions have been carried out without the card holder being aware of this while they were just standing in the payment queue.

Chip and PIN readers

Chip and PIN readers are similar to smart card readers but are used at EFTPOS terminals. The device has a slot into which the card is placed and the chip is read; the PIN is entered using the keypad. The reader also has a small screen which

gives instructions to the operator. They are similar to the contactless system, except for two points:

- the customer has to key in their PIN to make a transaction
- the cards do not make use of RF technology.

Uses

- Where payments are made using cards (restaurants, supermarkets, travel agents, etc.).

Advantages

- More secure system (PIN typed in must match up with PIN stored on chip).
- More robust system than magnetic stripe cards.

Disadvantages

- Fraud – need to be careful to ensure PIN isn't read by somebody else while typing it in.

2.2.2 Radio frequency identification (RFID) readers

This technology has already been mentioned in the description of contactless credit/debit card transactions.

Radio frequency identification (RFID) readers use radio waves to read and capture information stored on a **tag**. The tag can be read from a distance of several metres, which is one of its advantages over the barcode system. The RFID tag is made up of two components:

- a microchip that stores and processes information
- an antenna that is used to receive and transmit data/information.

The tags can be passive or battery powered. Passive tags use the reader's radio wave energy to relay the information; battery-powered tags use a small embedded battery to power the RFID.

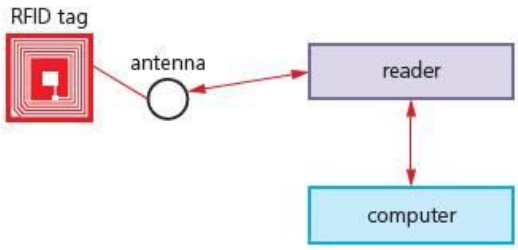


Figure 2.3 Radio frequency identification readers (RFIDs)

Uses

- Livestock tracking (so that the whereabouts of each animal on a farm is known; it also identifies which farm owns the animal).
- Retail (it is similar to barcodes but doesn't require any scanning; details, such as price, can be stored on the tag and then automatically read at a checkout – a big advantage is that several tags can be read at the same time, thus speeding up the checkout process).
- Admission passes (for example, in theme parks RFID cards eliminate the need to scan or swipe people before 'rides', reducing the waiting time; it also allows the tracking of people in the theme park and certain information, such as height or age, can be stored to prevent entry to certain rides on safety grounds).
- Libraries (books can be tracked in and out automatically by readers at the library entrance; no need to scan barcodes or magnetic stripe cards, making the process quicker and more accurate).

Advantages

- No line-of-sight contact is necessary; the tags can be read from a distance.
- It is a very robust and reliable technology.
- Very fast read rate (typically < 100 milliseconds to respond).
- Bidirectional data transfer (that is, it allows read *and* write operations to take place).
- Bulk detection is possible (i.e., detect several RFID tags at the same time).

Disadvantages

- Tag collision (this is when the signals from two or more tags overlap, interfering with each other).
- Because RFID uses radio waves, they are relatively easy to jam or interrupt.
- It is relatively easy to hack into the data/signal transmitted by the tag.
- RFID is more expensive than a comparable barcode system.

2.2.3 Magnetic ink character recognition/reader (MICR)

Magnetic ink character recognition (MICR) is a system that can read characters printed in a special ink (containing iron particles). Only certain characters written in a standard font can be read.

The system is now used primarily for reading the characters at the bottom of a bank cheque.

These characters are converted into a form that the computer can understand and then stored in a computer file.

Uses

- They are primarily used to process cheques in banking operations. When a cheque is presented its value is first printed on the cheque in the special ink. The cheques are then all gathered together (either at the end of the day or after some specified period) and then read using a **batch processing** method.

Advantages

- Offer greater security than OCR since the printed characters cannot be altered.
- There is no manual input, so errors are reduced.
- The magnetic ink characters can still be read even if somebody writes over them (for example, a signature).

Disadvantages

- Only certain characters can be read and the number of different characters is very limited.
- More expensive than other methods used in direct data entry.

2.2.4 Optical mark recognition/reader (OMR)

Optical mark recognition (OMR) is a device that can read marks written in pen or pencil. The places where the pen or pencil marks can be made are clearly shown in the image on the right (in this example, the numerical lozenge is shaded in each response using a pen). The position of the mark is stored in the computer's memory after being read by the OMR device.

Uses

- Used to read questionnaires, multiple-choice examination papers and many other types of form where responses are registered in the form of lines or shaded areas.

Advantages

- Very fast way of inputting the results of a survey, etc. The documents are fed in automatically and there is no user input.
- Since there is no typing, they are more accurate than keying in the data.
- They are more accurate than OCR methods.

Disadvantages

- The forms need to be carefully designed to make sure that the marks/shading are correctly positioned to gather accurate information.
- There can be problems if the forms haven't been filled in correctly; sometimes they have to be checked manually before being read, which is both time consuming and expensive.

2.2.5 Optical character recognition/reader (OCR)

Optical character recognition (OCR) is the name given to software that takes scanned text and converts it into a computer-readable form. The text can then be used in various application packages such as word processors, desktop publishing and presentation software.

Uses

- One of the most recent uses is the processing of passports and identity cards.

Advantages

- It is a much faster data-entry system than manually keying in data.
- Since no manual data entry, the number of errors is also reduced.

Disadvantages

- The system still has difficulty reading handwriting.
- Still not a very accurate technique.

Comparison of OCR and OMR

A company has decided to produce a questionnaire to gain information from customers. What features of OCR or OMR need to be considered when designing the data capture form? This comparison is needed before the form is designed and the appropriate input method chosen. The following table summarises the features of both methods.

Table 2.2 Comparison of OCR and OMR

OCR	OMR
Because this method reads handwriting, it is possible for customers to extend their answers to questions	Since this involves shading in lozenges to answer set questions, the information obtained is limited to the choices offered in each question
This method can read handwriting – but poor handwriting may cause reading errors	OMR relies on simply detecting where marks have been made on a page; the position of the marks is compared to a template stored in memory
OCR is used for converting printed documents to an editable electronic format	OMR simply reads the position of marks, so it is ideal for multiple-choice exam papers
OCR requires a complex recognition system	This method requires complex (and expensive) forms to be completed; but the recognition system is simpler than OCR
Fewer 'how to fill in' instructions are needed for forms designed to be completed and then read by OCR	While this method requires more 'how to fill in' instructions, it is easier and faster for customers to complete OMR forms than to complete OCR forms
While OCR is more accurate than data entered into a computer by keyboard, there are still problems recognising all types of handwriting, leading to inaccuracies	OMR is essentially a more accurate method for reading data than OCR

2.2.6 Barcode readers

Barcode readers are used to read information in the form of a barcode.

The readers are usually in the form of a barcode scanner and are often built into POS terminals in supermarkets. **Hand-held scanners or wands** (as shown in the photograph) are also very common for reading barcodes if portability is required (for example, if the barcodes are on large or fixed objects).

Uses

- Used in supermarkets and other shops where the goods are marked with a barcode; the barcodes are used to give information about the product which enables automatic stock control, itemised billing, etc. to take place.
- Used in libraries to keep track of books on loan.
- Used as a safety function in many companies to ensure that electrical equipment is checked on a regular basis (barcodes are placed on an item to identify it and a database holds all the information related to that barcode so it is possible to interrogate the system as part of a safety audit).

Advantages

- Much faster than keying in data manually and fewer mistakes will be made.
- If used as a way of recording data, they can improve safety.
- They allow automatic stock control.
- They are a tried and trusted technology.

Disadvantages

- Relatively expensive system to administer.
- Not foolproof (barcodes can be swapped around on items).
- Can be more easily damaged than RFID tags or magnetic strips.

Quick response (QR) codes

Another type of barcode is the **quick response (QR) code**. This is made up of a matrix of filled in dark squares on a light background. For example, the following QR code contains the message: 'Cambridge IGCSE ICT textbook Chapter 2'.

To make a comparison, normal barcodes (as described on page 34) can hold up to 30 digits; QR codes can hold over 7000 digits. This obviously gives greater scope for the storage of information.

As modern smartphones allow internet access on the move, QR codes can be scanned anywhere. This allows advertising of products on trains, buses, shopping malls and many other places. Using the built-in camera facility on modern phones, and by downloading the appropriate application (or App), it is possible to read the QR code. The code may contain a website link or some form of advertising; for example, the following QR code contains a telephone number and an advertisement for free pizzas if ordered today. On scanning the QR code, the phone number and advertisement will appear on the mobile phone's screen.

Advantages

- There is no need for the user to actually write down or key in a website address; this is done automatically by scanning the QR code.
- QR codes can store website addresses/URLs that appear in magazines, trains, buses or even business cards, providing a very effective method of advertising.

2.3 Output devices and their uses

As the name suggests, these are hardware devices that allow data to be output from a computer. Some devices hold the data temporarily (such as in a printer buffer/memory) whereas others produce permanent output in the form of a hard copy (such as a printer producing output on paper). There is a third type of output device that is used to control processes in conjunction with sensor input devices.

2.3.1 Monitors

CRT monitors

Cathode ray tube (CRT) monitors are the least expensive type of monitor, although they are becoming increasingly rare as TFT monitors are now taking over. They come in various sizes and make use of an electron gun firing against a phosphor screen. The picture is made up of tiny dots that are coloured red, green or blue – the intensity of each coloured dot makes up the vast range of colours interpreted by the eye.

Uses

- They were used as the primary output device for computers so the user can see immediately what they are typing in.
- They are used with light pens, for example, to allow designs to be created on screen.

Advantages

- The angle of viewing is still better than with most TFT monitors.
- They work with light pens in CAD/CAM applications.

Disadvantages

- They tend to be rather heavy and present a safety hazard if not supported properly.
- They run very hot and can cause fires if left unattended (especially as they get older).

- They consume considerably more power than modern TFT monitors.
- They can flicker, which can lead to headaches and eyesight problems with prolonged use.

Thin film transistor (TFT) monitors

Thin film transistor (TFT) monitors are taking over from CRT monitors as the main output device. One of the reasons for the rapid development of laptop computers can be attributed to the advancements made in TFT technology. The screen is made up of thousands of tiny **pixels**, which are made up of transistors controlled by a microprocessor. Each pixel has three transistors that are coloured red, green or blue – the intensity of each governs the effective colour of the pixel seen by the eye.

Uses

- They are used as the primary output device for computers so the user can see immediately what they are typing in.
- They are an integral part of laptop computers.

Advantages

- They are lightweight and don't pose the same risks as CRT monitors.
- They produce less glare than CRT monitors and also emit less radiation.
- They consume much less power and don't generate as much heat as a CRT monitor.

Disadvantages

- The angle of viewing a TFT is fairly critical otherwise the image isn't very clear (for example, if several people are looking at a screen at the same time).
- Definition is sometimes not as good as a CRT monitor.

LCD and LED monitors

The days of CRT monitors are almost gone. These days, most monitors and television sets are made using **liquid crystal display/diode (LCD)** technology. These are simply a development of the TFT monitors described above.

The front layer of the monitor is made up of liquid crystal diodes; these tiny diodes are grouped together in threes or fours, which are known as **pixels** (picture elements). The three colours that are grouped together use red, green and blue diodes. Those systems that use groups of four include a yellow diode – this is said to make the colours more vivid.

Because LCD doesn't emit any light, some form of backlit technology needs to be used. Modern LCD monitors are backlit using **light emitting diode (LED)** technology. This gives the image better contrast and brightness. Before the use of LEDs, LCD monitors used **cold cathode fluorescent lamp (CCFL)** as the backlighting method.

Essentially, CCFL uses two fluorescent tubes behind the LCD screen, which supplies the light source. When LEDs are used, a matrix of tiny LEDs is used behind the LCD screen. LEDs have become increasingly more popular due to a number of advantages over older CCFL technology:

- LEDs reach their maximum brightness almost immediately (there is no need to 'warm up' before reaching full efficiency)

- LEDs give a whiter light, which sharpens the image and makes the colours appear more vivid; CCFL had a slightly yellowish tint
- LEDs produce a brighter light, which improves the colour definition
- monitors using LED technology are much thinner than monitors using CCFL technology
- LEDs last almost indefinitely; this makes the technology more reliable and makes for a more consistent product
- LEDs consume very little power, which means they produce less heat as well as using less energy.

What of the future?

Future LED technology will make use of **organic light emitting diodes (OLEDs)**. These use organic materials (made up of carbon compounds) to create semi-conductors that are very flexible.

Organic films are sandwiched between two charged electrodes (one is a metallic **cathode** and the other a glass **anode**). When an electric field is applied to the electrodes they give off light. This means that no form of backlighting is required, which allows for very thin screens. It also means that there is no longer a need to use LCD technology, since OLED is a self-contained system.

As can be seen in the photo, OLEDs allow screens to be curved, which ensures a good picture from any angle.

But the important aspect of the technology is how thin this makes the screen. It will be possible, using OLED technology, to bend screens to any shape. If this is adopted by mobile phone manufacturers, it will be possible to develop phones that can wrap around your wrist – much like a watch strap (see smartwatches earlier).

Imagine screens so thin that they can be folded up and placed in your pocket until they are needed. Or how about using folding OLED displays attached to fabrics creating 'smart' clothing (this could be used on outdoor survival clothing where an integrated circuit, mobile phone, GPS receiver and OLED display could all be sewn into the clothing)?

Science fiction becomes science fact – yet again.

Advantages of using OLED compared to existing LED and LCD monitors/screens:

- the plastic, organic layers of an OLED are thinner, lighter and more flexible than the crystal structures used in LEDs or LCDs
- the light-emitting layers of an OLED are lighter; OLED layers can be made from plastic rather than the glass as used in LED and LCD screens
- OLEDs give a brighter light than LEDs
- OLEDs do not require backlighting like LCD screens – OLEDs generate their own light
- since OLEDs require no backlighting, they use much less power than LCD screens (most of the LCD power is used to do the backlighting); this is very important in battery-operated devices such as mobile phones
- since OLEDs are essentially plastics, they can be made into large, thin sheets (this means they could be used on large advertising boards in airports, subways, and so on)
- OLEDs have a very large field of view, about 170 degrees, which makes them ideal for use in television sets and for advertising screens.

Exercise 2c

Carry out some research into OLED technology (there are numerous internet sites to help you) and answer the following questions:

1 Why are inkjet printers helping to keep down the cost of OLED screens?
2 How are different colours generated using OLED technology?
3 How is the brightness of the display controlled?
4 OLEDs refresh 1000 times faster than LCDs; why would this be an advantage? Where could it be used to great effect?

LCD/LED screens are used on many hand-held devices, such as mobile phones, tablets and game consoles. The technology behind such screens was discussed at length in Chapter 1.

Modern LCD screens are very thin and very lightweight, and are very responsive to touch. Obviously, the new technologies described above will change the way we use these hand-held devices in the very near future.

2.3.2 Multimedia projectors

Multimedia projectors receive signals that can be either analogue or digital (although most modern projectors only work with digital inputs). The signal source is usually from a computer, television or DVD player. The image from the source is magnified and projected on to a large screen. The devices usually work with a remote control but also use virtual mouse technology, which actually becomes a cordless PC mouse with the same features as a mouse. It is then possible to direct the computer presentation without being tied to the computer. Another feature of the virtual mouse is the laser pointer. Most multimedia projectors take input from various types of video format.

Uses

- Training presentations (to allow the whole audience to see the images from a computer).
- Advertising presentations (large images showing product features, for example a new car, can be shown at exhibitions, shopping malls, etc.).
- Home cinema systems (projecting the images from a DVD or television).

Advantages

- Enables many people to see a presentation rather than crowding round a small computer screen.
- Avoids the need for several networked computers (for example, when looking at a video clip on an internet site – everybody can see the video on the large screen rather than logging on to a number of computers).

Disadvantages

- Images can sometimes be fuzzy.
- Expensive to buy from the outset.
- Setting up projectors can be a little difficult.

2.3.3 Printers

Laser printers

Laser printers produce very high-quality hard-copy output. The print rate per page is very quick if a large number of pages are being printed. They rely on large buffer memories where the data for the whole document is stored before the pages can be printed out.

Uses

- They are used where low noise is required (for example, in an office).
- If fast, high-quality, high-volume printing is required then laser printers are the best option.

Advantages

- Printing is fast (unless only a few pages are to be printed, in which case they are little faster than inkjet printers).
- They can handle very large print jobs.
- The quality is consistently high.
- Toner cartridges last for a long time (and the printers can sometimes be a cost effective option, particularly if colour outputs are not required).

Disadvantages

- Only really fast if several copies are being made.
- Colour laser printers tend to be expensive to run (four colour/black cartridges are needed, as well as diffuser kits, which are expensive to purchase).
- They produce ozone and volatile organic compounds because of their method of printing and type of toner/ink used (these have been linked to health hazards in the office).

Inkjet printers

Inkjet printers are used to produce good quality hard copies. Unlike laser printers, inkjet printers don't have large buffers, therefore printing is done a bit at a time. This is why printing is sometimes paused since the whole page can't be stored in the buffer and it has to wait for the computer to send more data.

Uses

- Used where low output volumes are required (high-volume jobs are difficult to do since the ink cartridges tend to be used up very quickly).
- If high-quality printing is required for single pages (or only a small print job) then these printers are ideal; for example, they are very good at producing photo-quality printouts.
- 3-D inkjet printers are now being used in industry to produce prototypes (see page 40).

Advantages

- High-quality output.
- Cheaper to buy than laser printers.
- Very lightweight and have a small footprint.
- Don't produce ozone and volatile organic compounds, unlike laser printers.

Disadvantages

- Slow output if several copies needed (little buffer capacity to store the pages).
- Can't do large print jobs (ink cartridges run out too quickly).
- Printing can 'smudge' if user is not careful.
- Can be expensive if used a lot (original ink cartridges are expensive to buy).

Dot matrix printers

Dot matrix printers are a type of impact printer where a print head (made up of a matrix of pins) presses against an inked ribbon. They tend to be slow, noisy and the output is not that good. They are still useful, however, where multi-part or continuous stationery is being used.

Uses

- They can be used in noisy environments (for example, garage workshops) and in applications where print quality is not that important.
- They are used in applications where multi-part stationery or the fact that they are an impact printer is of value (for example, producing wage slips).

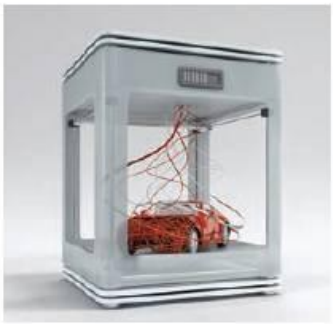
Advantages

- They can be used in environments that would be a problem to laser or inkjet printers (for example, dusty/dirty or moist atmospheres).
- Carbon copies or multi-part outputs can be produced.
- Very cheap to run and maintain.
- Easy to use if continuous stationery is required (for example, long print jobs such as wages slips).

Disadvantages

- Very noisy – not good in an office environment.
- Actually cost more than an inkjet printer to buy initially.
- Very slow, poor-quality printing.

3-D printers



3-D printers are primarily used in **computer-aided design (CAD)** applications. They are primarily based on inkjet and laser printer technology and can produce solid objects that actually work. The solid object is built up layer by layer using materials such as powdered resin, powdered metal, paper or ceramic.

The alloy wheel shown here was made using an industrial 3-D printer. It was made from many layers of powered metal (0.1 mm thick) using a technology known as **binder 3-D printing**. Other examples are discussed below.

The following information describes some of the features of 3-D printing:

- Various types of 3-D printers exist; they range from the size of a microwave oven up to the size of a small car.
- 3-D printers use **additive** manufacturing (i.e., the object is built up layer by layer); this is in sharp contrast to the more traditional method of **subtractive** manufacturing (i.e., the removal of material to make an object). For example, making a statue using a 3-D printer would involve building it up layer by

layer using powdered stone until the final object was formed. The subtractive method would involve carving the statue out of solid stone (that is, removing the stone not required) until the final item was produced. Similarly, **CNC** (computer controlled machine – a type of lathe) removes metal to form an object; 3-D printing would produce the same item by building up the object from layers of powdered metal.

- **Direct 3-D printing** uses inkjet technology; a print head can move left to right as in a normal printer. However, the print head can also move up and down to build up the layers of an object – each layer being less than a tenth of a millimetre (< 0.1 mm).
- Binder 3-D printing is similar to direct 3-D printing but this method uses two passes for each of the layers: the first pass sprays dry powder then, on the second pass, a binder (a type of glue) is sprayed to form a solid layer.
- Newer technologies are using lasers and UV light to harden liquid polymers; this further increases the diversity of products that can be made.

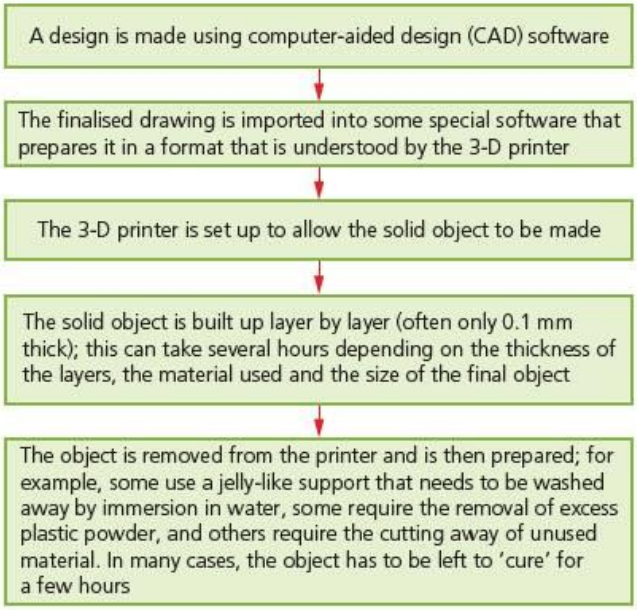


Figure 2.4 Creating a solid object using 3-D printers

The steps in the process of producing an object using 3-D printers is summarised in Figure 2.4.

3-D printing is regarded as being possibly the next 'industrial revolution' since it will change the manufacturing methods in many industries. The following list is just a glimpse into what we know can be made using these printers; in the years that follow, this list will probably fill an entire book:

- prosthetic limbs can be made to fit exactly on to the injured body part
- making items to allow precision reconstructive surgery (for example, facial reconstruction following an accident); the parts made by this technique are more precise in their design as they can be made from exact scanning of the skull
- in aerospace, manufacturers are looking at making wings and other aeroplane parts using 3-D technology; the bonus will be lightweight, precision parts
- fashion and art – 3-D printing allows new creative ideas to be developed
- making parts for items no longer in production, for example, parts for a vintage car.

These are just a few of the exciting applications that make use of this new technology.

Exercise 2d

Use the internet to research some new and innovative 3-D printing applications.

Advantages

- The manufacturing of items has become much easier than ever before. It is now theoretically possible to manufacture any product a user wants using only a 3-D printer. This has led the way for customised products, as it allows a user to create their own designs in 3-D and have them printed in solid form.

- Because 3-D printers can manufacture items relatively quickly, it allows rapid prototyping. This means that it will take a really short length of time for designs to be converted into working prototypes.
- Even though the cost of 3-D printing is very high, it is still less when compared to labour costs and other costs involved in manufacturing a product in the more conventional way. The fact that the cost of manufacturing using 3-D printers is the same for both small-scale and mass production is also a very useful benefit.
- Medical benefits are emerging, such as producing artificial organs, prosthetics and precision-made items for reconstructive surgery.
- Parts for machinery that are no longer made could now be manufactured using 3-D printers. A car made in the 1930s, for example, will no longer have parts available off-the-shelf. By scanning the broken part (using a 3-D scanner), or by obtaining its blueprint, it will be possible to simply email the file to a company and have the part made on an industrial 3-D printer. This clearly has many benefits in a number of applications.

Disadvantages

- The biggest possible drawback of 3-D printers is the potential to make counterfeit items or items that infringe others' copyright. 3-D printing technology essentially turns every owner of one of these printers into a potential manufacturer. Thus, it could become very difficult to trace the source of fake items; copyright holders would also have great difficulty in protecting their rights.
- All new technologies in the hands of the wrong people can lead to dangerous or illegal activities. With the possibility of creating almost anything with a 3-D printer, this technology could be used to manufacture dangerous items by almost anyone.
- There is the potential for job losses if this technology takes over from some types of manufacturing. Of course, this could also be seen as a benefit by some companies as it could lead to lower manufacturing costs for certain items.

2.3.4 Speakers

(Loud) speakers can be connected directly to a computer or are built into the monitor or casing (as in a laptop computer). Digital data from the computer is converted into analogue form (using a digital to analogue converter – DAC) and the signal amplified through the speakers. A sound card interface is needed in the computer to 'drive' the speakers.

Uses

- Output sound from multimedia presentations.
- Play downloaded sound files.
- Audio output of text on the screen (together with speech-generation software) helps users with disabilities.

2.3.5 Control applications

Actuators

Actuators are transducers* and are used to take signals from a computer and convert them into some form of motion, for example operating motors, pumps, switches and valves.

As part of the control process, digital signals are sent from the computer to an actuator to operate a device – usually conversion of the digital signal to analogue is required first (using a DAC).

*Transducers are devices that change variations in a physical quantity (such as pressure or rotation) into an electrical signal or vice versa.

Motors

The motor is turned on or off by the actuator.

Uses

- Used in automatic washing machines (to make the drum rotate), cookers (to switch on fans), water pumps in central heating systems, and in automatic glasshouses to open windows and switch on fans.
- Control of robot arms in industry.
- In computers to control fans, disk drives and DVD drives.

Buzzers

The buzzers are switched on or off by the actuator.

Uses

- Used in cookers and microwave ovens to tell the operator when the cooking process is complete.
- Used in burglar alarm systems to warn of intruders.

Lights

The actuator is connected to the switch that turns the lights on or off.

Uses

- Security lights.
- In glasshouses to control the lighting conditions.

Heaters

Actuators are connected to switches that turn the heater on or off.

Uses

- Automatic washing machines to heat up the water if necessary.
- Automatically control the temperature in an oven or hot plate.
- Control the heating in a central heating system.
- Temperature control in an automatic glasshouse.

3 Storage devices and media

In this chapter you will learn about:

- backing storage
- why back up data?
- types of access used by secondary storage devices
- types of internal and external secondary storage devices:
  - magnetic
  - optical
  - solid state.

3.1 Backing up of data

This chapter covers many forms of **secondary storage** and compares the advantages and disadvantages of each type. In Chapter 1 you learnt about the primary memory, known as RAM and ROM. We will consider a number of storage devices later but first it is important to consider why we need to back up data using these devices and also how data is accessed.

3.1.1 What is backing up of data?

Backing up refers to the copying of files/data to a different medium (disk, tape, flash drive, etc.) in case of a problem with the main secondary storage device. Backing up files and data on a regular basis is seen as good computing practice and many computer systems can be set to back up files automatically on a regular basis. An example would be the use of magnetic tapes to back up internet servers on a regular basis, or cloud storage companies using magnetic tape or hard disk drives to back up clients' data on a regular basis.

The backups are often stored in a different place to the main storage. This is in case of fire or some other situation that could lead to irretrievable loss of key data/files.

3.1.2 Why back up data?

There are various reasons why backups are made. Some of the more common reasons are considered below.

- To safegauard against loss of data due to the failure of the original secondary storage device; this could be due to hardware failure (e.g. head crash on a hard drive unit), problems caused by files being overwritten accidentally (or otherwise) or possible corruption of files (for example, caused by power surges).
- To safeguard against damage caused by hackers. This may not be their intention (they may only want to gain access to the information for other purposes, for example to find personal information such as bank account details). However, the very act of hacking in to files could cause problems such as corruption or data loss.
- Backups are also made in case the files need to be used elsewhere; this protects the originals against possible corruption or loss.
- Backups don't necessarily guard against the effect of a virus. The virus could attach itself to the files, which could mean that the backups are also affected. If the computer was 'cleaned' of the virus and then the backup files reloaded, there is a real risk that the virus could infect the computer system again. The best protection is not to get a virus in the first place.

3.2 Types of access

A number of secondary storage devices are discussed in Section 3.3. The way data is stored and read by each of these devices is very different, however.

This section briefly describes the two main methods of accessing data. It is important to understand three new terms here:

- field
- record
- file.

Suppose we are storing data about 20 cars in a car showroom. Data about each car – such as its colour, engine size, type of fuel, number of doors and whether it's new or used – are stored in an allocated space known as a **field**. All of the data about car 1, for example, is known as the **record** for that car. Putting all the data together for all 20 cars produces a **file** like this.

field 1	field 2	field 3	field 4	field 5	field 6	
car 1	red	1.5 litres	petrol	3 doors	new	record 1
car 2	blue	1.3 litres	petrol	5 doors	used	record 2
car 3	green	2.2 litres	diesel	5 doors	used	record 3
...	...	...	...	...	...	
car 20	white	1.6 litres	petrol	2 doors	new	record 20

Figure 3.1 Data for 20 cars in a showroom

3.2.1 Serial access

When using **serial access** it is necessary to start at the beginning of the file and then access each record in turn until the required record is found. In the example above, to find the record for car 15, it is necessary to first read all of the preceding records (that is, 1 to 14) until the required record is located.

It is primarily used on magnetic tape systems and is essentially a very slow form of data access. It is used in applications where speed of access, or where the order in which the data is accessed, isn't important (for example in utility billing, clearing bank cheques or producing pay slips).

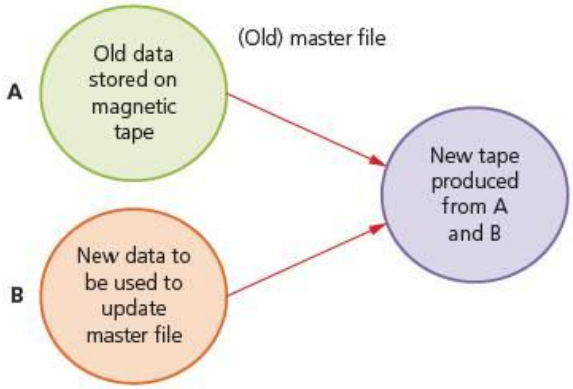


Figure 3.2 Updating a magnetic tape

When the original magnetic tape (called the **master file**) needs **updating**, an additional tape (called a **transaction file**) is required. The transaction file contains all the new data to allow the master file to be updated (although the transaction file is very often another tape, the new data could in fact be stored on a different medium). The updated tape is referred to as the new master file. When using tapes, it is essential that the records on both master file and transaction file are sorted in the same order (for example, sorted by customer number if it is a billing application – the field used to sort the records is often referred to as a **key field**).

This is an example of how a master file (MF) can be updated using a Transaction File (TF). The scenario here is a book shop that sells books. All of the books held in stock are stored on the MF in ISBN order – the ISBN acts as the key field for each record (each different book title will have its own record made up of the ISBN, title of book, author, genre, cost price and selling price). All the changes during the day will be stored on the TF – if a book sells, if new books come in, if a book is out of print, and so on. At the end of each day, the

MF is updated using the new data stored on the TF. The basic steps in the update process are shown below:

- at the end of the day, the TF is sorted in the same order as the MF (this will be done using the ISBN which is known here as the key field)
- a new master file (NMF) is created to store the updated records of the books in the shop
- the first record in the TF is then read and the first record in the MF is also read
  - the two records are compared with each other
  - if the key field on the MF < the key field on the TF, then no transactions took place and the MF record is written to the NMF; a new MF record is now read
  - if the key field on the MF = the key field on the TF, then a transaction took place and the new record from the TF is written to the NMF; the next record from both the MF and TF are now read
  - if the transaction file indicates a deletion then the record is simply not written to the NMF and a new record from each file is read
  - if the key field on the MF is greater than the key field on the TF, then the record doesn't yet exist and a new record is created on the NMF and the record is written from the TF to the NMF; a new TF record is now read
- the process is repeated until the end of the MF
- finally, any remaining records on the TF are written to the NMF.

Example

The Master File (MF) contains the following records with key fields shown:

The Transaction File (TF) contains the following records with key fields shown:

The first record from each file is read. The key fields both match, so the record with key field 1 is written from the TF to the new master file (NMF):

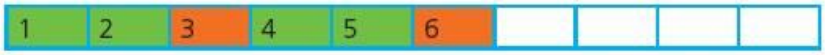
The second record is then read from the MF and TF; again the keys are equal so the record on TF with key field 2 is now written to the NMF:

The third record is then read from the MF and TF; this time the key fields are different (3 and 4). The MF key < the TF key, so the MF record with key 3 is now written to the NMF:

The next record from the MF is read. This time they are both 4 so the record on the TF is written to the NMF:

The next records form both MF and TF are read (6 and 5). The MF key is greater than the TF key, so a new record is created with key field 5. The new record is written to the NMF from the TF:

The next record on the TF is read. Again they are different (6 and 7). The MF key < TF key, so the MF record with key 6 is now written to the NMF:



This process continues until all the records have been checked and the final NMF emerges:

Exercise 3a

Continue the above exercise for the remainder of records to see if you arrive at the above NMF. What would happen if two of the records on the TF (with key fields of 4 and 8) needed deletion to be carried out? What would be the final NMF?

3.2.2 Direct access

Direct access is used with magnetic disks, optical media and solid state media. The computer uses the key field to calculate where data should be stored. It is then able to access the data directly from the calculated position. Consequently, access is much faster than with serial access. When updating files using direct access, the old records/data are simply written over by the new records/data. It is not necessary to sort records into any specific order first.

It is used in applications where data access speed is vital (for example, in **real-time** operations such as controlling a chemical plant or **online** systems such as booking air tickets or automatic stock control).

3.3 Secondary storage media

Dating right back to the advent of the personal computer, all systems have come equipped with some form of secondary storage. When a user loads data into a computer, the information is stored temporarily in the RAM – if the computer was turned off, this data would be lost. Secondary storage devices ensure that data is stored permanently so that it can be used again at a later date. This section will consider the various types of secondary storage and the media used.

Throughout the chapter, you will notice that the term **byte** is used to measure the size of memory or storage. Typically, **storage** sizes or file sizes are measured in kilobytes (kB), megabytes (MB), gigabytes (GB) and terabytes (TB) as shown in Table 3.1.

Table 3.1 File sizes

Storage size	Number of bytes	Number of bytes as power of 10
1 KB	1000 bytes	10^3 bytes
1 MB	1 000 000 bytes	10^6 bytes
1 GB	1 000 000 000 bytes	10^9 bytes
1 TB	1 000 000 000 000 bytes	10^{12} bytes

Note that this is different to memory sizes as used internally in the computer, where:
1 KB = 1024 (2^{10}) bytes, 1 MB = 1 048 576 (2^{20}) bytes, 1 GB = 1 073 741 824 (2^{30}) bytes and 1 TB = 1 099 511 627 776 (2^{40}) bytes. These values are all powers of 2.

This section reviews the various types of secondary storage devices available. These are either internal or external (that is, plug-in devices) to the computer.

Devices fall into the three different types of storage media:

- magnetic
- optical
- solid state.

3.3.1 Magnetic storage media

Magnetic storage media depend on the magnetic properties of certain materials (iron and nickel alloys being the most common). Magnetic material is coated on the surface of a disk or tape that can be magnetised in such a way as to represent a 1 or a 0. Many hard disk drives are made up of more than one disk and these disks are known as **platters**. Each platter is made from glass, ceramic or aluminium coated in a nickel alloy that can be magnetised. In the case of tape, plastic that is coated in a magnetic material is used to store the data.

Fixed/internal hard disk drive (HDD)

Fixed hard disk drives are available on all computers and are the main method used for data storage. On a PC this is usually a fixed hard disk with read/write heads allowing data to be written to or read from the disk surface. The disk surface is coated in a magnetic film that allows data to be stored by altering the magnetic properties to represent binary 1s or 0s (the fundamental units of computer memories). The hard disks usually store the **disk operating system (DOS)** and other systems software, as well as applications software and files. Applications software (such as spreadsheets and word processors) also needs a hard drive to allow them to quickly retrieve and save data.

Uses

- To store the operating system, systems software and working data/files.
- Storing applications software that needs fast retrieval and storage of data.
- Used in real-time systems (for example, robots, control of a chemical plant where data for the process is stored to allow real-time operations) and in online systems (for example, booking airline tickets or automatic stock control using EFTPOS, which allows immediate updating of the stock files).
- Used in file servers for computer networks.

Advantages

- They have a very fast data transfer rate and fast access times to data.
- They have very large memory capacities.

Disadvantages

- Can be easily damaged if the correct shut down procedure is not carried out; this can lead to a head crash which would result in a loss of data.
- They have many moving parts when compared to, for example solid state drives (SSDs).
- Their read/write operation can be quite noisy compared to SSDs.

Portable hard disk drives

These devices work in much the same way as fixed hard disk drives but are usually connected to the computer via the **USB (universal serial bus)** port and can be disconnected and used on different computers. The disks are generally capable of storing more data than the equivalent optical disk (CD, DVD and so on).

Uses

- They can be used as backup systems to prevent loss of data.
- They can be used to transfer data/files/software between computers.

Advantages

- The data access time and data transfer rate is very fast.
- They have a large memory capacity.
- They can be used as a method of transferring information between computers.

Disadvantages

- They can be easily damaged if dropped or subjected to a strong magnetic field; as with fixed hard disk drives, an incorrect shut-down procedure could also lead to loss of data.

Magnetic tapes

A **magnetic tape** is a very thin strip of plastic that has been coated in a magnetic layer. They are read and written to by a read/write head. The data is stored in magnetic areas that represent 1s and 0s. Data is read from the tape using serial access (see earlier description). This type of storage is useless in a real-time or online applications (due to the very slow data access speeds) and is best suited to offline or batch processing.

Uses

- In applications where batch processing is used, for example, clearing bank cheques, utility billing (gas, electricity, water) and producing pay slips; in these applications there is no need for any specific processing order and speed of data access is not essential.
- Used as a backup media since all the data needs to be stored.
- Used in long-term archiving of data; magnetic tapes have huge data storage capacities and are known to be very stable, which makes them ideal for long-term storage.

Advantages

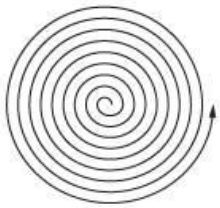
- They are generally less expensive (per byte) than the equivalent hard disk.
- It is a very robust technology (they don't deteriorate very much over time).
- They have a huge data storage capacity.
- The **data transfer rate** is actually fast (this should not be confused with data access time, which is very slow for magnetic tapes).

Disadvantages

- Very slow **data access times** (need to read all the earlier records on the tape until the required record is found – see Section 3.2).
- When updating, another tape is needed (see description in Figure 3.2 on page 45) to store the final updated version.
- They are affected by magnetic fields; a strong magnet can corrupt data stored on the tape.

3.3.2 Optical storage media

CD/DVD disks



CDs and DVDS are described as optical storage devices. Laser light is used to read data and to write data on the surface of the disk. Both CDs and DVDs use a thin layer of metal alloy or light-sensitive organic dye to store the data.

As can be seen from the diagram, they use a single spiral track that runs from the centre of the disk to the edge.

The data is stored in 'pits' and 'bumps' on the spiral track. A red laser is used to read and write the data. CDs and DVDs can be designated as follows:

- R – write once only
- ROM – can only be read
- RW – can be written to or read from many times.

DVD technology is slightly different to that used in CDs. One of the main differences is the use of **dual-layering**, which considerably increases the storage capacity. Basically, this means that there are two individual recording layers. The two layers of a standard DVD are joined together with a transparent (polycarbonate) spacer; a very thin reflector is also sandwiched between the two layers. Reading and writing of the second layer is done by a red laser focusing at a fraction of a millimetre difference compared to the first layer.

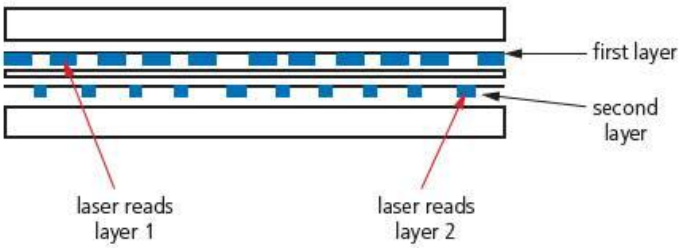


Figure 3.3 Dual-layering in a DVD

Standard, single-layer DVDs still have a larger storage capacity than CDs because the 'pit' size and track width are both smaller. This means that more data can be stored on the DVD surface. DVDs use lasers with a wavelength of 650 nanometres; CDs use lasers with a wavelength of 780 nanometres. The shorter the wavelength of the laser light, the greater the storage capacity of the medium.

CD-ROM and DVD-ROM

These optical disks are read-only memory (ROM), which means they cannot be written over and can only be read. The data is stored as a series of **pits** (equivalent to a binary value of 1) and **lands** (equivalent to the binary value of 0) in the metallic optical layer. The 'pits' are formed by a laser beam etching the surface at the manufacturing stage. Only a single track exists which spirals out from the centre of the disk.

The 'pits' and 'lands' are read by a low-powered laser beam that follows the data stream and reads from the centre outwards in a spiral. The light reflects differently off a 'pit' than it does off a 'land' and this is interpreted as 1s and 0s (that is, data) – hence the term digital media.

Uses

- CD-ROMs are used to store music files, software, computer games and reference software (such as an encyclopaedia).
- DVD-ROMs have much larger storage and are used to store films, computer data and ever-more sophisticated computer/arcade games.
- CD-ROMs and DVD-ROMs are used in applications where there is a real need to prevent the deletion or overwriting of important data.

Advantages

- They hold far more data than floppy disks (one CD/DVD could replace several floppy disks in some applications).
- They are less expensive than hard disk drive systems.

Disadvantages

- The data transfer rate/data access time is slower than for hard disks.

CD-R and DVD-R

The letter R here means the disk is recordable *once* only; it becomes a CD-ROM or DVD-ROM once it has been finalised (this means that the CD/DVD cannot have any additional data written to it). This is the last step in the CD/DVD process; finalising is also used as an alternative word for the 'closing' of a CD-R, in which Table of Contents (TOC) data are written on the disc to enable the computer to read the CD/DVD.

A thin layer of an organic dye (DVDs also use an additional silver alloy or gold reflector) is used as the recording media. A laser beam produces **heated spots** and **unheated spots**. On reading the disk, a laser beam is capable of distinguishing between the two types of spots and effectively reads the data stream from the centre outwards in a spiral action. This data is then interpreted as 1s and 0s.

Uses

- Home recordings of music (CD-R) and films (DVD-R).
- Used to store data to be kept for later use or to be transferred to another computer.

Advantages

- Cheaper than RW disks.
- Once burned (and finalised) they are like a ROM.

Disadvantages

- If finalised, the CD-R/DVD-R can only be recorded on once; if an error in the data has occured then the disk has to be discarded since it can no longer be written to.
- Not all CD/DVD players can read CD-R/DVD-R.

CD-RW and DVD-RW

The RW means these disks are a rewritable media and can be written over several times. Unlike CD-R/DVD-R, they don't become ROMs. The recording layer uses a special phase-changing metal alloy (often GeSbTe [Germanium-Antimony-Terbium alloy]; a number of different methods are used to produce these alloys). The alloy can switch between crystalline phase and amorphous phase (non-crystalline), thus changing its reflectivity to light depending on the laser beam power. **Spots** are produced that can be read by a laser and then interpreted as 1s and 0s. The system allows data to be written, erased and rewritten many times.

Uses

- Used to record television programmes (like a video recorder), which can be recorded over time and time again.
- Not as wasteful as R format as more files/data can be added to at a later stage (with CD-R/DVD-R it is only possible to do a write operation once if you have already finalised the disc).
- Used in CCTV systems.

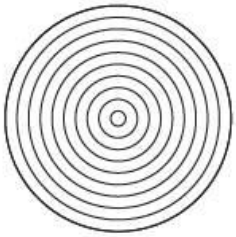
Advantages

- Can be written over many times.
- Can use different file formats each time it is used.

Disadvantages

- Can be relatively expensive.
- It is possible to accidentally overwrite data.

DVD-RAM



DVD-RAM uses a very different technology to CDs and DVDs. They have the following features:

- instead of a single, spiral track, they use a number of concentric tracks
- the use of concentric tracks allows simultaneous read and write operations to take place
- they allow numerous read and write operations (up to 100 000 times) and have great longevity (over 30 years), which makes them ideal for archiving
- DVD-RAMs can be written to and read from many times.

The recording layer is made from a similar phase-changing material as used in RW technology. When writing, a laser heats the phase-changing alloy on the disk to about 500 °C to 700 °C changing the reflective properties from shiny to dull (i.e. **pits**). If the disk needs to be erased, a laser heats the surface to about 200 °C to return the disk to its original shiny state. A low-power laser is used to read the written marks on the surface. The shiny and dull marks ('pits') represent data to a computer where they are interpreted.

Uses

- In recording devices such as satellite receivers to allow simultaneous recording and playback.
- Used in camcorders to store movies.

Advantages

- They have a long life (estimated 30 years minimum life).
- It is possible to do a rewrite operation over 100 000 times (compare this to the RW format, which only allows about 1000 rewrites).
- Writing on DVD-RAMs is very reliable – they have in-built verification software, so the accuracy of the data is ensured.
- Very fast access if the files are fairly small.
- No need to **finalise** the disk.
- Very large capacity (about 10 GB if double-sided format I is used).
- They offer the ability to read data at the same time as data is being written.

Disadvantages

- Not as compatible as R or RW format; many systems won't recognise the DVD-RAM format.
- Relatively expensive (about four times the cost of a DVD-RW disk).
- They have been superseded by newer technologies such as solid state memories.

Blu-ray discs

Blu-ray discs are another example of optical storage media. However, they are fundamentally different to DVDs in their construction and in the way they carry out read-write operations.

The main differences are:

- a blue laser, rather than a red laser, is used to carry out read and write operations; the wavelength of blue light is only 405 nanometres (compared to 650 nanometres for red light)
- using blue laser light means that the 'pits' and 'bumps' can be much smaller; consequently, Blu-ray can store up to five times more data than a normal DVD
- Blu-ray uses a single 1.1 mm-thick polycarbonate disk; normal DVDs use a sandwich of two 0.6 mm thick disks
- using two sandwiched layers can cause **birefringence** (light is refracted into two separate beams causing reading errors); because Blu-ray uses only one layer, the disks don't suffer from birefringence
- Blu-ray discs automatically come with a secure encryption system, which helps to prevent piracy and copyright infringement.

Table 3.2 summarises the main differences between CDs, DVDs and Blu-ray.

Table 3.2 Comparison of CDs, DVDs and Blu-ray

Disk type	Laser colour	Wavelength of laser light	Disk construction	Track pitch (distance between tracks)
CD	red	780 nm	single 1.2 mm polycarbonate layer	1.60 μm
DVD	red	650 nm	two 0.6 mm polycarbonate layers	0.74 μm
Blu-ray	blue	405 nm	single 1.1 mm polycarbonate layer	0.30 μm

Note: nm = 10^{-9} metres; μm = 10^{-6} metres.

Uses

- Home video consoles.
- Storing and playing back movies (one high-definition movie of two hours duration uses up 25 GB of memory).
- PCs can use this technology for data storage or backing up hard drives.
- Camcorders can use this media (in cartridge form) to store movie footage.

Advantages

- Very large storage capacity, therefore ideal for storing high-definition movies.
- Very fast data transfer rate.
- The data access speed is also greater than with other optical media.
- Blu-ray discs automatically come with a secure encryption system, which helps to prevent piracy and copyright infringement.

Disadvantages

- Relatively expensive.
- Encryption problems (which are used to stop piracy) when used to store video.
- There are fewer movie titles on Blu-ray format, which is reducing its impact on the home movie market.

All these optical storage media are used as backup systems (for photos, music and multimedia files). This also means that CDs and DVDs can be used to transfer files between computers. Manufacturers often supply their software using CDs and DVDs. When the software is supplied in this way, the disk is usually in a read-only format.

The most common use of DVD and Blu-ray is the supply of movies or games. The memory capacity of CDs isn't big enough to store most movies.

The future of optical media

In recent times both the CD and DVD are showing signs of becoming obsolete. Many computer systems now come with USB connectors only and no DVD or CD drive. The main method of transferring files between devices has become flash memory. Many people now store all their music in the following ways:

- on hard disk drive systems (set up as sound systems, as shown in the photo)
- in MP3 format on:
  - a computer/tablet
  - their mobile/smartphone
  - a portable music player (such as an iPod)
- using the 'cloud' to store all their files so they can access their music from anywhere in the world
- by 'streaming' their music from the internet; provided the user has an internet connection they can access music through a laptop computer, mobile phone, tablet or any other receiving device.

It is a similar story for movies, where streaming is becoming increasingly common. Many television sets are now set up as 'smart' televisions – this means it is now possible to simply stream movies or television programmes **on demand** without the need for any DVD or Blu-ray players. In effect, the television set has become the central computer with a link to the internet using wireless connection.

Floppy disks met the same fate in the early twenty-first century. How often do you see floppy disks? It is very likely that CDs and DVDs will meet the same fate and be replaced by one of the systems described above or something entirely new.

Exercise 3b

Using this student book and the internet, do some research to find out all the different ways to store music files and movie files.

Draw a table similar to the one shown below to list all the advantages and disadvantages of each of the methods you have identified.

Storage method	Advantages	Disadvantages

3.3.3 Solid state storage media

Solid state drives (SSD)

Solid state drives (SSD) are rapidly taking over from HDDs. They have no moving parts and all data is retrieved at the same rate no matter where it is stored. They don't rely on magnetic properties; the most common type of solid state storage devices store data by controlling the movement of electrons within NAND* chips. The data is stored as 0s and 1s in millions of tiny transistors within the chip. This effectively produces a non-volatile rewritable memory.

*NAND flash memory is a type of non-volatile storage that does not require power to retain data. NAND flash memory stores data in an array of memory cells made from floating-gate transistors which are insulated from each other by an oxide layer. NAND is a type of logic gate and is basically one of the building blocks of many electronic circuits including solid state storage devices.

However, a number of solid state storage devices sometimes use **electronically erasable programmable read-only memories (EEPROM)** technology. The main difference is the use of NOR* chips rather than NAND. This makes them faster in operation; however, devices using EEPROM are considerably more expensive than those that use NAND technology. EEPROM also allows data to be read or erased in single bytes at a time. Use of NAND only allows blocks of data to be read or erased. This makes EEPROM technology more useful in certain applications where data needs to be accessed or erased in byte-size chunks.

*NOR flash memory is also a type of non-volatile storage; a NOR gate is a type of logic gate that makes up many electronic circuits. NOR gates work in a different way to NAND gates, but the differences are outside the scope of this student book. Essentially, solid state memories made from NOR gates allow faster read/write operations than those made from NAND gates, but the storage devices cost much more to manufacture – consequently, most solid state storage devices use NAND gate technology.

Because of the cost implications, the majority of solid state storage devices use NAND technology. The two are usually distinguished by the terms **flash** (uses NAND) and **EEPROM** (uses NOR).

So, what are the main advantages of using SSD rather than HDD? The main advantages of SSDs are summarised below:

- they are more reliable (no moving parts to go wrong)
- they are considerably lighter (which makes them suitable for laptops)
- they don't have to get 'up to speed' before they work properly
- they have a lower power consumption
- they run much cooler than HDDs (both these points again make them very suitable for laptop computers)
- because there are no moving parts, they are very thin
- data access is considerably faster than HDD.

The main drawback of SSD is the questionable longevity of the technology. Most solid state storage devices are conservatively rated at only 20 GB write operations per day over a three-year period – this is known as **SSD endurance**. For this reason, SSD technology is not used in internet servers, for example, where a huge number of write operations take place every day. However, this issue is being addressed by a number of manufacturers to improve the durability of these solid state systems.

Memory sticks/pen drives

Memory sticks/pen drives can store several gigabytes of data and use the solid state technology described above. They are usually connected to a computer through the USB port and power to operate them is drawn from the host computer. They are extremely small and very portable. Most operating systems recognise these storage media, which means no additional software is needed to operate them.

Some expensive software now uses these storage methods (sometimes referred to as portable flash drives) as a form of security. They plug into the computer using the USB port and are known as **dongles**. The software installed on a computer sends out a request (in encrypted form) to the dongle asking for an encrypted validation key. Thus a person trying to carry out **software piracy** would have to break the code on the dongle first before they could use the software. Some systems go one stage further and have key bits of software stored on the dongle in encrypted form. The software looks for these pieces of encrypted code to enable it to run. This gives an added security benefit to the software.

Uses

- Transporting files between computers or used as a backup store.
- Used as a security device to prevent software piracy (known as a dongle).

Advantages

- Very compact and portable media.
- Very robust.
- Doesn't need additional software to work on most computers.
- They are not affected by magnetic fields.

Disadvantages

- Can't write-protect the data/files.
- Easy to lose (due to their small physical size).
- The user needs to be very careful when removing a memory stick from a computer – incorrect removal (for example, while it is still doing a read/write operation) will corrupt the data on the memory stick, rendering it useless.

Flash memory cards

These are a form of electrically **erasable programmable read-only memory (EEPROM)** and are examples of solid state memories.

Uses

- Storing photos on digital cameras.
- Used as mobile phone memory cards.
- Used in **MP3** players to store music files.
- Used as a backup store in hand-held computer devices.

Advantages

- Very compact and can be easily removed and used in another device or for transferring photos directly to a computer or printer.
- Since they are solid state memories, they are very robust.

Disadvantages

- Expensive per gigabyte of memory when compared to hard drive disks.
- Have a finite life regarding the number of times they can be read from or written to.
- Have a lower storage capacity than hard disks.

4 Networks and the effects of using them

In this chapter you will learn about:

- networks
- network devices such as routers, hubs and switches
- IP and MAC addresses
- Wi-Fi and Bluetooth
- how to set up and configure a small network
- intranets and extranets
- LAN, WAN and WLAN
- network security (e.g. policing)
- accessing the internet
- authentication
- viruses
- data protection acts
- faxes and emails
- video, audio and web conferencing.

Most computer systems are now connected together in some way to form what is known as a **network**. This ranges from basic school/home networks of only a few computers (often set up to share resources such as printers or software) to large networks such as the **internet**, which effectively allows any computer connected to it to communicate with any other computer similarly connected.

This chapter considers the types of network that exist and many of the features that are available because of networking. You will learn that devices such as **hubs** and **switches** are needed to distribute data within a network; that local area networks (**LANs**) can be connected together using **bridges**; and that devices such as **modems** and **routers** are needed to connect these LANs or single computers to external networks, such as the internet.

4.1 Networks

4.1.1 Network devices

Modems

Modem means '**mo**dulator **dem**odulator' and is a device that converts (i.e. modulates) a computer's digital signal into an analogue signal for transmission over an existing telephone line. It also does the reverse process, in that it converts analogue signals from a telephone line into digital signals (demodulates), to enable the computer to process the data.

Modems are essentially used to allow computers to connect to networks (for example, the internet) over long distances using the existing telephone networks.

Dial-up modems operate at transmission speeds of about 60 kilobits* per second, which is extremely slow by today's standards.

*60 kilobits = 60 000 bits. 1 bit refers to a **bi**nary digi**t** and has the value 1 or 0.

Modern broadband or **ADSL (asymmetric digital subscriber line)** modems operate at up to 100 Megabits* per second (12.5 Mbytes/second) when using fibre-optic cables (although the old technology copper cables can usually only offer a maximum of 20 Mbits/second). The term 'asymmetric' actually means that the modem is faster at **downloading** data (i.e. receiving data) than it is at **uploading data** (i.e. sending data).

*1 byte = 8 bits; 100 megabits = 100 million bits.

Although ADSL modems still use the existing telephone network, unlike dial-up modems they do **not** tie up the line while accessing the internet – they can always be 'on', so internet access is available 24 hours if necessary, and the landline telephone can be used at the same time. ADSL modems can allow telephone conversations and internet traffic to occur at the same time because of the wide bandwidth signal used (different frequencies are used to transmit internet signals so they don't interfere with normal telephone traffic). Cable modems also exist, which allow cable television providers to offer internet access as well as receiving television signals.

Hubs

Hubs are hardware devices that can have a number of devices or computers connected to them. They are often used to connect together a number of devices to form a LAN – for example, a star network (see later). Its main task is to take any **data packet** (this is a group of data being transmitted) received at one of its ports and broadcast it to **every** computer in the network. This essentially means that using a hub is not a very secure or efficient method of data distribution.

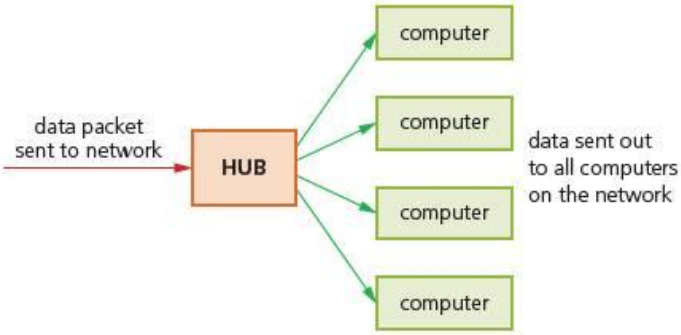


Figure 4.1 How hubs work

Switches

Switches are similar to hubs but are much more efficient in the way that they distribute data packets. As with hubs, they connect a number of devices or computers together to form a LAN.

However, unlike a hub, the switch checks the data packet received and works out its destination address (or addresses) and sends the data to the appropriate computer(s) *only*. This makes using a switch a more secure way of distributing data.

Each device or computer on a network has a **media access control (MAC)** address that uniquely identifies it. Data packets sent to switches will have a MAC address identifying the source of the data and additional addresses identifying each device that should receive the data (see Section 4.1.2 for more on MAC addresses).

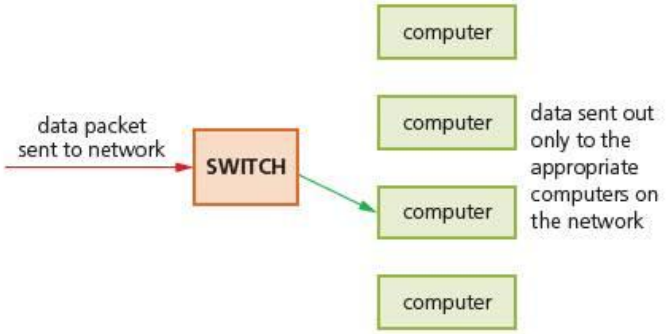


Figure 4.2 How switches work

Bridge

Bridges are devices that connect one LAN to another LAN that uses the same protocol (communication rules). They are often used to connect together different parts of a LAN so that they can function as a single LAN.

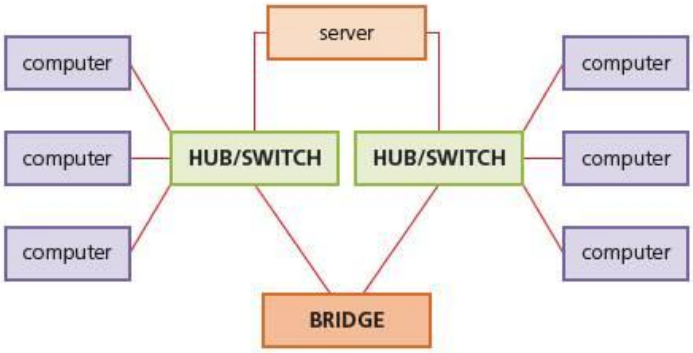


Figure 4.3 How bridges work

Bridges tend to be used to interconnected LANs (or parts of LANs) since sending out every data packet to all possible destinations would quickly flood larger networks with unnecessary traffic. For this reason a router is used to communicate with other networks, such as the internet.

Router

Routers enable data packets to be routed between the different networks, for example to join a LAN to a wide area network (**WAN**). A router would typically have an internet cable plugged into it and several cables connecting to computers and other devices on the LAN.

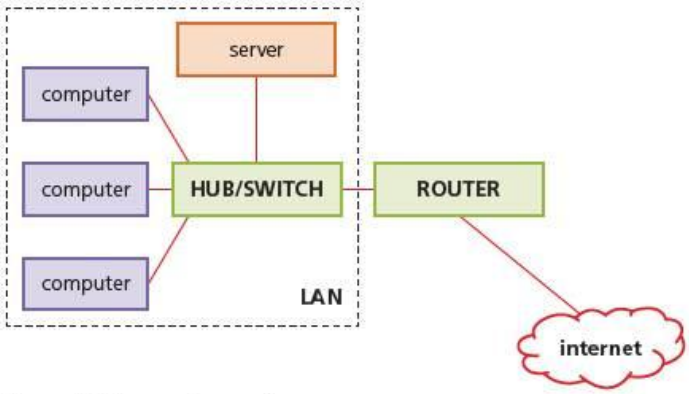


Figure 4.4 How routers work

Broadband routers sit behind a firewall. The firewall protect the computers on a network. The router's main function is to transmit internet and transmission protocols between two networks and also allow private networks to be connected together.

Routers inspect the data packets (see below) sent to it from any computer on any of the networks connected to it. Since every computer on the same network has the same part of an **internet protocol (IP)** address, the router is able to send the data packet to the appropriate switch and it will then be delivered using the MAC destination address (see Section 4.1.2). If the MAC address doesn't match any device on the network, it passes on to another switch on the same network until the appropriate device is found.

Data packets

The data is carried in the packet according to which protocol (set of rules) is used. Packets of data usually contain the following information:

- some form of header to identify the data packets
- the sender's IP address
- the receiver's IP address
- how many data packets make up the whole 'message'
- the identity number of each packet.

This information allows the router to route a packet across a network to its correct destination and allows the data packets to be reassembled in their correct order according to identity number at the receiving station.

When a router receives a packet of data, it checks the destination IP address against the stored routing table. The routing table stores the MAC address of the device, the assigned IP address and the lease time the IP address is assigned for. The bits forming the destination IP address in the data packet are used to point to the correct route. The packet is sent to a number of routers until it reaches its final destination.

Note: MAC addresses and IP addresses are discussed in more detail later.

Other hardware

Gateway

A **gateway** is a network point (or **node**) that acts as an entrance to another network. It is a key point for data on its way to or from other networks. All networks will have boundaries so that all communication within the network is conducted using devices such as switches or routers. If a network node needs to communicate outside its network, it needs to use a gateway.

Network interface card (NIC)

A **network interface card (NIC)** is needed to allow a device to connect to a network (for example, the internet). It is usually part of the device hardware and frequently contains the MAC address generated at the manufacturing stage.

Network cables

Even though many computer systems use Wi-Fi, **network cables** are still used because they have the following advantages over Wi-Fi:

- faster data transfer rates
- can be more secure than wireless networks.

The cables can be either copper or fibre optics – the latter offers higher data transfer rates and also better security (see notes on quantum cryptography).

4.1.2 Internet protocol (IP) and media access control (MAC) addresses

Each device on the internet is given a unique address known as its **internet protocol (IP) address**. This is a 32-bit number that is usually written in the form:

109.108.158.1

A home computer is given an IP address when it connects to the internet. This is assigned by the ISP and is unique for that particular internet session. The only IP addresses that remain fairly unchanged are the web servers. An IP address can be used instead of typing in the full URL; for example, http://109.108.158.1 would take you straight to the device containing web page corresponding to this address.

Differences between IP addresses and MAC addresses

As indicated in Section 4.1.1, a MAC address is a unique number that identifies a device connected to the internet. So what is the difference between an IP address and a MAC address? The IP address gives the *location* of a device on the internet, whereas the MAC address *identifies* the device connected to the internet.

You can think of the IP as the address of the house you live in (it will have some unique way of identifying it, such as a postcode or zone code). Using this example, the MAC address can be thought of as a way of uniquely identifying each person living in that house. It is possible to move house (so your IP address will change) but the same people will be living in the new house (so their MAC address will remain unchanged).

4.1.3 Wi-Fi and Bluetooth

Both **Wi-Fi** and **Bluetooth** offer wireless communication between devices. They both use radio frequencies as the carrier of data transmission.

How computers use Wi-Fi and Bluetooth to connect to networks

Wi-Fi

A wireless transmitter (WAP) receives information from a network via its connection (e.g. a broadband connection if the internet is used). This transmitter converts the received information into radio waves and then transmits them.

A device (e.g. a computer) receives the radio waves via an installed wireless adaptor which allows it to download the information from the data source. This, of course, works in reverse when the device wishes to transmit data over the network.

Wi-Fi is best suited to operating full-scale networks since it offers much faster data transfer rates, better range and better security than Bluetooth. A Wi-Fi-enabled device (such as a computer or smartphone) can access, for example, the internet wirelessly at any **access point (AP)** or **hot spot** up to 100 m away.

Bluetooth

Bluetooth sends and receives radio waves in a band of 79 different frequencies (known as channels). These are all centred on a 2.45 GHz frequency.

Devices using Bluetooth automatically detect and connect to each other, but they don't interfere with other devices since each communicating pair uses a different channel (from the 79 options).

When a device wants to communicate, it picks one of the 79 channels at random. If the channel is already being used, it randomly picks another channel. This is known as **spread-spectrum frequency hopping**.

To further minimise the risks of interference with other devices, the communication pairs constantly change the frequencies (channels) they are using (several times a second).

Essentially, Bluetooth is useful:

- when transferring data between two or more devices that are very close together (<30 metres distance)
- when the speed of data transmission is not critical
- for low-bandwidth applications (for example, when sending music files from a mobile phone to a headset).

Bluetooth creates a secure **wireless personal area network (WPAN)** based on key encryption.

Table 4.1 summarises some of the differences between Wi-Fi and Bluetooth.

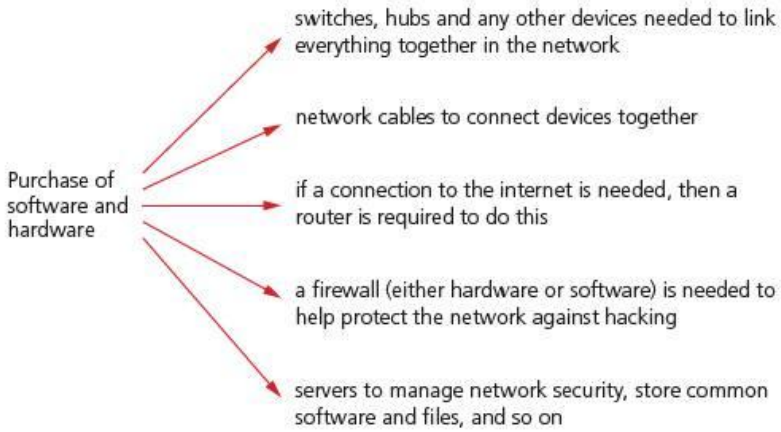
Table 4.1 Differences between Wi-Fi and Bluetooth

Feature	Bluetooth	Wi-Fi
Transmission frequency used	2.4 GHz	2.4, 3.6, 5.0 GHz
Data transfer rate (maximum)	25 Mbits/second (~3.1 Mbytes/second)	250 Mbits/second (~31 Mbytes/second)
Maximum effective range (metres)	30 m	100 m (but can be obstructed by walls etc., reducing effective range to only a few metres)
Maximum number of devices connected	Up to 7	Depends on the router used (can be one device or many devices)
Type of data transmission security	Key matching encryption	WEP (wireless equivalent privacy) and WPA (Wi-Fi protected access) are the most common security systems

4.1.4 How to set up and configure a small network

Suppose you were asked to set up and configure a small network of 10 computers. You would need to consider the following points:

Apart from all the hardware and software, you would also have to think about doing the following:



- setting up an IP account if internet access is required
- setting up the system (or buying appropriate hardware correctly configured) to allow for wireless connectivity
- configuring all the hardware and software so that they work correctly together
- if internet is required, ensuring that a high-speed broadband connection exists
- putting all the common software onto a server and also making sure that a network licence has been acquired so that all network users can make use of the software
- setting up privileges so that each user can only access their own area or common shared area
- setting up a network-manager-level of privilege do that they can monitor network usage, change passwords, etc.

Exercise 4a

Find out any other hardware or tasks that need to be carried out when setting up a small network. Ask questions such as 'would Wi-Fi or Bluetooth be the best type of connectivity?', 'Should PCs or laptops be used?', and so on.

4.1.5 Internet, intranets and extranets

The main features of the internet, intranets and extranets, and the differences between them, are covered at length in Chapter 10. Read Chapter 10 if you wish to cover this topic in some depth before carrying on with the rest of this chapter.

4.1.6 Local area networks (LANs) and wide area networks (WANs)

Local area networks (LANs)

These systems are usually within one building, or certainly not very far away from each other geographically. A typical LAN will consist of a number of computers and devices (for example, printers) that are connected to **hubs** or **switches**. One of the hubs or switches will usually be connected to a **router** and a **modem**

(usually **broadband**) to allow the LAN to connect to the internet; in doing so it then becomes part of a **WAN**.

Advantages

- The sharing of resources (such as expensive peripherals and applications software).
- Ease of communication between users.
- A network administrator to control and monitor all aspects of the network (for example, changing passwords, monitoring internet use and so on).

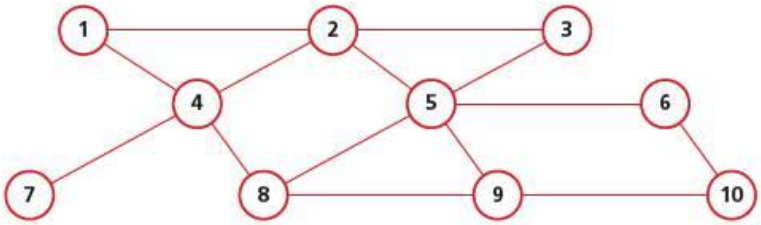
Disadvantages

- Easier spread of viruses throughout the whole network.
- Printer queues developing, which can be frustrating.
- Slower access to external networks, such as the internet.
- Increased security risk when compared to stand-alone computers.
- If the main server breaks down, in most cases the network will no longer function.

Wide area networks (WANs)

Wide area networks (WANs) are used where computers or networks are situated a long distance from each other geographically (e.g. in a different city or country). As mentioned earlier, if a number of LANs are joined together using a router or modem, then they can form a WAN. The most common examples of WAN include the internet and the network of ATMs (automated teller machines) used by banks.

Because of the long distances between devices, WANs usually make use of some public communications network (such as telephone lines or satellites) but they can use dedicated or leased communication lines which can be less expensive and also more secure (less risk of hacking).



A typical WAN will consist of end systems and intermediate systems (see diagram).

1, 3, 7 and 10 are known as end systems and the remainder are known as intermediate systems. The distance between each system can be considerable, especially if the WAN is run by a multinational company.

Wireless LANs (WLANs)

Wireless LANs (WLANs) are similar to LANs but there are no wires or cables. In other words, they provide wireless network communications over fairly short distances (a few metres) using radio or infrared signals instead of cables.

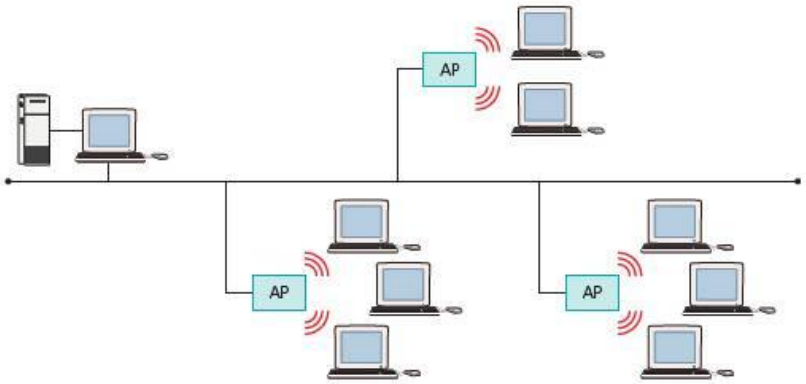


Figure 4.5 A network connecting WLANs

Devices, known as **access points (APs)** or wireless nodes, are connected into the wired network at fixed locations. Because of the limited range, most commercial LANs (for example, at a college campus or at an airport) need several APs to permit uninterrupted wireless communications. The APs use either **spread spectrum technology** (which is a wideband radio frequency with a range of about 30–50 m) or **infrared** (which has a very short range, about 1–2 m, and is easily blocked; it therefore has a limited use).

The AP receives and transmits data between the WLAN and the wired network structure. End-users access the WLAN through wireless LAN adapters that are built into the devices or are a plug-in module.

Advantages

- All computers can access the same services and resources (such as printers, scanners, internet access) from anywhere within range of the APs.
- As there is no cabling there is a safety improvement and increased flexibility (since the user no longer has to remain at their desk).
- Adding new computers and devices is very easy (all that is required is a WLAN adapter) and the costs are reduced since extra cabling isn't needed.

Disadvantages

- Security can be a big issue since anyone with a WLAN-enabled laptop can access a network if it can pick up a signal; it is therefore necessary to adopt complex data encryption techniques.
- There may be problems of interference, which can affect the signal.
- The data transfer rate is slower than in a wired LAN.

4.1.7 Accessing the internet

The relative advantages and disadvantages of using mobile phones, tablets, laptops and desktop computers were discussed in Chapter 1. Some of the advantages and disadvantages of using these devices to access the internet are summarised below.

Mobile phones and tablets

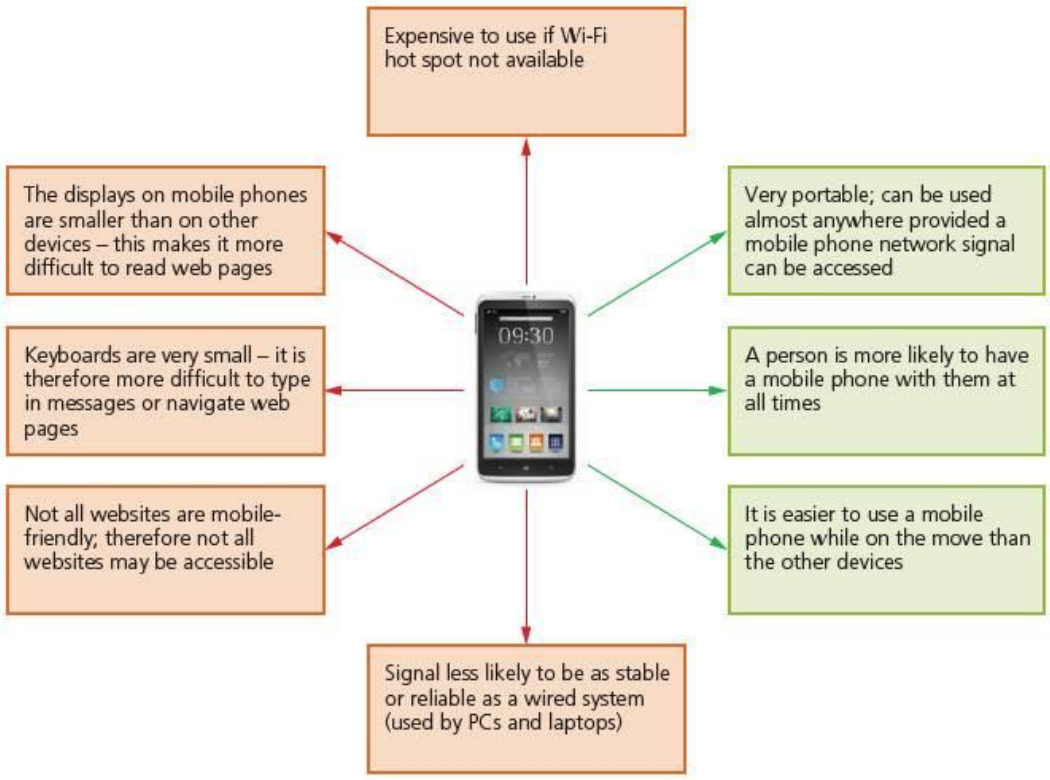


Figure 4.6 Advantages and disadvantages of connecting to the internet with a mobile phone

The same comments also refer to tablets (and phablets) but, as they usually have bigger screens and keyboards, they have an advantage in that respect when compared to mobile phones. The other advantages and disadvantages are similar to mobile phones – it all depends on the screen size of the tablet being used.

Laptops

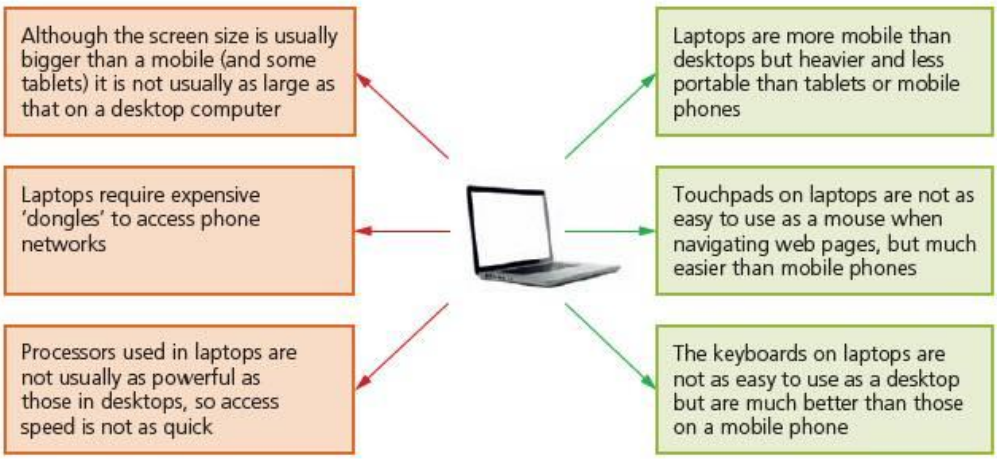


Figure 4.7 Advantages and disadvantages of connecting to the internet with a laptop

Desktop computers

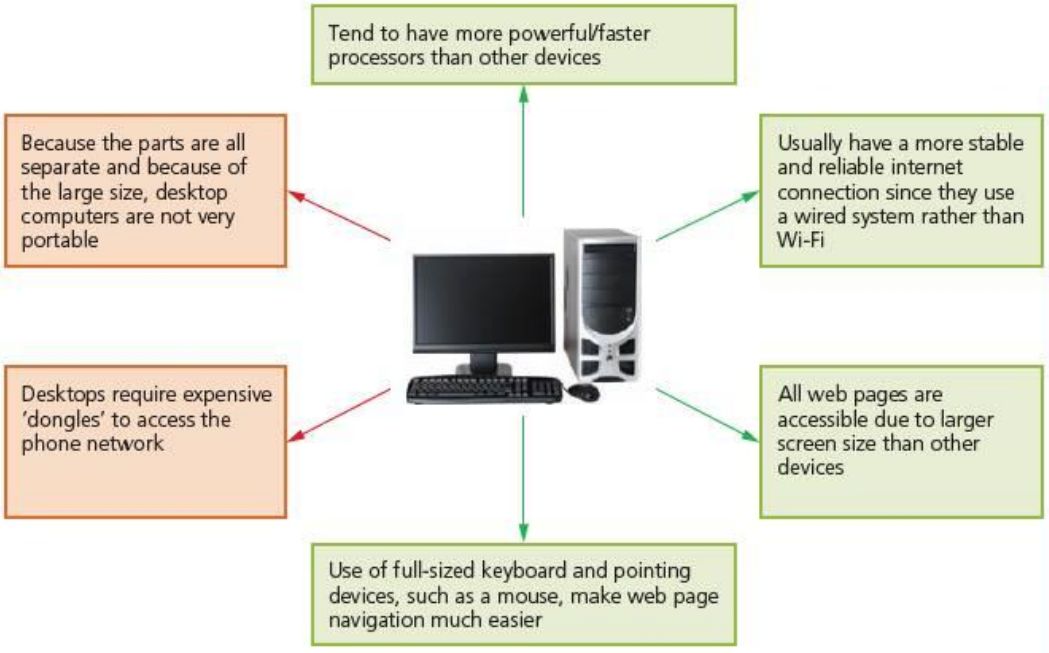


Figure 4.8 Advantages and disadvantages of connecting to the internet with a desktop computer

Exercise 4b

Refer to the notes in Chapter 1 and write an article on the relative advantages and disadvantages of using various devices:

- to access the internet
- to download information from the internet, using these various devices, to allow you to produce a presentation on a topic of your own choice.

Include a conclusion to indicate which device(s) you would choose.

4.2 Network issues and communication

4.2.1 Network security

Many aspects of security (such as hacking, phishing, pharming and viruses) are covered in depth in Chapter 8. This section covers some of the more general aspects of internet security.

When accessing the internet, users have to be very careful of many issues – not all of them obvious. Let us first consider the material found on the internet.

Should the internet be policed?

This question has raged for many years. The internet doesn't presently have any controlling body that ensures that it conforms to certain standards. There are many arguments in favour of having control, and as many arguments against it.

Arguments in favour of some form of control:

- it would help to prevent illegal material being posted on websites (for example, racist/prejudiced and pornographic material, terrorist activities, and so on)
- people find it much easier to discover information that can have serious consequences (for example, how to be a hacker, how to make bombs, and so on); although most of this information can be found in books, it is much easier to find it using a **search engine**
- it would help to prevent children and other vulnerable groups from being subjected to undesirable websites
- it would help to stop incorrect information being published on websites.

Arguments against some form of control:

- material published on websites is already available from other sources
- it would be very expensive to 'police' all websites and users would have to pick up the bill
- it would be difficult to enforce rules and regulations on a global scale
- it can be argued that policing would go against freedom of information
- laws already exist to deal with those who post illegal material/comments on websites.

One moral issue is the **social divide** created by computer technology and ICT. This is often referred to as the **digital divide**: those people who have the necessary IT skills and/or money to purchase and use computer equipment will benefit from the new technology; those who are not able to access this new technology, either through lack of money, skills or simply because they don't live in a country with the necessary infrastructure, are left even further behind, leading to this digital divide.

Inappropriate sites and the accuracy of information

The social and general impacts of using the internet or devices that rely on microprocessors have been discussed in earlier sections. It is now worth spending some time looking at the *quality* of information found on the internet when using a **search engine**. There are three main aspects to consider:

- reliability of information
- undesirability of certain websites
- security issues.

Reliability of information

- Information on the internet is more likely to be up to date than in books (websites can be updated very quickly).
- It is much easier to get information from websites (search engines quickly link key words together and find information that matches the criteria).
- There is a vast amount of information on the internet that is easier to locate than using the indices in several books.
- Information could also be incorrect, inaccurate or even biased, since it doesn't go through any checking process.
- There is a real risk of information overload, even if the search engines are used properly; it is possible to get millions of **hits**, which may make it difficult to find the relevant information.

Undesirability of certain websites

- There is always a risk of finding undesirable websites.
- There is also a risk of connecting to websites that are not genuine, which could lead to a number of problems (such as undesirable web links, security risks, and so on).
- Security risks (these are a real problem – this topic is covered in Chapter 10 and elsewhere throughout the book).

Security issues

Passwords are used in many instances when accessing the internet, for example when:

- accessing your email account
- carrying out online banking
- accessing social networking sites.

There are many more instances when you might need to type in a password and, in many cases, a user ID. It is important that passwords are protected; some ways of doing this are described below:

- run anti-spyware software to make sure that your passwords aren't being relayed back to whoever put the spyware on your computer
- change passwords on a regular basis in case they have come into the possession of another user illegally or accidentally
- passwords should not be easy to guess or break (for example, don't use your favourite colour, name of a pet or favourite rock group); passwords are defined as either 'strong' (hard to break or guess) or 'weak' (relatively easy to break or guess). Strong passwords should contain:
  - at least one capital letter
  - at least one numerical value
  - at least one other keyboard character (such as @, *, &).

  An example of a strong password would be: Sy12@#TT90kj=0.
  An example of a weak password would be: GREEN.

4.2.2 Authentication

Authentication is used to verify that data comes from a secure and trusted source. It works with encryption to strengthen internet security, for example.

Exercise 4c

Using the information above and information from Chapter 10 (and elsewhere within this book), write an article on the pros and cons of using the internet (rather than other methods, such as consulting books) to search for information when doing some research for a science or geography project.

Remember to draw a conclusion when you have finished giving your advantages and disadvantages.

Exercise 4d

Which of the following are weak passwords and which are strong passwords? Explain your decision in each case.

1. 25-May-2000
2. Pas5word
3. ChapTer@15
4. AbC*N55!
5. 12345X

User IDs and passwords are authentication techniques. Some forms of authentication include:

- digital certificates (see Section 8.4.4 for more details)
- biometrics (see Section 8.4.4 for more details)
- magnetic stripe cards/id cards/passports.

Magnetic stripe cards were covered in Chapter 2. These cards have a magnetic stripe on one side (made up of tiny magnetic particles on a plastic film). Each particle can act as a north-pole or a south-pole (which corresponds to the two binary values of 0 and 1).

The stripe is read by swiping it through a card reader (see Chapter 2). Data such as name, ID number, sex and date of birth may be contained on a magnetic stripe when used as a security device to allow entry to a building, for example.

Contactless cards can be read from a distance and don't have to be swiped through a card reader. This technology was discussed in Chapter 2. Contactless technology can be used in credit/debit cards, for example, to speed up payments in a shop, but they can also be used as a security device. If the card is in a wallet or a pocket, as the owner of the card walks through a security gate, readers either side of the gate quickly scan the security data stored on the tag/chip embedded in the card. Access will only be allowed if the scanned data matches data in a database.

Some ID cards also use a **holographic image (hologram)**. These are designed to make forgery of the card more difficult. Holographic images change colour or appear to have a moving object when the image is viewed from different angles. As these are difficult to make it stops somebody, for example, simply photocopying a card and using it illegally. The theory behind holograms was discussed in Section 1.5.6.

Another form of security is to have a photographic image of the card user printed on the card surface.

Passports make use of some of the technology described above. Many passports contain an RFID tag/chip, a photograph and a holographic image.

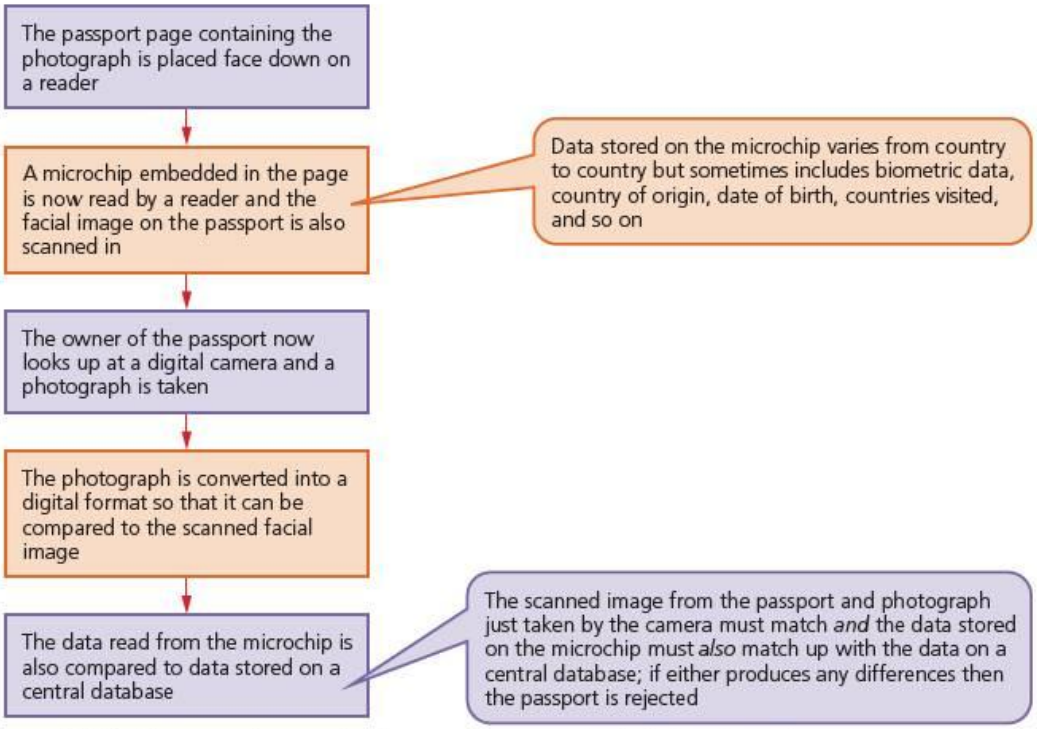


Figure 4.9 What happens when somebody approaches passport control at an airport?

4.2.3 Viruses

The risks of a computer being infected by a virus are discussed in detail in Chapter 8. This section considers how the risk of viruses can be minimised when using the internet or any situation where data is transferred from computer to computer or other electronic devices – it is important to point out that tablets and mobile phones can also be infected by viruses. Any electronic device with a storage capability can be affected by virus attacks.

Ways of preventing or minimising the risk of viruses are outlined below.

Antivirus software

Running **antivirus software** in the background on a computer will constantly check for virus attacks. Although various types of antivirus software work in different ways, they all have the following common features:

- they check software or files before they are run or loaded on a computer
- antivirus software compares a possible virus against a database of known viruses
- they carry out **heuristic checking** – this is the checking of software for types of behaviour that could indicate a possible virus; this is useful if software is infected by a virus not yet on the database
- any possible files or programs that are infected are put into **quarantine** that:
  - allows the virus to be automatically deleted, or
  - allows the user to make the decision about deletion (it is possible that the user knows that the file or program is not infected by a virus – this is known as a **false positive** and is one of the disadvantages of antivirus software)
- antivirus software needs to be kept up to date since new viruses are constantly being discovered
- full system checks need to be carried out once a week, for example, since some viruses lie dormant and would only be picked up by this full system scan.

Avoiding viruses when accessing the internet

One way to help prevent virus attacks when accessing websites on the internet is to avoid unknown or suspicious-looking websites. If in doubt, don't access the website – look for security indicators such as **https** or the padlock symbol  .

Also look out for odd behaviour in the URL. When accessing a new website, for example from an advert in an email, copy and paste the URL into the address bar at the top of the page rather than just clicking on the link in the email. This can help to avoid links to bogus/fake websites.

It is also not advisable to open emails (or any attachments) from unknown sources. Essentially, the best form of defence against malicious behaviour when making use of the internet is to apply common sense. Many of these issues will be discussed in more depth in Chapter 8.

Viruses from hardware devices

It is possible to pick up viruses from any device plugged into your computer. Apart from the obvious precaution of scanning the device for viruses, it is still unsafe to plug in a device from an unknown source. Even memory sticks or DVDs from friends or from school could still be infected unless they have also carried out all the necessary precautions.

4.2.4 Data protection acts

Most countries have some form of **data protection act (DPA)**. These are designed to protect individuals and to prevent incorrect or inaccurate data being stored.

Essentially DPAs are set up to protect the rights of the individual about whom data is obtained, stored and processed (i.e., collection, use, disclosure, destruction and holding of data). Any such act applies to both computerised and paper records.

Many data protection acts are based on eight principles, as outlined in Figure 4.10.

In many countries, failure to abide by these simple rules can lead to a heavy fine or even imprisonment to anyone who holds data about individuals.

There are general guidelines about how to stop data being obtained unlawfully:

- don't leave personal information lying around on a desk when not attended
- lock filing cabinets at the end of the day or when the room is unoccupied
- do not leave data on a computer monitor if it is unattended; log off from the computer if away from your desk for any length of time
- use passwords and user ids, which should be kept secure; passwords should be difficult to guess/break and should be changed frequently (see earlier notes on passwords)
- make sure that anything sent in an email or fax (including attachments) is not of a sensitive nature.

1 Data must be fairly and lawfully processed.
2 Data can only be processed for the stated purpose.
3 Data must be adequate, relevant and not excessive.
4 Data must be accurate.
5 Data must not be kept longer than necessary.
6 Data must be processed in accordance with the data subject's rights.
7 Data must be kept secure.
8 Data must not be transferred to another country unless they also have adequate protection.

Figure 4.10 Main principles of data protection acts

All of the above are in addition to other security safeguards discussed elsewhere in this book.

4.2.5 Network communication

Faxes and emails

There are two basic ways of sending a fax (abbreviation for facsimile – a copy):

- a physical fax (a dedicated machine connected to a telephone line; it requires the number of the recipient to be dialled before the document is copied and then sent electronically)
- electronic faxing (this requires a network, such as the internet, for the fax to be sent).

Physical fax machines

Fax machines have been used for many years to send and receive paper documents.

A standard fax machine allows documents to be sent to another fax machine using a normal telephone line. The user places the document in the fax machine tray, lifts the receiver and dials the fax number of the recipient and then presses <send>. At the receiving end, the document is printed on another fax machine. It can be quite a slow way to send a document if the fax line is busy or if there are several pages to send.

However, a more modern way is **electronic faxing** (or online faxing) which makes use of computer technology and the internet. Electronic faxing has the following advantages over the more traditional method described above:

- costs are reduced as there is no need to buy a fax machine, ink/toner or paper
- transfers using electronic methods are encrypted, improving security
- transmissions are sent to an email account, which is password protected
- there is no issue of a 'busy signal' preventing the fax being sent.

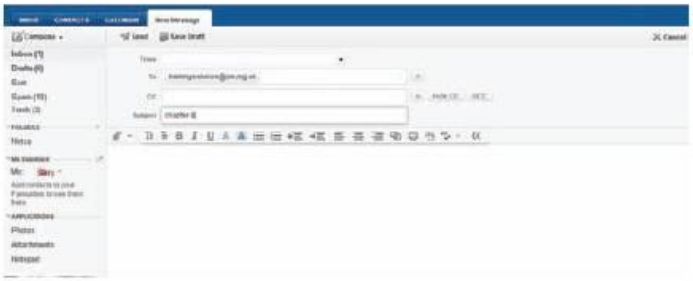
At this point you may be wondering what is the difference between an electronic fax and an email? The simple answer is not a lot. The only real difference is that online faxing is always associated with an email address *and* a fax number. The fax number is similar to the traditional fax number and needs to be known by the sender. Having this number allows a user to send fax messages to the recipient. Once a fax is received, the online fax service provider sends an email with the fax message attached in a tiff or pdf format. The sender of the fax can either use an email account or log into any online account to send the fax.

Figure 4.11 Sending an electronic fax

It is important to realise that it is possible to send a fax from your computer to another device connected to the internet *or* to a traditional fax machine, where the document will be printed out in the normal way.

Emails

Electronic mail (email) is discussed in many parts of this book. Emails are particularly useful when sending attachments (for example, documents, videos, music, and so on). Emails can be sent to, or sent from, any device connected to the internet. When sending attachments it is usually important to have a good, stable internet connection – particularly when sending or receiving large files. The basic difference between emails and electronic faxes was described above; all the advantages and disadvantages of emails apply to electronic faxing when it is sent from computer to computer.



Emails require an account with an ISP. When sending an email, it is necessary to include the email address (which **must** be exact), a subject line and any attachments if required.

The recipient simply has to log on to their account and read the emails in their inbox.

It is now worth comparing emails with traditional, physical faxes (as indicated above, there are few differences between electronic faxes and emails so they won't be part of this comparison).

Table 4.2 Comparison of traditional faxes and emails

Traditional faxes	Emails
• They are more likely to be intercepted since the document needs to be printed out and the fax machine is potentially accessible to many people in the office • Signatures on faxes are accepted legally • The quality of the documents printed out can be quite poor at times • If the telephone line is busy (or shared), there can be a considerable delay in sending the fax • It can be a slow process if several documents are to be sent, since each document needs to be scanned before it is transmitted	• More secure than faxes (password protected and usually sent to an individual's computer) • No need to print the document (cost saving and more environmentally friendly) • The document is usually of a much better quality • Unlike paper-based faxes, documents received in emails can be modified or easily copied and pasted into other documents • Documents and files can be sent and received from any device that has internet connectivity • It is much easier to send to multiple recipients at the same time – with a fax you have to dial up the fax number of each recipient before sending • People are more likely to have access to email accounts than a fax machine

Exercise 4e

Carry out an assignment to compare emails, faxes and traditional post as a way to send documents and items to people.

Video conferencing

Video conferencing is a communication method that uses both video and sound. It is a substitute for face-to-face conferences between a number of people, who may be in a different part of the country or live overseas. It is carried out in **real time** and makes use of some form of network. The basic hardware includes:

- webcams
- large monitors/television screens
- microphones
- speakers.

There are a few items to consider when a conference is about to begin:

- it is essential to agree a time and date for the conference to take place
- the delegates in each conference room must log in to the video conference system
- the video conference set-up needs to be checked before the meeting goes live
- webcams need to be placed in the correct position so that all the delegates in the room are within visual contact (the webcams will capture the images and then transmit them to the other delegates – they will see the images on their own large screens)
- microphones need to be placed centrally so that all of the delegates can speak – the sound is picked up by the microphones and transmitted to the other delegates (they hear the voices through speakers in their own conference room)
- it is important for one person to be the main contact in each conference room to make sure that each delegate is able to be heard; this is particularly important if more than two video conference rooms are linked up at the same time.

In addition to the hardware items described above, it is important to realise that software plays an important role in a successful video conference.

Table 4.3 Software used in video conferencing

Software	Description
Webcam and microphone software drivers	It is vital that the correct software is used to ensure that the webcam and microphone transmit their images and sound to the other delegates (these are sometimes referred to as **hardware drivers**)
CODEC	CODEC can stand for **co**der–**dec**oder or **co**mpression–**dec**ompression. The first is used to encode or decode the digital data stream to allow data to be transmitted (encoded) and played back (decoded). The second is used to compress the data before it is transmitted and then decompress it again at the receiving conference room
Echo cancellation software	**Echo cancellation software** allows talking to take place in real time and permits the synchronisation of communication. Microphones can pick up sound from the speakers (i.e. creating an echo); this software copies received signals and checks for parts of the signal that reappear but are delayed slightly. The reappearing parts are removed from the signal (i.e. the echo is removed)

Potential issues with video conferencing

- Potential time lag in responses/delays when talking.
- Jerking images – usually due to poor internet/network performance or a poor bandwidth.
- Can be very expensive to set up in the first place (both the hardware and the software are expensive to purchase and set up correctly).
- There can be problems if the delegates live in different countries where the time zone differences are large.
- Training people to use the system correctly can be both costly and time consuming.
- It can be demotivating for staff if they believe that one of the 'perks' of their job is international travel.
- The whole system relies on a good network connection – if it breaks down or the signal strength is diminished in any way, then the video conference can be almost unusable.

Advantages

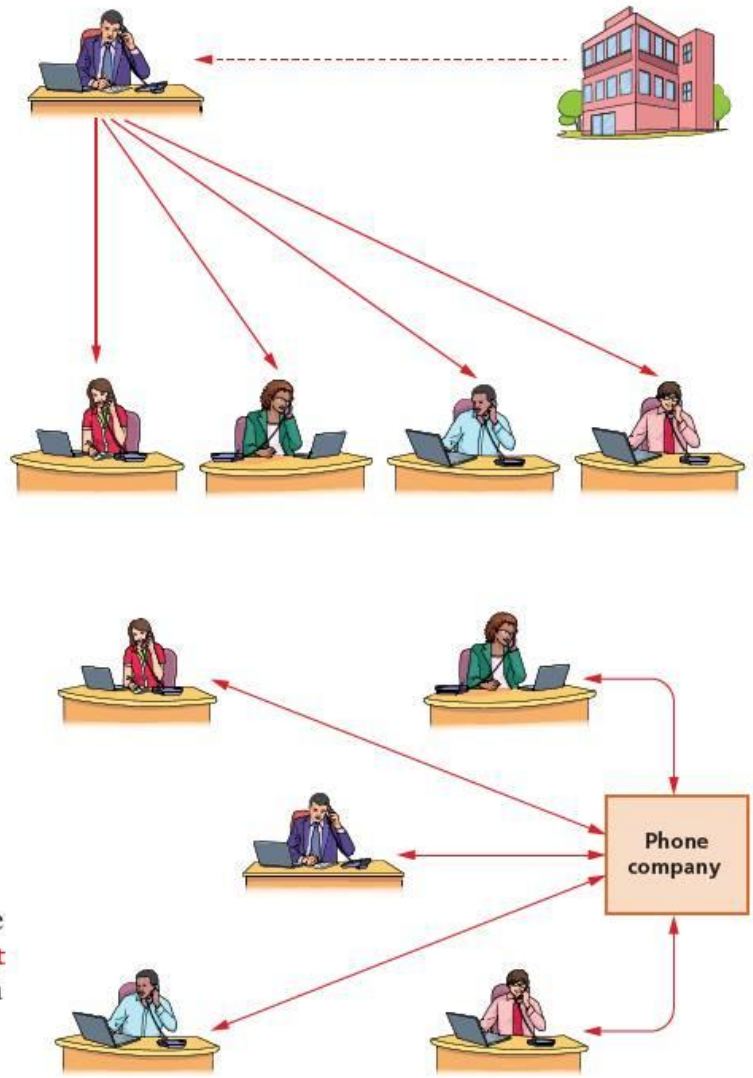
- As people are in their own building, it is much easier to access important documents or bring in 'experts' at key parts of the conference – this would be difficult if they were a long way away from their office.
- It is possible to hold conferences at short notice (a conference date can be set up within a few hours as no person needs to travel far).
- Not travelling physically to meetings reduces costs:
  - reduced travelling costs
  - no need to pay for hotel accommodation or venue hire
  - it also reduces the cost of taking people away from their work for two or three days to travel – people are still paid their wage even though they are not in the office, so this is a large 'hidden' cost.
- It may be better to use video conferencing than have delegates travel to potentially unsafe places around the world.

Audio conferencing

Audio conferencing refers to meetings held between people using audio (sound) equipment. The equipment used can be the telephone, a computer (with built-in microphones and speakers) or an internet phone.

Audio conferencing can be done over the telephone network (often referred to as a **phone conference**). The procedure to be carried out when doing a phone conference is detailed below.

1. The organiser of the phone conference is given two PINs by the phone company. One PIN is the personal PIN (e.g. 2151) given to the organiser and the second PIN is the participants' PIN (e.g. 8422).
2. The organiser contacts all of the participants and informs them of their PIN and the data and time of the phone conference.
3. When the phone conference is about to start, the organiser dials the conference phone number and, once he/she is connected, keys in his/her personal PIN (2151 in this case).
4. The participants then call the same conference number to join in – once they get through they each input the PIN given to them by the organiser (8422 in this case). Without this PIN, it will be impossible to join the phone conference.



It is possible to hold an audio conference using a computer provided a microphone and speakers are connected. This makes use of **Voice over Internet Protocol (VoIP)**. It is also possible to hook up an internet telephone, which usually plugs into the router or other internet device.

Using VoIP allows an organiser to create a group of people to take part in the conference call. The group is created by dragging and dropping user names and telephone numbers into the group. When the conference is to take place, the organiser clicks on the required group and the conference is initiated. Using VoIP allows communication using voice, instant messaging and video (by using an attached webcam). If some of the users don't have an internet connection or don't have access to a computer, it is possible to add actual telephone numbers (landline or mobile) to the group. The only real drawback is the quality of the sound when using this technique since it is totally reliant on a fast, stable broadband connection – otherwise 'drop out' (loss of voice on occasions), echoing (when the user can hear their own voice being echoed back as they speak) or a very noisy line making it difficult to understand.

Web conferencing

Web conferencing (often referred to as a **webinar**) uses the internet to permit conferencing to take place. Multiple computers are used with this system, all connected over the internet. As with video conferencing, it is carried out in real time and allows the following types of meeting to take place:

- business meetings to discuss new ideas
- presentations
- online education or training.

The only requirement is a computer and a high-speed, stable internet connection. To carry out web conferencing, each user either downloads an application or logs on to a website from a link supplied in an email from the conference organiser.

Delegates can leave or join the conference as they wish. The organiser can decide on who can speak at any time using the control panel on their computer. If a delegate wishes to speak, they raise a flag next to their name. Delegates can post comments using instant messaging for all delegates to see at any time.

Some of the main features include:

- slide presentations using presentation software that can be posted on the conference website in advance of the meeting
- it is possible for any delegate to draw or write on a 'whiteboard' using their own keyboard or mouse
- it is possible to transmit images or videos using the webcam throughout the conference
- documents can be shared by uploading them to the website before the conference begins
- as described earlier, it is possible to chat verbally or by using instant messaging throughout the conference.

As indicated earlier, web conferencing clearly links into video conferencing and audio conferencing through the use of webcams and built-in microphone and speakers. Essentially it is possible to have a conference using any device that allows these functions (for example, tablets and smartphones would both permit this type of group communication).

5 The effects of using ICT

In this chapter you will learn about:

- the effects of ICT on employment
- the effects of ICT on working patterns
- microprocessor-controlled devices in the home.

This chapter considers the effects of ICT on employment as well as our everyday life in the home. The four main areas where ICT has had an effect on employment include:

- **Manufacturing** – robots have replaced human workers in many areas of manufacturing, for example welding car bodies, spraying metal items with paint, assembling items and manufacturing circuit boards.
- **Shop work** – online shopping has reduced the need for high-street shops, leading to a loss of staff.
- **Banking** – the introduction of ATMs and online banking has led to the closure of many high-street branches.
- **Office work** – spreadsheets, word processors and databases have taken over many of the tasks carried out by office staff.

5.1 The effects of ICT on employment

The use of computers and microprocessors has revolutionised many aspects of how we work. From the offices to manufacturing, every task humans do has been affected in some way by electronic devices and their associated software. This has had both positive and negative effects on employment.

5.1.1 Negative effects – job losses

The introduction of ICT systems – whether to improve efficiency, reduce costs or improve safety – has led to redundancies in many areas of industry and commerce. The following sections consider the impact that ICT has had on office work and manufacturing.

Office work

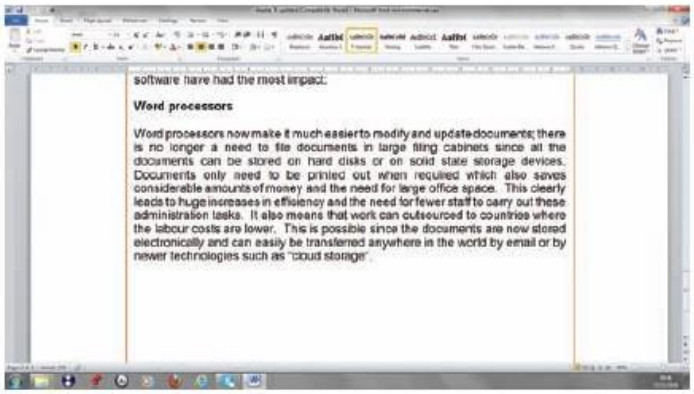
Let us consider a company where the day-to-day tasks are all presently carried out manually by people in the following departments:

- administration
- human resources
- payroll.

By introducing computer systems and new software, the work could be done by fewer staff and in a much shorter time scale. This could lead to many redundancies and the need for the remaining staff to retrain, as they have to learn how to use the new technologies. Skills such as filing and carrying out numerical analysis manually have effectively been replaced by sophisticated software.

Three types of software have had the most impact in offices: word processors, spreadsheets and databases.

Word processors

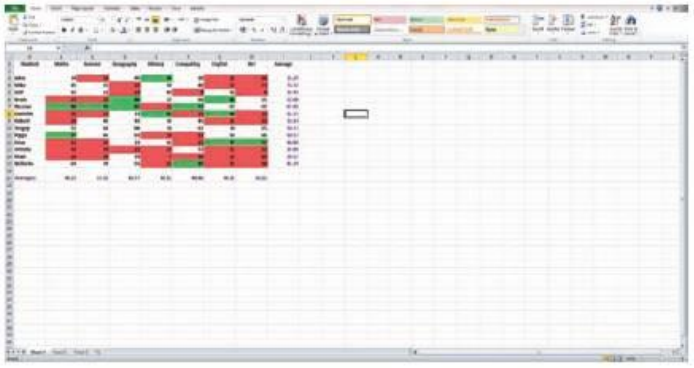

software have had the most impact:

Word processors

Word processors now make it much easier to modify and update documents; there is no longer a need to file documents in large filing cabinets since all the documents can be stored on hard disks or on solid state storage devices. Documents only need to be printed out when required which also saves considerable amounts of money and the need for large office space. This clearly leads to huge increases in efficiency and the need for fewer staff to carry out these administration tasks. It also means that work can outsourced to countries where the labour costs are lower. This is possible since the documents are now stored electronically and can easily be transferred anywhere in the world by email or by newer technologies such as "cloud storage".

Word processors make it much easier to modify and update documents. There is no longer a need to file documents in large filing cabinets since all the documents can be stored on hard disks or on solid state storage devices in electronic formats. Documents only need to be printed out when required, which also saves considerable amounts of money and the need for large office space. This clearly leads to huge increases in efficiency and the need for fewer staff to carry out these administrative tasks. It also means that work can be outsourced to countries where the labour costs are lower. This is possible since the documents are stored electronically and can easily be transferred anywhere in the world by email or by newer technologies such as 'cloud storage'.

Spreadsheets



Spreadsheets have revolutionised the way that payroll clerks calculate monthly salaries or wages. There is no longer any need to do the calculations manually or to type out the salary/wage slips. Spreadsheets automatically calculate salary/wages based on hourly rates and the number of hours worked. By linking into databases, it is also possible to carry out all of the deductions, such as tax, insurance and so on. This can be done by using embedded formulas known as macros. This has led to a reduction in staff since a spreadsheet reduces the time taken to calculate salaries/wages – the software effectively replaces several clerks. The software can be set up to do the calculations on a particular day automatically and then print out the salary/wage slips without any manual intervention.

Spreadsheets can be used in many areas where calculations or graphs or charts need to be produced. One good example is a teacher in a college monitoring the progress of their students by entering their marks into a spreadsheet for a number of subjects (see the example spreadsheet above). This type of software has the following advantages in this application:

- graphs and charts can be produced to show how the students compare to each other
- graphs and charts can also be used to show student progress over a given time period; use of 'rolling averages' or trend lines can be used to monitor changes in performance
- it is also possible to use 'conditional formatting' to show which students are performing badly (for example, by highlighting results in red) or well (for example, by highlighting results in green)
- using functions, such as sorting or averages, allows the teacher to quickly see which students are doing particularly well and how they compare against the class average.

These features leave teachers more time to spend on lesson preparations and can be linked into word processors to produce annual student reports to send out to parents. How has the introduction of spreadsheets affected staff at the college? Essentially, the number of administrative staff (who work with the teachers to produce reports, graphs and results sheets) can be reduced, but the teachers need to be fully trained in the use of spreadsheets.

Databases

Other office work, such as human resources, has also been changed by the introduction of computers and software. Tasks such as updating personnel data (e.g. salary, address, phone number, department, etc.) on a regular basis can now be done more effectively using database software. It is possible to cross-check many factors regarding staff working in a company using sophisticated database structures. For example, if new job opportunities were created in a company, the system could automatically cross-check several key factors for its existing staff (such as experience, qualifications, personal qualities and IT skills). A shortlist of potential candidates could then be produced. This would have taken several staff many days if they had to cross-check paper files – the use of databases means the task can be done in minutes. This task would have been further complicated if the company had several sites in different parts of the country. Staff records can now easily be centralised and data can be transferred between sites electronically. This makes it a very quick and easy task to produce a staff shortlist. Obviously, this again has led to a reduction in human resources staff, and the need for intensive training in the use and setting up of effective database structures.

Whilst the use of the above software packages has clearly entailed reducing staff numbers, on the plus side, there has been a huge increase in the need for better trained people, (and good trainers to train them) as well as the creation of new jobs which are IT-related, such as a network manager or IT technicians. The office has also become a more pleasant and safer place to work (no noisy typewriters or the dangers of heavy overfilled filing cabinets).

Manufacturing

Job losses due to ICT have affected industry even more than in the office environment. The introduction of robots, for example, has revolutionised how items such as cars are produced. Car manufacturing makes considerable use of robotics. One robot is capable of doing the same tasks as a number of workers, greatly reducing the need for manual labourers.

Robots are capable of carrying out the following tasks:

- spraying the bodies with paint
- assembling all the body parts
- assembly of the engine and transmission
- fitting the windscreens.

Robots are fitted with different devices, known as end effectors, to allow various tasks to be completed, for example a spray gun (to paint the car body), welding gun (to allow the body parts to be assembled) or vacuum/suction cups (to gently pick up windscreens and attach them to the car). All of these tasks are carried out quickly and accurately, time after time, replacing the need for human labour.

Only the more intricate tasks, such as fitting seats, dashboards and interior trim, are usually carried out by a skilled human workforce.

Factory workers have had to retrain to gain the following new skills:

- maintenance of the robots
- quality control
- design and development
- marketing
- training other workers.

Advantages of robots over humans

- Higher productivity (this can be considerable in mass production factories).
- More consistent results (robots are not necessarily more accurate, but every car is identical, which means a big increase in reliability and easier maintenance for customers).
- They work non-stop without breaks, holidays or time for shift handovers.
- They don't get bored by repetitive tasks.
- They don't go on strike.

Even taking into account expensive maintenance costs, robots still work out cheaper in the long term than paying humans wages.

Disadvantages of robots over humans

- Robots are expensive to purchase and set up in the first place.
- They often need to be reprogrammed for every new task they have to carry out, which can be expensive and time-consuming.
- If an error occurs in the robot's programming, or if it develops a mechanical problem, a number of production errors will occur until the fault has been identified (however, this is becoming less of a problem as self-diagnostics become increasingly sophisticated: robots can detect errors in their own operation and halt production until the fault is rectified).

5.1.2 Positive effects

While the introduction of new software packages and robots has clearly resulted in staff reductions, the positive side is the need for better-trained people, the need for trainers, and the creation of new ICT-related work.

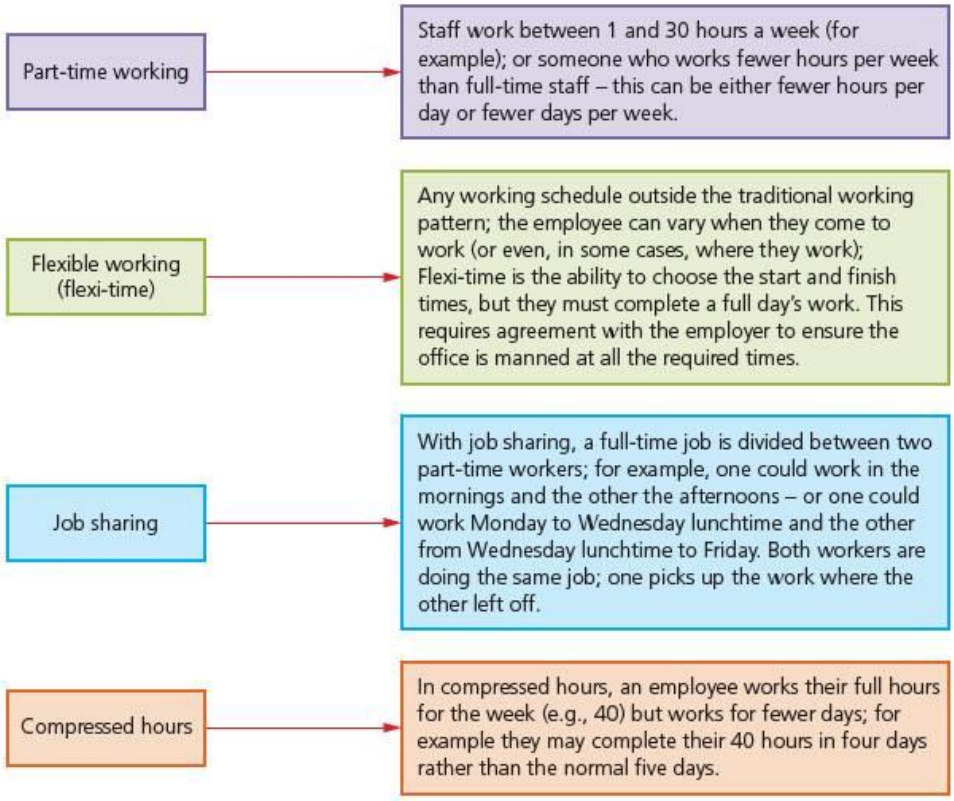
Offices have become more pleasant and safer places to work (no noisy typewriters or the dangers of heavy, overfilled filing cabinets), while the introduction of robots in manufacturing has led to a cleaner, safer, quieter and altogether more pleasant working environment.

There has also been a large increase in job opportunities in some areas, for example:

- network managers and computer technicians
- website designers
- systems analysts
- programmers to write operating systems, applications software (such as spreadsheets and word processors) and computer games
- computer engineers (who build and maintain computer systems)
- computer programmers
- delivery drivers to deliver goods to customers.

5.2 The effects of ICT on working patterns

The introduction of ICT into the workplace has led to a number of changes in working patterns for staff. Essentially, the old concept of the '9 to 5' working day (the normal full-time work pattern) has given way to much more flexible working patterns. The four main additional types of work pattern are shown below.



What are the main reasons for having these different work patterns? Essentially this leads to more contented staff, since they can work hours that suit their lifestyle or home circumstances. It can allow them to avoid rush-hour commuting in the morning and evening, and often leads to more highly motivated staff, which is good for staff and company alike.

Obviously employers see advantages in these work patterns as well:

- a contented workforce is more likely to stay in the job, thus reducing the company's recruitment and training costs for new staff
- flexi-time allows them to remain open for longer hours
- job sharing ensures the company has more than one person with a particular skill set
- compressed hours often lead staff to be more focused on their work
- varied work patterns give more flexibility during busy times and during staff sickness.

Table 5.1 summarises the five types of working patterns.

Table 5.1 Different working patterns

Working pattern	Example
Full time	Five days a week, eight hours a day from 9a.m. to 5p.m.
Part time	Five days a week, four hours a day from 10a.m. to 2p.m.
Flexi-time	Five days a week, eight hours a day from 11a.m. to 7p.m.
Job sharing	Five days a week, 20 hours each worker: • Worker 1: 9a.m. to 5p.m. Monday to Tuesday, 9a.m. to 1p.m. Wednesday • Worker 2: 1p.m. to 5p.m. Wednesday, 9a.m. to 5p.m.Thursday to Friday
Compressed hours	Four days a week, ten hours a day from 8a.m. to 6p.m.

The work patterns are illustrated in the following work schedule:

5.3 Microprocessor-controlled devices in the home

Many common household devices are now fitted with microprocessors to control a large number of their functions. The devices fall into two main categories:

- labour-saving devices
  - automatic washing machines
  - microwave ovens
  - cookers
  - automatic dishwashers
  - robotic vacuum cleaners

  - bread-making machines
  - smart fridges and freezers
- other types of device
  - alarm clocks
  - television sets
  - central heating and air conditioning systems
  - home entertainment systems.

Essentially, a microprocessor-controlled labour-saving device allows people to get on with other things while the device carries out their tasks. Microprocessors within the second type of device make them easier to use and give them additional features, such as 'intelligent tuning' in television sets.

Table 5.2 summarises what effects on a person's lifestyle the introduction of microprocessor-controlled devices might have.

Table 5.2 Advantages and disadvantages of microprocessor-controlled labour-saving devices

Advantages	Disadvantages
• People no longer have to do manual tasks at home • There is no longer a need to stay home while food is cooking or clothes are being washed • They give people more time for leisure activities, hobbies, shopping and socialising • It is possible to control ovens and central heating systems, for example, using smartphones – a web-enabled phone allows devices to be switched on or off while the owner is out • Automated burglar alarms give people a sense of security and well-being as they give a very sophisticated level of intruder warning at all times • Smart fridges and freezers can lead to more healthy lifestyles (they can automatically order fresh food from supermarkets using their internet connection) as well as prevent food waste	• Labour-saving devices can lead to unhealthy lifestyles (because of the reliance on ready-made meals) • They tend to make people rather lazy since there is a dependence on the devices • People can become less fit if they just lie around at home while the devices carry out many of the previous manual tasks • Tasks carried out by people in the past are now done by microprocessor-controlled devices, which means there is a potential to lose these household skills

Table 5.3 gives more general advantages and disadvantages of the technology which are not necessarily related to lifestyle changes.

Table 5.3 Advantages and disadvantages of other microprocessor-controlled devices

Advantages	Disadvantages
• Microprocessor-controlled devices save energy since they are far more efficient and can, for example, switch themselves off after inactivity for a certain time period • It is easy to 'program' these devices to do tasks (for example, QR codes on food packaging can simply be scanned and the oven automatically selects the cooking programme, rather than having to turn knobs and press buttons manually)	• The devices lead to a more wasteful society – as it is usually not cost effective to repair circuit boards once they fail, the device is just thrown away • People who are not very confident around electronic devices (technophobes) can find them complex to operate • Leaving devices on stand-by (for example televisions or satellite receivers) is very wasteful of electricity

5.4 Potential health problems related to the prolonged use of ICT equipment

Since health and safety aspects are generally considered together, the potential health issues are covered in considerable depth in Chapter 8, together with ways to minimise or even remove the risks entirely.