Chapter 2

Computer Hardware

1 Objectives

- Describe the history of computing and show how this has produced the current types of computers used in business.
- Describe the categories of computer currently available, and the functions, characteristics and applications of each.
- Describe the typical structure of a business computer and identify the major physical components.
- Describe the functions and management of control unit, arithmetic and logic unit and memory.
- Describe the characteristics, functions, and applications of current input and output devices.
- Describe the applications, relative speeds and capacities of current secondary storage devices.
- Describe the types of hardware used and facilities available to support data communications.

2 Introduction

In this chapter we will describe the full range of popular computer hardware and how it is used in business. We will place the greatest amount of emphasis on desktop computer hardware; that is Personal Computers and the equipment associated with them.

The typical way that this is done in most books is to cover all the relevant pieces of hardware in sequence. We will not adopt that approach; instead we will use a historical background to introduce computer hardware.

Computers have only existed for about 50 years and some understanding of that history helps us to understand why we have the types of computer hardware used today.

Using this approach will allow us to:

- understand the structure of modern computers;
- recognise some trends in development;
- understand the commercial developments that lead to the introduction of the PC.

3 History

Much of the history of computing is concerned with performing calculations. Frequently, these calculations were based on simple arithmetic, but were so large, or inconvenient, or slow to perform by hand that many people sought methods to

automate them. The early history of computing is dominated by the search for machines that can do these calculations for us or at least help to make them less tedious.

3.1 Number Representing Machines

Mechanical computers have been used for thousands of years. In the beginning such devices simply helped us to remember and record stages in calculations.

- Fingers, stones or sticks were used to represent numbers. These could be used with simple rules to carry out quite complex arithmetic on big numbers. Stones and bones are difficult to manipulate quickly and it was easy to lose one, so there was some significant draw backs with this method.
- An abacus is a frame with wires and beads that slide on the wires to represent and manipulate numbers. Abacuses build on the early idea of using small stones but have some big advantages. The beads can be moved very quickly with a flick of the finger. The beads cannot get lost, and the abacus can be made small enough to carry around easily. By designing the abacus to work with a set of easily memorised rules it is possible to do all the common arithmetic operations quickly and accurately. Variations on this theme are still used in many countries in the Far East, particularly for simple calculations in shops. Interestingly, the shape and form of the abacus differs from one country to another; the one shown in figure 1 is quite different from the Japanese version.

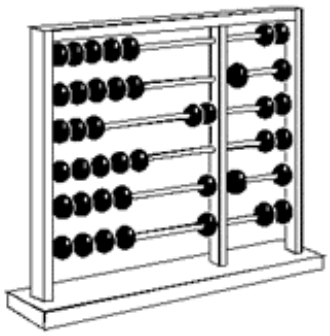

Figure 2. 1 An Abacus

- A breakthrough in mechanical calculations came with the discovery of logarithms by John Napier. Logarithms are based on a simple mathematical idea, which allows the multiplication and division of numbers to be done by a simple addition and subtraction. This was a big improvement, because multiplying such numbers is possible, but very tedious by hand. In order to make use of this method, numbers have to be looked up in the table of logarithms. Where did this table come from? It had to be calculated by hand, number by number. John Napier spent twenty years from about 1594 onwards producing this first table. Obviously work done over twenty years is bound to contain errors and this is a weakness of this type of table.

Strangely enough, logarithms are still used in all modern PCs as we shall see later in this chapter.

Study Note

Logarithm (log) tables came in a wide variety of different sizes depending on the accuracy needed. For some applications, a whole series of heavy books were needed. Nowadays schoolchildren (at least in UK) never see logarithm tables because pocket calculators have replaced them for normal work. This has happened in the last 15-20 years.

3.2 The Slide Rule

The slide rule is a simple mechanical calculating device that uses logarithms. William Oughtred and others developed it around 1622. It performs multiplication and division by sliding a moving rule against fixed calibrations.

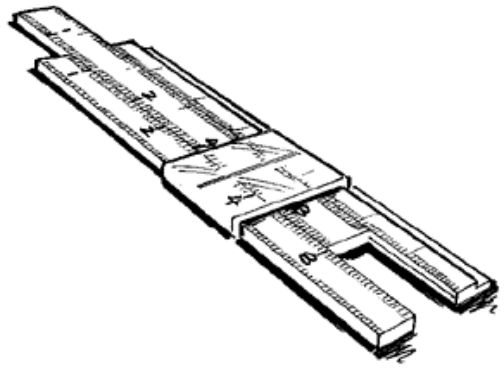

Figure 2. 2 Slide Rule

Slide rules were extremely useful for approximate calculations, and much quicker than using log tables. If accurate calculations were needed, log tables and other mathematical tables (for trigonometry etc.) were still necessary. Unfortunately, they were expensive to produce and often contained inaccuracies. What was needed was a means of automating these calculations, or possibly a means of producing such tables automatically and accurately. Much of the next period of computing history revolved around these goals.

Study Note

The author used a slide rule daily in the early part of his career. With practice it was possible to do most engineering calculations quickly and reasonably accurately. The author has no intention of disposing of his slide rule! Do not worry about old tools like this – you will never need to use them.

3.3 Mechanical Calculators

The arithmetic engine, produced by Blaise Pascal in 1642 was the first real calculating machine. Digits from 0 to 9 were arranged on wheels. Turning one wheel a full revolution caused its neighbour to be advanced one notch. The arithmetic engine worked on a similar principle to the mechanical mileometers used in cars, borrowing ideas from clock gear mechanisms. This machine is often referred to as Pascal's box. It was a big improvement in addition. Multiplication and division is a bit more difficult but Gottfried Von Leibnitz designed a calculator that could do this in 1694.

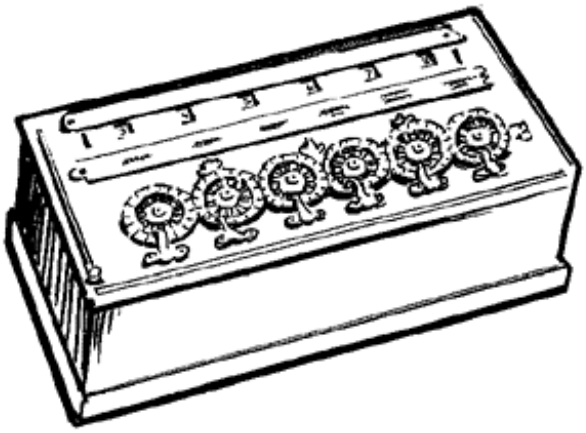

Figure 2. 3 Arithmetic Engine

3.4 Mechanical Computers

The most ambitious and important mechanical computers were designed by Charles Babbage, an Englishman. He first produced the difference engine, which could be used to compute and check some types of mathematical tables. This was important because such tables had to be produced by hand and usually contained errors. Babbage's difference engine was capable, in principle, of finding such errors.

The analytical engine was also designed by Babbage. This was an extraordinary advance on any other mechanical calculator. It was really the first computer in that a *program* controlled it, which allowed it to be used to solve many different problems. The input was through the medium of punched cards originally developed by Joseph Maria Jaquard in France to control looms automatically. Unfortunately, Babbage was never able to construct this machine but recently, parts of it have been produced using modern manufacturing techniques. The design for the analytical engine contained the same elements as any modern computer, but using mechanical parts instead of electronics. In principle Babbage's machine was a computer just the same as the PC on our desk, but infinitely slower.

Study Note

This may seem to be very strange statement to make. How can we possibly say that a mechanical device is equivalent to our Pentium III processor PC? Strange as it might seem it is true and was proved by a brilliant British mathematician called Alan Turing in 1936. He showed that all computers (in the terms that we have described them) have exactly the same capabilities, they just differ in how fast they perform. It does not matter how much more complex and powerful the next generation of microprocessors is; they will still obey this fundamental law. Unfortunately explaining why this strange idea is true goes beyond this workbook, but you will undoubtedly became familiar with the theory if you study computers to a more advanced stage.

Exercise 2.1 ***1 hour***

Charles Babbage was one of the most important figures in the development of mechanical computers and his later work contained all the major components of our modern computer systems.

a) Only a small fraction of Babbage's designs were constructed in his lifetime. Why do you think this was so? Try to think of at least two reasons. You may need to do some research to answer this question.

b) What do you think was the most significant of Babbage's ideas? State the reasons for your choice.

3.5 Electromechanical Processors

Study Note

Review the definitions given in Chapter 1 to understand the distinction being made between data and information. This is very important.

The next big development came about as a result of a problem faced by the American government. Like all Western countries, the USA carried out a census of its population periodically. By 1880 the amount of data collected during the census was becoming very large, and much worse, it was becoming impossible to process the data to obtain useful information.

As a result of observing these problems Dr Hermann Hollerith proposed a system using punched cards to represent the census data. This idea won a competition to find an efficient way of analysing the 1890 American census.

The presence or absence of a hole in particular positions would indicate the presence or absence of particular characteristics about the individuals in the census. In order to read the cards he passed rods through them. The rods made contact with a bowl of mercury to form an electrical contact which caused a counter to advance by one.

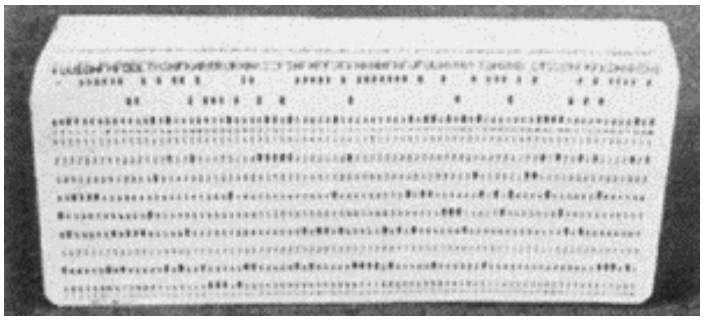

Figure 2. 4 Punched Card

Later punched card devices abandoned mercury and used much simpler electromechanical and eventually photoelectric sensors.

The punched card designed by Hollerith was still the main input media in most electronic computers until the 1970s. Usually, a single card was used to store the data for a single object, such as a person.

Punched cards allowed quite complex processing. For example, it might be useful to sort all the record cards into order based on, say, people's ages. This could be done manually but it would take a long time.

All kinds of simple electromechanical devices can be used to sort and process punched cards.

Some typical equipment is listed below:

- A sorter for arranging the punched cards in a desired sequence.
- A collator to selectively merge cards into a single sequence.
- A printer to print out the contents of the cards.

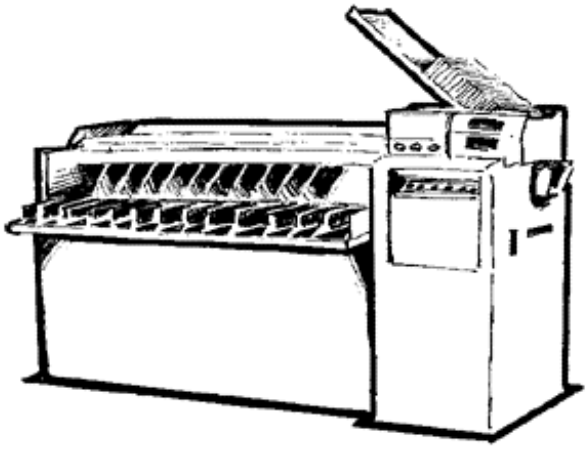

Figure 2. 5 Sorter

This was the first useful electromechanical computing system. Electromechanical systems are limited by the speed at which cards (and sometimes paper tape) can be moved around. They are also limited by the speed of simple electrical switches (relays). These quickly became a serious constraint and engineers started to apply electronics, which is much faster and does not involve lots of moving mechanical parts.

3.6 Electronic Processors

Although Babbage conceived the idea of a program controlling a computer, it was only when electronics became available that the concept became really practical. The major breakthroughs came in England during World War II in Manchester, Cambridge and in the USA shortly after the war.

The big improvement was in switching. All computers contain a lot of switches and the speed of these largely determines the speed of the computer. There is a practical limit to the speed of mechanical switches, but this can be radically improved with the use of electronics. The first electronic device that could switch quickly was the vacuum tube or valve.

Figure 2. 6 Electronic Valve

Electronic valves are now rather rare. They were (and are) glass tubes, about 6cm long with connecting pins on their base. One of the first general-purpose computers, called the Electronic Numerical Integrator and Calculator (ENIAC), developed in 1946, was a gigantic machine with eighteen thousand valves. It consumed many kilowatts of power, generated lots of heat, had to be water cooled and had a very high failure rate compared to present day computers.

Study Note

The first machine using electronic valves in this way was called COLOSSUS and was built under great secrecy in Bletchley Park UK in about 1943. The purpose of COLOSSUS was to help crack German codes, specifically the famous Enigma code. This was done successfully and had an immense impact on history. COLOSSUS had about 2,000 valves and used punched paper tape. Until quite recently, the existence of CLOSSUS was still a secret. Because of this you will not find it described in older computer science textbooks. Alan Turing worked on the machine and the problem of code breaking. This is all just interesting history; you will not be expected to learn theses facts.

4 Generations of Computer Systems

Since the first electronic computers were built in the 1940s, a number of developments in electronics have led to computer hardware being categorised by generation, that is, its place in the history of the computer.

4.1 First Generation

During the 1940s, the first generation of computers used electronic components including vacuum tubes.

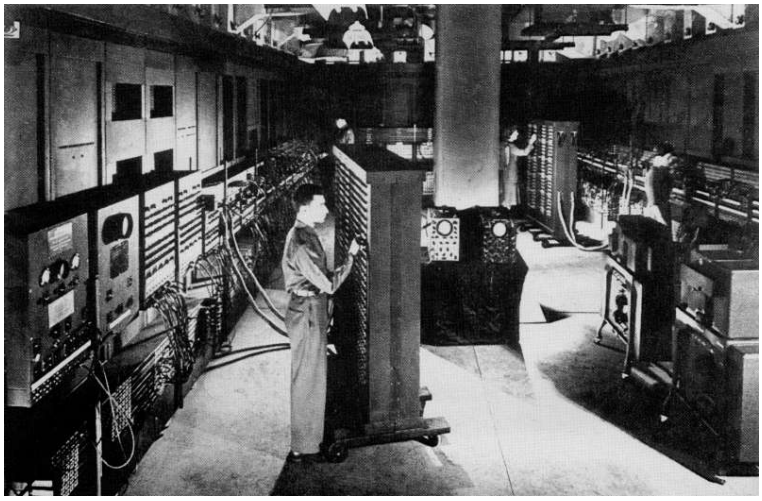

Figure 2. 7 First Generation Computer

The first computer to allow a program to be stored in memory was the Electronic Delay Storage Automatic Computer (EDSAC), developed at the University of Manchester. The vacuum tubes were fragile, subject to overheating and caused frequent breakdowns.

4.2 Second Generation

The introduction of low cost and reliable transistors allowed the computer industry to develop at a tremendous rate during the late 1950s. The cost and size of the machines was radically reduced so it became possible for large commercial organisations to make use of computers. Examples of such machines include LEO III, UNIVAC and ATLAS.

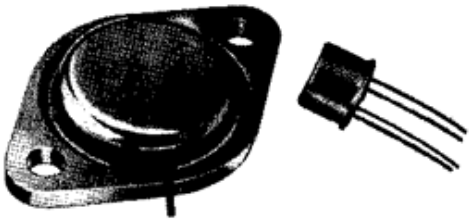

Figure 2. 8 Transistor

Transistors have enormous advantages over valves. They are tiny in comparison with valves, produce very little heat and can switch extremely quickly. All these factors in combination caused a total revolution in computer systems.

4.3 Third Generation

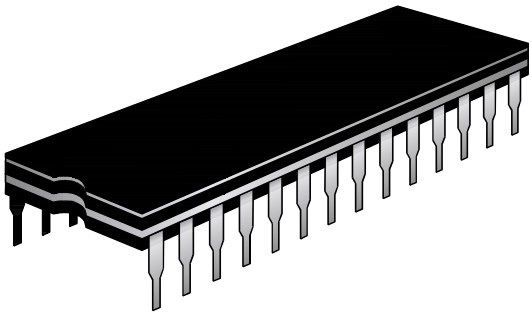

Figure 2. 9 Integrated Circuit

The development of Integrated Circuit (IC) technology in the mid-1960s heralded the development of more powerful, reliable and compact computers, such as the IBM 360 series.

Integrated circuits are a compact way of packaging together many transistors on the same piece of silicon. This again increased speed and reduced the complexity of the wiring of systems.

4.4 Fourth Generation

This generation is typified by Very Large-Scale Integration (VLSI) of circuits that allowed the development of the microprocessor, which in turn allowed the production of the microcomputer. VLSI takes the idea of the IC to its logical conclusion. Rather than packaging a few hundred transistors on a piece of silicon, VLSI takes the idea seriously and packs in millions. For example, the Pentium Pro processor puts about 68 million transistors on a piece of silicon smaller than a postage stamp. All computers used today make use of such silicon chip technology. The gains are just the same as for second generation: speed, cost and reduced size.

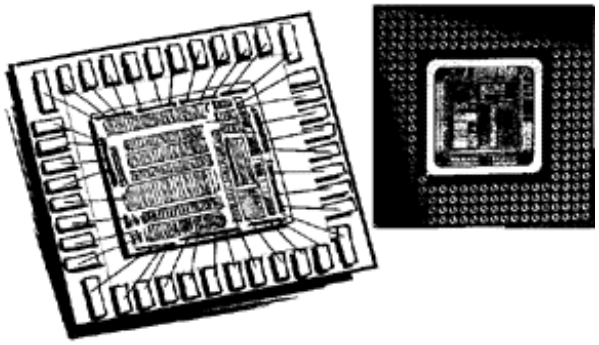

Figure 2. 10 VLSI

At present, most computers are still of the fourth generation variety. The main focus of development has been the development of techniques that can pack more and more transistors onto the surface of a chip. This is likely to continue for a few more years, but eventually a new approach will be needed if we are to continue the current pace of development.

Study Note

In order to pack in more transistors, it is necessary to make them smaller. This means that smaller and smaller component details must be printed onto the silicon surface. This is becoming very difficult and the semiconductor companies must continually invent new production technologies to keep up. Eventually, we will reach limits imposed by the law of physics. After that a lot of imagination will be needed to make further improvements, but all our past experience suggests that this will happen.

5 Developments in Telecommunications

Computers and communication systems have developed together. As better and faster computers were introduced into the business world, the demand for ways of communicating between computers in different offices grew tremendously. We need to understand this type of communication just as much as the development of computer systems. Early communication systems were developed for the transmission of voice, as in telephone systems. These were transmitted as analogue messages. What does this mean? First a definition:

Definition

Analogue – The representation of a continuously changing physical variable (sound, for example) by another physical variable (such as electrical current).

The telephone handset picks up the vibrations in the air (our voice). The microphone in the handset converts this varying sound into a varying electrical voltage. The voltage is an analogue of the voice signal. At the other end of the telephone connection the process is reversed. The analogue electrical signal is converted in the handset back into sound, which the other party hears. The ordinary domestic telephone system is based on sending and receiving analogue messages.

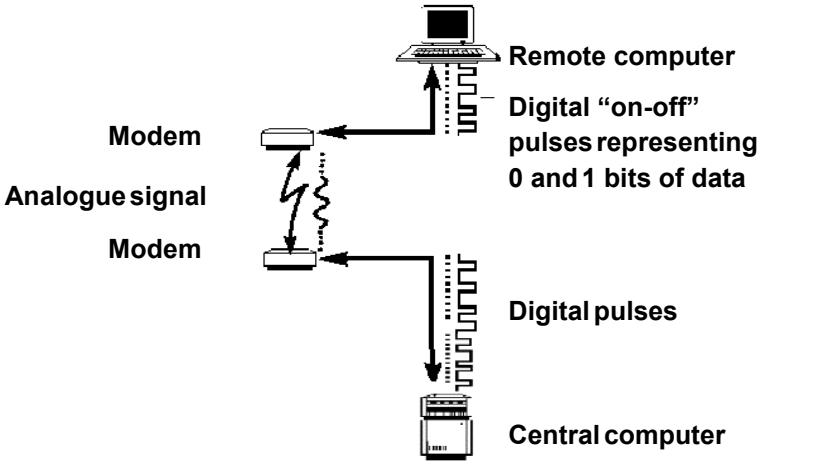

Figure 2. 11 Data Communication

Computers do not work directly with analogue singles. They are fundamentally digital devices – so we need another definition:

Definition

Digital – Devices that represent data in the form of digits, based on the binary system where the binary digits (bits) are zero or one. Also, pertaining to data that consist of digits.

Essentially, digital signals are based on numerical values. In computers there are binary numbers but we will postpone this detail until later.

As computer systems grew and became distributed, so the need for machine to machine communication developed. This initially took place over the normal telephone network with special devices (modems) linking the computers to the network. Modems convert digital signals into the analogue signals that the telephone is designed to handle. At the other end of the connection, another modem converts the signal back into digital form.

Study Note

It is true that the bit of the telephone system that connects your telephone to the local exchange is analogue. This part (the local loop) is the most old fashioned part of the entire network. The connections between the exchanges use much more modern technology that is normally based on digital techniques. This does not invalidate the discussion of how telephone handsets work.

Digital messages can be organised into packets and the packets can be transmitted in an approach similar to the postal system. This type of transmission provides a high level of accuracy. Communication systems can be used to link computers together or link terminals to computers. This makes it possible to use a computer from a remote distance, or for two computers to exchange information or work co-operatively.

6 Types of Computers

Every book on computers talks about different types of computer. We are going to stick to that format but with a very large warning. The distinctions between different types of computer become less clear all the time. Frequently it is more of a marketing than a technical issue.

We will start by describing the most popular type of computer – the microcomputer, of which the PC is the most common type.

6.1 Microcomputers (PCs)

Definitions

Microcomputer – A microcomputer is a computer that is based on a microprocessor.

Microprocessor – A microprocessor is a Very Large Scale Integrated chip that contains all the core features of a computer.

In the 1940s it was confidently predicted that around ten computers would satisfy the needs of the whole world. In 1991 around 6 million personal computers were sold in Europe, 1 million of these in the UK!

Exercise 2.2 ***20 minutes***

Try to work out why people thought that ten computers would be enough. *Hint – think about the early application of computers.*

6.2 History of Microcomputers (PCs)

In the 1970s the application of microelectronics led to decreases in the size and price of computers whilst increasing their capabilities. A wide range of microcomputers were developed and marketed to the small user in industry and commerce.

Up to that point, computers had all been large, cumbersome machines needing specialised accommodation. However, in 1971 the microprocessor was invented. A single chip could be built with all the parts of the heart of a computer, the Central Processing Unit or CPU.

As a result of the miniaturisation and low cost, this invention made microcomputers possible. The first of these microcomputers was built in 1974 and was a mail order kit available in the US and sold for $397. By the early 1970s companies which made television and radio components had seen the market for do-it-yourself computers and were making computer components.

Small companies began to grow and in 1975 Apple produced the Apple computer. Also around this time Bill Gates formed a company called Microsoft. This company wrote software for the BASIC programming language and went on to produce further software for the Apple computer. In 1977 Apple launched the Apple II. This machine was a big hit with schools because it was very competitively priced and the first generation of computer literate children developed.

The programs written for the microcomputer up to this stage had been specialised, custom built packages or games software. Development was slow until people designed application packages. The first popular package was a spreadsheet called Visicalc. Now PCs are used to run sophisticated spreadsheets like Lotus 1-2-3 and Microsoft Excel together with word processing packages such as Microsoft Word and WordPerfect.

The original microcomputers had low capacity twin floppy drives. This only allowed very simple programs to be used and gave very limited storage capacity. As programs became more complex, disks had to be swapped in and out of the drive for even fairly basic tasks such as spell checking. The advent of the hard disk drive paved the way for more powerful, faster machines.

Today's PCs have Intel Pentium chips, many megabytes of memory and large hard disks. They have CD-ROM drives so video sequences with stereo sound and moving pictures can be run and edited. Encyclopaedias and other large books are now available on CD-ROM. These systems can be linked to the Internet.

Exercise 2.3 ***30 minutes***

PCs were available for business use in 1980s with less than a tenth of RAM or disk capacity that we now think is essential, yet serious word processing and other applications were common.

Why do we now need computers with such big memory in comparison with those days? *Hint – think about the style of documents that we now use compared to those ten years ago*.

6.3 IBM PC

As the microcomputer market grew, the biggest supplier of computers in the world, IBM, entered the market in 1981 with the IBM Personal Computer (PC). The name stuck and the PC was born. Within one year IBM became the largest supplier of PCs in the world.

Before IBM launched its PC, all microcomputers were closed. This meant that you could not take, say, a Visicalc spreadsheet from a Commodore computer and load it onto an Apple computer. When IBM launched their PC it came with an operating system called MS-DOS (Microsoft Disk Operating System) and IBM allowed other manufactures to copy or clone their design and use MS-DOS. This created a more open environment.

Today, companies such as Compaq, Toshiba, Dell and Gateway all earn good revenues from manufacturing IBM compatible PCs and as the technology has become more reliable and more available other, smaller, companies have joined the IBM compatible market-place.

The PC-AT (Advanced Technology) was launched by IBM in 1984. This used a newer processor and a hard disk. These computers could run bigger, more complex software. All of the current range of PC clones is derived from this model.

The first IBM PS/2s were launched in 1987. These machines were a major evolution. They introduced the 3½ inch disk drive across the whole range. This is the floppy disk in a hard plastic case, which is still in use today.

The Apple Macintosh was produced in 1984. This was easy to use and understand and introduced users to the graphical user interface, using a mouse and icons. It was not really until the advent of Windows Version 3 that IBM compatible PC users had anything like the same advantages.

Study Note

PCs dominate the desktop with Apple Macintosh holding a small percentage, mostly in some vertical market sectors such as graphic design and desktop publishing. This is why this workbook is oriented quite strongly towards the PC.

6.4 Minicomputer Systems

Before the advent of the microcomputers, small computers were called minicomputers. Today a typical minicomputer supports many users simultaneously. A minicomputer can also be used for a dedicated special purpose system like a hotel reservation or banking systems.

Minicomputers are often used in a medium sized organisation for a range of applications such as payroll, financial accounts, costing, sales administration, production planning etc.

IBM's AS400 is a popular range of minicomputer. These computers are proprietary, that is, they use their own unique systems software supplied by IBM. This software cannot be used on any other type of computer.

The UNIX operating software now dominates the minicomputer market outside the AS400 arena and most companies, like Hewlett Packard and Sun Microsystems provide hardware that will run UNIX. IBM also produces a minicomputer, the RS6000, that will run the UNIX operating system.

Study Note

There are many different types of UNIX and this limits the usefulness of the concept of an open system. There is a trend towards the use of UNIX on PCs rather than Windows. This is partly because of the availability of a free version of UNIX called LINUX, named after Linus Torvalds, a student who developed the core version of UNIX.

These minicomputers compete with microcomputers using Microsoft Windows NT Server, a form of software quite different from that used on desktop PCs.

6.5 Mainframes

Early computers were called mainframes, a term still in use today for large computers. Large corporations such as banks, that have very large amounts of data to process, use mainframes. The mainframe is used as the main computer to which other minicomputers and microcomputers, in different departments and sections, are connected.

IBM dominates the mainframe marketplace although there are other companies that still produce machines of this class.

6.6 Supercomputers

Some of the complex scientific applications like weather forecasting, nuclear research etc, require a large volume of data to be manipulated within a short time. Supercomputers are very large computers capable of handling massive volumes of data and performing millions of calculations every second.

Study Note

Supercomputers are very unusual. The major customers are governments and very large corporations.

They are used for some special type of applications, not for the type of business applications that we consider in this workbook.

Exercise 2.4 *1 hour*

What type of computer would you use for the following applications?

a) A weather forecasting system

b) A large banking system with a big database.

c) A supermarket stock system driven by barcode readers at the tills.

d) General office word processing.

e) A system that could calculate how a car body would crumple in a crash.

f) A musician composing music and wanting to print out the results.

g) A department with fifty employees who all need to access the same data. (Hint – think about the data, not the individual employees).

h) A worker who needs to operate from home and on the road.

i) A system that could be used to simulate nuclear explosions (without having to carry out actual tests).

j) A system that could be used by a disabled person who could not speak to communicate verbally with others.

k) A system that could be used to break secret codes.

l) A cartoonist producing material for a newspaper.

7 Computer Architecture

While the actual computer is a piece of hardware, a computer system is a combination of elements that work together to process data and produce an end result – information. We will now take apart a computer and describe these elements and how they work together. The technical jargon often used to describe this view of a computer is computer architecture.

7.1 Architecture?

The basis of any system consist of receiving input, processing the input and producing an output. This follows from the work we did in Chapter 1. Just to illustrate this idea again before we start to look at computers, consider a manufacturing business as an analogy.

A manufacturing system receives an input of raw materials and processes these materials to produce the finished goods. A computer system receives an input of data, processes the data and produces an output of information.

Figure 2. 12 A Computer System

To do this the computer system utilises hardware (the physical components of the system) and software. We will now define those physical computer system components.

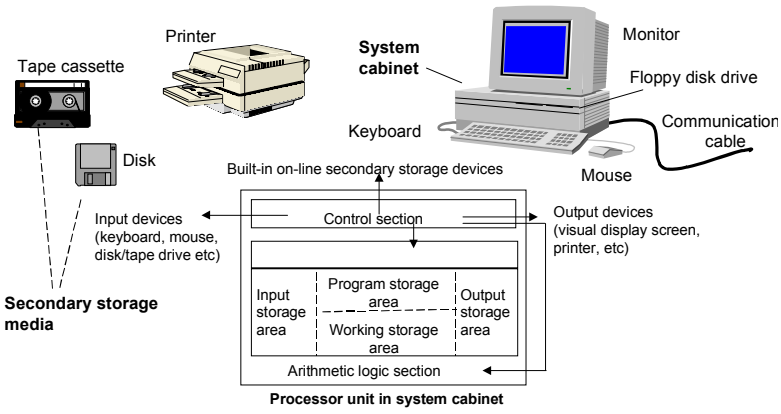

Figure 2. 13 Computer System Components

7.2 Input Devices

Before the computer can perform any tasks there must be an input of data. This can be done using such devices as keyboards, mice, optical scanners, light pens and, in the latest computers, voice input. Alternatively, the data may be retrieved from a storage medium such as a magnetic disk. There are such a large variety of input devices that we will devote a section of this chapter to describe them.

7.3 Central Processing Unit

In the centre of Figure 2.14 is the Central Processing Unit (CPU). In most desktop computer systems this is a single microprocessor. A microprocessor is simply the whole CPU put together on one integrated circuit or chip. Not all

computer systems are based on microprocessors; some of the largest and most powerful systems use many individual components to make up a CPU.

The CPU is the part of the hardware that carries out the instructions within a program. We can break the CPU down into several parts.

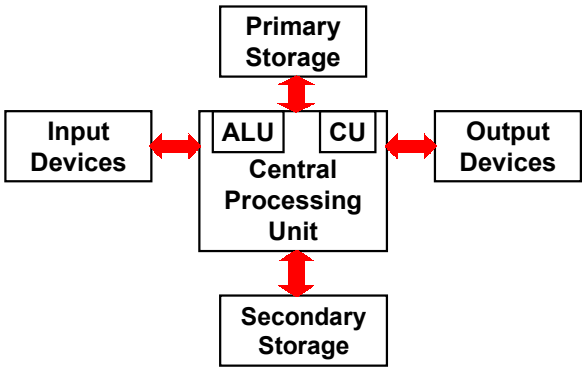

Figure 2. 14 System Structure

The Arithmetic/Logic Unit (ALU)

All arithmetic calculations are performed in the Arithmetic/Logic Unit (ALU) section of the CPU. The ALU acts as a calculator, performing arithmetic operations such as addition, subtraction, multiplication, division and logical comparisons such as deciding whether two numbers are equal.

Data is placed into Random Access Memory (RAM) by the CPU. Once there, it can be transferred as needed to the Arithmetic/Logic section, where calculations take place. No processing occurs in RAM. Data can move from RAM to the Arithmetic/Logic Unit and back again many times before the processing is finished. Once completed, the final results are sent to an output device.

Study Notes

Remember - all the processing (calculations) happens within the CPU; the RAM is purely passive, simply storing data.

The Control Unit (CU)

The Control Unit fetches data from RAM for processing by the ALU. By controlling the running of the program instructions, the control unit of the CPU maintains order and directs the operation of the entire system.

Although the control unit does not process data, it acts as a central nervous system for the other data manipulating components of the computer.

The Clock

The CPU is driven by a system clock that governs the speed of the computer. This clock is usually based on a quartz crystal external to the CPU. The crystal vibrates at a very high frequency and this drives all the operations of the CPU in a precise timing. The crystal is similar to one found inside a wristwatch.

7.4 Primary Storage (RAM)

All computer systems have primary storage or memory. This is commonly referred to as RAM (Random Access Memory), particularly in connection with PCs.

Study Note

If you read PC magazines, you will see lots of references to RAM but no reference to *primary storage*. It is useful to make the distinction between primary storage, which is where a program must reside in order to run, and secondary or backing storage, which is used to provide long term high volume storage of data and programs. You will also find this terminology used in textbooks and more advanced courses and you should be familiar with it.

Figure 2.15 shows a typical RAM chip. These are rarely used in this single chip form but are combined into a module containing several chips as shown in Figure 2.16.

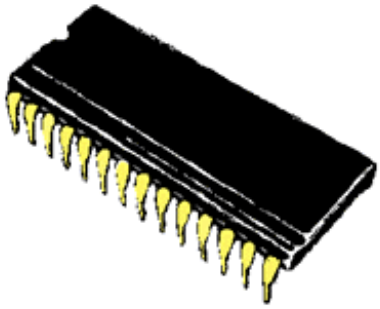

Figure 2. 15 RAM Chip

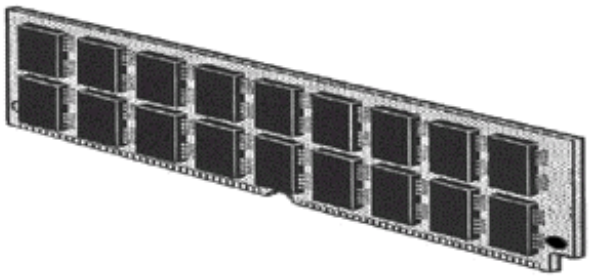

Figure 2. 16 RAM Module

RAM is used as:

- an input storage area to hold the input data prior to processing;
- a working storage area to hold the data currently being processed;
- an output storage area before the data is transferred to an output device;
- a program storage area to hold the program while it is running.

Data held in RAM is lost when the computer is switched off.

Study Note

The fact that RAM is lost when the power goes off is important. The technical description for memory that has this property is volatile. Non-volatile memory does not lose its contents when the power is removed. Secondary storage is non-volatile. You may be asked to explain this difference.

7.5 Secondary Storage

Data is only held temporarily in RAM, so computers must incorporate some means of secondary storage – a permanent medium in which data will be retained when the machine is switched off.

Computers accept data and/or program instructions from the processor, retain them and return them to the processor as needed to complete the processing tasks. Data on a secondary storage medium cannot be processed until it has been retrieved into primary storage. On microcomputers this secondary storage will usually be provided by hard disks.

Secondary storage usually has a much greater capacity than primary storage. It is cheaper than primary storage, but much slower.

7.6 Storage Capacity Elements

All the work you have done comparing the disk and RAM sizes used bytes to measure capacity. The word byte has become an everyday part of the English language so we do not usually stop to dine it. In this course we need to be more precise. We will start off by defining something smaller than a byte – a bit.

Definition

Bit – A bit or binary digit is the fundamental unit of data used by computers. It can take the value 0 or 1.

The data used internally by a computer is all based on binary numbers (0,1) rather than the more familiar decimal numbers (numbers 0,1,2,3,4,5,6,7,8,9) we use in everyday life. What is the reason for this strange decision? Computers use binary numbers because it is much easier for two states (0 and 1) than the 10 states that would needed for decimal numbers. It is also much easier to design the CPU to carry out the binary arithmetic than decimal arithmetic. Everything that the computer processes must be turned into binary data – including pictures, sound, documents and drawings.

Definition

Byte – A byte consists of a series of 8 bits. Bits are normally combined together into bytes.

Figure 2.17 shows the correspondence between decimal and binary numbers. Notice how the binary numbers are much longer than the same decimal number.

Decimal Number	Binary Number	Decimal Number	Binary Number
0	0	6	110
1	1	7	111
2	10	8	1000
3	11	9	1001
4	100	10	1010
5	101	11	1011

Figure 2. 17 Basic Binary Notation

Computer storage is frequently measured in Kilobytes (Kbytes) or Megabytes (Mbytes). While a kilo in the metric system is used to represent 1,000 in the computer industry it equates to 1,024 bytes, but commonly this difference is ignored to simplify measurement of storage.

7.7 RAM Addressing

The name Random Access Memory tells us that it is possible to randomly access (read and write) any part of this form of memory. How is this done?

Conceptually, RAM consists of many storage locations, each identified by a unique numeric address.

Many computers can store a byte in each of these storage locations, thus it is possible to locate distinctly every byte in memory by its address. This is the approach used by the PC.

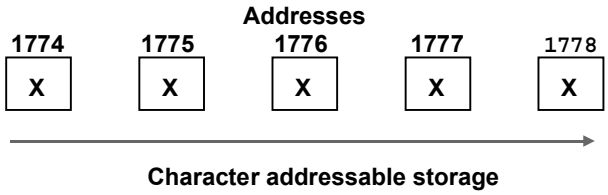

Figure 2. 18 Storage Location and Addressing

Computers designed in this way are said to be character or byte addressable. Thus a sequence of characters such as SANDY would require five storage addresses, while '#180' would occupy four addresses.

Study Note

Not all computers work like this. Some group together a series of bytes at each address.

7.8 Output

The last part of our system architecture, as shown in Figure 2.14, is output.

The whole point of processing data is to be able to output the resulting information. Output devices take results from the CPU and convert them into a form that can be used by people (for instance printed or displayed reports). In a PC, a colour monitor, desktop printer and audio speakers are typical output devices. Larger and faster printers, and magnetic tape units are often used for output in larger systems.

Input and output devices are sometimes called peripheral devices or just peripherals. This is because they connect to the outside or peripheral of the main computer unit. We will return to peripherals in a later section.

8 Secondary Storage

Secondary storage is used for the long term storage of programs and data. Recall that secondary storage is non–volatile, so we rely on it for storage when we switch off the computer.

8.1 Disk Storage

Many different types of secondary storage devices are based on spinning disks upon which data is recorded. This type of device allows any particular item of data on the disk to be read directly, without having to read all the rest of the

recorded data. This type of device is often referred to as a Direct Access Storage Devices (DASDs)

Study Note

You should be able to recognise and describe a range of secondary storage devices. You should also be able to compare and contrast the characteristics of each type.

These devices include:

- Magnetic disk drives.
- Optical storage such as CD-ROM and DVD (Digital Versatile Disc).

Within each category of direct access device listed, there are a great number of variations in design, performance, capacity and cost.

Study Note

This type of device is often referred to as a Direct Access Storage Device (DASD), especially in literature that describes mainframe systems.

8.2 Magnetic Disk Drives

The most important form of disk based storage is the magnetic disk. All PCs rely on this form of secondary storage but they are used in virtually every system, from mainframe systems down to the smallest laptop.

Two of the basic types of magnetic disk are:

- Hard disk drives.
- Floppy disk drives.

We will first consider the hard disk that is usually hidden inside the main system box of the PC.

The physical disk is typically made of thin metal or plastic plates coated on both sides with a magnetisable recording material. These disks may remain permanently in their housing or they may be packaged in portable or replaceable assemblies. Some disk drives have more than one physical disk. If this is the case, a space is left between the spinning disks to allow access arms with small read/write heads to move to any storage location on the disk surfaces.

All hard disks have the same logical structure, even if they differ in their physical design. Figure 10 shows the logical view. On a magnetic disk, data is organised into a number of concentric circles on the disk surface, called tracks. Each track has a designated location number. A single track is divided into sectors or blocks. The sectors are fixed in size.

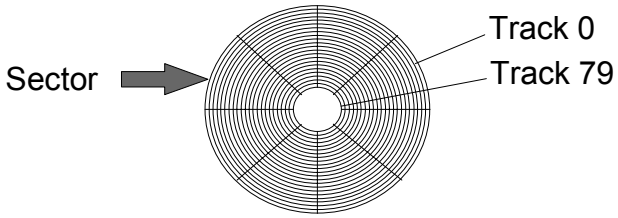

Figure 2. 19 Disk Format

Most high capacity disk drives use multiple disks stacked a set distance apart on a spindle. Each surface of the disk usually has its own read and write head. These heads are arranged one above another and moved together. As the disk spins, a cylinder is described by each of the tracks positioned under the heads. All data in this cylinder is equally accessible to the computer without moving the read/write heads. A large amount of data can be transferred to, or read from, the disk while the heads are positioned over a particular cylinder. This has the effect of reducing the time taken to access data.

Study Note

Modern disk drives, particularly those used in PCs, have a lot of electronics built into the drive. This means that the number of cylinders actually present may be different from what the rest of the PC can see. The electronics can make the drive look like a drive of another physical layout.

Magnetic Disk Access Mechanisms

In order for a disk drive to read or write to a disk, the disk must be spinning at a constant speed. Floppy disk drives only begin rotating the disk when they are required to read or write data. Hard disks spin continuously, often at thousands of revolutions per minute.

Magnetic Disk Access Times

The performance (speed) of a disk depends mostly on how fast it rotates and how fast the read and write heads can move. Generally, the higher the performance of a hard disk the more it is likely to cost. The hard disks used in most PCs are not

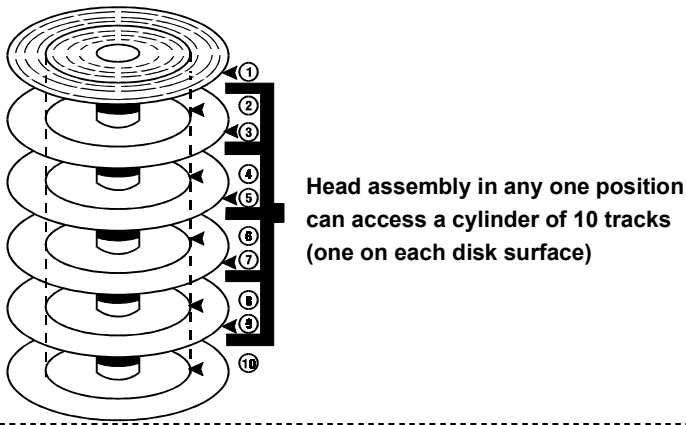

Figure 2. 20 Magnetic Disk Access Mechanism

designed to provide very high performance, but to provide the largest storage capacity for a given price.

Hard disks used on minicomputers and mainframes are a lot more expensive, but can provide much higher performance.

Hard Disk Drives

Hard disk drives (sometimes called Winchester disks) contain a number of aluminium disks coated with extremely fine-grained magnetisable material.

During computer operation, the disks, which are fixed on a single spindle, rotate continuously.

The disks and the head mechanisms are enclosed in a sealed case which protects them against dust and moisture. This is necessary because the gap between a read/write head and the disk as it spins is about one hundred thousandth of an inch. By comparison, a particle of smoke from a cigarette, which is approximately 25 times larger, would cause irreparable damage if it were allowed to enter the casing of the drive. Figure 2.21 shows what these look like with the lid removed.

Figure 2. 21 Hard Disk Drive

Study Note

Do not dismantle your hard disk to check if it looks like this! Hard disks are sealed to keep dust out and will fail very rapidly indeed if you remove the lid. Hard disks usually have labels that state that the warranty is void if the cover is removed.

Floppy Disk Drives

Floppy disks or diskettes are one of the simplest forms of magnetic disk. They are made of flexible plastic that is covered with a magnetisable coating.

The disk is enclosed in a protective casing which enables it to be inserted into an appropriate disk drive without damage. Floppy disk drives only begin rotating the disk when they are required to read or write data.

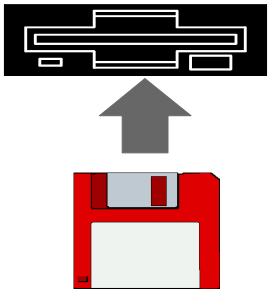

Figure 2. 22 Floppy Disk Drive

All PCs use 3½ inch size floppy disks, although some newer types of floppy disk are becoming available that provide much higher storage capacity.

Study Note

The newer formats are beginning to appear much more frequently. For example, the ZIP disk is available in 100 MByte *and* 250 MByte formats.

Floppy disks have a write-protect mechanism which prevents the disk being accidentally overwritten. The disk casing has a small hole in one corner with a sliding plastic tab. The tab is positioned away from the hole (so that the hole is visible) when the disk is to be write-protected.

When a floppy disk is inserted into a drive, a small electric motor rotates the disk to enable the reading/writing of data. A light on the front of the computer shows when the computer is reading or writing the disk. Users should never try to insert or remove a disk when the light is on.

Exercise 2.5 ***15 minutes***

Floppy disks were often used to deliver large scale software applications, but this happens much less frequently now, other storage media are used instead. Why do you think this is the case?

8.3 Optical Drives

CD-ROMs are the most common type of optical disc drive and are now found on most business PCs.

CD-ROMs (CD Read Only Memory) use storage techniques based on light instead of relying on the principles of magnetism as in the case of other disks. They are based on the Compact Disc (CD) which is widely used in consumer

audio equipment to record high quality music. Tiny pits visible only under the microscope are burned or pressed into a thin coating of metal or other material deposited on a disc.

- **Compact Discs (CDs)**
  - **Read Only**
  - **Recordable**
  - **Rewritable**
- **Digital Versatile Discs (DVDs)**

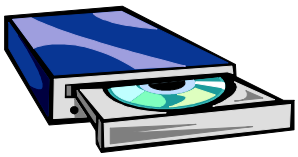

Figure 2. 23 Optical Drives

The pit patterns represent the streams of digital data that are used to encode images and sounds. A beam of laser light is used to read the pit patterns and convert these patterns into digital signals. The pits burned or pressed into optical discs cannot be erased, and the discs can not be reused to record new signals. A CD-ROM disc stores about 650 megabytes of data, which is sufficient to store all the volumes of a large encyclopaedia.

Recent developments have produced writeable and rewriteable CD-ROMs. These are known as CD-R and CD-RW respectively.

The latest development in optical storage utilises the DVD (Digital Versatile Disc or Digital Video Disc). This is used in domestic form for storing movies with a high quality format. It can also be used with PCs in both read only and writeable formats.

Exercise 2.6 ***20 minutes***

Apart from capacity, what other major advantages do CD-ROMs possess for data storage and delivery.

9 Serial Access Storage Devices

Serial access devices are those in which a particular item of data can only be read after reading all the intervening items of data. The original serial access storage devices used with computers were punched card and paper tape mechanisms. These are now only of historical importance. The only important serial access storage device in current use is magnetic tape.

9.1 Magnetic Tape Drives

Tapes are ideally suited to sequential processing of large volumes of data or as secondary storage backup for working data. They are also inherently more secure

from interference and data corruption than fixed disks due to the fact that the only time they can be accessed is when they are placed in the tape drive.

Magnetic tape has a relatively fast transfer rate and is principally used as a data backup medium and for high-speed, large-volume applications.

Today, there are three basic types of magnetic tape device in general use:

- reel-to-reel tape devices;
- cartridge tape devices;
- digital audio tape (DAT) devices.

9.2 Reel-to-Reel Tape Drives

We will not spend a lot of time on reel-to-reel tape because you are unlikely to encounter it when working with a PC. Reel-to-reel computer tape is plastic tape covered with a magnetisable coating. Data is stored on it one character code at a time, each code using the full width of the tape.

Tapes like these are still used on some large mainframe systems, although even there, alternative formats are now common. The tapes used on these systems are often organised into large libraries and stored in extensive racking.

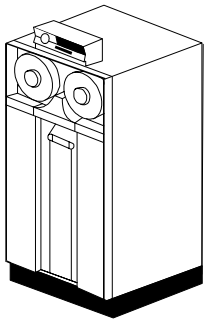

Figure 2. 24 Reel-to-Reel Tape Drive

9.3 Quarter Inch Cartridge (QIC) Tapes

In this format, tape is usually housed in a cartridge mechanism and is typically 0.25 inches wide. This leads to the terminology of QIC (Quarter Inch Cartridge). QIC cartridges use a slightly different principle to record data than the reel to reel tapes. They do not record across the entire width of the tape, but use a narrow track along the entire length, reversing at the end of the tape to use the next parallel track.

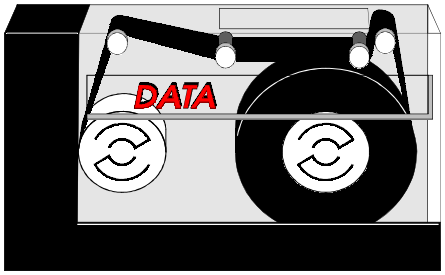

Figure 2. 25 Cartridge Tape

Study Note

There are literally dozens of different QIC formats, few of which are in common use.

9.4 Digital Audio Tape Drives

Recent developments in the field of tape storage have produced DAT (Digital Audio Tape) drives that store data using sophisticated digital recording methods. Originally designed for audio use, DAT is an ideal medium for storing large amounts of data in a small volume.

DAT tape is an extremely reliable and cost-effective form of data storage that is beginning to replace other forms of tape cartridge, particularly for archive purposes where large amounts of data need to be backed up.

Exercise 2.7 *20 minutes*

DAT tapes are quite cheap compared to the other available cartridge tape formats. Why do you think this is true?

10 Formatting, Copying and Caring for Storage Media

Magnetic media is so important in our daily use of PCs that we need to pay particular attention to its use and storage.

10.1 Formatting Magnetic Media

Magnetic disks cannot store data unless they are first formatted. Formatting involves magnetically marking out the areas that will contain the data. Many manufacturers of magnetic media now pre-format floppy disks and tape for use on specific systems. Hard disk drives are now usually low level formatted by the

manufacturer – providing the basic structure for storing data – and then high-level formatted when installed in a computer.

Once formatted, data can be written to the medium and overwritten repeatedly.

Study Note

Do not try to reformat the hard disk in any PC unless you are absolutely certain that you need to do this and understand the implications.

Buying pre-formatted floppy disks is also a good idea and removes the need for you to worry about this task.

10.2 Caring for Storage Media

To most organisations and even individual computer users, the data stored on a computer system is of extremely high value and, in some instances, may be beyond price. Most organisations could not function without their computerised data, therefore, the magnetic media that holds that data needs to be carefully handled and stored.

There is a constant danger that dust particles, hot liquids, fire, stray magnetic fields and impact may directly cause data loss. Magnetic media should be protected from such dangers.

Optical storage media, although less prone to data loss, still needs to be protected against obvious damage and in particular surface scratches. While surface scratches tend not to affect audio CDs because of a system called over-sampling, CD-ROMs only have data recorded once and any serious scratches can obliterate items of data by preventing them from being read.

Common-sense precautions for looking after storage media include:

- Clearly label the media, identifying the files contained, version numbers, dates and any other relevant information.
- Never touch the surface of the media.
- Never place magnetic media near or on top of monitors, computer cases, wires (even low voltage) or any other electrical appliances.
- Keep all media away from radiators and other sources of heat.
- Store the media in a regulated environment protected from fire, water and unauthorised persons.
- Keep at least one copy of backup media at a different physical location from original copies.
- Smoking, eating and drinking should be prohibited in the vicinity of computer equipment and media storage areas.

Implementing these precautions will ensure that data is secure and retains its integrity.

11 Peripherals

Now we will describe the hardware that can be attached to the computer to allow us to get data in and out.

Arguably, the most important output device is used to present visual data to the user. We will concentrate on how this works for a PC.

11.1 Monitors and Graphics Displays

A monitor is a device that receives a signal from text or graphics card and displays the data on a cathode ray screen or a screen using some other type of technology. PCs usually package the monitor separately from the system unit. The monitor is often placed on top of the system unit. Figure 2.26 shows a typical monitor unit.

Figure 2. 26 Monitor

The Cathode Ray Tube

Cathode Ray Tubes (CRT) are much the same technology as used in a television. The image is created by a beam of electrons fired from the back to the front of a vacuum tube. This is now the most old-fashioned part of any computer system and whilst it is still the most common technology it is being challenged by other techniques such as the Liquid Crystal Display.

Liquid Crystal Displays

Laptop computers use Liquid Crystal Displays (LCDs) similar to those utilised in calculators and watches. The screen contains a layer of liquid crystal cells. Varying electrical charges are applied to some of the cells to produce the image.

The size of LCD has increased significantly over the last few years. This is despite the difficulty in producing large displays. This increase in size has allowed the LCD to enter the market previously occupied by the CRT based monitor.

Computer Terminals

In older systems, the monitor, electronics and keyboard are all packaged together to produce a terminal, a device that can be connected remotely to a computer and handles the entire interaction with a user.

Study Note

Terminals are usually much cheaper than PCs. They can be used with minicomputers to deliver a very low cost per user. They are still frequently found in large scale commercial systems.

Graphics Cards

Modern PCs use a graphics card (a printed circuit board) to generate the signals needed by the monitor. These are able to produce textual and graphics signals in a large number of colours. They are essential for the support of Microsoft Windows. The cards are fitted into the main unit of the PC, so are not strictly a peripheral, although without them the monitor will not operate.

All current PC graphics cards are based on an IBM standard – the Video Graphics Array (VGA). Almost all new PCs extend the capabilities of the VGA standard to produce images with more colours and more detailed graphics. Such extended VGA cards are commonly called SVGA or Super VGA cards.

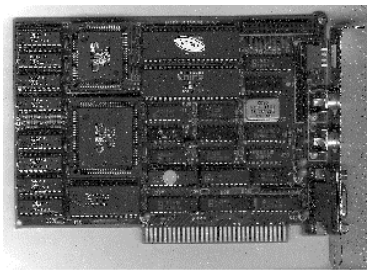

Figure 2. 27 Graphics Card

Study Note

There has been a very rapid rate of change in PC Graphics cards. The latest versions are really complete computers in their own right, including large amounts of memory. They can typically carry out very high speed calculations to show how three dimensional shapes would appear, together with a range of surface textures and lighting effects. All of this could be done by the CPU, but this would leave little time to do more useful work, so such graphics cards add appreciably to the performance of a system.

11.2 Keyboards

The most common input device is the keyboard, which is basically the same as the mechanical typewriter keyboard in that it has keys for printing upper and lower case letters, numbers and a variety of symbols.

However, since it is used to print out more than just letters and numbers, it usually has extra keys to perform these additional actions:

- Function keys – have a special meaning for the program which is being run. Sometimes they act as a shortened version of complex but frequently used instructions, since they have to be pressed once to start the action required.
- Control/Alt keys – allow keys to have more than one meaning when pressed at the same time in the same way that SHIFT changes alphabetic characters from lower to upper case; ALT stands for alternative.
- Cursor keys – move a small pointer (cursor) on the display screen. The cursor is a symbol displayed on the screen at the position where the next character to be keyed in will be entered, or where an existing character is to be deleted or altered.
- Return/Enter key – moves the cursor to a new line; or indicates the end of a piece of input to the computer. It is the most frequently used key, as it is also the one used to signal to the computer that it should begin to process the command that has just been typed in.
- ESC key – this is the escape key. It is used to indicate to a program that the current function is no longer required.
- Numeric keypad keys – are separate from the numeric keys at the top of the keyboard; sometimes there is a special key to alternate them between another function, like controlling the cursor. They usually have their own RETURN and mathematical keys.

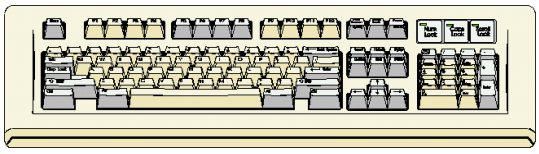

Figure 2. 28 Keyboard

11.3 Mouse

All modern PCs are delivered with a mouse, which is essential for working with Microsoft Windows.

The mechanical mouse has a small rubber ball on the underside. As the mouse is moved across a flat surface the ball makes contact with two rollers, one tracking vertical movements, the other horizontal movements. These send signals to the computer so that it can track the movements of the mouse. The mouse also has one, two or three buttons that are used to issue commands as set by the software.

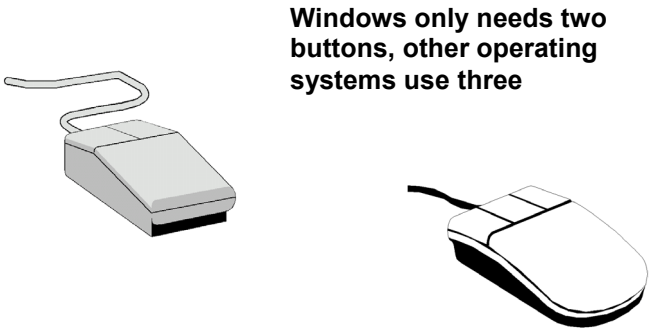

Figure 2. 29 The Mouse

11.4 Graphics Tablets

Graphics tablets are found on graphics workstations and engineering workstations. They are an alternative to a mouse but are much more suitable for any activity where drawing graphics is necessary.

A special pen, or stylus, attached to the tablet is used to draw images. However, the pen does not mark directly on the tablet. The tablet senses the exact position of the stylus as it moves and transmits this information to the processor. The developing sketch is displayed on the monitor.

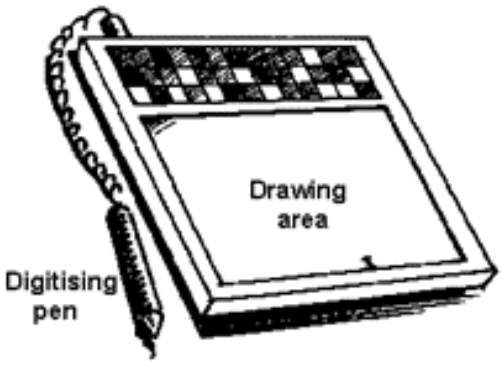

Figure 2. 30 Graphic Tablet

Study Note

Many people who use CAD systems and other graphic oriented applications consider that using a mouse for graphical input is like drawing with a brick, A graphics tablet pen allows much more precise and natural drawing. Some pens go even further and have pressure sensitive tips that can be interpreted by software to draw thinner and thicker lines.

Now we will describe a series of output devices.

11.5 Printers

Most computer systems need a printer to produce hard copy of information.

Printers are the primary output devices used to prepare permanent documents for human use. How they print and how fast they operate classify printers. There are two basic types of printers, impact and non-impact, depending on how they make marks on paper. Impact printers are based on the same idea as a typewriter; some form of mechanical device hits a ribbon and transfers ink to the paper, making up the outline of a character.

Impact printers are:

- Hammers and ribbons.
- Slow.
- Noisy.
- Use with multipart forms.
- Mostly character based.

Non-impact printers form an image without hitting the paper. Impact printers are described first in this chapter.

Dot Matrix Printers

In a dot matrix printer, an arrangement of tiny hammers in a print head strikes a ribbon to produce the desired characters. Each hammer prints a small dot on the paper. The print head is moved across the width of the paper as the hammers produce the dots so the letters are formed by a combination of dots. Dot matrix printers are cheap, but their print quality is poor.

The main use of dot matrix printers is with multipart business forms such as orders and invoices. These forms require impact to produce an image on each sheet. Dot matrix printers are now a small part of the total printer market.

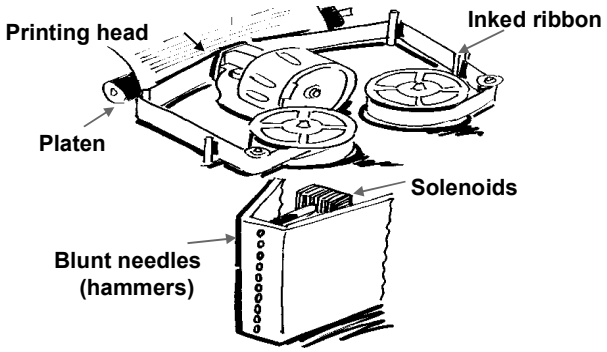

Figure 2. 31 Dot Matrix Printing

Line Printers

Line printers use impact methods to produce an entire line of output at a time, in contrast to dot matrix printers that produce one character at a time.

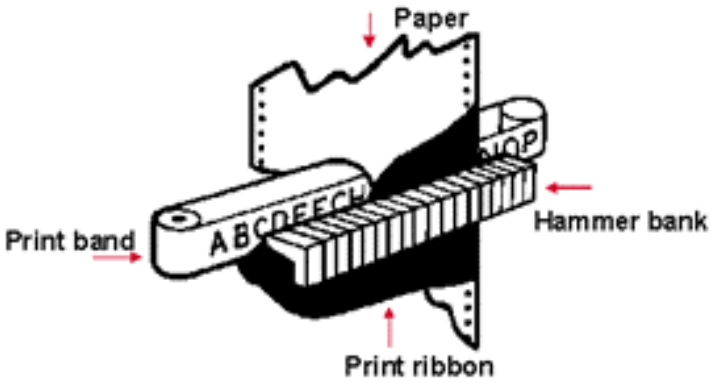

Figure 2. 32 Chain/Band Printer

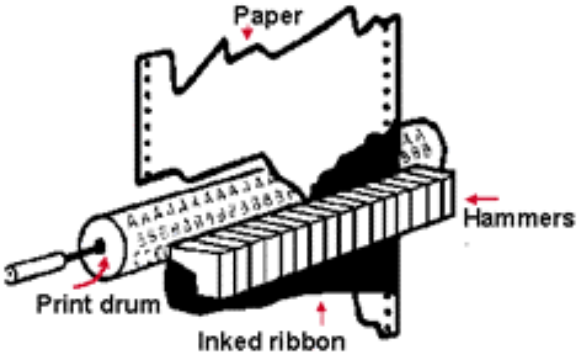

Figure 2. 33 Drum Printer

Drum printers use a rotating drum with text characters, but are otherwise similar.

These printers are mainly used on large mainframe systems and are likely to be phased out within a few years in favour of more modern technology.

> **Study Note**
>
> Line printers usually use the large format green ruled continuous stationary that you have probably seen and used. The use of this type of technology is diminishing rapidly in favour of A4 format page printing.

11.6 Non-Impact Printers

The non-impact printer category has grown significantly in recent years. It is likely that this trend will continue until non-impact technology is the standard approach for most forms of printing. We will describe two different types of non-impact printers.

Non impact printers are:

- No hammer contact.
- Faster.
- More versatile.
- Graphics.

Laser Printers

Laser printers are non-impact devices that use laser light to produce the dots needed to form a page of characters or graphics at a time. Laser printers use a laser beam to write the desired output image on a copier drum which then transfers this image to plain paper as a pattern of toner, a black powder. The

toner is then fused (melted) onto the paper. These printers have become very popular as desktop, workgroup and mainframe printers.

Most laser printers print in black only, but there is a trend towards colour laser printing, particularly as a desktop and small office printer. This trend is likely to continue, despite the high price of fast colour laser printers.

Laser printers are extremely flexible. They can print any combination of text and graphics on a page. Line printers are incapable of this mixture of text and graphics.

Figure 2. 34 Laser Printer

Ink Jet Printers

Like laser printers, ink jet printers are non-impact devices. They are much cheaper to buy than laser printers, but the cost per printed page may be much higher.

Although ink jet printers are non-impact printers, they do resemble dot-matrix printers in that they have a print head. Nozzles in the print head spray high-speed streams of ink onto paper to form characters.

Ink jet printers are much slower than laser printers and smudging may occur if incompatible paper stock is used and also because most inks are not water-fast. A major advantage of ink jet printers is that they can hold colour cartridges and they can be used to produce excellent colour output, close to photographic quality.

Graphics Plotters

Users of some application such as CAD, Geographical Information systems (GIS) and graphics designers may need to print large format images. A graphics plotter is ideal for this type of application.

Graphics plotters use pens or ink jets to produce images on paper or film. The distinguishing feature of plotters is that they can produce much larger images

than other types of printer. For engineering and architectural use, paper widths of around one metre are common.

Ink jet plotters are able to produce large drawings containing many colours.

The pens of the plotter are replaced by an inkjet head, but otherwise the principles are the same. The advantage of an inkjet plotter over a pen plotter is that they can produce filled areas with a wide variation of colour and density, something that is impossible in a pen plotter.

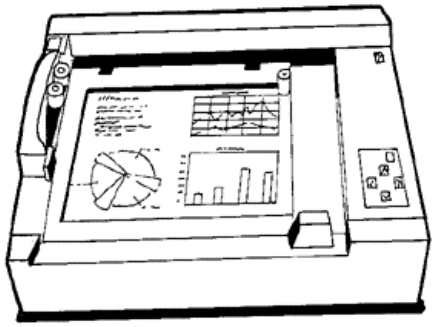

Figure 2. 35 Graphics Plotter

Exercise 2.8 ***40 minutes***

Classify the following types of hardware into input, output, primary storage and secondary storage.

a) A dot matrix printer.

b) A 21" colour monitor.

c) A keyboard with integral numeric keypad.

d) A mouse.

e) A graphics tablet.

f) A RAM memory module containing 16MB.

g) A colour laser printer.

12 Other Input/Output Devices

Now we have reviewed the most common types of input and output devices we will briefly describe a few less common types.

12.1 Point of Sale Terminals

These specialised devices are used in most supermarkets all over the world.

Point of Sale (POS) terminals are used in retail or wholesale organisations such as supermarkets for customer transactions. They are replacing the simple cash registers as they can do everything a cash register does plus many other things. POS terminals all rely on barcodes and these versatile labels can be used for many other applications as well.

Manufacturers print a Universal Product Code (UPC) barcode consisting of light and dark bars, on most items sold in grocery stores. These are generally called barcodes.

When barcoded items are received at a supermarket's automated checkout stand, they are moved across a fixed scanning window. As items are scanned, the bars are decoded.

When barcodes are used for other applications, such as manufacturing and logistics barcode reader reads them. These take a wide variety of different forms from a simple scanning pen to guns that can be used remotely from the barcode label. Figure 2.36 shows a barcode and a typical barcode reader.

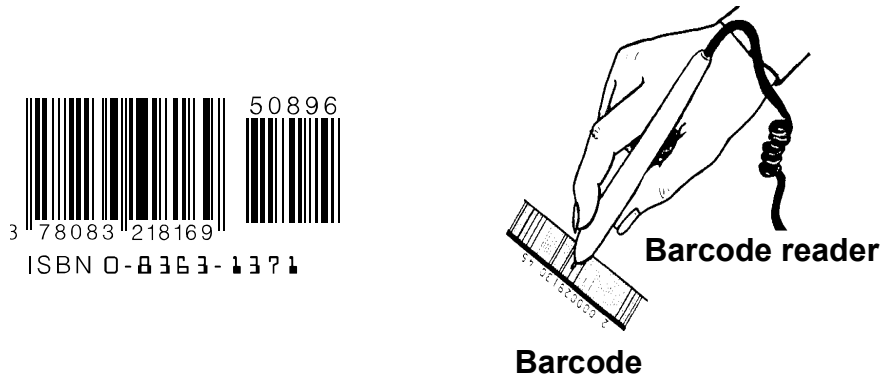

Figure 2. 36 Barcode/Barcode Reader

12.2 Automated Teller Machines

Cash dispensers or ATMs (Automated Teller Machines) have become a familiar sight in our high streets. A plastic embossed card with information encoded on a magnetic strip is inserted into a slot and a security number input on a small numeric keyboard, together with the amount required to be withdrawn.

The whole transaction is prompted by instructions shown on a small display screen. Details of the transactions are recorded and used either immediately or later for updating the master files.

Another use of magnetic strips on plastic cards is for security. Holders can use them to log-on to the computer or as keys to secure areas.

Figure 2. 37 Magnetic Strip – Bank Card

12.3 Smart Cards

Smart cards are an alternative to magnetic strip cards. Smart card technology substitutes a built-in microprocessor chip for the magnetic strip. This chip stores data to reduce the chances of fraud and abuse. Also, data representing a specific amount of cash can be stored in the chip before the card is issued to a customer. As the card is used to make purchases, the purchase amount is deducted from the stored balance by special electronic registers used by merchants.

12.4 Magnetic Ink Character Readers

Magnetic Ink Character Recognition (MICR) is widely used by banks to process the tremendous volume of cheques being written each day. The cheques are precoded along the bottom with the bank's identification number and with the account holder's number. These numbers and other special symbols are printed with a special ink that contains magnetisable particles of iron oxide.

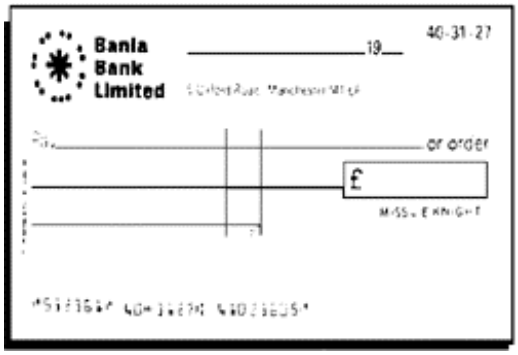

Figure 2. 38 A Sample Cheque Encoded with MICR Characters

12.5 Optical Character Readers

Optical Character Recognition (OCR) techniques permit the direct reading of any printed character. Unlike MICR, no special ink is required. This OCR flexibility makes it possible for organisations to eliminate or reduce the effort required to type in data. Most of these devices will recognise machine printed characters in a variety of different typefaces or fonts.

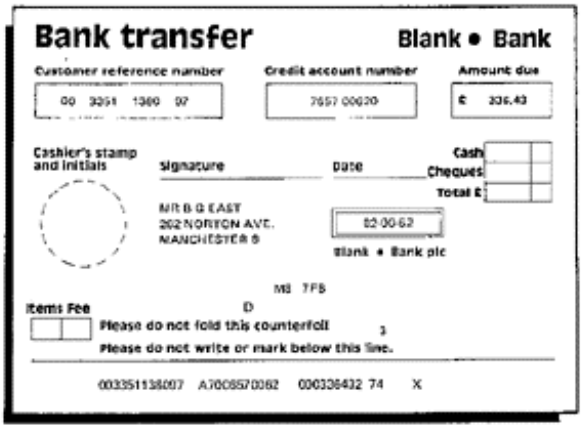

Figure 2. 39 Bill using Optical Character Recognition

12.6 Scanners

Scanners capture an image in digital form, transforming a picture into data that can be passed to the computer system.

Hand scanners contain an optical sensing array that can be dragged across a document to capture an image. Some skill is required to make sure that the scanner is moved at a steady rate.

Flat bed scanners, as their name suggests, have a flat glass platen on which a document can be placed for scanning. Flat bed scanners can handle a whole page at a time and due to their static nature, are more accurate than hand scanners.

With the increased power and reduced cost of personal computers and peripherals, flat bed scanners have become very cheap and widely used. They have largely displaced the hand scanner. Figure 2.40 shows a typical layout of this type of scanner.

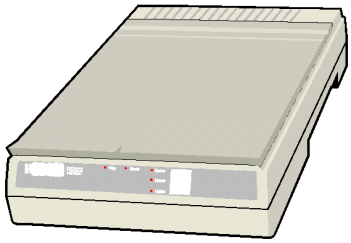

Figure 2. 40 Flat Bed Scanner

12.7 Voice Recognistion and Response

Computer scientists have been working on voice recognition and response for many years. Until recently the level of success was very limited, but there are now products that can provide useful functionality.

Voice recognition devices are designed to convert human language into machine language. All the earlier devices made use of input media on which data in alphanumeric codes was stored. Data had to be first transcribed from the common human usable form into computer input media.

Just as a voice recognition system will allow you to talk to a computer, so, too, will a voice response system permit a computer to talk back to you. Audio-response systems are available to respond to human inquiries that are transmitted over telephone lines to a central computer.

The advantages of peripherals that could be used to recognise people and objects visually and to accept verbal commands and input would be immense. They would overcome the obstacle of keyboard data entry that still prevents many people from making full use of computer systems.

Exercise 2.9 ***40 minutes***

Select some appropriate output devices for the following types of application. If you think more than one type of device would be useful, name them all. Give some reasons for your choice.

a) An engineer using a graphics workstation to design mechanical components.

b) A programmer using a microcomputer to write programs.

c) A small business accounts system printing invoices.

d) A writer of novels.

e) A large company which runs reports on departmental performance every week for all managers.

13 Summary

- During this chapter we have used a historical viewpoint to move from the earliest day of calculating machines through four generations of computers.
- This historical perspective has helped us to understand the difference between different types of computer systems.
- We have seen how telecommunications have developed alongside computer hardware and complement it to provide the facilities we need to build useful systems.
- Finally we have described a wide range of peripherals.

14 Answers

Exercise 2.1

Charles Babbage was one of the most important figures in the development of mechanical computers and his later work contained all the major components of our modern computer systems.

a) Only a small fraction of Babbage's designs were constructed in his lifetime. Why do you think this was so? Try to think of at least two reasons. You may need to do some research to answer this question.

b) What do you think was the most significant of Babbage's ideas? State the reasons for your choice.

Answer 2.1

a) Babbage's designs required extremely precise manufacturing techniques that were not really possible in his lifetime. This would have made it very difficult to complete his Analytical Engine. Babbage had great difficulty raising the money needed for his projects. This is not surprising given the complexity and originality of his ideas and the difficulty in building the machines.

b) The most original idea was the concept of a program that could be used to make the machine carry out different types of calculations. It is this idea that makes our modern computers so versatile. It is possible that Babbage did not realise just how important this idea was but he clearly considered it to be central to the design of his Analytical engine.

Exercise 2.2

Try to work out why people thought that ten computers would be enough. *Hint – think about the early application of computers.*

Answers 2.2

The reason that people thought that a small number of computers would be enough was that they were thinking simply in terms of the initial applications of computers that were mostly mathematically oriented. There were very few of these applications.

Exercise 2.3

PCs were available for business use in 1980s with less than a tenth of RAM or disk capacity that we now think is essential, yet serious word processing and other applications were common.

Why do we now need computers with such big memory in comparison with those days? *Hint – think about the style of documents that we now use compared to those ten years ago*.

Answer 2.3

During the last ten years, users have become used to working with extensive graphics and other forms of multimedia. These require much more disk space and RAM than simple textual documents.

Exercise 2.4

What type of computer would you use for the following applications?

a) A weather forecasting system

b) A large banking system with a big database.

c) A supermarket stock system driven by barcode readers at the tills.

d) General office word processing.

e) A system that could calculate how a car body would crumple in a crash.

f) A musician composing music and wanting to print out the results.

g) A department with fifty employees who all need to access the same data. (Hint – think about the data, not the individual employees).

h) A worker who needs to operate from home and on the road.

i) A system that could be used to simulate nuclear explosions (without having to carry out actual tests).

j) A system that could be used by a disabled person who could not speak to communicate verbally with others.

k) A system that could be used to break secret codes.

l) A cartoonist producing material for a newspaper.

Answer 2.4

a) Supercomputer.
b) Mainframe.
c) Minicomputer.
d) PC.
e) Supercomputer.
f) PC.
g) Minicomputer.
h) Laptop PC
i) Supercomputer
j) PC
k) Supercomputer
l) PC

Exercise 2.5

Floppy disks were often used to deliver large scale software applications, but this happens much less frequently now, other storage media are used instead. Why do you think this is the case?

Answer 2.5

Application software has grown larger and larger so that it is becoming impractical to use floppy disks. Up to twenty floppy disks were needed for some packages and had to be loaded in sequence. CD-ROMS are much more practical and convenient way of distributing software.

Exercise 2.6

Apart from capacity, what other major advantages do CD-ROMs possess for data storage and delivery.

Answer 2.6

CD-ROMs cannot be accidentally or deliberately erased or modified. They can be pressed at very high speed and easily printed in colour to describe their contents. There is no other form of removable data storage with this set of characteristics.

Exercise 2.7

DAT tapes are quite cheap compared to the other available cartridge tape formats. Why do you think this is true?

Answer 2.7

DAT tapes are cheap because they are based on a format that was originally intended for domestic audio use. This meant that their production processes were designed for high speed and high volume, keeping the costs small.

Exercise 2.8

Classify the following types of hardware into input, output, primary storage and secondary storage.

a) A dot matrix printer.

b) A 21" colour monitor.

c) A keyboard with integral numeric keypad.

d) A mouse.

e) A graphics tablet.

f) A RAM memory module containing 16MB.

g) A colour laser printer.

Answer 2.8

a) Output.
b) Output.
c) Input.
d) Input.
e) Input.
f) Primary storage.
g) Output.

Exercise 2.9

Select some appropriate output devices for the following types of application. If you think more than one type of device would be useful, name them all. Give some reasons for your choice.

a) An engineer using a graphics workstation to design mechanical components.

b) A programmer using a microcomputer to write programs.

c) A small business accounts system printing invoices.

d) A writer of novels.

e) A large company which runs reports on departmental performance every week for all managers.

Answer 2.9

a) A graphics plotter would be needed for drawing output and a laser printer for calculations and documentation.

b) A laser printer would be good choice, but a dot matrix printer would be sufficient.

c) A dot matrix printer is a sensible choice.

d) Either an ink jet or a laser printer would be suitable. If the writer was producing long novels a laser printer would be better.

e) This is a typical mainframe application for which a traditional line printer is still a possible choice, although many businesses now use high speed laser printers for this type of work.