CHAPTER 3

Storage devices and media

In this chapter you will learn about:

- back-up storage
- why it is necessary to back up data and files
- the types of access used by the backing stores
- the types of internal and external backing storage devices:
  - magnetic
  - optical
  - solid state.

3.1 Backing up data

The first two sections in this chapter consider the need for backing up data and the different ways of storing and accessing data. Section 3.3 then discusses many forms of **backing storage** and compares the advantages and disadvantages of each type. The comparative performance and main uses for each type of store are also discussed in some depth.

What is backing up of data?

Backing up refers to the copying of files and data to a different medium (disk, tape, flash drive, etc.) in case of a problem with the main 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.

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

Why back up data?

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

- Data could be lost due to failure of the original storage device. This could be due to hardware failure (e.g. head crash on a hard drive unit), problems caused by files being over-written accidentally (or otherwise) or possible corruption of files (e.g. caused by power surges).
- Hackers could be responsible for the corruption or even loss of data. This may not be their intention (they may only want to gain access to the information for other purposes, e.g. to find personal information such as bank account details). However, the very act of hacking into files could cause problems such as corruption or data loss.
- Backups are also made in case the files need to be used elsewhere. The original files are then protected against possible corruption or loss.

However, backups do not necessarily guard against the effect of a virus. The virus could attach itself to the files which could mean that the backups were also affected. If the computer was 'cleaned' of the virus and then the backup files were re-loaded

there would remain the risk that the same virus could infect the computer system again. The best protection is not to get a virus in the first place (discussed in Chapter 6).

3.2 Types of access

The way data is stored and read by different backing storage devices varies considerably. This section briefly describes the two main methods of accessing data.

Serial access

With this system, to access data it is necessary to start at the beginning and then access each piece of data in turn until the required information is found.

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

When a magnetic tape needs **updating**, an additional tape is required so that the old information can be **merged** with the new data (itself often on another tape, but the new data could be stored in various ways) to produce the updated tape (see Figure 3.1).

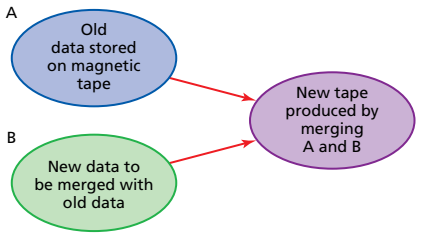

Figure 3.1 Updating the data on a magnetic tape

Direct access

This method is used with magnetic disks and with optical media (such as CDs and DVDs). The computer uses a key field to calculate where data has been stored. It is then able to access the data directly from the calculated position. Consequently, access is much faster than with serial access.

It is used in applications where access speed is vital (e.g. in **real-time process control** systems such as controlling a chemical plant or **online** systems such as booking air tickets or automatic stock control).

When updating media which uses direct access, the new data is written to the next available location and its position is calculated using the built-in algorithm.

3.3 Backing storage media

Dating back to the development of the personal computer, all computer systems have come equipped with some form of backing storage. When a user types data into a computer, the information is stored temporarily on the **RAM** – however, this information would be lost as soon as the computer was turned off. Backing storage devices ensure that data is stored permanently and can be used at a later date. This section will be considering various types of backing storage and the media used.

Backing storage devices are either internal or external (i.e. plug-in devices) to the computer, and are one of three types:

- magnetic
- optical
- solid state.

Fixed hard disk

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 which allows data to be stored by altering the magnetic properties to represent binary 1s or 0s (the fundamental units of computer memories). The hard drive disks usually store the **disk operating system (DOS)** and other important software and files. Applications software (e.g. spreadsheets and word processors) need a hard drive to allow them to quickly retrieve and save data.

Uses

- Fixed hard drives are used to store the operating system and working data.
- They are used for storing applications software that needs fast retrieval and storage of data.
- Real-time systems (e.g. robots, control of a chemical plant) and online systems (e.g. booking airline tickets, automatic stock control (using EPOS)) used fixed hard drives.
- They are 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

- They can be fairly easily damaged (e.g. if the correct shut-down procedure on a laptop computer has not been correctly carried out and the computer is then moved).
- They lack portability unless a portable hard disk drive is used (see next sub-section).

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 a **universal serial bus (USB)** 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

- Portable hard disks can be used as back-up systems to prevent loss of data.
- They can be used to transfer data, files and software between computers.

Advantages

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

Disadvantages

- As with fixed drives, a portable hard disk can be easily damaged if the user accidentally drops it or does not shut it down correctly after use.

Floppy disk drives

Floppy disks are still used on some computer systems. They consist of a thin disk of plastic which is housed in a plastic case with a window where the disk can be accessed. As the disk rotates, a read/write head is used to add or read data stored on the surface.

Uses

- They are still used where small files need to be transferred/stored (e.g. word-processed documents).
- Some older computer systems still make use of this method of storage.

Advantages

- Using a CD to store a small file (e.g. a word-processed document) is often regarded as wasteful – especially if CD-R is used.
- It is a very simple technology. Floppy disk drives are also extremely low cost items to buy.

Disadvantages

- Floppy disks have a very low memory capacity when compared to CD/DVDs, for example.
- Very few modern computers have floppy disk drives.
- The data transfer rate is slow compared to more modern data storage devices.
- Floppy disks are not very robust.

Magnetic tapes

A **magnetic tape** is a very thin strip of plastic which is coated in a magnetic layer. They are read and written to by a read/write head. The data is stored in magnetic areas which represent 1s and 0s. Data is written to and read from the tape in sequence (i.e. in order) – for example, if five records A, B, C, D and E were stored they would be in the order E D C **B** A on the tape; so if record **B** was to be read it would be necessary to read E, D and C first *before* getting to the required record. This is known as **serial access**. This type of storage is useless in a real-time or online application (due to the very slow access speeds) and is best suited to offline or batch processing.

Uses

- Magnetic tapes are used in applications where batch processing is used, for example in 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 important).
- They are used as a back-up media since all the data needs to be stored.

Advantages

- They are generally less expensive than the equivalent-capacity hard disk.
- It is a very robust technology.
- The data transfer rate is fast.

Disadvantages

- Access time is very slow.
- When updating, another tape is needed (i.e. original tape + tape with the changes produces an updated tape).

Optical storage media

Optical storage devices, such as CD and DVD, all use optical (i.e. light) read/write methods, unlike tapes and floppy/hard drive disks which are magnetic media. A laser beam is used to write to and read from the optical media.

The CDs and DVDs are manufactured either from a single polycarbonate disk or from two polycarbonate disks bonded together. A very thin layer of metal or organic dye is used as the recording media. The big advantage of these storage media is that they are portable and can store large data files (e.g. films, music or multimedia files) which would be too large for a floppy disk.

CD-ROM and DVD-ROM

CD-ROMs and DVD-ROMs 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 which 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 (i.e. data) – hence the term digital media.

Uses

- CD-ROMs are used by manufacturers to store music files and software, computer games and reference software (such as an encyclopedia).
- DVD-ROMs have much larger storage capacity than CD-ROMs and are used to store films. They are now increasingly used to store computer data and ever-more sophisticated computer and arcade games.

Advantages

- They hold far more data than floppy disks, so 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 and data access time are slower than for hard disks.

CD-R and DVD-R

The letter 'R' here means the disk is recordable *once* only and then it becomes a CD-ROM or DVD-ROM. These use a thin layer of an organic dye as the recording media; DVDs also use an additional silver alloy or gold reflector. 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

- They are used for home recordings of music (CD-Rs) and films (DVD-Rs).
- They are used to store data to be kept for later use or to be transferred to another computer.
- They are used in applications where it is necessary to prevent the deletion or over-writing of important data).

Advantages

- CD-Rs and DVD-Rs are cheaper than RW disks.
- Once burned (and **finalised**), they are like ROM disks.

Disadvantages

- They can only be recorded once, so if an error occurs then the disk has to be thrown away.
- Not all CD/DVD players can read CD-R/DVD-R.

CD-RW and DVD-RW

The 'RW' means that these disks are a re-writable 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. The alloy can switch between crystalline and amorphous (non-crystalline) phases, thus changing its reflectivity to light, depending on the laser beam power. **Spots** are produced which can be read by a laser and then interpreted as 1s and 0s. The system allows data to be written, erased and re-written many times.

Uses

- CD-RWs and DVD-RWs are used to record radio and television programmes, but can be recorded over time and time again.
- They are used in closed circuit television (CCTV) systems.

Advantages

- CD-RWs and DVD-RWs can be re-used many times.
- They can use different file formats each time they are used.
- The RW format is not as wasteful as the R format since files or data can be added at a later stage.

Disadvantages

- CD-RWs and DVD-RWs can be relatively expensive media.
- It is possible to accidentally overwrite data.

DVD-RAM

DVD-RAM is a recent addition to the optical media group. Unlike other CD and DVD formats, DVD-RAMs have several discrete concentric tracks rather than a single spiral track. This gives them the advantage that writing and reading can occur at the same time. This makes it possible to watch an already recorded television

programme at the same time as a different programme is being recorded. DVD-RAMs can be written to many times.

Figure 3.2 compares the single spiral track found on normal CDs and DVDs with the discrete single tracks found on a DVD-RAM.

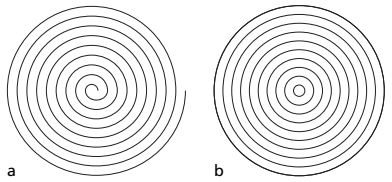

Figure 3.2 **a** Spiral tracks on a normal CD or DVD **b** Discrete tracks on a DVD-RAM

The recording layer is made from a similar phase-changing material to that used in RW technology. When writing, a laser heats the phase-changing alloy on the disk to about 500–700°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 (pits) marks represent data to a computer where they are interpreted.

Uses

- DVD-RAMs are used in recording devices such as satellite receivers to allow simultaneous recording and playback.
- They are used in camcorders to store films.

Advantages

- DVD-RAMs have a long life – minimum life is estimated to be 30 years.
- It is possible to do a re-write operation over 100,000 times, compared with the RW format which only allows about 1,000 re-writes.
- Writing on DVD-RAMs is very reliable, as they have in-built verification software to ensure the accuracy of the data.
- Access is very fast if the files are fairly small.
- There is no need to finalise the disk.
- They have a very large capacity (about 10 Gbyte if double-sided format is used).
- They offer the ability to read data at the same time as data is being written.

Disadvantages

- DVD-RAMs are not as compatible as R or RW format, as many systems will not recognise their format.
- They are relatively expensive, costing about 4 times as much as a DVD-RW disk.

Blu-ray disks

Blu-ray disks have the largest capacity of all the optical media available and go up to 100 Gbyte (at the present time). The laser beam used is at the blue/violet end of the spectrum, rather than red which is the colour of the lasers used in other optical media. Consequently, the light used has a shorter wavelength, allowing more data to be stored/read on the disk.

Uses

- Blu-ray disks are used in home video consoles.
- They are used for storing and playing back films: 1 high-definition film of two hours duration uses 25 Gbyte 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 film footage.

Advantages

- They have a very large storage capacity, and so are ideal for storing high definition films.
- The data transfer rate is very fast.
- The data access speed is also greater than with other optical media.

Disadvantages

- The disks are relatively expensive .
- At the time of writing, blu-ray systems still have encryption problems (which are used to stop piracy) when used to store video.

Solid state backing store

Solid state technology is being developed to the point where solid state drives will soon replace hard disk drives in laptop computers. This is due to their inherent thinness, their much faster data access time and the fact that they are extremely robust.

They are similar to magnetic and optical media in that data is still stored as 1s and 0s. However, instead of changing the magnetic properties on the thin film surface of a rotating disk, these solid state systems control the movement of electrons within a microchip. The 1s and 0s are stored in millions of miniature transistors within the microchip: if the transistor conducts a current, this is equivalent to a 1, otherwise it is a 0.

They consequently have no moving parts, consume much less power and are extremely robust.

They are used primarily as removable storage devices and are collectively known as flash memory. The most common examples are memory sticks/pen drives and memory cards.

Memory sticks/pen drives

Memory sticks/pen drives can store several Gbytes 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 that no additional software is needed to operate them.

Some expensive software increasingly use 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 commit **software piracy** would have to crack 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

- Memory sticks and pen drives are used for transporting files between computers or as a back-up store.
- They are used as a security device – a dongle – to prevent software piracy.

Advantages

- They are very compact and portable media.
- They are very robust.

Disadvantages

- It is not possible to write protect the data and files.
- Their small physical size means that they are easy to lose.

Flash memory cards

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

Uses

- Flash memory cards are used to store photos on digital cameras.
- Mobile phones use them as memory cards.
- They are used in **MP3** players to store music files.
- They are used as a back-up store in handheld computer devices.

Advantages

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

Disadvantages

- They are expensive per Gbyte of memory when compared to hard drive disks.
- They have a finite life in terms of the number of times they can be read from or written to.
- They have a lower storage capacity than hard disks.