Cambridge

OL- IGCSE

ICT

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Chapter 03

Storage devices and media

3.1 Magnetic media and magnetic storage devices

Magnetic media, dating back to the 19th century, utilize the properties of magnetism to store data. An iron oxide coating can be magnetised to represent binary 1-values and demagnetised to represent binary 0-values, allowing for large data storage. Common devices include magnetic tape drives and HDDs.

3.1.1 Magnetic tape drives

A magnetic tape is a very thin strip of plastic which is coated in a magnetic layer (iron oxide). They are read from or written to by a read/write head in a magnetic tape storage device. The data is stored as a magnetised area (which represents a 1) or demagnetised area (which represents a 0).

Uses of magnetic tape

» Use in applications where batch processing is used

» Used as a backup media where vast amounts of data need to be stored.

» Used in long-term archiving of data; magnetic tapes have huge data storage capacities and are known to be very stable, which makes them ideal for long-term storage.

▲ **Figure 3.1** Magnetic tape drive

Advantages of magnetic tapes

» They are generally less expensive (per byte) than the equivalent hard disk drive.

» It is a very robust technology (they do not deteriorate much over time and remain stable).

» They have a huge data storage capacity.

» The **data transfer rate** is fast

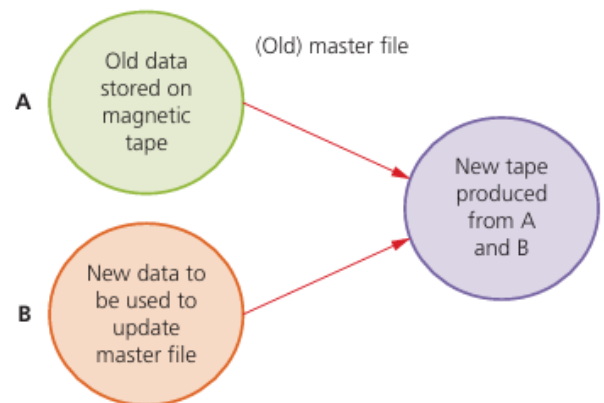▲ **Figure 3.2** Updating a magnetic tape

Disadvantages of magnetic tape

» Very slow data access times (they use serial access, which means all the previous data needs to be read until the required data is found) - whilst magnetic tape data access time is slow, the data transfer rate is still high.

» The use of magnetic tapes for data storage is outdated due to the slow and error-prone process of updating data using a master tape and transaction tape, resulting in the loss of data.

» They are affected by magnetic fields, a strong magnet

Advice

Data transfer rate is the rate at which data can be sent from a storage device to a computer (or vice versa). **Data access time** is the time it takes to locate specific data stored on the storage media.
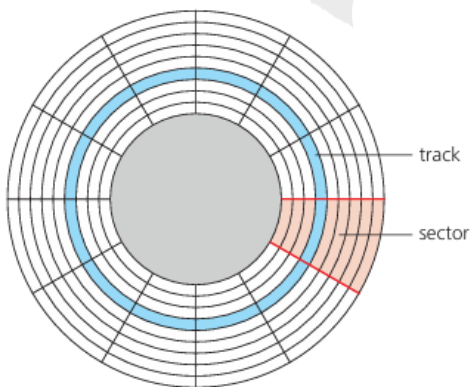
3.1.2 Hard disk drives (HDD)

Hard disk drives (HDD) are still one of the most common methods used to store data on a computer. Data is stored in a digital format on the magnetic surfaces of the hard disks (or platters, as they are usually called).

Data on an HDD can be read using direct access – this means, unlike magnetic tape, earlier data does not have to be read first before the required data is found. We will now look in more detail at how HDD works:

» Actuators are used to move the read/write heads (voice coils are used as the actuators; these are like the electromagnets used in speakers – hence their name).

» A read/write arm swings the read/write head back and forth across the platter; the platter is rotating at up to 10 000 rpm (revolutions per minute).

» Each read/write head contains a tiny magnet which allows the data on the platter to be read.

» Platters are made from glass, ceramic or aluminium which are coated in iron oxide.

» There are two read/write heads per platter (one for the top surface and one for the bottom surface). » Data is stored in concentric, circular tracks; each track is broken up into sectors (see Figure 3.4).

» A map of the sectors is stored on the HDD and is known as a file allocation table (FAT);

Latency, the time it takes for a specific block of data on a data track to rotate to the read/write head, is a significant issue with hard disk drives, as they require numerous head movements to seek the correct blocks of data.

▲ **Figure 3.4** Hard disk platter (showing tracks and sectors)

▲ **Figure 3.3** Hard disk drive – the hard disk (platter) is the media and the hard disk drive (HDD) is the storage device

Uses of fixed hard disk drives

» To store the operating system, systems software and working data/files.
» Storing applications software.
» Used in real-time systems (for example, robots, control of a chemical plant) and in online systems (for example, booking airline tickets, automatic stock control (using EPOS)).
» Used in file servers for computer networks.

Advantages of fixed hard disk drives

» They have a very fast data transfer rate and fast access times to data.

» They have very large memory capacities.

Disadvantages of fixed hard disk drives

» They can be easily damaged (for example, if the correct shut-down procedure on a computer has not been correctly carried out, it is possible to sustain a head crash).

» They have many moving parts which can affect their overall reliability.

» Their read/write operation can be quite noisy when compared to solid-state drives.

3.1.3 Portable hard disk drives

Portable hard disk drives are essentially HDDs external to the computer and can be connected to the computer using one of the USB ports. In this way, they can be used as a backup device or another way of transferring files between computers.

Uses of portable hard disk drives

» They can be used as backup systems to prevent loss of data.

» They can be used to transfer data/files/software between computers.

Advantages of portable hard disk drives

» The data access time and data transfer rate are very fast.

» They have a large memory capacity.

» They can be used as a method of transferring information between computers.

Disadvantages of portable hard disk drives

» As with fixed disk drives, they can be easily damaged if the user accidentally drops it or does not correctly shut down the drive after use.

» Data transfer rate is not as fast as for fixed hard drives

3.2 Optical media and optical storage devices
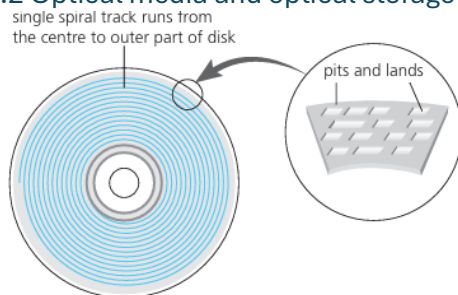

▲ **Figure 3.5** Optical media

3.2.1 CD/DVD optical disks

CDs and DVDS are described as **optical media** and are read from or written to by **optical storage devices**. Optical storage devices can be built into a computer or connected externally via a USB cable. They rely on the optical properties of laser light, which is used to read data and to write data on the surface of the disk.

The data is stored in **pits** and **lands** on the spiral track (lands are the gaps between pits).

This means the wavelength of the reflected laser light is slightly different to the original laser light, causing **destructive interference**.

DVD technology is slightly different to that used in CDs. One of the main differences is the potential for **dual** layering which considerably increases the storage capacity.
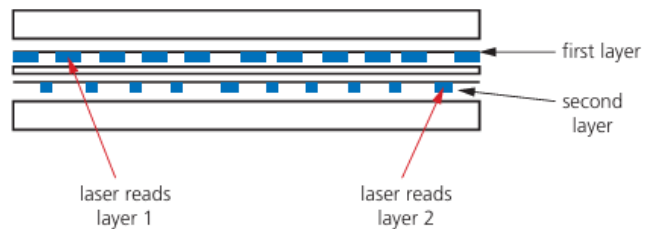
▲ **Figure 3.6** Dual-layering in a DVD

Uses of CD-R and DVD-R

» Home recordings of music (CD-R) and films (DVD-R).

» Used to store data to be kept for later use or to be transferred to another computer.

Advantages of CD-R and DVD-R

» Cheaper medium than RW disks.
» Once burned (and finalised) they behave like a ROM.

Disadvantages of CD-R and DVD-R

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

Uses of CD-RW/DVD-RW

» Used to record television programmes which can be recorded over, time and time again (although increasingly replaced by HDD recording systems).
» Used in CCTV systems.
» Can be used as a backup device for files and data.

Advantages of CD-RW/DVD-RW

» Can be written over many times.
» Can use different file formats each time it is used.
» Not as wasteful as R format because the files/data can be added at a later stage

Disadvantages of CD-RW/DVD-RW

» Can be relatively expensive media.
» Possible to accidentally overwrite data.

Uses of cd-rom/dvd-rom

» These optical disks are read-only memory (ROM) which means they cannot be written over and can only be read. They are a permanent method of data storage.

» CD-ROM is used to store music files and to store software, computer games and reference software (such as an encyclopaedia).

» DVD-ROM has much larger storage and is used to store films; but now it is increasingly used to store computer data and the evermore sophisticated games.

» CD-ROMs and DVD-ROMs are used in applications where there is a real need to prevent the deletion or overwriting of important data.

advantages of cd-rom/dvd-rom

» They are less expensive than hard disk drive systems.

disadvantages of cd-rom/dvd-rom

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

3.2.2 Blu-ray discs

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

The main differences between DVD and Blu-ray are:

» A blue laser, rather than a red laser, is used to carry out Blu-ray read and write operations; the wavelength of blue light is only 405 nanometres (compared to 650 nm for red light).

» Using blue laser light means that the pits and lands can be much smaller; consequently, Blu-ray can store up to five times more data than normal DVD.

» Single-layer Blu-ray discs use a 1.2 mm thick polycarbonate disk; however, dual-layer Blu-ray and normal DVDs both use a sandwich of two 0.6 mm thick disks (i.e. 1.2 mm thick).

» Blu-ray disks automatically come with a secure encryption system which helps to prevent piracy and copyright infringement.

» The data transfer rate for a DVD is 10 Mbps and for a Blu-ray disc it is 36 Mbps (this equates to 1.5 hours to store 25 GB of data).

▲ **Figure 3.7** Blu-ray disc

comparison of the capacity and interactivity of DvDs and Blu-ray discs

» A standard single-layer DVD has a storage capacity of 4.7 GB (enough to store a two-hour standard definition movie).

» A single-layer Blu-ray disc has a storage capacity of 27 GB (enough to store a two-hour high-definition movie or 13 hours of standard definition movies).

» A dual-layer Blu-ray disc has a storage capacity of 50 GB (enough to store 4.5 hours of high-definition movies or 20 hours of standard definition movies).

» Blu-ray devices allow greater interactivity than DVD devices.

▼ **Table 3.1** Comparison of CD, DVD and Blu-ray

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

(NOTE: nm = 10^{-9} metres and µm = 10^{-6} metres.)

(Blu-ray can currently go up to six-layer technology, but this is outside the scope of this book.)

Uses of Blu-ray discs

» Home video consoles.

» Storing and playing back movies (one high-definition movie of two hours duration uses up 25 GB of memory).

» Computers can use this technology for data storage or backing up hard drives.

» Camcorders can use this media (in cartridge form) to store movies.

Advantages of Blu-ray discs

» Very large storage capacity, therefore ideal for storing high-definition movies.

» Very fast data transfer rate. » The data access speed is also greater than with other optical media.

» Blu-ray discs automatically come with a secure encryption system, which helps to prevent piracy and copyright infringement.

Disadvantages of Blu-ray discs

» Relatively expensive discs.

» Encryption problems (which are used to stop piracy) when used to store video.

» Introduction of HD (high definition) DVD players has reduced the advantages of using Blu-ray disc technology

3.3 Solid-state media and solid-state storage devices

Solid-state technology eliminates latency issues in HDDs by ensuring data retrieval at the same rate. It stores data by controlling electron movement within NAND chips, resulting in non-volatile rewritable memory. This technology is commonly referred to as flash memories or flash drives.

3.3.1 Floating gate and control gate transistors

Flash memories make use of a grid; at each intersection on the grid there is a floating gate and a control gate arranged as follows:

The floating gate transistor retains its charge, making the memory non-volatile. When programmed, electrons are attracted to the control gate, trapping them in the floating gate. This allows control over bit values at each intersection. Solid-state devices should be used annually to ensure memory retention.
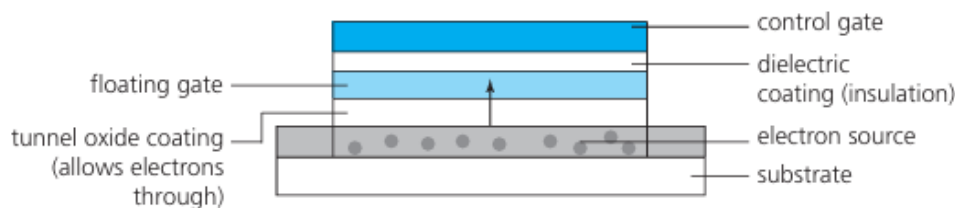
▲ **Figure 3.8** Floating gate and control gate (solid-state memory)

A dielectric coating separates two transistors, allowing the floating gate transistor to retain its charge, making the memory non-volatile. When programming an intersection cell, electrons are attracted to the control gate, trapping them in the floating gate. However, after 12 months, the charge can leak, requiring annual use.

3.3.2 Solid-state drives (SSD)

Uses of SSDs

Solid-state drives have revolutionized computers, replacing HDDs as the main backing storage. They store files, applications, and operating systems, enabling thinner laptops and lighter devices. Solid-state technology has also contributed to the development of smartphones and tablets.

Advantages of SSDs

The main benefits of SSDs are:

» They are more reliable (no moving parts to go wrong)
» They are considerably lighter (which makes them suitable for laptops)
» They do not have to 'get up to speed' before they work properly
» They have a lower power consumption
» They run much cooler than HDDs (both these points again make them very suitable for laptop computers)
» Because of no moving parts, they are very thin
» SSD data access time is only 0.1 milliseconds compared to 10 milliseconds for HDD » data transfer speed for SSDs is also much faster than for HDDs

disadvantages of SSds

SSD endurance, the durability of solid-state storage devices, is a key drawback, with most rated at 20 GB write operations per day over a three-year period. Despite this, manufacturers are improving SSD endurance, making it more common in servers and **cloud storage** devices.

3.3.3 Pen drives

Pen drives (memory sticks) are small portable devices that make use of solid-state technology. Some devices combine the functionality of a **portable media player** with USB flash storage; such devices require a battery to play music on the go.

Uses of memory sticks/pen drives

» Transporting files between computers or using as a backing store.

» Used as a security device to prevent software piracy (known as a dongle).

▲ **Figure 3.9** Pen drive/memory stick

Advantages of memory sticks/pen drives

» Very compact and portable media.
» Very robust.
» Does not need additional software to work on most computers.
» They are not affected by magnetic fields.

disadvantages of memory sticks/pen drives

» Cannot write protect the data/files by making it 'read-only'.
» Easy to lose (due to the small physical size).
» The user needs to be very careful when removing a memory stick from a computer

3.3.4 Memory cards

A memory card makes use of solid-state technology. They can be inserted into a device which can read the card or allow data to be written to the card. The cards come in various memory sizes.

Uses of memory cards

» Storing photos on digital cameras.

» Used as mobile phone memory cards. » Used in MP3 players to store music files.

» Used as a backing store in hand-held computer devices.

Advantages of memory cards

» Very compact – can be easily removed and used in another device or for transferring photos directly to a computer or printer.

» Because they are solid-state memories (and have no moving parts) they are very durable.

» They can hold large amounts of data.

» Digital devices, such as compact cameras and smartphones, are able to read and write to memory cards, allowing the user to transport large collections of photographs, songs or information with them.

Disadvantages of memory cards

» Expensive per gigabyte of memory when compared to hard disk drives.

» Have a lower storage capacity than hard disks.

» Have a finite life regarding number of times they can be read from or written to.

» Memory cards, specifically the micro-SD card, are the smallest storage devices available; this means they are more likely to be lost, stolen or damaged.

» Not all computers come with memory card readers built in; users will often be required to purchase a card reader or USB converter to view the data on a memory card.

3.4 The future of storage devices

In recent times, both the CD and DVD are showing signs of becoming obsolete. Many computer systems now come only with USB connectors and no internal DVD or CD drive.

Many people now store all their music in the following ways:

» On hard disk drive systems (set up as sound systems, as shown in Figure 3.10)
» In MP3 format on: – a computer/tablet– their mobile/smartphone– a portable music player (such as an iPod)
» Using the cloud to store all their files so they can access their music from anywhere in the world
» By streaming their music from the internet; provided the user has an internet

▲ **Figure 3.10** Sound system

connection, they can access music through a laptop computer, smartphone, tablet or any other receiving device.

It is also a similar story for movies, where streaming is becoming increasingly more common. Many television sets are now set up as **smart televisions** – this means it is now possible to simply stream movies or television programmes **on demand** without the need for any DVD or Blu-ray players.

Revision questions

1. June/2023/Paper_0417/11/No.11
Portable hard drives can be Solid State Drives (SSDs) or Hard Disk Drives (HDDs).
Explain why the SSD may be better to use than the HDD.

2. June/2023/Paper_0417/12/No.12
Movies can be stored on Blu-ray discs or an internal hard disk.
(a) Describe why Blu-ray discs are preferred to an internal hard disk for storing movies.
(b) Hard disks and Blu-ray discs are examples of backing storage.
(i) State two characteristics of backing storage.
(ii) Identify two other types of backing storage.

3. Nov/2023/Paper_0417/12/No.8(b, c, d)
State the most appropriate storage medium from its description.
(b) Internal storage where the current instruction is stored.
(c) A solid-state storage that is used in digital cameras.
(d) An optical storage medium that stores high-definition (HD) movies.

4. March/2022/Paper_12/No.3
Network devices are used in computer systems.
Complete each sentence by identifying the most appropriate network device.
(a) The network device that is used to transmit the data along an analogue telephone line is a
(b) The network device that connects a LAN to a WAN is a
(c) The network device that allows data to be directed to a specific computer on a LAN is a
(d) The internal network device that allows a computer to connect to a LAN is a

5. June/2022/Paper_11/No.4
Many laptop computers use the cloud to store data. A technician has produced a report on his laptop computer but
has stored the report on a memory stick rather than storing it on the cloud.
Describe two advantages of using a memory stick rather than the cloud to store data.

6. June/2022/Paper_12/No.6
Laptop computers use Solid State Drives (SSD) rather than Hard Disc Drives (HDD).
Describe two disadvantages of using an SSD rather than an HDD in a laptop computer.

7. June/2022/Paper_12/No.5
A library is considering the way it issues books. The librarians are planning to use RFID rather than bar codes.
Describe the advantages of using RFID rather than bar codes.

8. June/2022/Paper_13/No.4
Computers can store data in the cloud rather than using storage devices in the computer.
(a) Describe three benefits of storing data in the cloud.
(b) Describe three drawbacks of storing data in the cloud.

9. Nov/2022/Paper_11/No.12

Many students prefer to store data on external storage devices like pen drives or portable hard disk drives.

Describe four advantages of using a pen drive rather than a portable hard disk drive.

10. Nov/2022/Paper_13/No.10

(a) For each of the following types of backing storage give one example of its associated media. Your answers must be different in each case.

(b) Describe three differences between optical and magnetic backing storage.

11. Nov/2022/Paper_13/No.15(a)

An employee is carrying out work for her company at home. The work she is doing is confidential. She has been advised by her company to use encryption. She wishes to transfer some of this work to the office.

(a) Discuss two different methods she could use to transfer this work to the office. Include in your answer the advantages and disadvantages of each method.

12. June/2020/Paper_12/No.14

There are two types of storage within a computer, internal memory and backing storage.

Discuss the differences between internal memory and backing storage.

13. June/2020/Paper_13/No.9

Lanfen has purchased a new computer. The computer has no internal storage. All the data is stored in the cloud.

Compare and contrast computers that use cloud-based storage and computers that have internal backing storage.

14. June/2020/Paper_12/No.13

Modern laptop computers tend to use external solid state storage rather than external optical storage.

Compare and contrast the use of solid state storage with the use of optical storage to store data.

15. June/2021/Paper_13/No.14

Magnetic tapes are used in organisations for backing up data.

Describe the advantages and disadvantages of using magnetic tapes rather than flash memory for backing up data.