FACTFILE:
GCE DIGITAL TECHNOLOGY

AS2: FUNDAMENTALS OF DIGITAL TECHNOLOGY

Rewarding Learning

Hardware and Software – Architecture 2

Learning Outcomes

Students should be able to:
- explain the need for secondary storage;
- describe secondary storage media: magnetic, optical and flash;
- evaluate the use of secondary storage media for common applications;

Content in Architecture 2

- ✔ Secondary storage: why is it necessary?
- ✔ Magnetic, optical and flash storage media described
- ✔ Secondary storage media in common applications

Secondary Storage

Secondary storage: why is it necessary?

You will remember that main memory, at any time during the operation of the computer, stores a portion of the operating system, application software currently running and other data items the processing unit needs to have fast and direct access to when carrying out operations. Main memory will hold these items only for as long as they are being used by the processor. It would be unrealistic to assume that all programs and data being held by the computer could be held indefinitely as: –
- Main memory is volatile, meaning that as soon as the power is removed the data is lost;
- Main memory has limited capacity.

The above two points mean for example that if main memory is volatile we have no means of being able to permanently store the results of processing, it also means that we would have to reprogram our computer to complete a task each time we needed to use them. This would greatly negate the advantages of having high speed processors to complete tasks for us. For this reason we need to have a secondary or an auxiliary storage device which can be used to hold copies of the programs we are using so they can be reloaded for use without the need for reprogramming. We can also therefore use secondary storage devices to allow us to reload the results of previous processing.

Using secondary storage devices to keep a permanent copy of our processing means that other people can use the same computer but also; depending on the features of the device and its portability in particular, we can take the results of processing and use them on another computer.

Magnetic, optical and flash storage media described

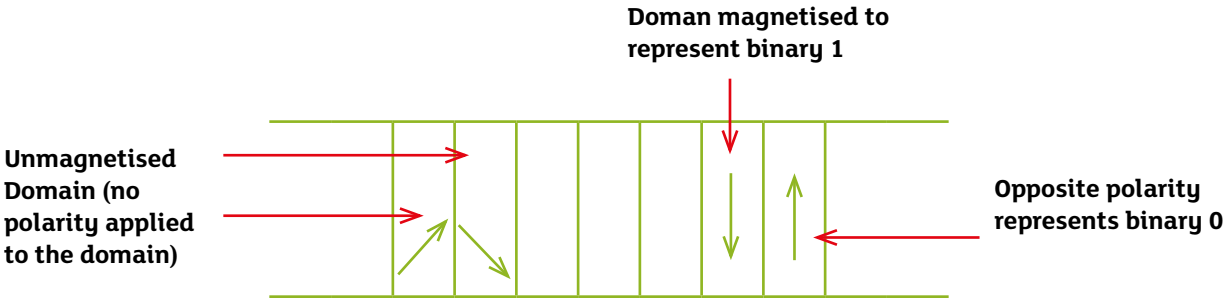
A variety of media exist for use as backing storage devices. These devices can be categorised as Magnetic, Optical and Flash.

Magnetic Media
Magnetic media refers to devices which use different patterns of magnetisation to store data. Magnetic storage devices provide a non-volatile storage medium. Hard discs represents one example of magnetic storage media.

Information can be read from and written to the disc using read/write heads which operate very closely to the surface of the disc. A magnetic material, such as iron oxide or chromium oxide, is embedded in the disk.

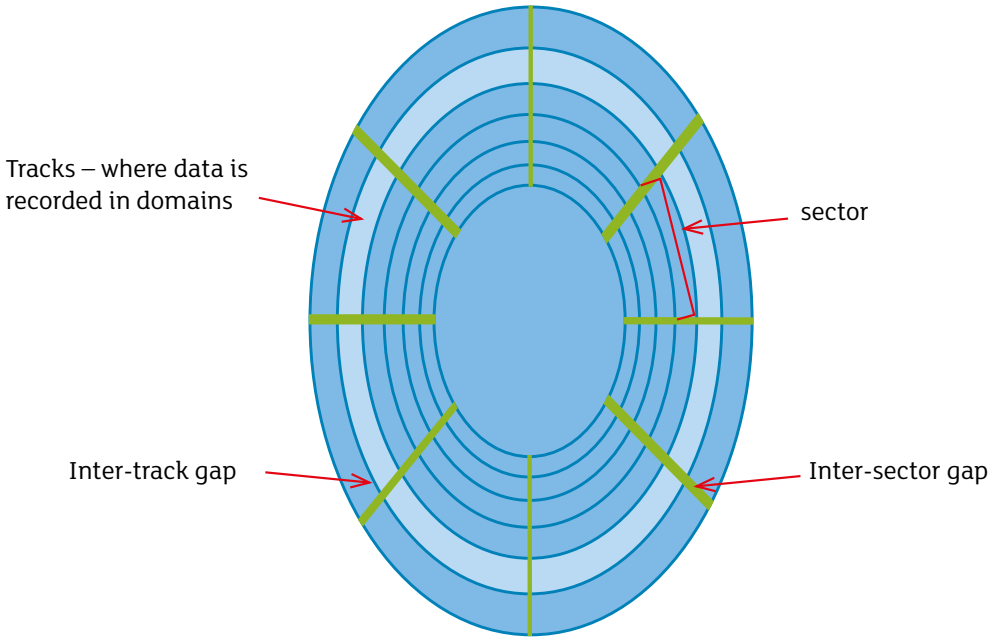
To record data, a recording head moves past the disk while electric currents passing through it produce a magnetic field.

The magnetic surface of the hard disc drive is contains tiny magnetic regions known as domains and each domain can be magnetised on one of two polarities to represent 1 or 0. Domains are invisible to the human eye.



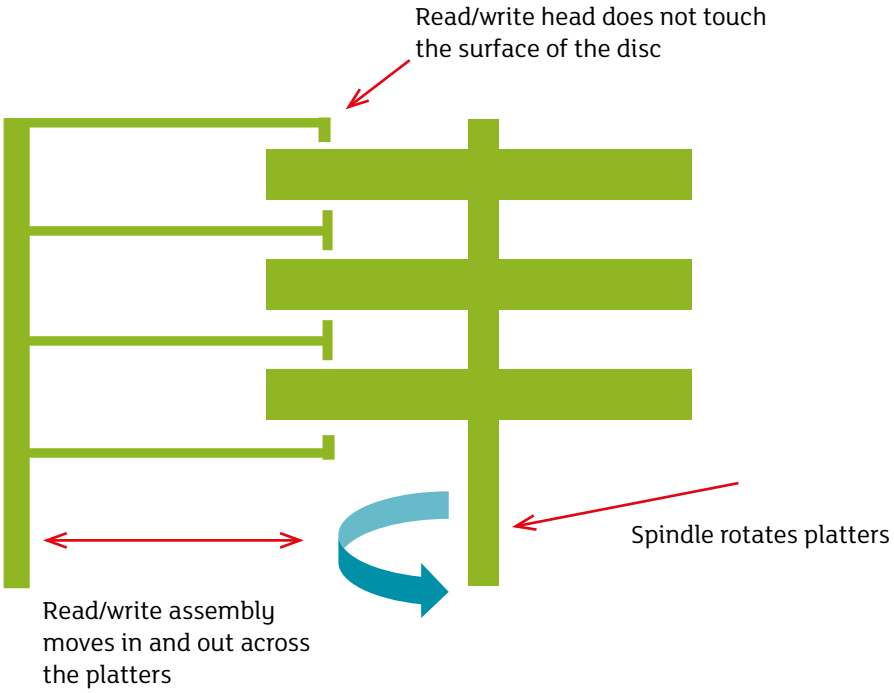
Magnetised domains on the surface of a hard disc drive

The data is stored in a very orderly pattern on the disc surface. Bits of data are arranged in concentric, circular paths called tracks. Each track is broken up into smaller areas called sectors; forming a block of data. When the contents of the disc are being updated data is transferred between the processor and the disc in sectors. Each sector can be accessed randomly using read/write heads which move backwards and forwards across the disc. The disc rotates underneath the read/write heads.



The hard drive inside your computer will have an assembly of hard disc surfaces (called platters). Most hard discs will have more than one platter to increase the storage capacity of the device. The drive shown here has two platters and four read/write heads so data can be read from and written to all surfaces in the disc pack.

The read/write heads are on a fixed assembly unit which means all of the read/write heads move in and out at the same time. Before data can be stored on the surface of a disc it is processed first using a complex mathematical formula to determine the location for storage. All of the read/write heads will move into place and the read/write operation can then take place.



During the write process as one track on a disc surface fills up the corresponding track on the surface underneath will be used to record the rest of the data associated with that file; building up what is known as a cylinder of data or a seek area.

Optical media

Optical storage refers to any storage media where data is held in digital format and which are read from or written to using a red laser. CD's, DVD's, Blu-Ray discs are all examples of optical media.

The surface of an optical disc is coated in a thin layer of aluminium to make a reflective surface. Data is stored in the form of pits (for binary 0) and lands (for binary 1). To read the content of the disc, light is shone onto the surface of the disc from a laser. A pit reflects light more dimly than a land, and a diode is used to measure the difference in reflectivity to determine if a one or a zero is being represented. To write 1' & 0's on CD, a laser beam is used. To write 1, the laser beam is turned on, which turns a pit up to the reflecting layer. To write 0, the laser beam is not turned on & hence, no pit is burned.

The pits and lands used to record the data on an optical storage device are arranged in a long, tightly wound spiral. The spiral starts in the centre of the disc and continues out towards the outer edge of the disc. The tighter wound the spiral of data is, the higher the capacity of the disc.

CD-ROM

CD-ROMs used for distributing software and music files are created using a glass master which is used to burn the pits on the surface of the disc using the method explained above. CD's typically use a laser with a 780 nanometer wavelength to read from and burn data onto the surface of the disc.

Writeable CD's: CD-R and CD-RW

CD-Recordable (CD-R) and CD-rewritable (CD-RW) discs allow the user to add their own content to the surface of the disc for storage. The CD-R does this by using a layer made from a special dye which changes properties when hit by the 'write' laser.

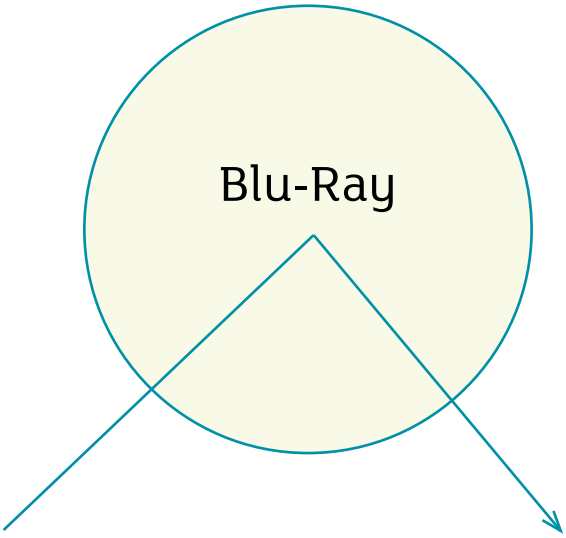
CD-RW are coated with a slightly different material called a multi-phase alloy. Data is burnt onto it in the same way; with a laser. However, if the contents are to be altered, a different level of heat is applied to the discs surface. This will convert the surface back to its original alloy state before the new contents can be written onto the disc.

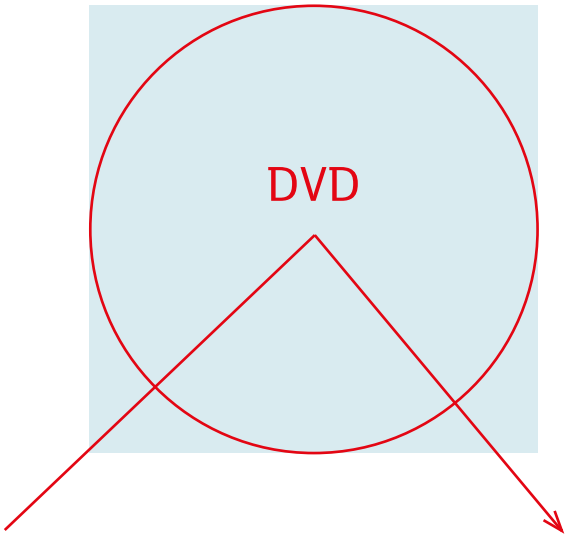
DVD

A single layer DVD has a capacity more than seven times the size of a typical CD. A DVD uses a laser with a 650 nanometer wavelength, which means it can burn smaller pits onto the surface of the disc. Since the light is focused onto a smaller surface then more data can be recorded on the available area.

Dual layer DVDs operate by placing another semi-transparent layer on top of the original. In order to read the second layer the angle of the laser is altered to focus either on the bottom layer or the top layer when reading the data.

Blu-Ray and HD-DVD
Blu-ray and High density DVD both use a 450 nanometer blue laser to read data from the disc. Since blue light has a much shorter wavelength than red light the blue-laser can write more data onto the surface of the disc.





Flash Storage
Flash memory uses solid state technology to store data on a non-volatile storage medium. Since there are no moving parts (everything is electrical as opposed to mechanical) the contents of flash memory are therefore electrically erased and reprogrammed multiple times.

Flash storage media use transistors to store data. A normal transistor has three main components, they are called the source, the drain and the gate or control gate. The transistor operates like a pipe and is used to carry electricity from the source to the drain. In between the source and the drain is a gate or control gate which can be opened or closed to switch the transistor off, representing binary 0. When the control gate is opened and the transistor is therefore switched on it represents a binary 1.

A flash transistor is a little different. It has an additional gate called a floating gate positioned above the control gate. The floating gate is insulated from the rest of the transistor so it can store some of the electrical charge used to represent the binary data. Even when the power is removed the electricity is trapped in between the two gates so the binary data is retained. The data can be erased by applying a negative charge to the transistor to make the trapped electricity drain back down again away from the floating gate. The process of removing trapped electricity from the floating gate is known as tunneling.

Secondary storage media in common applications

Media Type	Applications	Advantages	Disadvantages
Magnetic Hard Disc	Fixed hard drives used for secondary storage; storing installed programs, data files, operating system files. Portable hard drives used for secondary storage; backing up fixed hard disc drives on standalone machines or networks (Network attached storage devices or Direct attached storage devices).	High storage capacity. Non-volatile storage. Data can be altered. Provides random access to data. Stores data without the need of a constant electricity supply.	Should be contained in a sealed unit; damage to the unit can cause a disc crash and data can become corrupted. Easily damaged. Consumes a lot of power. Can be noisy in operation as it involves the movement of mechanical parts. Portable hard drives are slightly slower than the fixed hard drives.
CD-ROM	Distribution of software and music, electronic books.	Provides random access to data. High data stability.	Surface can easily be damaged rendering content unreadable. Limited storage capacity.
CD-R / CD-RW	Suitable for backing up data, distributing data files to others users.	CD-R can be written to once and read many times (WORM – write Once read Many). CD-RW can be written to, erased and re-written many times. High data stability.	Surface can easily be damaged rendering content unreadable. Limited storage capacity. CD-RW cannot be re-written an indefinite number of times.
DVD	Distribution of high quality video	Non-volatile. Higher storage capacity than CD-ROM. Provides random access to data. High data stability.	Can be easily broken They require special drive to read and write.
Blu-Ray	Distribution of high definition video	Non-volatile Higher storage capacity than DVD so used to store HD video. Provides random access to data. High data stability. Mass storage capacity.	Easily broken They require special drive to read and write. Relatively expensive.
Flash memory	SD cards in cameras BIOS chip on computer USB Memory drives	No moving parts. High speed access. Small size makes it portable. Provides random access to data Non-volatile. Contents can be re-written. Very little power needed.	Cannot be re-written to an indefinite number of times. Higher development cost per byte.

Questions

1 Explain what is meant by the term secondary storage and why it is necessary on any computer system. [3]

2 Explain the process associated with storing binary data on the surface of a magnetic disc. [2]

3 Magnetic disc drives are said to build up a cylinder of data when storing large files. Explain the term 'cylinder of data'. [4]

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4 Explain how the process known as tunnelling can be used to alter the contents of a flash storage device. [5]

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5 Dual-layer DVDs and CD-ROMs use the same basic principles for recording data. Describe how data is stored on the surface of both media and how the process differs to support the increased storage capacity associated with Dual-layer DVD's [6]

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