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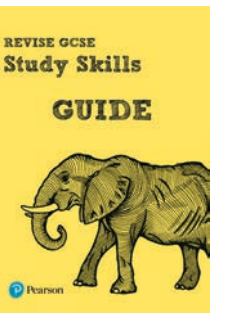

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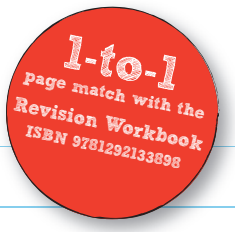
Contents



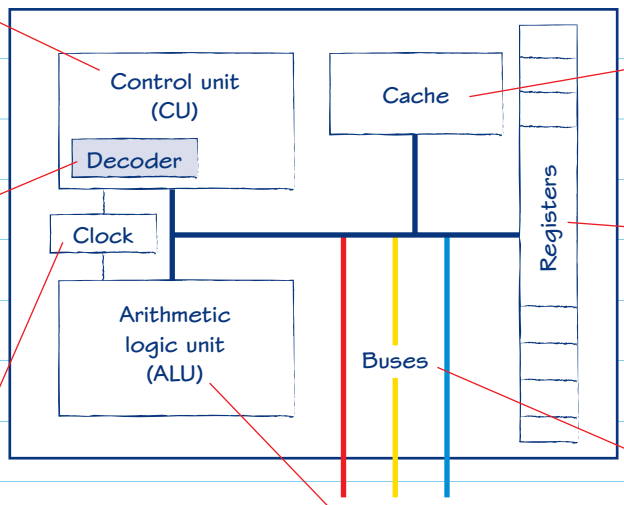
A small bit of small print

OCR publishes Sample Assessment Material and the Specification on its website. This is the official content and this book should be used in conjunction with it. The questions in *Now try this* have been written to help you practise every topic in the book. Remember: the real exam questions may not look like this.

The central processing unit

The central processing unit (CPU) carries out (executes) all of the stored program instructions.

Components of the CPU



Controls all the other components of the CPU. It contains the **decoder**.

Very fast random access memory (**RAM**).

Interprets program instructions and tells the ALU what operations to carry out.

Memory locations. Some perform special functions in the **fetch–decode–execute** cycle.

Electrical conductors that carry electrical signals between components in the CPU and between the CPU and other components on the motherboard.

Controls the rate at which program instructions are carried out, by sending control electrical signals at regular intervals, called **cycles**.

Performs arithmetic and logical operations to carry out program instructions.

Worked example

Matthew has bought a laptop with a 2.2 GHz central processing unit (CPU).

(a) State the purpose of the CPU. **(1 mark)**

The function of the CPU is to fetch and execute program instructions stored in memory.

(b) Describe what is meant by a 2.2 GHz CPU. **(2 marks)**

A 2.2GHz CPU has a clock speed of 2.2 GHz. This gives the number of instructions which can be processed each second. A 2.2 GHz processor can complete 2.2 billion processing cycles per second.

Part (a) uses the word **state** so you do not need to give a detailed description. In part (b), make sure you include at least two distinct statements in your description.

Clock speed

The CPU carries out one program instruction for each **clock cycle**. Clock speed is usually measured in **gigahertz (GHz)**. 1 GHz is 10^9 cycles per second. Most home computers have clock speeds between 1 and 3 GHz. The clock speed is one significant factor that affects the performance of the CPU. Other factors include cache size, the number of cores and type of RAM, and hard drive speed.

See page 5 for more about factors which affect the performance of the CPU.

Now try this

1 List **three** components of a central processing unit (CPU). **(3 marks)**

2 Explain why a computer with a 2.2 GHz CPU might be considered preferable to one with a 1 GHz CPU. **(2 marks)**

Components of the CPU

The way in which the CPU is designed and carries out the instructions with other components is called 'von Neumann architecture'.

von Neumann architecture

In 1945, John von Neumann designed a stored program computer where both the program and data are stored in the memory. This is the design we use today.

The components are:

- a processing unit or CPU
- a program counter
- memory to store data and instructions
- input and output mechanisms.

John von Neumann (right) and the stored program computer.

Control unit

The control unit coordinates the actions of the computer. It sends out control signals to other parts of the CPU and to other components of the computer.

Control signals make everything happen inside a CPU and computer.

An important element is the **decoder**. This works out (decodes) what the program instructions mean. It then sends control signals to other components to carry out the required actions.

Arithmetic and logic unit

The arithmetic and logic unit (ALU) performs arithmetic and logical operations. It carries out activities such as:

- ✓ addition, subtraction, multiplication and division
- ✓ comparisons between two different numbers.

Registers used in fetch–decode–execute cycle

Program counter – holds the address of the next instruction to be fetched.

Memory data register (MDR) – a temporary store (buffer) for anything copied from memory.

Registers

Memory address register (MAR) – holds the address of the memory location currently being read (fetched) or written to.

Accumulator – stores the results of calculations carried out by the ALU.

Worked example

List **two** registers of the CPU with specific functions in the fetch–decode–execute cycle. **(2 marks)**

Program counter.

Memory address register.

The question asks you to **list** two registers, so no description or explanation is required.

Other registers listed could have been the memory data register and the accumulator.

Now try this

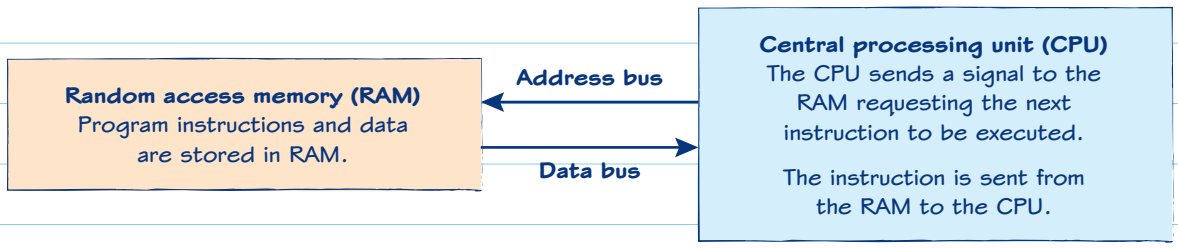
Describe the role of the control unit in the operation of the central processing unit. **(4 marks)**

Fetch–decode–execute cycle 1

The CPU uses the fetch–decode–execute cycle to carry out the program instructions.

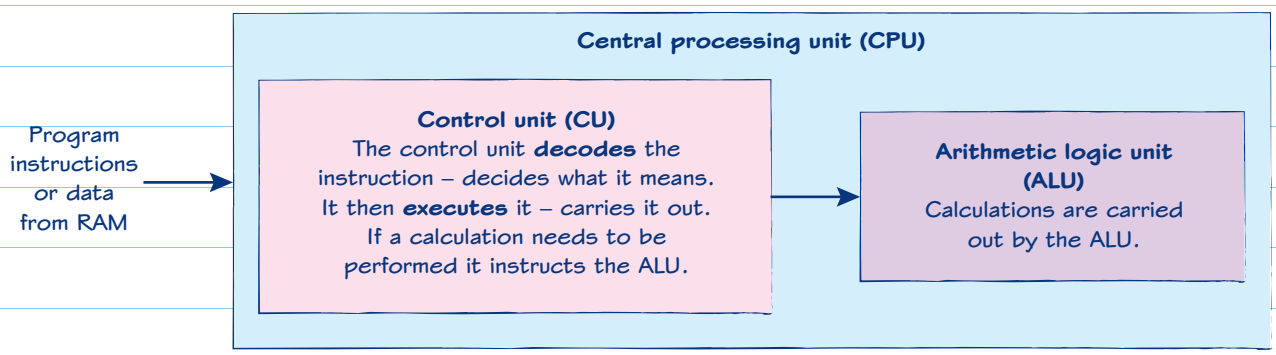
Fetch

During the fetch stage, instructions and data are **transferred from the RAM to the CPU**.



Decode and execute

During the decode and execute stages the instructions are **interpreted and carried out**.



Worked example

State what is done at each stage of the fetch–decode–execute cycle. **(3 marks)**

Fetch: The next instruction to be executed is transferred from the RAM to the CPU.

Decode: The CU interprets the instruction.

Execute: The CU then carries out the instruction. It instructs the ALU if calculations need to be performed.

If a question uses the command word 'state' you only need to state your answers, not explain them.

Now try this

Explain how program instructions stored in computer memory are processed by the central processing unit. **(3 marks)**

Fetch–decode–execute cycle 2

The registers, which are memory locations within the CPU, play an important role in the fetch–decode–execute cycle.

How instructions are executed

This program instructs the CPU to carry out the calculation 6 + 13 and then to store the result.

Program counter 0		MAR 0
MDR	LOAD 3	The instruction at address 0 is fetched to the MDR. It is decoded to mean 'fetch the data from address 3 and put it in the accumulator'.
Accumulator	13	13 is stored in the accumulator.

RAM	
Address	Contents
0	LOAD 3
1	ADD 4
2	STORE 5
3	13
4	6
5	

Program counter 1		MAR 1
MDR	ADD 4	The instruction at address 1 is fetched to the MDR. It is decoded to mean 'fetch the data from address 4 and add to the value in the accumulator'.
Accumulator	19	6 is added to the accumulator to give a total of 19.

RAM	
Address	Contents
0	LOAD 3
1	ADD 4
2	STORE 5
3	13
4	6
5	

Program counter 2		MAR 2
MDR	STORE 5	The instruction at address 2 is fetched to the MDR. It is decoded to mean 'store the value in the accumulator in memory address 5'.
Accumulator	19	19 is stored in memory address 5.

RAM	
Address	Contents
0	LOAD 3
1	ADD 4
2	STORE 5
3	13
4	6
5	19

Worked example

State the role of the following registers in the fetch–decode–execute cycle.

- The program counter. **(1 mark)**

The program counter holds the memory address of the next instruction to be processed.

- The memory data register (MDR). **(1 mark)**

The memory data register holds an instruction or data that has been fetched from the memory before it is used.

The question asks you to **state** and therefore a long explanation or description is **not** required. The statements should just state the role and not go into detail about how the roles are carried out.

Now try this

State the role of these registers in the fetch–decode–execute cycle.

- The memory address register (MAR).
- The accumulator. **(2 marks)**

Performance of the CPU

The speed at which the CPU processes program instructions can be increased by improving its design and adding components.

Clock speed

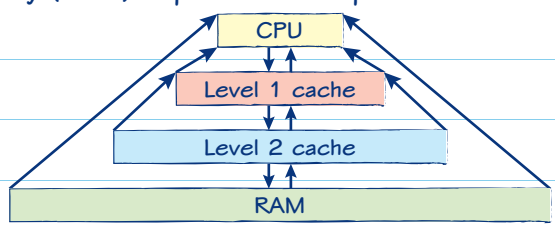
The clock is a vibrating quartz crystal and the **faster it vibrates, the faster the instructions are processed** – at least 1 per cycle. Rates of 3GHz are common in modern computers.

The processor **generates a lot of heat** and the amount increases with the rate at which it processes instructions. The faster the clock speed, the hotter it gets, which causes it to malfunction and therefore it cannot be increased indefinitely.

The processor must have a **heat sink** and a fan to dissipate this heat. Liquid nitrogen is needed to cool supercomputers with clock speeds of 9GHz.

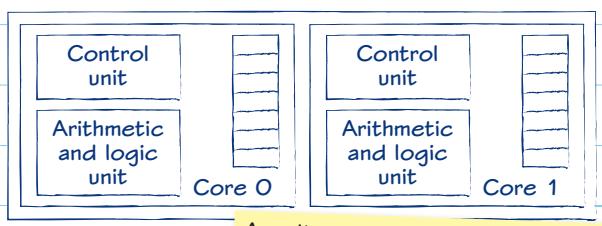
Cache memory

- Cache memory is **very fast memory**, usually within the processor itself.
- The cache speeds up processing by **storing recently or frequently used instructions** so that they do not have to be fetched from the main memory which is much slower.
- As the cache becomes larger it takes longer to find the data and so it becomes slower. Therefore, it is split into different levels, e.g. L1, L2 with the smallest nearest to the CPU.
- Cache memory is far too expensive to use for the main memory (RAM) in personal computers.



Multi-core processors

A **multi-core processor** contains more than one CPU. Multi-core processors can give faster processing speeds than single-core processors, and can work on different tasks at the same time.



A multi-core processor with two cores - a dual-core processor.

Using multi-core processors

- The cores can work together on the same program – ***parallel processing***.
- The cores can work on different programs at the same time – ***multitasking***.
- Not all programs will run at twice the speed with a dual-core processor.
- The programs may be sequential so that one task requires output from a previous task and so the second task cannot start until the first has finished.

Worked example

Explain why the cache size affects the performance of the CPU. **(4 marks)**

Cache is high speed memory used to store frequently used program instructions. The larger the cache size, the less often the slower main memory needs to be accessed, speeding up data transfer. The performance of the CPU will be improved as it does not have to wait as long for the data to be delivered. However, if the cache becomes too large then the data access time increases and so the cache is split into units e.g. L1, L2, L3.

The question uses the word **explain** so you should give a detailed account stating that it is faster to transfer data and where data is transferred from and to.

Now try this

Explain why increasing the number of cores in a processor does not necessarily increase the rate at which all programs are processed. **(2 marks)**

Embedded systems

An embedded system is a computer system built into another device in order to control it.

Components in embedded systems

Components in embedded systems are on a single printed circuit board (PCB). They include the:

- processor
- memory
- input and output interfaces.

Input devices may be manual switches and dials, such as on washing machines. The input interfaces must convert changes in them into electrical signals. A PCB is the base that supports the components that are soldered to it or fitted into sockets.

Tasks

Each embedded system is **built for a small range of specific tasks** unlike desktop and laptop computers that are general purpose and are capable of carrying out many different tasks.

Washing machine

Digital camera

These devices all have embedded systems to control their functions

Microwave oven

Real-time systems

Embedded systems are called **real-time systems** because they must ensure an immediate response in order for the system to react to different situations, e.g. when the button is pressed on a camera or when the brakes are applied in a car.

Worked example

Many modern devices use embedded systems to function properly.

Explain **one** function of an embedded system in a washing machine. **(2 marks)**

It monitors the water temperature so that it can turn the heating element on and off to maintain the correct temperature.

The question uses the word **explain** so you need to give a function **and** the reason why the function is needed.
You could also have answered that the embedded system monitors the spin speed setting so that it sets the motor to the correct speed.

Now try this

Many modern devices contain embedded systems.

(a) Define the term 'embedded system'. **(1 mark)**

(b) Explain the role of embedded systems in real-time applications. **(2 marks)**

RAM and ROM

RAM and ROM are two types of computer memory.

RAM

Random access memory (RAM) is where the computer stores data and instructions when an application is running.

- Data can be read from and **written to** RAM.
- RAM is **volatile** – if you turn off the power, data in RAM is lost.

RAM is often removable. You can upgrade many computers by adding more RAM.

ROM

Read only memory (ROM) is used to store instructions that don't need to be changed during normal use.

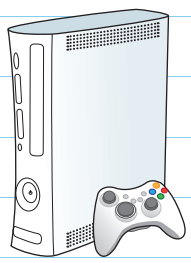
- Data can only be **read** from ROM.
- ROM is **non-volatile** – it retains data even if the power is turned off.

In a PC, the sets of instructions needed for the computer to start up are stored in ROM. These instructions need to be stored and saved even after the power is turned off.

How much RAM?

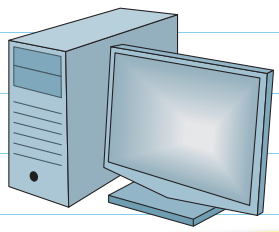
Some applications (such as photo- or video-editing) require greater amounts of RAM. Here are four common devices with typical amounts of RAM.

Smartphone: 2GB



Games console: 4GB

Laptop: 8GB



Workstation: 16GB or more

Worked example

(a) Describe the role of programs stored in ROM. **(2 marks)**

Programs stored in ROM carry out specific tasks including initialising hardware components and starting the operating system when a computer is switched on.

(b) Describe the difference between volatile and non-volatile memory. **(2 marks)**

The content of non-volatile memory is not lost when the power is turned off whereas the content of volatile memory is erased. The content of volatile memory changes constantly whereas the content of non-volatile memory is fixed and cannot be altered.

Questions like this require both elements to be addressed in the description in order to be awarded the marks.

Now try this

1 State which type of memory is used to store application data during execution. **(1 mark)**

2 Give **two** differences between RAM and ROM. **(2 marks)**

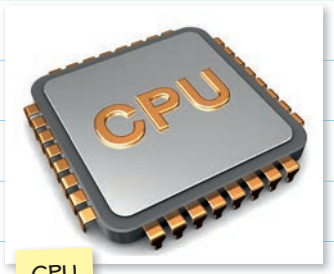
Virtual memory

Virtual memory is an area of the hard disc drive or solid-state drive used as temporary RAM when the actual RAM is full.

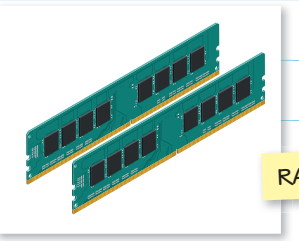
Use of virtual memory

Program instructions and data are constantly moving between the CPU and the RAM.

RAM may become full if many programs are running.



CPU



If there is no free RAM, the operating system (OS) will **swap out** some of the data stored in RAM to the **virtual memory** on the hard disc drive and swap in the requested data into the free area of the RAM.

Hard disc drive

Swapping data

Usually the **least recently used** stored data is swapped out. If data is swapped out and is then needed again, it is swapped back in from the virtual memory at the expense of other data. The more RAM a computer has then the less virtual memory will be needed. Adding more RAM will **significantly improve the performance** of a computer.

Make sure you include both **how** and **why** it is used.

Disadvantages of using virtual memory

- The read/write speed of a magnetic hard drive is much **slower than RAM**. There will be a significant performance drop if the system has to rely too heavily on virtual memory.
- If the OS is constantly swapping between RAM and the hard disc drive, programs will run more slowly. This is called **disc thrashing**.

Worked example

A computer's operating system uses 6 GB of virtual memory.

(a) Explain how a computer uses virtual memory and why it may be necessary. **(2 marks)**

A computer uses virtual memory by moving to it the least recently used instructions and data from main memory. This allows other data to be loaded into the main memory. A computer uses virtual memory to compensate for not having a sufficient amount of RAM.

(b) State **one** advantage and **one** disadvantage of the use of virtual memory. **(2 marks)**

An advantage of virtual memory is that program operation will continue even when the main memory is full.

A disadvantage of virtual memory is that there is a fall in performance as it is much slower to access the data.

Now try this

Explain why adding more RAM to a computer will improve its performance. **(2 marks)**

Secondary storage 1: optical and magnetic devices

Data can be stored on secondary storage devices. There are three main types of storage device: magnetic discs, optical discs and solid-state (flash) memory.

For more on solid state (flash) memory, see page 10.

The need for secondary storage

Data and programs are stored **permanently** on secondary storage devices but the CPU cannot access them directly and so they must be transferred to (loaded into) the main memory.

Secondary storage devices can also be used to transfer stored data between computers.

Magnetic storage

Magnetic storage is used in hard disc drives (HDDs) and digital tape drives which are often used for backing up large computer systems. **Magnetic discs** consist of stacks of non-removable discs coated with magnetic materials.

Hard disc drive

Data is encoded as opposing magnetic polarities on the surface of the disc. Electromagnets in the read/write heads read and write the data.

The cost of magnetic storage is very low. Hard disc drives in budget laptops have capacities of at least 1 terabyte.

Digital tape drive

Worked example

A small business backs up the data on its computer system every day.

Compare backing up the data to a magnetic hard disc with backing up to an optical disc. **(4 marks)**

Data is written to and read from a magnetic hard disc more quickly than to/from an optical disc, so backing up and restoring would be quicker.

Hard discs are permanently located within a hard disc drive so are less portable than optical discs, such as DVDs, which can be removed from the drive when not in use. Portable hard drives are very light and compact so could be stored off-site. Optical media tends to be more durable than magnetic media. DVDs offer unlimited storage because the business can use as many as needed. HDDs can store several terabytes of data which would probably be enough for the business.

For more on the features of secondary storage, see page 11.

Optical storage

Optical storage includes:

- compact discs (CDs) that store 700MB
- digital versatile discs (DVDs) that store 4.7GB
- Blu-ray discs that store up to 50GB.

Optical discs use a laser to read and write data. The data is encoded as a series of pits in a spiral track running from the inside to the outside of the disc.

CD, DVD and Blu-ray drives write and read data onto discs using light from lasers.

Now try this

Explain why secondary storage devices are needed. **(3 marks)**

Had a look ☐ Nearly there ☐ Nailed it! ☐

Secondary storage 2: solid-state memory

Unlike magnetic and optical storage devices there are no moving parts in solid-state devices.

Solid-state memory

Solid-state memory is made of **flash memory**. Flash memory is **non-volatile** storage that can be electrically erased and reprogrammed. Flash memory uses arrays of transistors (switches). Transistors can operate in two states, 0 and 1, and are switched from one to the other using electrical signals. Data is encoded as sets of binary digits. 8 GB of solid-state storage require 32 billion transistors.

The question asks you to **explain**. Don't just state 'they use electricity, magnetism and light'.

Worked example

Explain how each of these secondary storage devices physically records data.

- Magnetic hard drive.
- Flash memory USB stick.
- Optical disc drive. **(3 marks)**

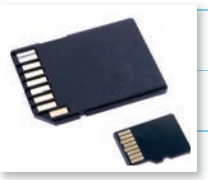
Hard disc drives use electromagnetism to store data magnetically on metal discs.

Data is stored in flash memory by using electricity to change the state of the transistors it is made of.

DVDs use light produced by a laser to store data on the disc by changing its surface.

Uses of solid-state memory

Solid-state memory is used for data storage in portable devices such as cameras and mobile phones.

Solid-state drives (SSDs)		Solid-state drives (SSDs) can provide secondary storage instead of magnetic discs.
Secure digital (SD) cards		Secure digital (SD) cards and microSD cards are used in portable devices such as phones, cameras and tablets.
USB flash drives		USB flash drives are convenient compact forms of flash memory for sharing and transferring data.

Now try this

1 List **two** advantages of using a flash memory device rather than a magnetic hard disc drive for data storage. **(2 marks)**

2 State **one** disadvantage of using flash memory. **(1 mark)**

Storage 3: capacity, speed and cost

The different storage devices have different properties.

Comparison of secondary storage devices

Type of storage	Capacity	Speed	Cost
Magnetic 	Very large 1–2 TB is common in home computers. Can store 1000 to 2000 movies (assuming an average size of 1GB).	Fast Random access: data can be read instantly from any part of the disc. Can find and supply required data in milliseconds (thousands of a second).	Very low Magnetic drives storing terabytes of data are common in most home computers.
Optical 	Low CDs store 700MB DVDs store 4.7 GB Can store four movies.	Slow	Very low
Solid state 	Moderate Solid state drives are usually from 128–512 GB but the capacity is rapidly increasing. Can store up to 500 movies.	Very fast Can access data in nanoseconds (thousands of a millisecond).	More expensive than magnetic drives and optical devices. Solid state storage is a relatively young technology. Storage capacity is rapidly increasing and the cost is falling.

☐ good ☐ moderate ☐ poor

Worked example

A school has a number of different data storage requirements.

State which type of secondary storage is most suitable for each of the purposes listed below. Give a reason for your choice.

- Hand-held data-logging devices used for fieldwork.

Solid state. Very fast access speed for taking readings and not sensitive to being moved around.

- Storage drives on the school's file server to save all of the students' work.

Magnetic. Very large capacity, reliable and low cost.

- Copies of a video of a school production to be given to parents. **(6 marks)**

Optical. Discs are cheap and portable and most home computers can access them.

Make sure you state an appropriate type of storage and suggest a reason. If you can easily think of more than one reason then you could write them down, just to be sure.

Now try this

Explain why nowadays many laptops and desktop computers have built-in solid-state drives rather than hard disc drives. **(3 marks)**

Had a look ☐ Nearly there ☐ Nailed it! ☐

Storage 4: portability, durability and reliability

The different secondary storage devices each have benefits and drawbacks depending on the situation.

Comparison of secondary storage devices

Type of storage	Portability	Durability	Reliability
Magnetic 	Not very portable as physical knocks may cause the read/write heads to hit the discs and corrupt data.	Very durable.	Very reliable.
Optical 	More portable than a hard disc drive but discs are relatively large.	Easily scratched and data can be corrupted. Data cannot be overwritten. Stored data degrade over time.	Very reliable if they are not scratched.
Solid state 	Very portable. Small solid-state storage devices can be fitted inside cameras and mobile phones.	Limited number of erase/write cycles.	Very reliable and data are not affected by magnetic fields (as they are in magnetic drives).

good moderate poor

Worked example

Anna is buying a new laptop computer. She has the choice between a magnetic hard disc drive and a SSD for file storage.

Discuss the benefits and drawbacks of these alternative secondary storage devices. **(6 marks)**

At present, the storage capacity of hard disc drives is greater than for SSDs so Anna would be able to store more files.

Also, at present, the cost of hard disc drive storage is cheaper than for SSDs although the cost is falling.

SSD data access speeds are far greater than for hard disc drives.

SSDs have no moving parts so they are ideal for laptops as they will not be damaged if they are dropped.

As data becomes fragmented, access is slower on hard disc drives as the read/write heads have to move to different platters to access different parts of the same file. Fragmentation does not slow data access in SSDs as there are no moving read/write heads.

The two methods, hard disc drives and SSDs, have to be compared and each point should mention both.
Just saying that 'SSDs are fast at accessing data' would not answer the question as the answer is not comparing the SSD with a hard disc drive.

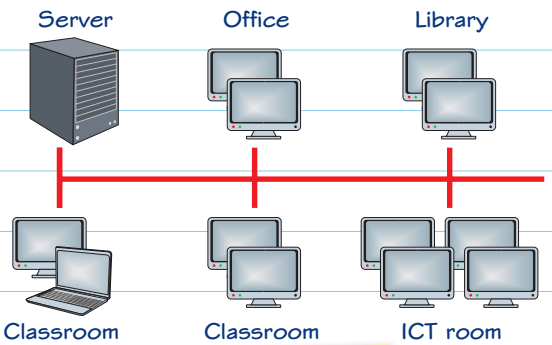
Now try this

Identify **four** factors, other than cost, that should be considered when choosing a secondary storage device. **(4 marks)**

Networks 1: LANs and WANs

A computer network is a group of computer systems and other devices linked together so that they can communicate and share resources such as printers. Networks can be as small as two computers and a printer in a home network.

Local area network (LAN)



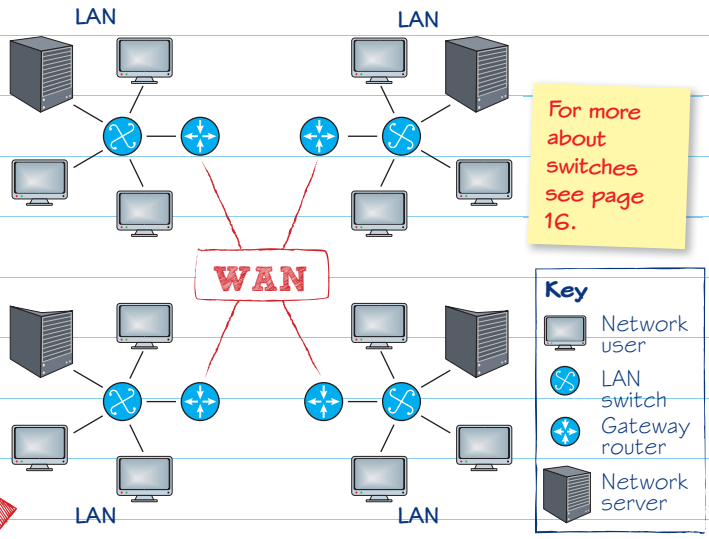
A **local area network** is a network in a small area such as a home, school, office building or group of buildings on a single site. It exists within a small geographical area. A LAN is usually managed by a local manager or team at the site. Many people have a home LAN that allows the members of a household to access the internet using a wireless router.

The internet is a global system of interconnected computer networks. Hyperlinks can take you from a host computer in one LAN to a computer in another. The internet is therefore an example of a huge WAN.

See page 17 for more about the internet.

Wide area network (WAN)

Wide area networks connect separate LANs over a large geographical area to form a network of networks. Large companies can connect LANs at their different sites in order to share resources and data. Computers in a WAN can communicate with computers and users in other locations.



For more about switches see page 16.

The WAN will be managed by several different people or parts of an organisation working together (collective ownership). Alternatively, each LAN could be managed independently (distributed ownership).

Factors affecting network performance

- **Bandwidth** is the maximum amount of data that can pass through the medium per second.
- **Hardware** and **software** limitations (switches and routers) can affect performance.
- A high **number of users** can cause network congestion, leading to packets being queued before they can be transmitted by routers and switches.
- **High network traffic** can lead to collisions of data packets resulting in transmission errors. The packets have to be resent.

Worked example

State **one** way in which a local area network (LAN) and a wide area network (WAN).

(1 mark)

A LAN is a network that is restricted to one building or site.

A WAN is a network of separate LANs over a large geographical area.

Now try this

A retailer wants to share data between its head office and its 300 high street stores.

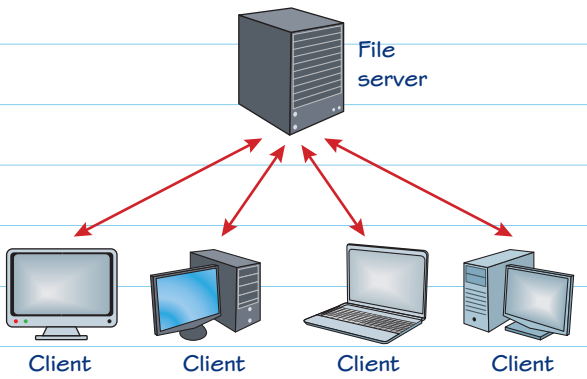
Explain why the business would use a WAN rather than a LAN for this purpose. **(2 marks)**

Had a look ☐ Nearly there ☐ Nailed it! ☐

Networks 2: client–server and peer-to-peer

Computer networks can range from small networks on a single site to much larger networks operating across continents and there are different types to cater for the needs of both.

Client–server network



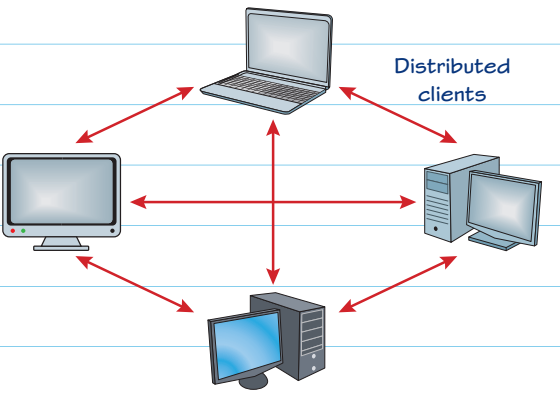
In client–server networks there are two types of computer:

- **file servers** – computers which control access and manage the network
- **clients** – computers on which the users work.

Using a client–server network

- Users **log in** to the servers to access programs and data stored on them.
- Servers are responsible for network security by allocating login names and passwords to users.
- All files are held on the servers and can be backed up centrally.

Peer-to-peer network



In peer-to-peer networks, there is only one type of computer.

- There is **no server** to manage the network. All the computers are connected together equally.
- They are **all equal** and can communicate with each other directly without having to go through a server.

Using a peer-to-peer network

- Each client can act as a server. Other clients can share programs, data, and printers.
- Security is distributed – each user can grant rights to others and allocate passwords.
- Data is stored on each client and not centrally.
- Each user is responsible for backing up each client.

Worked example

List **three** benefits of using a client–server rather than a peer-to-peer network. **(3 marks)**

Network security is controlled centrally rather than on each client.
All files can be saved centrally rather than on each client.
All backups can be done centrally rather than having to be done on each client.

The question asks you to **compare** the two types of network system by listing the benefits and drawbacks of one system over the other. You cannot just list the properties of a peer-to-peer network. You must show how these are benefits and drawbacks when compared with a client–server network.

Now try this

List **three** benefits and **three** drawbacks of using a peer-to-peer network rather than a client–server network. **(3 marks)**

Transmission media

Devices on a network communicate through cables (wired) or by radio waves (wireless).

Cable (wired)

Devices are physically connected using either **copper wire** or **fibre optic cable**.

Copper wire	Fibre optic cable
Transmits data as electric signals.	Transmits data as pulses of light.
👍 Cheaper than fibre optic.	👍 Transmit signals at faster speeds and over greater distances than copper wire.

Bandwidth

Bandwidth is the amount of data that can be transmitted per second. Bandwidth is measured in bits per second (bps).

- Copper cable: up to 1 Gbps.
- Fibre optic: up to 10 Gbps.
- Wireless: up to 600 Mbps.

Radio waves (wireless)

Wireless networks use radio waves, which are part of the electromagnetic spectrum, to communicate. The most commonly used frequencies for data transmission in wireless networks are 2.4 GHz and 5 GHz. (1 GHz = 10^9 cycles per second.) The frequency range is divided into 14 channels spaced 5 MHz apart. Users can change the operating channel of their Wi-Fi device to prevent interference.

Protocols and security

Protocols are the rules that computers must follow when communicating over a network.

- Ethernet protocols are used in cable networks.
- Wi-Fi protocols are used in wireless networks. Wi-Fi is one wireless technology that uses radio waves.
- Other wireless protocols include Bluetooth, 3G, 4G and Wi-Fi Direct.

There are no physical connections in Wi-Fi networks, so networks must be protected by encryption algorithms. The most commonly used are Wired Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA).

Cable and wireless networks

	Cable	Wireless
Bandwidth	High – up to 10 Gbps	Low – up to 600 Mbps
Installation	Difficult – must run cables throughout the site.	Easy – just need wireless access points.
Cost	Expensive – cost of cables and installation.	Cheap – just cost of wireless access points.
Security	Good – need to plug computer into a socket.	Poor – anyone within range can access the network. Must use security passwords.
Interference	Good – there is no interference with cables.	Not so good – signals can be affected by walls and other electronic equipment.
Mobility	Poor – need to plug computer into a socket.	Good – access can be from anywhere within range.

Worked example

(a) State **two** types of cable that can be used to network computers. **(2 marks)**

Copper wire and fibre optic cable.

(b) State **one** other transmission medium that can be used to connect computers together to form a network. **(1 mark)**

Microwaves or radio waves.

The question asks you to **state** and so simple statements are required without explanations.

Now try this

A school is considering whether to install a cable or wireless network.

Explain **three** benefits of each type of network when used in a school situation. **(6 marks)**

Had a look ☐ Nearly there ☐ Nailed it! ☐

Connecting computers to a LAN

Hardware is required to connect all computers in a local area network (LAN).

Network interface controller

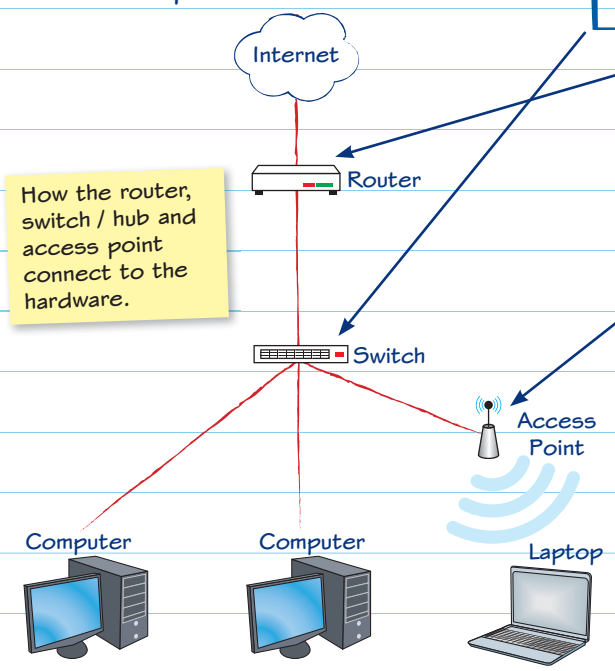
Computers need a **network interface controller (NIC)** (or **adapter**) to connect to a network. The NIC formats the data sent to and received by the computer. NICs are often built on chips on the computer motherboard.

MAC address

Every NIC is created with its own unique **media access control (MAC)** number programmed into it. The MAC address ensures that data is directed to the correct computer.

Hub or switch?

- Hubs and switches are used to link computers so that they can communicate with each other once they have connected to the network using the NIC.
- **Hubs** send every message to every computer on the network. This creates extra unnecessary network traffic.
- **Switches** read the destination addresses (the MAC addresses of the computers to which the message is being sent) of the messages and relay them only to the intended recipients.
- Switches and hubs affect the performance of networks by their effect on the amount of network traffic.



How the router, switch / hub and access point connect to the hardware.

Routers

- Routers connect different networks together.
- They read address information and forward the messages to the correct network.
- Routers are used to transfer data between a home network and the internet.

Wireless access points

- Wireless devices need wireless access points to connect to cabled networks.
- They convert data received through cables into wireless signals and vice versa.
- Like hubs, they do not read the destination addresses and direct messages to all devices.
- Wireless access points are often used for hotspots in public buildings.

Worked example

Both hubs and switches can be used to connect the devices in a network.

(a) Explain **one** advantage of using a switch rather than a hub. **(2 marks)**

A switch reads the address information of each message and directs it to the correct recipient. This reduces the amount of network traffic whereas a hub sends a message to every computer, creating extra network traffic.

(b) State the function of a network router. **(1 mark)**

A router forwards data traffic between computer networks.

In part (a) be careful not to confuse a switch with a router. A router connects different networks together.

Part (b) uses the word **state**, so a statement about its function is needed. Stating 'it transmits messages from one network to another' would also have been a correct response.

Now try this

Explain how a network switch is able to identify the correct computer to which it must transmit a message. **(2 marks)**

The internet

The internet is a wide area network (WAN) – a huge network of networks with the computers linked by a combination of wired and wireless transmission media.

Hosting

A **host** is a computer accessed by users at remote locations over networks, including the internet.

Web hosting companies rent space on their servers for websites. The hosting companies handle all of the technical and security issues.

Domain names

Every computer using the internet has a unique **internet protocol (IP)** address so that the other computers know where to send any requested data such as web pages. The IP address is used on the internet in the same way as the MAC address is used on the LAN.

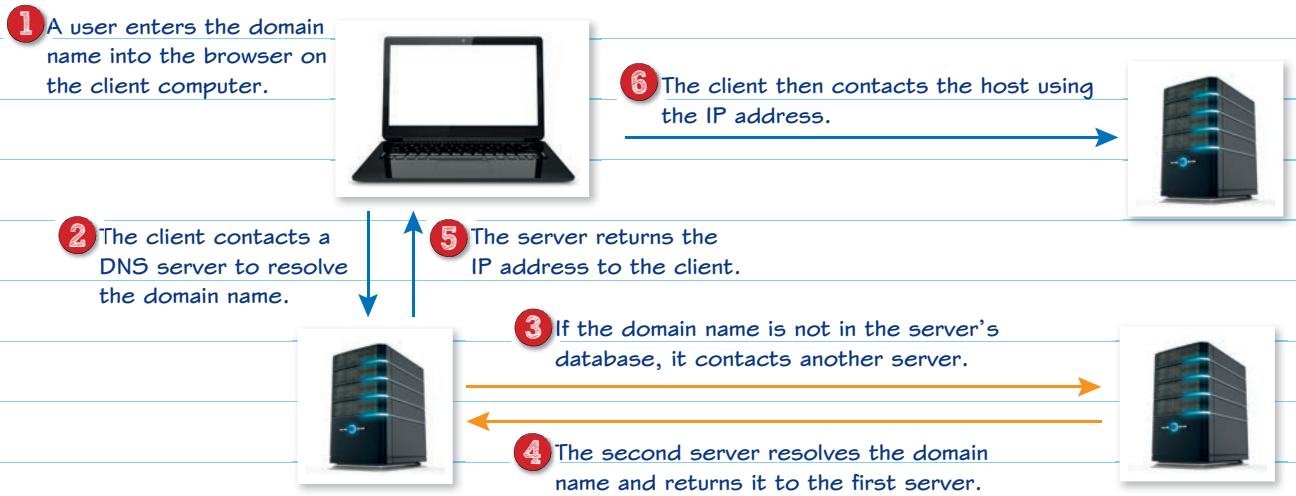
IP addresses are either 32 bit (IPv4) or 128 bit (IPv6) numbers.

IP addresses are represented as URLs, e.g. www.mysite.co.uk as they are easier to remember mysite.co.uk is the **domain name**.

When a user uses the domain name, a **domain name service (DNS)** translates it back into the IP address.

Domain name service (DNS)

When a browser requests access to a host using its domain name, the client computer contacts a DNS server. The DNS server contains a database of domain names that allows it to look up the domain name and return the IP address. This is known as **resolving the domain name**.



Worked example

(a) Define what is meant by web hosting. **(2 marks)**

A web host provides space for a website on a server so that it can be accessed by internet users.

(b) Give **two** advantages of using a web host. **(2 marks)**

The user does not need the technical knowledge to set up a web server or ensure that it is secure from hackers.

Part (a) asks you to **define**. Two points are required and the answer explains that space is provided on a server and that it allows access to internet users.

Part (b) asks you to **give** and full explanations are not required. Other correct answers could be that the user does not need to keep their computer switched on all the time or does not need to have a very high speed broadband connection.

Now try this

1 Explain why domain names are used. **(2 marks)**

2 Describe the process that takes place when a user requests access to a host using its domain name. **(3 marks)**

Had a look ☐ Nearly there ☐ Nailed it! ☐

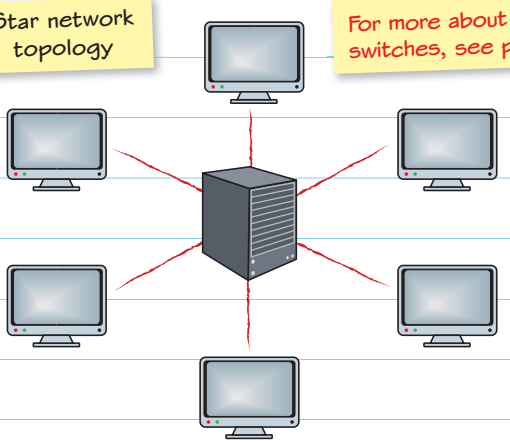
Network topologies

The topology of a network describes how the devices are arranged and connected together.

Star topology

In a star network, each computer or client is connected **individually** to a central point or **node**, which can be a file server, hub or switch.

Star network topology

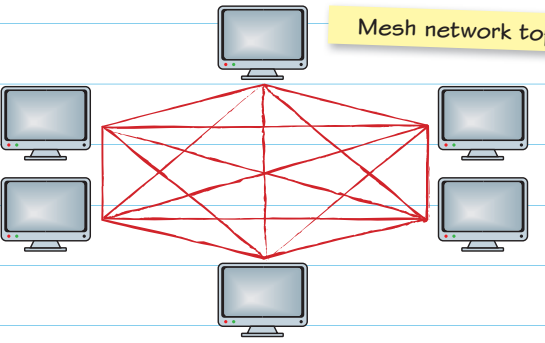


For more about hubs and switches, see page 16.

Mesh topology

In a mesh network, each computer or client is connected to **all the other computers** in the network. Every computer sends its own signals but also relays data from the others. Mesh networks are commonly used with wireless networks where there is high demand.

Mesh network topology



Using a star network

- 👍 Data is only directed to the intended computer directly.
- 👍 Network traffic is kept to a minimum.
- 👍 If one link fails, all the other devices will continue to operate.
- 👍 It is easy to add new devices without disrupting the network.
- 👎 If the central point fails, then so will the entire network.
- 👎 Requires a lot of cable as each computer is connected individually to the central component.

Using a mesh network

- 👍 Data can be transmitted from different devices simultaneously.
- 👍 If one component fails, there is always an alternative route for data.
- 👍 Can handle high volumes of data traffic.
- 👍 Adding more devices will not slow the data transmission.
- 👎 Overall cost is high. More cable is required unless a wireless network is used.
- 👎 Difficult to manage and requires expert supervision.

Worked example

A small business has set up a network with a star topology.

Give **three** reasons why the business might choose a star topology for its LAN. **(3 marks)**

It is easy to add new devices without disrupting the network.

Data can be sent only to the intended recipient without having to send it to all computers, which increases the efficiency of the network as there will be less network traffic.

If one computer fails it does not affect the rest of the network and the work of the business will be able to continue.

You must give **three** different reasons and a statement about each, this student has only given three. You could make comparisons with other topologies that highlight the advantages.

You do not need to spend time drawing accurate diagrams of computers. Simple boxes labelled 'computer' will be enough.

Now try this

1 State what is meant by the term 'network topology'. **(1 mark)**

2 With the aid of a diagram, describe a mesh network topology. **(3 marks)**

3 Explain **one** advantage of a mesh network over a star network. **(2 marks)**

Protocols 1: browsers and email clients

Protocols are the rules that computers must follow when they are communicating and sending and receiving data over a network.

Protocols

Protocols are needed to ensure that data is sent and received accurately, and that it is sent to the correct address on a network. Protocols need to include:

- data formats, to ensure that data can be exchanged consistently and correctly
- address formats, to identify senders and recipients and to ensure that data goes to the right places
- routing, to provide the right information so that data can flow through networks correctly.

TCP/IP

TCP/IP stands for **T**ransmission **C**ontrol **P**rotocol/**I**nternet **P**rotocol. TCP/IP is a set or **stack** of protocols that allows a computer to communicate across a wide area network. The protocols:

- split the data into smaller **packets**, reassemble packets on arrival and encrypt/decrypt as required
- add an address in order to transmit the data to the correct destination
- notify the sending computer that the data has been received.

For more about TCP/IP, see page 20.

Protocols used by applications such as web browsers and email clients

FTP	**File Transfer Protocol** provides the rules for file transfer between computers. It is often used to transfer files that are too large for attachment to emails.
HTTP	**Hypertext Transfer Protocol** provides the rules to be followed by a web browser and a web server when requesting and supplying information. It is used for sending requests from a web client (a browser) to a web server and returning web content from the server back to the client.
HTTPS	**Secure HTTP** ensures that communications between a host and client are secure by encrypting communications.
SMTP	**Simple Mail Transfer Protocol** provides the rules for sending email messages from client to server and then from server to server until it reaches its destination.
POP	**Post Office Protocol** is used by a client to retrieve emails from a mail server. All of the emails are downloaded when there is a connection between client and server.
IMAP	**Internet Message Access Protocol.** Unlike POP, the messages do not have to be downloaded. They can be read and stored on the message server. This is better for users with many different devices as they can be read from all devices rather than being downloaded to just one.

Worked example

TCP/IP is a protocol stack used to transmit data over a wide area network.

List **three** tasks carried out by protocols in the transmission of data over a network. **(3 marks)**

Split the data into packets.

Add the address of the recipient computer.

Notify the sending computer when the data is received.

Now try this

POP and IMAP are both email protocols. Explain how they differ from each other and give a benefit of each. **(3 marks)**

This is a **list** question, so it does not need any descriptions or explanations.

Had a look ☐ Nearly there ☐ Nailed it! ☐

Protocols 2: network layers

Protocols are organised into separate layers of the four layer TCP/IP suite. It is sometimes called a 'stack' as the protocols are organised in four levels.

Network layers

The protocols of the TCP/IP stack are organised into layers through which all data must pass. Incoming and outgoing data pass through the layers where packaging data are added or read.

The four layer TCP/IP model

Each layer of the model has a specific job to do in order for communication to take place over the network.

Purpose	Layer	Protocols
Provides services to applications such as web browsers and email clients. This is where requests are made to web servers or emails are sent.	Application layer	FTP, HTTP, HTTPS, SMTP, POP, IMAP See page 19 for more on these protocols.
Divides data sent from the application layer into packets. Checks that data sent has been received and notifies sender that data has been received.	Transport layer	Transmission Control Protocol (TCP) User Datagram Protocol (UDP)
Adds the source and destination IP addresses to the data and routes it to the recipient computer.	Internet layer (also called Network layer)	Internet Protocol (IP)
Uses network-specific protocols to ensure correct transmission of data through the local network.	Network Access layer (also called Data Link layer)	Ethernet or Wi-Fi Protocols

Worked example

TCP/IP is a protocol stack used in networking. Place the four layers of the TCP/IP stack into order (1–4, where 1 is the top layer and 4 is the bottom layer). **(2 marks)**

Layer	Order (1–4)
Transport	2
Network Access	4
Internet	3
Application	1

This question does not require any descriptions or explanations.

The question must be read carefully to ensure that you know whether 1 represents the top or the bottom layer.

Mnemonics are a good way of remembering things and the following one helps with remembering the order of the layers:

TCP/IP comes in A TIN.

Now try this

TCP/IP is a protocol stack used in networking.

Explain what is meant by the term 'protocol stack'. **(3 marks)**