IGCSE 03 Hardware (1)

Von Neumann architecture main novel features

1. The concept of a central processing unit (CPU or processor).
2. The processor was able to access the memory directly.
3. Computer memories could store programs as well as data.
4. Stored programs were made up of instructions which could be executed in sequential order.

Components of a typical CPU

Arithmetic Logic Unit(ALU):

1. internal part of the CPU that carries out **calculations** on data.
2. The **arithmetic part** uses the usual operators such as multiply, divide, add and subtract.
3. The **logic part** carries out comparisons such as 'equal to', 'grater than' and 'less than'.
4. Values need to be placed in the **accumulator** for calculations to be carried out.

Computers can have more than one ALU.
The ALU allows multiplication and division using shifting operators

Control Unit(CU):

1. **controls the flow of data** through the CPU.
2. also **controls the interactions** between the different parts of the CPU..
3. **Signals are generated** during the Fetch-Decode-Execute cycle to control all components of the computer.
4. **decode**

Registers:

1. internal memory locations within the CPU.
2. The **temporarily hold data** and instructions during processing
3. Registers are used to move data and instructions into and around the different components of the CPU

System clock:

1. used to produce timing signals on the control bus to ensure all functions are **synchronised**.
2. Changing clock speed can improve performance but there is always the risk of **overclocking** (which can lead to overheating and system crashes).

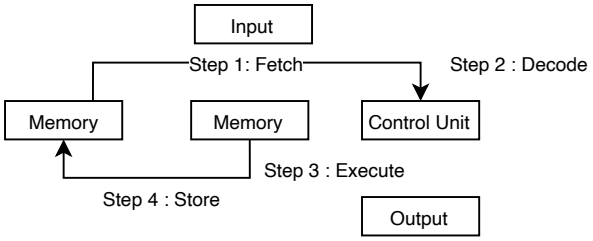
Buses:

1. connected to one another and this is usually done through buses.
2. A bus is a series of conductors, or pathways, which can be considered a sort of 'highway' for information. Three separate buses are used:
   1. The **dafa bus** carries the data.
   2. The **address bus** carries the memory address.
   3. The **control bus** carries the instructions.

Memory

How to speed up CPU Performance

1. increases the **processing speed** of the CPU
2. The **width of the address bus and data bus** increases the processing speed of the CPU
3. **Caches**, which store frequently used instructions and data, can speed up CPU performance. The larger the **cache memory size** the better the CPU performance.
4. Using a **different number of cores** can also improve CPU performance.



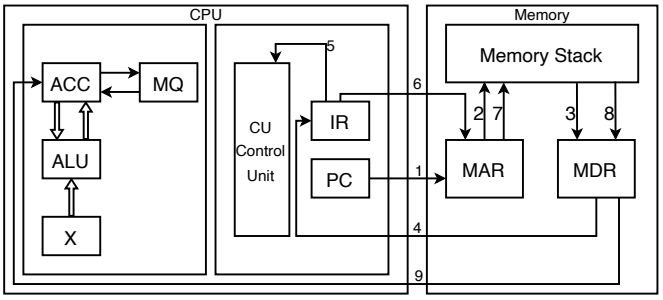
The Fetch-execute cycle:

Step 1 - **Fetch the instruction**: The CPU fetches the necessary data and instructions and stores them in its own internal memory locations (the IAS). To fetch the instruction the CPU uses the address bus.

Step 2 - **Decoding the instruction**: The CPU now needs to understand the instruction it has just fetched. To do this it needs to decode the instruction.

Step 3 - **Executing the instruction**

Now the CPU understands the instruction, it can execute the instruction.
Once the CPU has executed the instruction the cycle can begin again for the next instruction.



Fetch : PC → MAR → Memory → MDR → IR
Decode: IR → CU
Execute: IR → MAR → Memory → MDR → ACC

Representation of the fetch stage of the fetch-execute cycle:
MAR ← [PC]
PC ← [PC] + 1; MDR ← [[MAR]]
CIR ← [MDR]

Embedded System

An embedded system is a combination of hardware and software designed to carry out **a specific task**.

Microcontroller

Made up of a CPU with RAM, ROM and peripherals all embedded on **a single chip** to carry out a **specific task**.

Microprocessor

Integrated circuit consisting of CPU only (no peripherals).

System on a chip

May contain a microcontroller as one of its components; usually includes a CPU, memory, input/output (I/O) ports and secondary storage **all on a single chip**.

Embedded System benefits:

1. They are **small in size** and therefore easy to fit into devices.
2. Compared to other systems, they are relatively **low cost** to make.
3. They are usually **dedicated to one task** making for simple interfaces and often no requirement for an operating system.
4. They consume very **little power**.
5. They can be **controlled remotely** using a mobile phone, for example.
6. Very fast reaction to changing input (operate in real time and are feedback orientated); with mass production comes reliability.

Embedded System drawbacks:

1. It can be **difficult to upgrade** some devices to take advantage of new technology.
2. **Troubleshooting faults** in the device is a specialist task.
3. Although the interface can appear to be simple (such as a single knob) in reality it can be more confusing (for example, changing the time on a cooker clock can require several steps).
4. Any device that can be accessed over the internet is also **open to hackers viruses** and so on.
5. Due to the **difficulty in upgrading and fault finding**, devices are often just thrown away rather than being repaired (very wasteful).
6. Can **lead to environmental issues** created by an increase in the 'throw away' society if devices are discarded just because they have become out of date.

Examples of embedded systems:

1. **security systems** (use sensors, such as temperature, acoustic and pressure, to monitor for intruders and sound an alarm if necessary)
2. **set-top box to record and play back television programmers** (allow aerial, cable, satellite or Wi-Fi inputs and can be controlled remotely)
3. **lighting applications** (to control lighting depending on time of day, whether a room is occupied and brightness of ambient light; makes use of sensors and actuators to monitor and control lighting levels)
4. **vending machines** (monitor selection, money entered, tilting of machine and delivery of items using actuators and motors; uses sensors to detect tilting, temperature and to count money entered)
5. **washing machines** (selection is via keypad which allows wash program to be selected)
6. **motor vehicles** (fuel injection system, Global Positioning System (GPS) navigation, in-car entertainment, anti-lock braking system (ABS), and so on).

Instruction set

Instructions are a **set of operations** that need to be decoded in sequence;
each operation is made up of an **opcode** and an **operand**.
Instruction sets are **low level language** instructions that instruct the CPU how to carry out an operation.

IGCSE 03 Hardware (2)

Input Devices

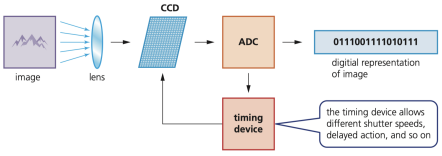
Barcode: A barcode is a series of dark and light parallel lines of varying thickness. The numbers 0 to 9 are each represented by a unique series of lines.

Barcode Scanner(readers):

1. the barcode is first of all **read by a red laser or red LED** (light emitting diode)
2. light is **reflected back off the barcode**; the dark areas reflect little or no light, which allows the bars to be read
3. the reflected light is **read by sensors** (photoelectric cells)
4. as the laser or LED light is scanned across the barcode, a pattern is generated, which is **converted into digital data** – this allows the computer to understand the barcode

Digital Cameras:

Digital images taken by cameras can easily be transferred to a computer (or other device) via **USB port**, **Bluetooth** (wireless transfer) or **memory card reader.**



Keyboard:

1. physical keyboards
2. virtual keyboards
3. touchscreen

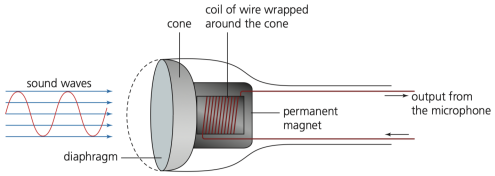
Entry of data via a keyboard is a slow process which is also prone to error and can lead to injuries such as **repetitive strain injury (RSI)**.

Microphones:

a number of applications:

1. **sensor** - detect sound in an intruder detection system
2. **input text into a computer** - particular benefit to a disabled person who cannot use a keyboard
3. **doing voiceovers on presentation slides**

Microphones convert sound into electric currents of varying amplitude. The electric current can be converted into digital data and then stored in a computer memory.



Optical mouse:

The optical mouse is an example of a **pointing device**. It uses tiny cameras and a red LED light source to allow the exact position of the mouse to be calculated.

Advantages of an optical mouse compared to a mechanical mouse:

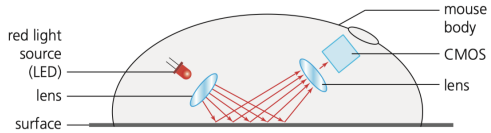
1. **No moving parts** therefore more reliable.
2. Dirt **can't get trapped** in any components.
3. **No need for special software.**

Advantages of a wired mouse (using USB) compared to a wireless mouse

1. Unlike Bluetooth, wired connections have **no signal loss**.
2. **Cheaper to use** (no need for batteries).
3. **Fewer environmental issues** (for example, disposal of batteries).

Scanners

2D scanners



Computers equipped with **optical character recognition (OCR)** software allow the scanned text to be converted into a **text file format**

usages:

1. **airports**: read passports enabling automatic border controls
2. **Scanning faces**: control entry to a building or as a security device on a smartphone to prevent unauthorised use.

3D scanners:

3D scanners scan solid objects and produce a 3D image that can then be used in computer-aided design (CAD) software or even sent to a 3D printer allowing the scanned object to be duplicated.

3D scanner technology uses lasers, X-rays, magnetic resonance or white light.

usages:

1. **tomography**: medical applications to build up images of parts of the human anatomy
2. **magnetic resonance imaging (MRI)** scanners use radio frequencies.

Touch screens:

Capacitive touch screens:

1. surface captive screens
2. projective capacitive screens: multi-touch facility (pinching and sliding) is allowed.

Infrared touch screens:

1. Uses a glass screen and an array of sensors and infrared transmitters.
2. Allows multi-touch facility.
3. Has good screen durability.

Resistive touch screen:

1. Made up of two layers of polymer and glass.
2. Low sensitivity and doesn't allow multi-touch facilities.
3. Has good resistance to dust and water.

Output Devices

Actuators: a mechanical or electromechanical device, such as a relay, solenoid or motor.

Light projectors:

Light projectors are used to project computer output onto a larger screen or interactive whiteboard;

Liquid crystal display (LCD) projector:

1. Uses many micro mirrors arranged on a DMD chip.
2. These mirrors can move according to the data sent to them from the computer.
3. Micro mirrors produce a greyscale image of the light source
4. A bright light is shone on the DMD chip passing through an RGB filter where the greyscale image is now converted into a full-colour image.

Advantages:

1. Gives a **sharper image** than DLP projectors.
2. Has **better colour saturation** than DLP projectors.
3. More **efficient** in its use of energy than DLP technology – consequently it generates less heat.

Disadvantages:

1. Although improving, the contrast ratios are not as good as DLPs.
2. Has a **limited life**
3. Since LCD panels are organic in nature, they tend to **degrade with time**

Digital light projectors (DLP):

1. A powerful beam of light is sent to a chromatic-coated mirror which splits the image into red, green and blue components.
2. The images are recombined using a prism which produces an enlarged full-colour image.

Advantages:

1. **Higher contrast ratios**.
2. **Higher reliability/longevity**.
3. **Quieter** running than LCD projector.
4. Uses a single DMD chip which equates to no issues lining up the images.
5. **Smaller and lighter** than LCD projectors.
6. It is better suited to dusty or smoky atmospheres than LCD projectors.

Disadvantages:

1. Image tends to suffer from '**shadows**' when showing a moving image.
2. Does not have **grey components** in the image.
3. The **colour definition** is frequently not as good as LCD projectors (that is, the colour saturation is not as good).

Printers:

Inkjet printers

Inkjet printers rely on **spraying liquid ink** droplets from a reservoir onto paper; they use either **thermal bubble** or **piezoelectric** technology to create the ink bubbles and droplets. Stepper motors move paper up a line at a time and the print head moves across the page left to right.

The inkjet ink cartridges and paper trays are **only suitable for relatively small print runs**

Laser printers

Laser printers rely on using **dry powder ink** (known as toner); this solid ink is melted onto the paper using a **fuser**. The position where text or images is to be printed is **charged negatively on a drum using a laser**. Positively charged ink then sticks to the areas of negative charge on the **drum** which is then transferred to a sheet of paper as the drum rotates. The **whole page is produced in one go**.

Ink/toner cartridges and paper trays are much larger than those used in inkjet printers; consequently, laser printers are more suitable for **large print runs**

3D printers:

3D printers are used to produce solid objects that actually work; the printers are based on inkjet and laser printer technology.

Direct 3D printing uses a print head moving left to right and up and down as it **builds up the thin layers**

Binder 3D printing works in a similar way to direct printing, except there are two passes of the print head for each layer; the first pass is dry powder and the second pass is a binding agent

usages:

1. **medicine**: prosthetic limbs and reconstructive surgery
2. **aerospace**: make light-weight parts
3. **fashion and art**: create one-off dresses
4. **sculptures**: make copies of rare paintings
5. **making parts for items**: vintage and veteran cars

LED screen

An LED screen is made up of many tiny light emitting diodes. Each LED is red, green or blue. By varying the electric current to each diode, its brightness is controlled which results in millions of different colours.

LED screens are used in large outdoor advertising displays and large scoreboards at sporting events.

LEDs are used to backlight LCD screens because:

1. they reach maximum brightness immediately
2. they produce a very white light which gives good colour definition
3. they last almost indefinitely and consume very little power.

LCD screen

LCD screens are made up of millions of tiny liquid crystals arranged as a matrix (array) of pixels. By varying the electric field to the liquid crystals their properties change.

Since LCDs do not produce any light, they need to be backlit with a light source, such as LEDs.

OLED screen (organic light emitting diodes)

1. allow very thin screens (2 mm or less in thickness), which means they can be formed into almost any shape
2. provides brighter colours than LED backlit LCD screens
3. allow for true black, unlike LCD
4. consume very little power.

Speakers

Loudspeakers produce sound from varying electric currents.

digital to analogue converter (DAC)

IGCSE 03 Hardware (3)

Sensors:

1. Sensors are input devices which read or measure physical properties from their surroundings.
2. Real data is analogue in nature; this means it is constantly changing and doesn't have a single discrete value. This is usually achieved by an analogue to digital converter (ADC). This device converts physical values into discrete digital values.

Sensors

Sensor	Description	Example applications
Temperature	Measures temperature of the surroundings by sending signals; these signals will change as the temperature changes.	1. control central heating system 2. control/monitor chemical processes 3.control/monitor temperature in a greenhouse
Moisture	Measures water levels in, for example, soil (it is based on the electrical resistance of the sample being monitored).	1. control/monitor moisture levels in soil 2. monitor moisture levels in a food processing factory
Humidity	Slightly different to moisture; measures the amount of water vapour in, for example, a sample of air (based on the fact that the conductivity of air will change depending on amount of water present).	1. monitor humidity levels in a building 2. monitor humidity levels in a factory manufacturing microchips 3. monitor/control humidity levels in the air in a greenhouse
Light	Use photoelectrical cells which produce an output (in the form of an electric current) depending on the brightness of the light.	1. switch street lights off or on depending on light levels 2. switch on car headlights automatically when it gets dark
Infrared (active)	Use an invisible beam of infrared radiation picked up by a detector; if the beam is broken, then there will be a change in the amount of infrared radiation reaching the detector (sensor).	1. turn on car windscreen wipers automatically when it detects rain on the windscreen 2. security alarm system (intruder breaks the infrared beam)
Infrared (passive)	Measure the heat radiation given off by an object; for example the temperature of an intruder or the temperature in a fridge.	1. security alarm system (detects body heat) 2. monitor the temperature inside an industrial freezer or chiller unit
Pressure	A transducer that generates different electric currents depending on the pressure applied.	1. weigh lorries at a weigh station 2. measure the gas pressure in a nuclear reactor
Acoustic/ sound	Basically microphones that convert detected sound into electric signals/pulses.	1. pick up the noise of footsteps in a security system 2. detect the sound of liquids dripping at a faulty pipe joint
Gas	Most common ones are oxygen or carbon dioxide sensors; they use various methods to detect the gas being monitored and produce outputs which vary with the oxygen or carbon dioxide levels present.	1. monitor pollution levels in the air at an airport 2. monitor oxygen and carbon dioxide levels in a greenhouse 3. monitor oxygen levels in a car exhaust
pH	Measure change in voltages in, for example, soil depending on how acidic the soil is.	1. monitor/control acidity levels in soil 2. control acidity levels in a chemical process
Magnetic field	Measure changes in magnetic fields the signal output will depend on how the magnetic field changes.	1. detect magnetic field changes (for example, in mobile phones and CD players) 2. anti-lock braking systems in cars
Accelerometer	Measure acceleration and motion of an application, that is, the change in velocity (a piezoelectric cell is used whose output varies according the change in velocity).	1. measure rapid deceleration in cars, and apply airbags in a crash 2. change between portrait and landscape mode in mobile phones
Proximity	Detect the presence of a nearby object.	detect when a face is close to a mobile phone screen and switch off screen when held to the ear
Flow (rate)	Measure the flow rate of a moving liquid or gas and produce an output based on the amount of liquid or gas passing over the sensor.	1. in respiratory devices and inhalers in hospitals 2. measure gas flows in pipes (for example, natural gas)
Level	Use ultrasonics (to detect changing levels in, for example, a tank) or capacitance/ conductivity to measure static levels (for example, height of water in a river) note level sensors can also be optical or mechanical in nature.	1. monitor levels in a petrol tank in a car 2. in a pharmaceutical process where powder levels in tablet production need to be monitored 3. leak detection in refrigerant (air conditioning)

difference between primary memory and storage device:

primary memory:

1. Directly addressable by the CPU
2. Contains RAM, ROM and cache memory

secondary storage:

1. **Not directly addressable** by the CPU
2. All are **non-volatile** devices
3. Can be external or internal to the computer
4. Examples include **HDD, SSD, DVD, memory stick, Blu-ray disc**

random access memory(RAM):

1. **can be written to or read from**, and the data can be changed by the user or the computer (i.e. it is a temporary memory)
2. used to **store data**, files, part of an application or part of the operating system **currently in use**
3. it is **volatile**, which means memory contents are lost when powering off the computer.

Dynamic RAM (DRAM):

1. needs to be **constantly refreshed**
2. If it **wasn't refreshed**, the capacitor's charge would leak away very quickly leaving every capacitor with the value 0.

Dynamic DRAM advantages over SRAM:

1. they are **much less expensive** to manufacture than SRAM
2. they consume **less power** than SRAM
3. they have a **higher memory capacity** than SRAM.

Static RAM(SRAM):

1. A major difference between SRAM and DRAM is that SRAM doesn't need to be constantly **refreshed**.
2. It makes use of flip flops, which hold each bit of memory.

Differences between DRAM and SRAM

DRAM	SRAM
consists of **a number of transistors** and capacitors	uses **flip flops** to hold each bit of memory
needs to be **constantly refreshed**	doesn't need to be constantly refreshed
less expensive to manufacture than SRAM	has a faster data access time than DRAM
has a **higher memory capacity** than SRAM	**CPU memory cache** makes use of SRAM
main memory is constructed from DRAM	
consumes **less power** than SRAM	

read-only memory (ROM):

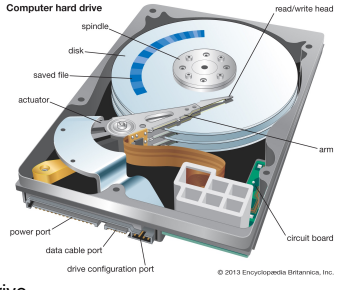
1. they are **non-volatile** (the contents are not lost after powering off the computer)
2. they are **permanent memories** (the contents cannot be changed or written to by the user, the computer or any application/program)
3. the contents can **only be read**
4. they are often used to store data that the computer needs to access when powering up for the first time (the basic input/output system (**BIOS**)); these are known as the start-up instructions (or bootstrap)

RAM	ROM
temporary memory device	**permanent** memory device
volatile memory	**non-volatile** memory device
can be written to and read from	data stored cannot be altered
used to store data, files, programs, part of OS currently in use	always used to store BIOS and other data needed at start up
can be increased in size to improve operational speed of a computer	

Secondary and off-line storage:

1. storage devices that are **not directly addressable** by the CPU.
2. **non-volatile devices** that allow data to be stored as long as required by the user.
3. data access time is considerably longer than with RAM or ROM
4. All applications, the operating system, device drivers and general files are stored on secondary storage.

Magnetic storage:



1. Data is stored in a digital format on the magnetic surfaces of the disks (or platters, as they are frequently called).
2. The hard disk drive will have **a number of platters** that can **spin** at about 7000 times a second.
3. **Read-write heads** consist of electromagnets that are used to read data from or write data to the platters.
4. A number of read-write heads can access all of the surfaces of the platters in the disk drive.
5. Data is stored on the surface in **sectors** and **tracks**.
6. A sector on a given track will contain a fixed number of bytes.
7. hard disk drives have very **slow data access** when compared to, for example, RAM.
8. The effects of latency then become very significant. Latency is defined as the time it takes for a specific block of data on a data track to rotate around to the read-write head.

IGCSE 03 Hardware (4)

Solid state drivers (SSD)
1. they are **more reliable** (no moving parts to go wrong)
2. they are considerably **lighter** (which makes them suitable for laptops)
3. they don't have to '**get up to speed**' before they work properly
4. they have a lower power consumption
5. they run **much cooler** than HDDs (both these points again make them very suitable for laptop computers)
6. because of no moving parts, they are very **thin**
7. data access is **considerably faster** than HDD.

Benefits of SSDs compared to HDDS:
1. More reliable (no moving parts).
2. Much lighter weight.
3. No need to 'get up to speed' before data access.
4. Less power consumption.
5. Run much cooler.
6. Very thin due to solid-state technology.
7. Much faster data access.

Drawbacks of SSDs compared to HDDs:
1. Longevity (SSD endurance) is still an issue (but this situation continues to improve).
2. The memory chips in a solid-state storage device have a limited number of write cycles – this can lead to unrecoverable data loss.
3. If the controller chip, memory cache, or one of the NAND memory chips has been damaged, it may be impossible to recover the data.

Memory sticks, **flash memories**, **SD cards** and **SSDs** all use solid-state technology.

Memory sticks/flash memories: They usually connect to the computer through the USB port. Their main advantage is that they are very small, lightweight devices, which make them very suitable as a method for transferring files between computers.

USB benefits:
1. It is a **universal standard**
2. It can't be inserted the wrong way around
3. **Supports different transmission speeds**
4. Automatically detects if correct driver installed

CD/DVD disks: CDs and DVDs are described as optical storage devices. Laser light is used to read and write data to and from the surface of the disk.

similarities between a CD and a DVD:
1. Both need a red laser to read/write data
2. Both are spun to be read
3. Both use spiral tracks for data
4. Both are optical storage
5. Both are off-line storage // both non-volatile
6. Both use pits and lands to store data

difference between CD and DVD:
1. DVD can be dual layer, but CD can only be single
2. DVD has higher storage capacity
3. DVD has a shorter wavelength laser
4. DVD are spun faster
5. DVDs have a higher data transfer rate

Blu-ray discs： optical storage media

main differences between DVD and Blu-ray：
1. a blue laser, rather than a red laser, is used to carry out read and write operations; the wavelength of blue light is only 405 nanometres (compared to 650 nm for red light)
2. 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, duallayer Blu-ray and normal DVDs both use a sandwich of two 0.6 mm thick disks
3. Blu-ray disks automatically come with a secure encryption system that helps to prevent piracy and copyright infringement
4. the data transfer rate for a DVD is 10 Mbps and for a Blu-ray disc it is 36 Mbps.

Virtual Memory
RAM is known as the physical memory and virtual memory is the **RAM plus swap space**
Part of memory mapping is called **paging**, which is used by memory management to store and retrieve data (a **page** is a fixed length **contiguous** block of data utilised in virtual memory systems).
Virtual memory gives the illusion of unlimited RAM; even when RAM is 'full', pages of data can be moved to and from HDD/SSD to give the illusion that RAM is always available.

Benefits of virtual memory
1. With virtual memory, programs can be **larger than physical RAM and still be executed**.
2. Virtual memory **reduces the need to buy and install extra RAM** (which is expensive).

Routers
Routers enable **data packets** to be routed between different networks, for example a **local area network (LAN)** to a **wide area network (WAN)**.

Routers take data transmitted in one format (protocol) from network 'A' and convert the data to another format (protocol) that network 'B' understands. This allows communication between networks to take place.

Cloud storage
Cloud storage is the storing of vast quantities of data on remote physical servers.

three types of cloud storage
1. Public cloud – the client and cloud storage provider are different companies.
2. Private cloud – a dedicated system behind a firewall where the client and storage provider operate as a single entity.
3. Hybrid cloud – a combination of public and private cloud provider where the most sensitive data is stored on the private cloud.

Data redundancy
When using cloud storage, the same data is stored on more than one server in case of maintenance/repair

Benefits of cloud storage
1. Customer/client files stored on the cloud can be **accessed at any time** from any device anywhere in the world provided internet access is available.
2. There is **no need** for a customer/client to carry an **external storage device** with them, or even use the same computer to store and retrieve information.
3. The cloud provides the user with **remote back-up** of data with obvious benefits to alleviate data loss/ disaster recovery.
4. If a customer/client has a failure of their hard disk or back-up device, cloud storage will allow **recovery of their data**.
5. The cloud system offers almost **unlimited storage capacity**.).

Drawbacks of cloud storage
1. If the customer/client has a slow or **unstable internet connection**, they would have many problems accessing or downloading their data/files.
2. **Costs** can be high if large storage capacity is required; it can also be expensive to pay for high download/ upload data transfer limits with the customer/client internet service provider (ISP).
3. The potential failure of the cloud storage company is always possible – this poses a risk of **loss of all back-up data**.
4. **Data security issues** – how safely stored and protected is the data from hacking, natural disasters and malware?

Network hardware
network interface card (NIC): allow a device to connect to a network.
The NIC contains the **Media Access Control (MAC)** address, generated at the manufacturing stage.
Wireless NICs (WNICs):
plug into the USB port or can be part of an internal integrated circuit.

MAC address: Media Access Control addresses
MAC addresses identify a device connected to a network.
They are made up of 48 bits written in groups of six hex digits
NN - NN - NN - DD - DD - DD
manufacturer's code **device serial number**

IP Address: Internet Protocol addresses
When a device connects to a network, a router assigns the device an Internet Protocol (IP) address, via a Dynamic Host Configuration Protocol (DHCP) server, which is **unique to that network**.

two versions of IP address:
1. **IPv4** (32-bit address with the format A.B.C.D where A, B, C and D can take the values 1 to 255; for example, 215.180.1.80)
2. **IPv6** (128-bit address with the format eight groups of four hex digits; for example, A8FB:7A88:FFF0:0FFF:3D21:2085:66FB:F0FA).

Differences between Dynamic and Static IP Address

Dynamic IP Address	Static IP Address
Changes every time a device connects to a network.	**Permanently** assigned.
Greater privacy since it changes each time a user logs on.	Since static IP addresses don't change, it allows each device to be **fully traceable**.
Dynamic IP addresses can be an issue when using, for example, Voice over Internet Protocol (VoIP) since this type of addressing is less reliable as it can disconnect and change the IP address causing the VoIP connection to fail.	Allows for **faster** upload and download **speeds**.
	More **expensive** to maintain since the device must be constantly running so that information is always available.

Differences between MAC and IP Address

MAC Address	IP Address
Identifies the **physical address** of a device on the network.	Identifies the **global address** on the internet.
Unique for device on the network	May not be unique.
Assigned by the manufacturer of the device and is part of the NIC.	Dynamic IP address is assigned by the ISP using DHCP each time the device connects to the Internet (see later).
Can be universal or local.	Dynamic IP addresses change every time a device connects to the internet; static IP addresses don't change.
When a packet of data is sent and received, the MAC address is used to identify the sender's and recipient's devices.	Used in routing operations as it specifically identifies where the device is connected to the internet.
Uses 48 bits.	Uses either 32 bits (IPv4) or 128 bits (IPv6).
Can be UAA or LAA.	Can be static or dynamic.