Tiverton High School Year 10
J277 GCSE Computer Science
Knowledge Organiser / Recap
Part 1: The Von Neumann Architecture and CPU

Unit 1-1-1 Architecture of an Electronic Computer

A **computer** is an **electronic device** that follows a **stored program of instructions**.

The **program** of instructions tell it **how** to process data and how to make things happen e.g. activate outputs.

A **computer system** is a **collection** of parts that **work together** to perform a task. It is comprised of **hardware** and **software**.

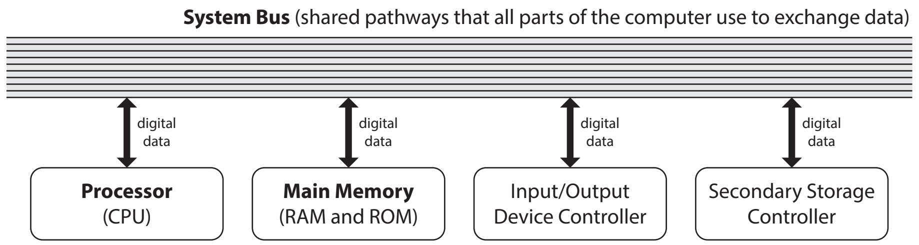
Modern electronic computers are organised in a particular way. This is called the **Von Neumann Architecture**.

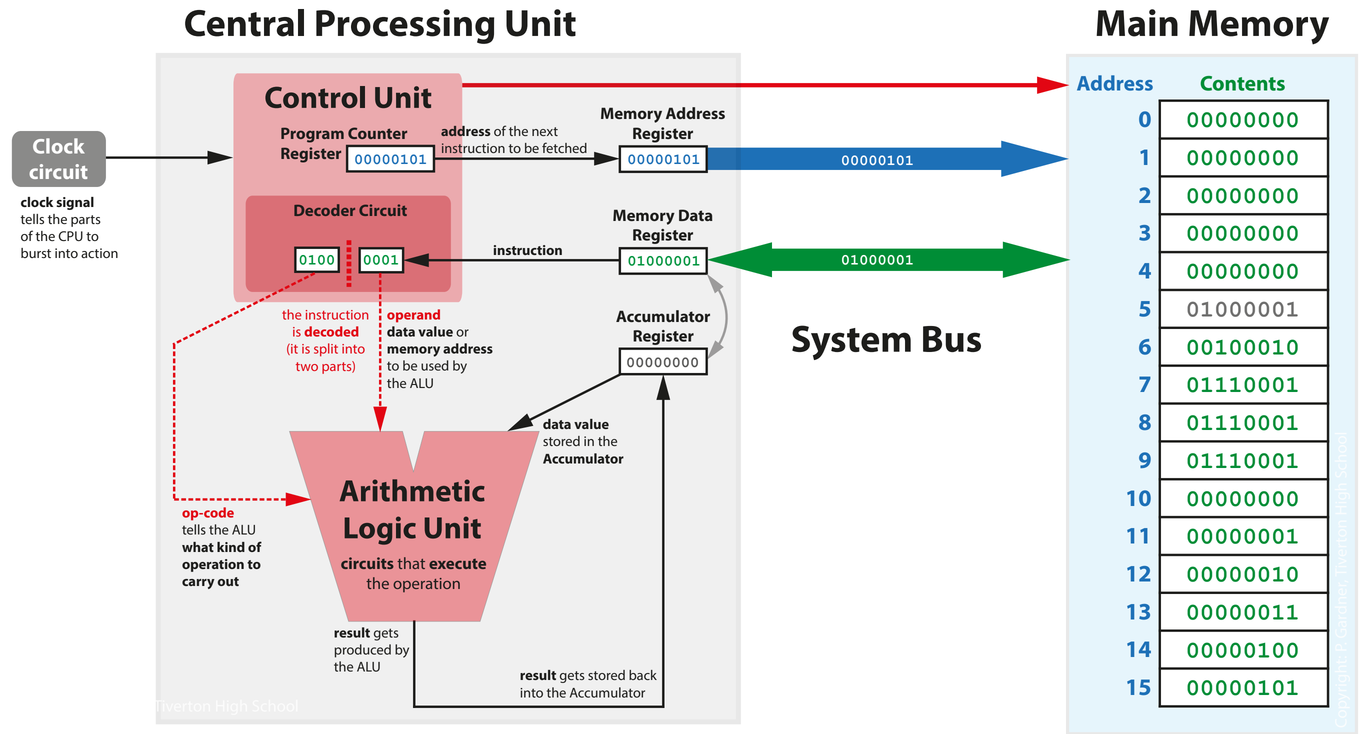
They must contain a **Central Processing Unit (CPU)**, a **main memory** and a **system bus**.

The **CPU** is needed to **execute** the **instructions** from the **program**.
The **Main Memory** (Primary Memory) is used to **store** the **program instructions** and **data values** that the CPU is using.
A **system bus** is a set of **pathways** that program instructions and data can travel along, between different parts of the computer.

Primary Storage (Main Memory) is memory inside the main computer. It is used to hold the program of instructions that the computer will carry out and the data that it will process. Most primary storage is **RAM (Random Access Memory)**.
RAM is **volatile** - it can only store things while the computer is **switched on**.

Secondary Storage Devices store data for **long term/when computer is switched off**.
Examples: **Hard-disk drive**, **solid-state drive**, **optical drive**, **USB Flash-drive**, **magnetic tape drive**.





Unit 1-1-1 Architecture of the Central Processing Unit

The main parts **inside** the CPU are the **Control Unit** and the **Arithmetic Logic Unit**.

Together, these parts carry out the **Fetch-Decode-Execute cycle** to run a computer program.

The **Control Unit supervises the fetching and decoding of each program instruction from main memory**.

The **Arithmetic Logic Unit carries out** (**executes**) **mathematical** (**arithmetic**) **and logical operations** (**comparisons**).

The CPU also contains **Registers**. A register is a **single high-speed memory location inside the CPU**.

The **Program Counter** is a special **register** inside the Control Unit that **holds the memory address of the next program instruction that needs to be fetched** from main memory into the CPU.

When transferring data values and program instructions between the CPU and main memory, the computer uses the **MAR** and **MDR** registers.

MAR (**Memory Address Register**) is used to determine **which memory address will be used in a transfer** between the CPU and main memory.

MDR (**Memory Data Register**) is used as a **buffer** (a holding place) for the actual **value** being transfered into/out of the CPU.

Once the Arithmetic Logic Unit has carried out an operation, any **result** that is produced will usually be stored in a special register called the **Accumulator register**.

Unit 1-1-2 Performance of the CPU

Clock speed - **Increasing the clock speed can potentially increase the number of instructions executed per second**
e.g. increasing clock speed from 2 MHz to 2.5 MHz.

Cache size - **Increasing the cache size will reduce the number of memory transfers between the CPU and RAM**,
so it may speed up processing. With a large cache memory, **less time is spent transferring data between the CPU and RAM**.

Number of cores - **Increasing the number of cores may increase the number of instructions executed per second**
e.g. use a **quad-core** CPU instead of a **single-core** CPU.

Unit 1-1-3 Embedded Systems

An **embedded system** is a **dedicated single-purpose computer** that is **built into some other electronic device**.
The embedded computer **controls the operation of that device**.

Embedded systems usually use **cheap, simple electronic components**, so they are **ideal for mass-produced electronic devices and consumer goods**.

Examples of embedded systems include **burglar-alarms**, **central-heating controllers**, **microwave ovens**, **dishwashers**, **washing machines**, **digital TV receiver boxes** and **smart-TVs**, **robot vacuum cleaners**, **satellite-navigation systems**, **car-alarms** and **engine immobilisers**, **fuel management systems**, **traffic lights** and **pedestrian crossings**, **lifts/elevators**.

An embedded system usually contains these parts:
A **simple CPU** to execute program instructions. This processor may not be very fast or process many bits in one operation.
A **small amount of RAM** to store values that change while the control program is running (e.g. variables that are needed).
A **non-volatile ROM chip** or some **flash memory** to hold the low-level program that the system will run when you switch it on.
Some **input/output ports** that allow it to connect to other components, such as buttons, LED lights, timers etc.

Many of these parts can be built into one single, compact chip, called a "**System On A Chip**".
An embedded system **usually contains fewer parts/components than a general-purpose desktop computer**.
Because they contain fewer, simpler parts, they **usually cost less to produce** and **consume less power than a full-size computer**.

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Part 2: Number Bases and Data Representation

Unit 1-2-3 Number Bases

Binary means base-2 **Denary means base-10** **Hexadecimal means base-16**

Humans traditionally use **denary (base 10)** when dealing with numbers.
Computers always use **binary (base 2)** to store and process digital data.

Electronic computers contain millions of tiny **transistor** components. A transistor behaves like a **switch**, that can only be turned **on** or **off**.

Because binary only uses two possible digits, these closely match the on/off states of the transistors that computers are made of. The **on** or **off states** of transistors can be used to represent the two different number symbols that binary uses:

off means **0**
on means **1**

Unit 1-2-4 Converting Binary to Denary

128	64	32	16	8	4	2	1
0	1	0	0	1	0	1	0

= (**1** x 64) + (**1** x 8) + (**1** x 2) = **74** in base ten

Unit 1-2-4 Converting Binary to Hexadecimal

Convert binary value **01011101** to hexadecimal

0101 **1101**

8	4	2	1
0	1	0	1

= (**1** x 4) + (**1** x 1)
= **5** in base ten
= **5** in hexadecimal

8	4	2	1
1	1	0	1

= (**1** x 8) + (**1** x 4) + (**1** x 1)
= **13** in base ten
= letter **D** in hexadecimal

So binary value **01011101** is **5D in hexadecimal**

Unit 1-2-4 Converting Hexadecimal to Denary

Hexadecimal is a more **compact** and **convenient** way to represent large numbers than binary.

Large numbers can be represented using **fewer** hexadecimal digits.

Hexadecimal numbers can only uses the symbols **0123456789ABCDEF**

A means **10**
B means **11**
C means **12**
D means **13**
E means **14**
F means **15**

16	1
2	**D**

2 groups of 16, plus **D** units.
(**2** x 16) + (**D** x 1)
(**2** x 16) + (**13** x 1)
32 + 13
45 in base 10.

Unit 1-2-4 How Computers Store Text

A **character** is a **symbol** that can be represented and stored by the computer system.
The full collection of ALL of the characters that a computer can represent/store is called a **character set**.
Each character symbol is represented using a **special number**: a **character code**.
All character codes are always stored inside the computer as patterns of **binary digits**.

ASCII is the **American Standard Code for Information Interchange**. It can be used for writing in the English language.
Plain **ASCII** text is often stored using **7 bits per character**.

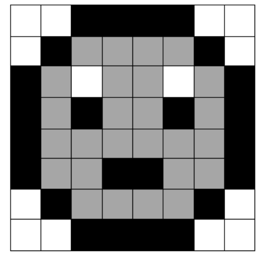
Unicode is a better character set. It can represent **any** language in the world, including Russian and Chinese, not just English.
Unicode uses **up to 32 bits (4 bytes)** to store each character code.

中文 р у с с к и й 日本語 ☺

Emoji pictures are character symbols from the Unicode character set. ASCII and Extended-ASCII do not contain any emojis.

The same English text can be stored more efficiently using ASCII rather than Unicode (because each character code only uses 7 bits).

Unit 1-2-4 How computers Store Images



Bitmap images are **pictures** that are made up of **pixels** (picture elements).

A **pixel** is a small coloured dot in a picture.

All of the pixels are arranged in a grid, a little bit like a mosaic.

The **colour** of each pixel is stored in the memory of the computer using binary digits... **1**s and **0**s.

The **bit-depth** of an image means **how many binary digits are used to store each pixel**.

A **1-bit image** uses exactly **1 bit to store each pixel** in the picture. This allows **2 possible colours**.
A **2-bit image** uses exactly **2 bits to store each pixel** in the picture. This allows **4 possible colours**.
An **8-bit image** uses exactly **8 bits to store each pixel** in the picture. This allows **256 possible colours**.

Photoshop uses **24-bit images**. It uses **24 bits to store each pixel**. This allows **16,777,216 possible colours** for **realistic** pictures.

The **resolution** of an image defines how large the individual pixels are drawn.

Resolution means the **density** of the pixels in an image: **how many pixels will fit into a certain area**.
The higher the resolution, the more life-like the image/better quality, but the more data will be included in the bitmap file.

Most computer **screens** use **72 dots per inch** - large pixels.
Many **printers** use **150 dots per inch** or **300 dots per inch** - the smaller pixels produce a more **detailed** picture on paper.

Many image files contain **extra data**, as well as the pixel data. The extra data is called **meta-data**.

Meta-data can be used by programs to **reconstruct** and display images from a file of binary data.
It includes the **width**, the **height**, the **resolution** and the **bit-depth** of the image.

Extra meta-data can also be included in an image file, such as the **file format**, the **date/time it was created or last changed**, **who owns the copyright** and the **GPS coordinates of where a photo was taken**.

Unit 1-2-4 How Computer Store Audio - Sounds and Music

To represent audio/sound inside a computer, soundwaves are converted to **digital data**.

First of all, a sound wave must be captured by a microphone as **analogue electrical signals**.

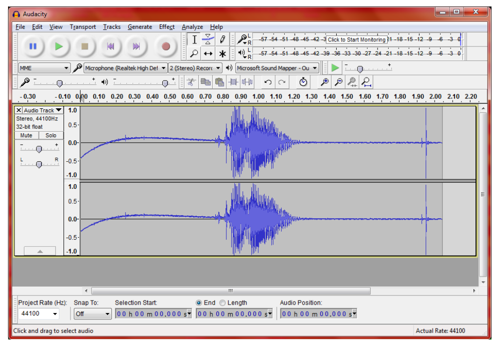
The **height of the sound wave** can then be **measured** at **regular intervals**. We call each measurement a **sample**.

The **number of sample measurements that are generated each second** is called the **sample-rate**. This is specified in **Hertz (Hz)**.

Each sample/measurement is stored in the computer using a binary number.
The **number of binary digits used in each sample** is called the **sample-size**.

A realistic audio file will need to use thousands of samples a second. Common sample rates include **22050 Hz** or **44100 Hz**.
A **higher sample rate** leads to a **larger audio-file**, but a **better-quality recording**.
A **larger sample size** allows more higher frequencies and lower frequencies to be captured, not just mid-frequencies.

To reconstruct a sound from binary data, an audio file needs to contain extra **meta-data** that describes how the binary data is structured and how to play it back:



Duration of the sound (how many **seconds** the recording lasts).

Sample-Rate (**how many samples were used each second** e.g. **8000 Hz**).

Sample-Size (**how many bits each sample contains** e.g. **32 bits**).

Channels (**how many speakers are needed** e.g. **1 for mono**, **2 for stereo**).

Date & time that the audio file was **created or last changed**.

Author, **genre** or **copyright information** about **who** created the recording.

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Part 3: Memory, Storage and Files

Unit 1-2-1 Primary Storage (Main Memory)

Primary storage means **memory that is inside the main computer**. Primary storage usually includes some RAM and some ROM. Primary storage is used to store program instructions and data **for programs that are running**.

RAM means **Random Access Memory**. The contents of any memory location in RAM can be **examined** (read) and also **changed** (written). **RAM is volatile**. All data that was stored in RAM will be **lost** when the power is turned off to the computer. When you switch on the computer, RAM is totally empty.

ROM means **Read-Only Memory**. Instructions and data are **permanently** etched into the circuitry of a ROM chip. **ROM** is **non-volatile**. **The contents of ROM cannot be changed or erased**, they can only be examined. They are **read only**. Anything stored in ROM is **persistent**. The contents of ROM will be **kept**, even when the power is switched off.

RAM and ROM are both made up of **memory locations**. Each memory location can hold a certain number of binary digits. The **contents** of a memory location either hold a **data value** to be processed or a **program instruction** to be executed. Each memory location is given a unique **memory address** (a number) so that you don't confuse it with any other memory locations.

Before you can run a program, it must first be **loaded** into the computer's main memory (the RAM) from secondary storage (e.g. disk). The program instructions are usually copied from a file on a hard disk into a block of memory locations in RAM.

A computer has a limited amount of **physical RAM** to hold programs and data. A hard-disk drive has much more storage space than physical RAM. Data can be stored **temporarily** in a special file on a hard-disk drive to free up space as physical RAM becomes full. Temporarily using secondary storage space instead of physical RAM is called **virtual memory**.

Unit 1-2-2 Secondary Storage

Secondary storage devices are used for **long term storage** of data and instructions. We say that secondary storage is "**persistent**" or "**non-volatile**". Programs and data are stored in **files**. Files are stored **even when the computer is switched off**.

Magnetic Hard Disk Drive
A **high capacity** device that can often store as much as **8 TB** of data on one drive.
Data is stored using tiny **magnetised** areas on a rapidly spinning metal disk.
Magnetic hard-disks can be **damaged** accidentally by a **sudden impacts** or if it is dropped.
Data can be **corrupted** or **erased** accidentally by **magnetic fields** from **speakers**, or **heat**.

Solid State Drive
An alternative to using a magnetic hard disk drive, but does not contain any moving parts.
Data is stored using **tiny components** in **solid-state circuits** called **flash memory**.
Solid-state drives are not affected by magnetic fields or extreme temperatures.
They are very **lightweight** and **impact-proof**, making them ideal for use in laptops.
They cannot hold quite as much data as magnetic disk drives and are **more expensive per GB**.
Solid State Drives can sometimes start to **wear out** after data has been written to the same area a large number of times. Areas of the drive can then become **less reliable** for storing your data.

CD-ROM
A **removable optical disk** that stores data as tiny **pits**, burnt into the surface by a **laser beam**.
A single CD-ROM usually stores up to **700 MB** of data.
Highly **portable**, making it ideal for **backing up files** or **transferring data** to other computers.
Very **cheap to manufacture**, making them ideal to **distribute software utilities** and **audio**.
CDs are **not very durable**. One **scratch** can make individual files or the whole disk **unreadable**.

DVD-ROM
A **removable optical disk**, similar to a CD-ROM, but with a much larger storage capacity.
A single DVD-ROM can store enough compressed data for a **whole feature-length movie**.
It can usually store at least **4.7 GB** of data, although some types of DVD can store much more.
Because a DVD can hold more data than a CD, they are used as **installation disks** for software.

Blu-ray
An **removable optical disk** that can store enough data for **several hours of HD video**.

Unit 1-2-3 Units of Data Storage

A **bit** is the **smallest** amount that a computer can store - one **binary digit**.
8-bit binary means a **pattern** of exactly **8 binary-digits**.
8-bits allow **256 possible combinations** between **00000000** and **11111111**.
This is why 8 bits can represent between **0** and **255** in base ten.

1 byte	=	**8 bits** (an ASCII character takes 1 byte)
1 kilobyte	=	**1000 bytes**
1 megabyte	=	**1000 kilobytes** (or 1000 x 1000 bytes)
1 gigabyte	=	**1000 megabytes** (or 1000 x 1000 x 1000 bytes)
1 terabyte	=	**1000 gigabytes** (or 1000 x 1000 x 1000 x 1000 bytes)
1 petabyte	=	**1000 terabytes** (or 1000 x 1000 x 1000 x 1000 x 1000 bytes)

Unit 1-2-5 Data Storage: Compression and File Types

Music and video files can contain a lot of data. Large files and streams of data can take a long time to transfer over the Internet. If the file can be **compressed**, either by **reorganising** or **reducing the amount of data**, then it can be sent and received **faster**.

Compression re-organises data. Compressed files usually has a **smaller file size** than the original. It takes the computer **time** to compress the data – it's got to work out how to organise the data in a more **efficient** way. Before you can use the data again, the computer needs to **de-compress** the file, which also takes time. It must **re-organise the data** into a form that can be used easily.

Sometimes, parts of the original data are **removed** during compression. When the file is uncompressed again, some of the data will be **lost forever**. This is called **lossy compression**. The data that was removed can **never** be recovered again.

When compressing **executable programs** and **text documents** we need to use **loss-less compression**. Otherwise, if a program instruction was lost, **the program would not be the same**. The **meaning** of a text document could also be **changed**.

Text Documents

.txt is an uncompressed **plain text document**. The text file contains only **unformatted text characters**.

.rtf is an uncompressed **rich-text file**.
The text file contains characters which can be **formatted** using **bold**, **italics**, **colour**, **font sizes** etc.

.pdf is an Adobe **Portable Document Format** file.
It can hold **rich-text**, **font definitions** and high-quality **vector diagrams**.
Because the file contains the **font definitions** for each font face used it is **portable** - the document will look the same, regardless of the type of computer or phone being used.
PDF files can also compress text and pictures to reduce the amount of data that they hold.

Images

.bmp is an uncompressed **bitmap image** format used widely by Microsoft Windows programs.

.tif is an uncompressed **high-quality bitmap image** that can contain **millions of colours**.
TIFF file sizes can be very large as they often contain so much uncompressed data.

.jpg is a bitmap image that uses **lossy compression**.
JPEGs are used widely for **photographs** and can include **millions of colours**, making pictures very **realistic**.

.gif is a compressed bitmap image that can only use up to **256 different colours**.
This is only suitable for **simple graphics** and **animations**, or regions of **flat colour** that are all the same.

.png is a **Portable Network Graphic**. This stores high-quality graphics using one or more separate layers.

Audio/Sound/Music

.wav is an **uncompressed audio waveform**. These files are often very large, but result in high-quality audio.

.mp3 is an **audio file** that uses **lossy compression**.
The MP3 file is usually approximately 10 times smaller than their original. The sound quality can be quite low.

Video/Movies

.avi is an **uncompressed video file** used widely by Microsoft Windows programs.

.mp4 is a **compressed video file** that uses **lossy compression**.

Programs

.exe is an uncompressed **executable program file**.

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J277 GCSE Computer Science
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Part 4: Networks

Unit 1.3.1 Types of Networks

A **stand-alone** computer is a computer that is not connected to any other computer or device.
Stand-alone means a device is not networked. All resources and data that a standalone computer uses are **local** (directly connected).

A **network** is a **collection** of two or more computer devices that are **connected** together.
Networked devices can share resources, programs and data e.g. **printers**, **databases of information**, collections of **documents**.
A networked device can access resources **remotely** using one or more communication links.

A **Local Area Network (LAN)** covers **one single site** (which may include a small number of buildings that are close together).
The distances between devices in a LAN are usually quite small. Devices are often very close together, in the same room or building.

A **Wide Area Network (WAN)** covers a much larger physical area than a LAN.
A Wide Area Network can **link devices together over long distances**. Devices may be many miles apart on different physical sites.
A WAN can cover a whole city, a county, a country or many countries. A WAN may use **leased** or **public communication links**.
Supermarkets, **banks**, **County Councils**, the **police** and the **NHS** all have their own Wide Area Networks.

A **Peer-To-Peer network** is a very small and simple network. It is usually used in a home or by a small business.
In a Peer-to-Peer network, **no single device is in control of the network**. They are all equally important.
Peer-to_peer networks are ideal for simple sharing, such as sharing files between devices or sharing a printer.
Peer-to-Peer networks often use **Wi-Fi** connections or direct **Bluetooth** connections between devices. They are simple to set up.

Some networks are **Client-Server networks**. This means that some devices on the network provide important services or resources to other devices.

A **server** is a networked device that provides a service or resource when **requested** by another device (usually a **client** device).
A server may **control access to a resource**. It may refuse persmission to certain devices that ask for access.

A **client** is a networked device that **requests** to use **services** or **resources** from one or more **servers** on a network.

Unit 1.3.1 Network Hardware

Network Interface Controller (NIC)
This is computer **circuitry** that allows the device to **transmit and recieve data from other networked devices**.
It is installed in a computer device so that the device can be connected to a network. It may be built directly into a motherboard, or can be a separate circuit-board that plugs into an expansion slot..

Hub
A **hub** is a device that **passes data to all devices on a network**, even those that the data is not intended for. This leads to a lot of unwanted data traffic on the network and slow performance.

Switch
A **switch** is a device that **passes data to the one device on a network that the data is intended to reach**.
A switch results in less network traffic than using a hub, so it results in faster network performance.

Wi-Fi access point
A **Wi-Fi access point** can be used to connect devices to a Local Area Network **without cables**.
You can connect smartphones, tablets, laptops and desktop computers. Wi-fi radio signals can usually travel through walls and floors, but not thick concrete. They are slower than transmitting data over cables.

Router
A **router** is a device that allows you to **join networks to other networks**, **allowing data packets to pass between them**.
A router **examines the address of each data packet to determine where it should be sent next**.

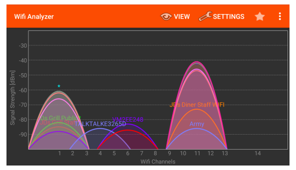
Unit 1.3.1 Factors that affect the performance of a network

Distance between devices.
The further away devices are from each other, the longer it may take for data to be transmitted between them. Electrical data signals travelling over a copper cable weaken over long distances.

Number of devices trying to use the network.
If many devices attempt to use a network resource (such as a server or a particular file) then the network might experience delays. A server may not be able to cope with the demands placed upon it, causing "time out" errors and retries.

Bandwidth available.
If the amount of data being sent by one or more devices uses up all of the available bandwidth, other devices will not be able to transmit their data. Without enough bandwidth, the network may be slow because devices are kept waiting to communicate.

Radio interference, obstacles, physical problems.
Radio signals from other devices may interfere with data being transmitted. If more than one Wi-Fi access point is **transmitting using the same range of frequencies** (**"channel"**) then their data transmissions may be **corrupted**, meaning they might need to repeat their transmission many times.



Trees, thick concrete structures or steel can **block** wireless signals, leading to poor network performance. Devices may need to transmit their data repeatedly until it is successfully received, or they may lose a critical connection altogether.

Communication links may become damaged or broken, meaning that data cannot be transmitted using the most efficient route, or perhaps cannot be transmitted at all.

Reliability of hardware and software components.
An essential service may **fail** or "**fall over**", meaning that other parts of the network cannot operate normally. This could be due to a program crash, causing delays while the program is fixed or restarted.
It could also be due to a failed hardware component, such as a broken hard-disk drive or a network card.
In some organisations, the computer network is "**misson critical**", meaning that the organisation cannot operate without it.

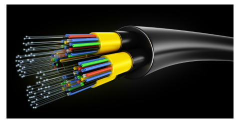
Unit 1.3.1 Transmission Media

Connections can be made between devices using different kinds of transmission medium:

Copper cables

e.g. **twisted pair ethernet cables** or thicker shielded **coaxial cables**.
Data is transmitted over copper cables using **electricity**.
Copper cables allow relatively fast transmission but can be affected by other cables nearby, by **electrical interference** or **lightning strikes**.
Copper cables can make it very easy to connect new devices and are very cheap. They can only be used over relatively short distances as the transmitted data signals weaken with distance e.g. up to 100m.

Fibre-optic cables



High-speed, high-capacity bundles of **glass fibre** that carry data as **light**, rather than electricity.
Fibre-optic cables are expensive and technical to install, but can be used reliably over very long distances, such as connecting different countries together under the sea.
They are often used as a backbone connection as part of the infrastructure of a network or the internet.
Fibre-optic allows **extremely fast data transmission** and many people can share the use of the same cable due to its massive bandwidth. To connect the UK and USA, only approximately 25 cables are needed under the Atlantic Ocean for all of the internet traffic between the two countries.

Wi-Fi links

Data is send and recieved using **radio signals** rather than using any cables.
Wi-Fi is ideal for situations where it is difficult to install cables, such as in old buildings, and many devices can be configured to use a single **Wireless Access Point** device.
Wi-Fi transmission is **slower** than using copper cables or fibre-optic.
Wi-Fi data packets also need to be **encrypted** to protect them from **interception** by others.

Micro-wave links

These are slow radio links that allow data to travel over **long distances** e.g. to and from satellites in space.
Micro-waves are useful where it would be very difficult to install a cable e.g. for a moving ship at sea.
Micro-wave reciever dishes usually need to be lined up precisely to focus and recieve data signals.
Micro-wave transmitters and recievers are relatively expensive, but they can be used **anywhere on Earth**.

Bluetooth

Bluetooth is a particular kind of **very high-frequency radio link** that allows data to be exchanged between personal devices. It is relatively slow, but can be used for **wireless keyboards** and **mice**, **headphones** and **smartphone-to-computer file transfers**. Bluetooth devices are often **paired** together, exchanging setup information to make communication more secure and to stop unauthorised transfers.

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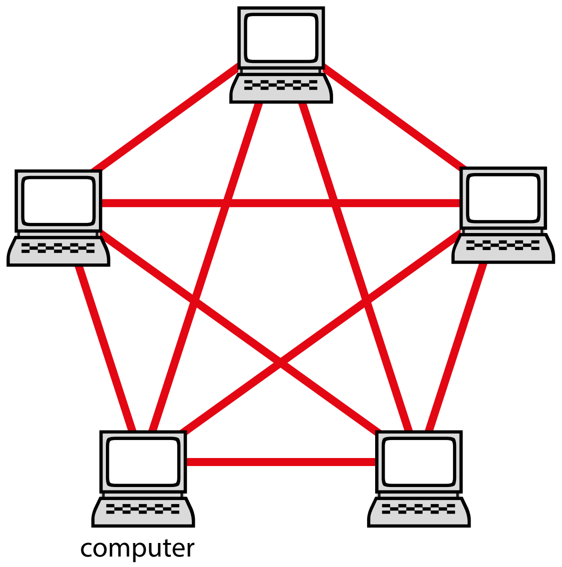
Part 5: Network Topologies

Unit 1.3.1 Mesh Topologies

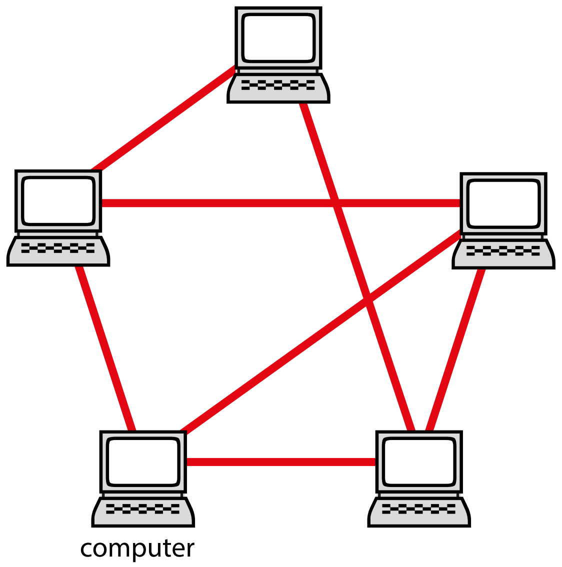
Full-Mesh Topology

Every single computer device in the network has a **direct connection to every other computer device**.



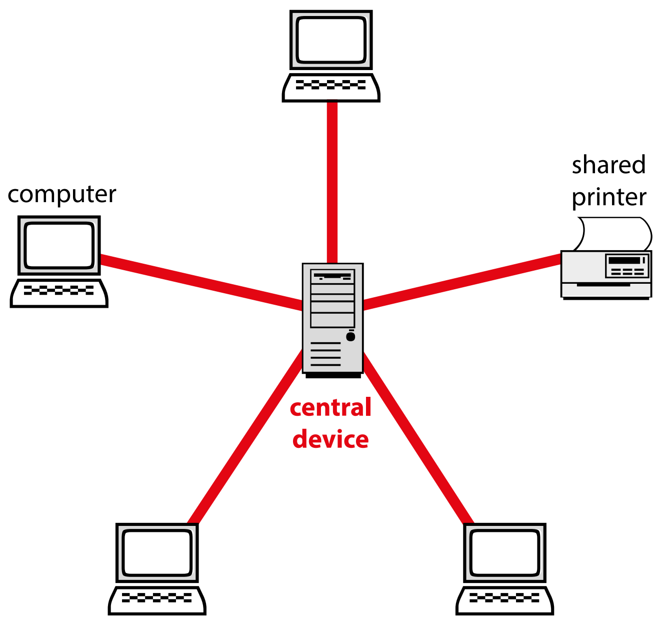
Partial-Mesh Topology

Every single computer device in the network is **connected to every other device**, either through a **direct** connection or an **indirect** connection.



Unit 1.3.1 Star Topology

Uses a **central device** to **control** all **data transmission across the network** between client devices



In a star network **each device has a single connection to a central computer device**.

The central device controls the operation of the network.

All communication between any client devices **must pass through the central device**.

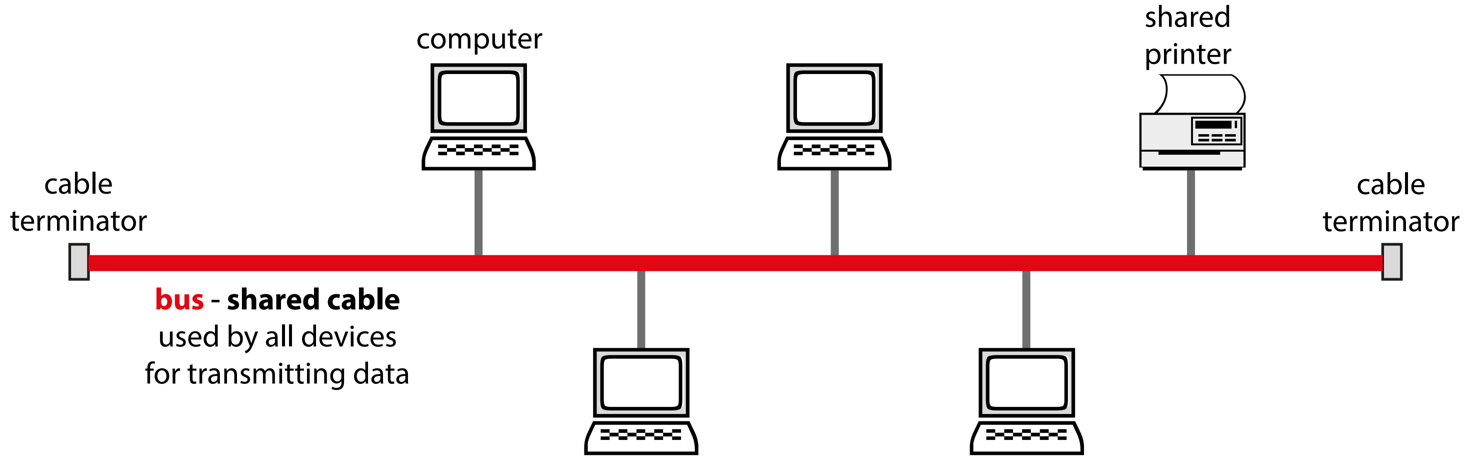
Communication between devices is fast because there are only two links between any client devices on the network.

If the central device breaks down then the **whole** network will be affected: **none of the devices will be able to communicate with each other**.

Unit 1.3.1 Bus Topology

The bus network topology uses the **Ethernet protocol** to control **data transmission** and **collision detection**.

No single computer or device is in control of the network.

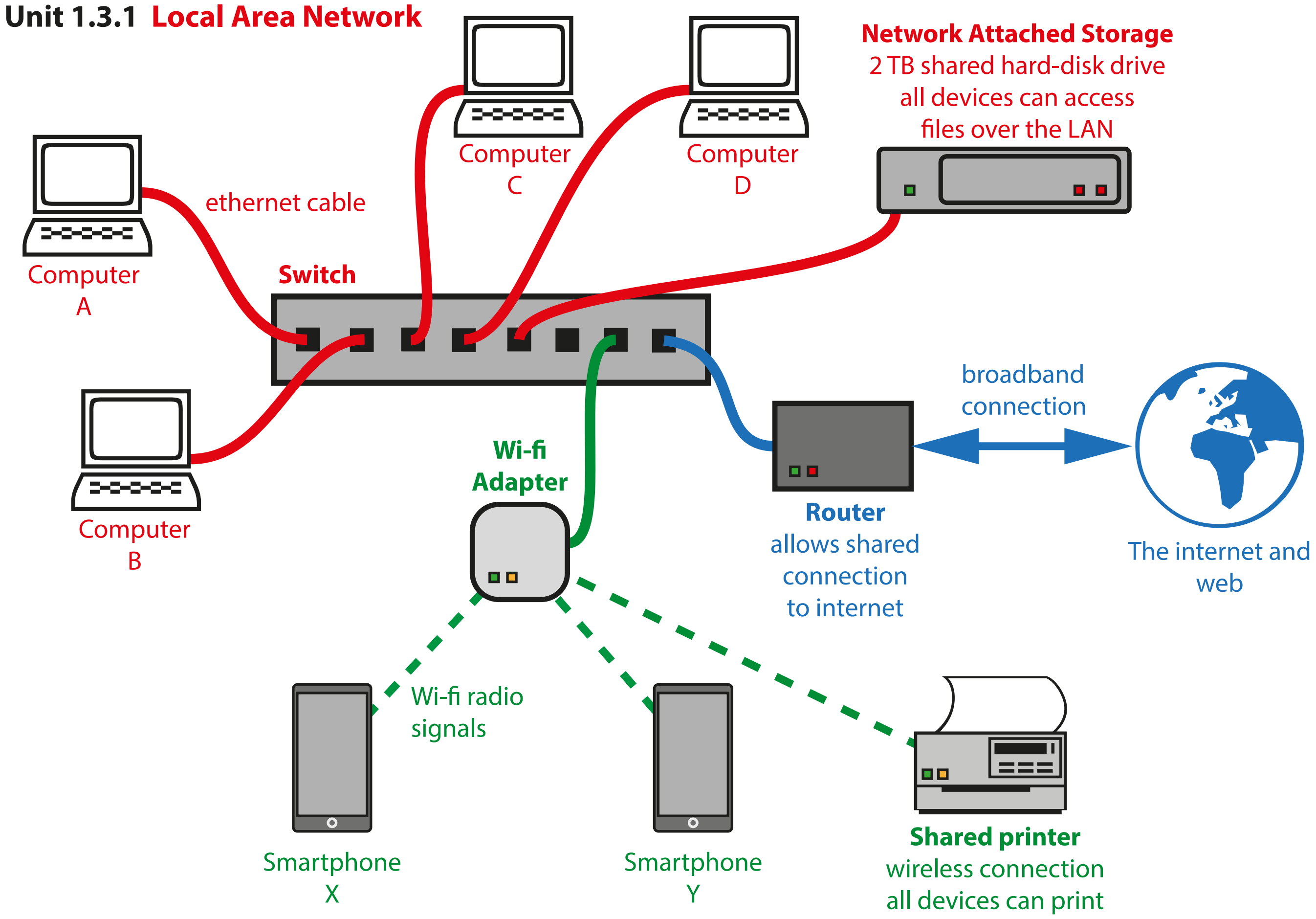


All devices are connected together through a **shared communication cable**, called a **bus**.
All data that passes between devices **must** travel along the bus.
The data is delivered to **all** devices connected to the bus... they **all** get it!
Data is only processed by the device that it was intended for… other devices **ignore** data that was not meant for them.

Only one device can send data across the shared bus cable at a time.
If two devices transmit data **at the same time** then the data will get mixed up - their data transmissions will become **corrupted**.
When two devices send their data at the same time this is known as a **collision**.
To **detect** and **recover** from collisions, the **Ethernet protocol CSMA/CD** is used.

Bus networks are simple to build. They are also reliable: a problem with a single device is unlikely to affect the overall network.
However, a problem with the bus may affect the **whole** network: if the bus cable breaks, none of the devices can communicate at all.

Unit 1.3.1 Local Area Network



Tiverton High School Year 10
J277 GCSE Computer Science
Knowledge Organiser / Recap
Part 6: Protocols, Addressing and the Internet

Unit 1.3.2 Data Packets and IP Addressing

Data is transmitted in short bursts called **data packets**. When transmitting large files, they are split into **sequences** of packets.
Each packet travels across one or more **communication links** in a network

Data packets must be sent and recieved in a very **precise** way to ensure successful communication between devices.
A **network protocol** is **a set of rules or conventions which control the communication between devices on a network**.
Protocols provide **strict definitions** about the **structure** of data packets and **how** they should be sent.
They also determine what to do when data packets have been **lost** or **corrupted** during transmission.

When recieving data, protocol software **puts the data packets back together in the correct order** to reconstruct the original data that was sent. The protocol **automatically detects errors** and **lost-packets**, requesting them to be re-sent.

Structure of a data packet

IP address of the **sender**	**IP address of destination** device	**Sequence number**	**Total packets**	**Payload** actual data that you want to send	**Checksum** to detect errors
124.63.0.5	182.45.0.60	3	10	Your password has been accepted.	38

Every device on a network has a unique **Internet Protocol address** (**IP address**). which is **32 bits long**.

IP v4 addresses must consist of **4 numbers**, separated by a **dot**. Each part uses **8-bits**, allowing values between **0** and **255**.
Example IP v4 addresses: `168.0.192.1` `255.70.12.65`

IPv6 addresses use 128 bits, which means many more IP addresses are possible than when using 32 bit IPv4 addresses.
An **IP v6 address** is represented uaing **eight groups of four hexadecimal digits**, each group representing **16 bits**.
The groups are separated by **colon** symbols **:**
Example IP v6 address: `1805:0ca8:85f3:0000:0000:8b5a:0420:3741`

IP addresses can be changed, but **every device on a network must have a different IP address**.
If two devices have the **same** IP address it will be unclear which of them is meant to recieve each particular data packet.

Unit 1.3.2 MAC Addressing

MAC address means **Media Access Contol address**.

A MAC address **uniquely identifies a device on a network** by identifying the **network adapter** hardware that the device is using.
It is a **unique code** which is built into the **Network Interface Controller** (**NIC**) hardware.

The MAC address is used to make sure that **devices never get mixed up** during network communications.

Each MAC address is made up of **48 binary digits**.
`000101001101001011001110100101101101101001011001`

...but they are usually written in **hexadecimal** (easier for humans to read and write down.
`14-D2-CE-96-DA-59`

MAC addresses cannot ever be changed because **they are built into the hardware of each device when it is manufactured**.

Because each MAC address is **unique**, no two hardware devices in the world have the **same** MAC address.
Criminals can be traced using MAC addresses - the MAC addresses proves which device was used when breaking the law.

Units 1.3.1 and 1.3.2 The internet

"**Internet**" means "**Inter-Networking**" – **communication BETWEEN networks**.

The Internet is a way of **connecting networks together**. It joins Local Area Networks and Wide Area Networks from many different countries. To connect a network to the internet, most people connect through an **Internet Service Provider** (**ISP**).
An ISP provides a **gateway router** for your network to connect to.

Packets can travel across the Internet using **different routes** to get to their destination. **Backbone internet routers** receive data packets. Each router examines the destination IP address that shows where the packet is trying to get to. The router then decides which communications link to use and sends the packet on the next stage of it's journey, towards it's intended destination.

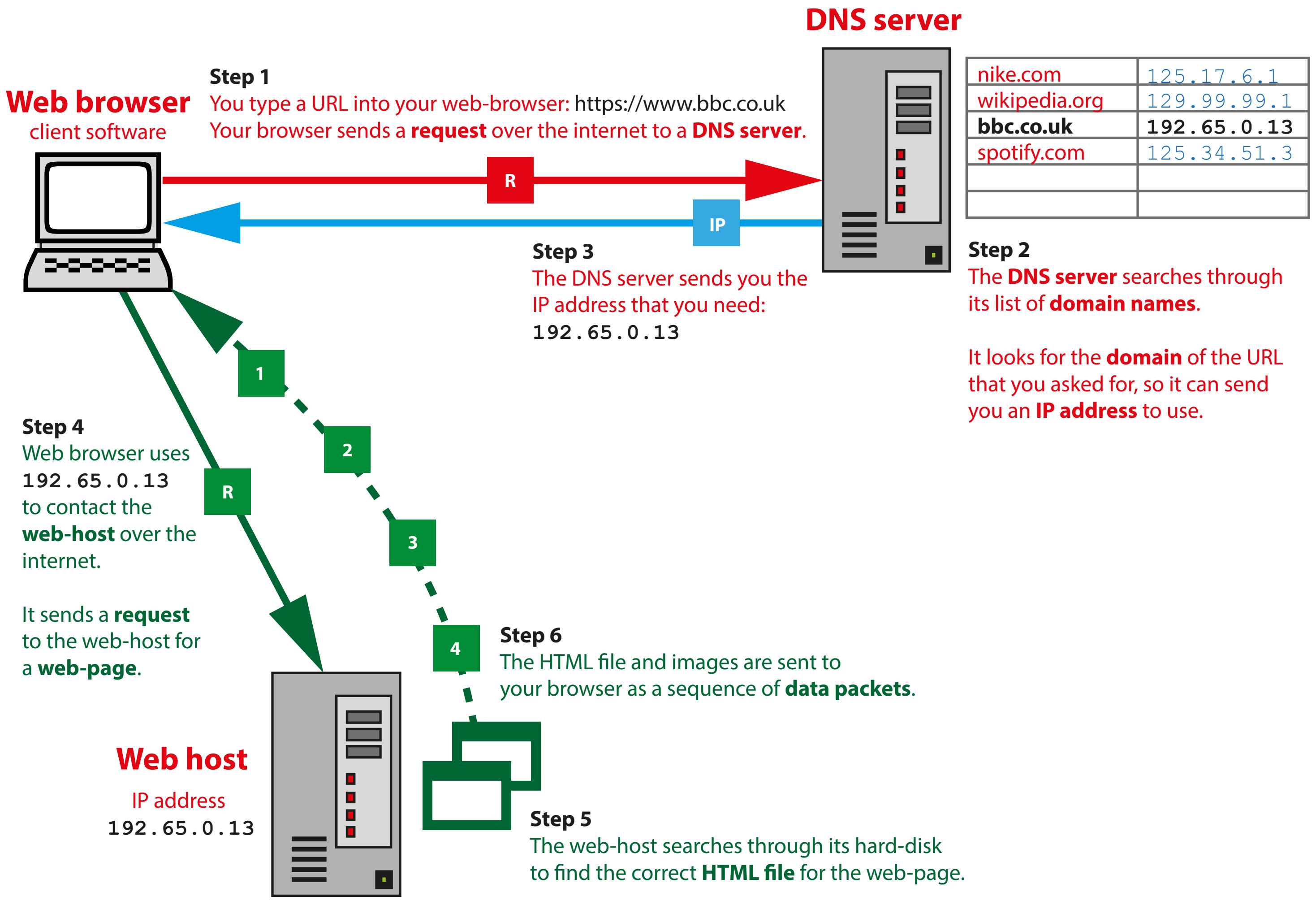
This **packet switching** process needs to happen really quickly so that packets are not kept waiting. If a queue of packets waiting to be routed fills up, the router may no longer cope with the traffic, leading to slow network performance.

The internet uses **redundant links** to allow data packets to take **different** routes to their destination as efficiently as possible.
Because of the redundant links, it is very difficult to **censor** parts of the internet - there are many routes through between devices.

When communicating across the Internet, a **collection** of inter-related protocols needs to be used, called the **protocol stack**.
The protocol stack defines all of the different processes and protocols that will be used to send and receive data.

The internet uses the **TCP (Transmission Control Protocol)** and **IP (Internet Protocol)** to split data into packets and route it.

Unit 1.3.1 Domain Name System (DNS)



The numbers in an IP address can be difficult for people to remember e.g. `255.70.12.65`

We can use **text aliases** instead which are equivalent to the numbers. These are called **domain names**. e.g. `bbc.co.uk`

Special computer servers on the Internet called the **Domain Name System (DNS)** **translate text domain names to IP addresses**.