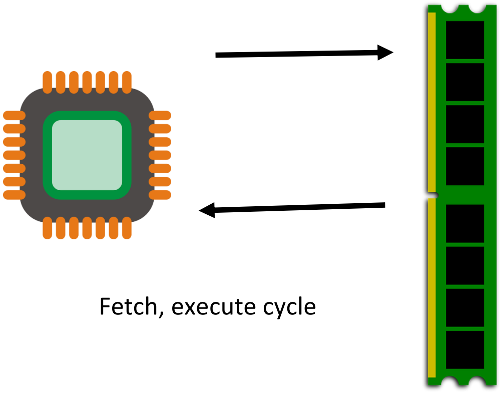
GCSE Computer Science
Component 01

Revision

System Architecture

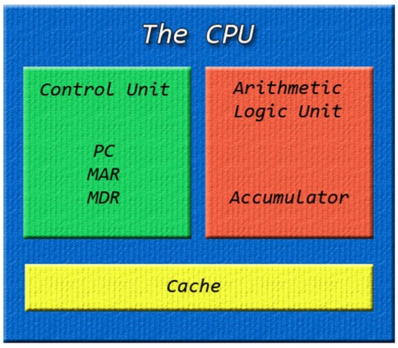
A CPU is the part of the computer that completes the processing. It can be said to **fetch** and **execute** instructions from main memory. This is called the **fetch execute cycle.**



Fetch, execute cycle

Some CPUs are better than others. Factors that affect the speed include:

1. **Clock speed**—the number of fetch execute **cycles per second**. This is measured in Hz. 2GHz is the same as 2,000,000,000 cycles per second.
2. **Number of cores**—most modern CPUs have more than one CPU core. This is like splitting the CPU up into several mini-CPUs. The more cores the more **instructions can be processed at once**. e.g. a quad core processor has four cores and can process four instructions at once.
3. **Cache—**fetching instructions from memory takes time. A good idea is to put the most **commonly used instructions** in some super fast memory located on the CPU itself. This is called cache. The bigger the cache, the more instructions can be stored there and the faster the CPU will run.



The CPU has two main parts:

1. **Control Unit (CU)** —Provides **control signals** so data goes to the place it is supposed to. Controls **timing signals** including the clock speed. Sends signals to memory, the ALU and I/O devices.
2. **Arithmetic Logic Unit (ALU)** - performs any **maths** (arithmetic) calculations, performs **logic** calculations (e.g. is x < y).

Camera
Game machine
Electronic book, Tablet
Smart phone
Television
Mobile phones
Industry, Airlines, Space
Car
Broadcasting, Medical
Printer
Amusement machines
Digital signage

An **embedded system** is a computer that is fully **contained within the device it controls**.

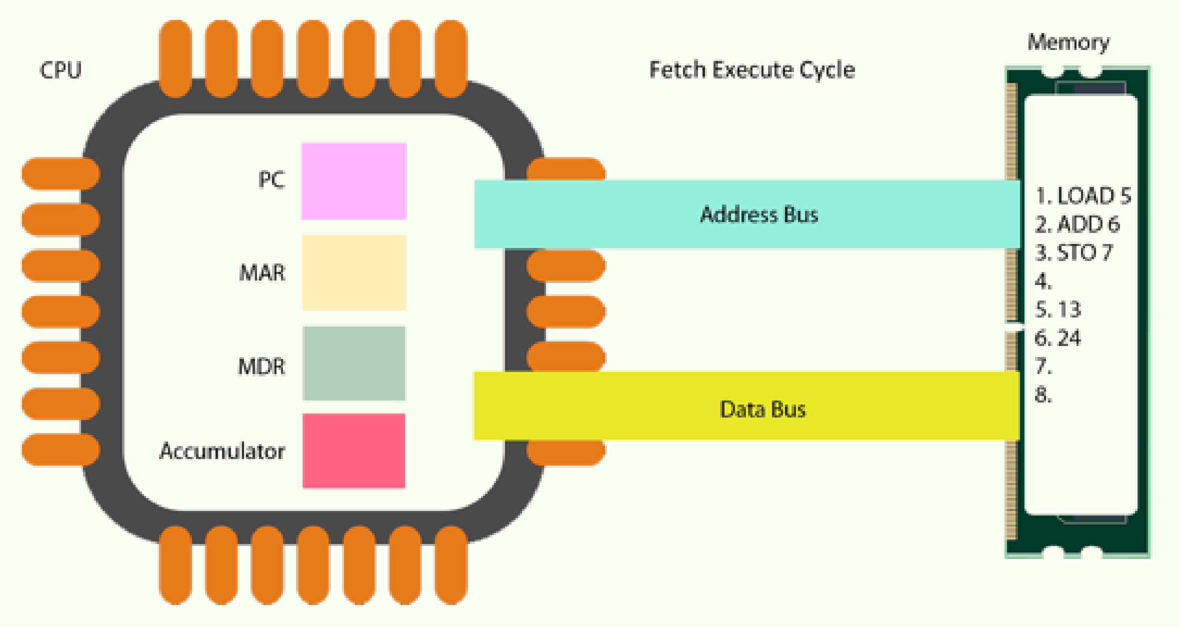
However it still has all the features of the other computers we have been learning about! e.g. a CPU fetches instructions from memory

Examples:

- Microwave
- Plane
- Washing machine

VON NEUMANN ARCHITECTURE

Modern CPUs still follow a design made decades ago by John von Neumann. They have a series of registers which are small storage locations on the CPU. These registers are used in the fetch execute cycle.



The Program Counter (PC) -

1. <u>points to the next instruction</u> **in memory**

2. copies its value (which is a **<u>memory address</u>**) to the MAR

3. gets **<u>incremented</u>** by 1 (1 is added to it) so that it points to the next instruction

The Memory Address Register (MAR) -

1. receives a **<u>memory address</u>** from the PC

2. sends the memory address along the **<u>address bus</u>** to the correct location in memory

The Memory Data Register (MDR) -

1. the instruction and data is sent along the **<u>data bus</u>** and stored in the MDR

Accumulator -

1. when the instruction is executed the **<u>results are stored</u>** here. Holds a running total of the operation currently happening.

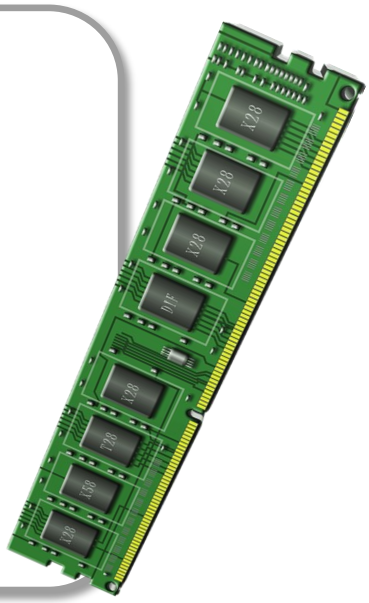
Primary Storage

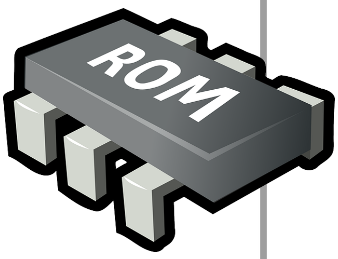
Primary storage includes **RAM**, **ROM**, **cache** and the **registers** inside the CPU.

Primary storage can be **directly accessed by the CPU**.

RAM

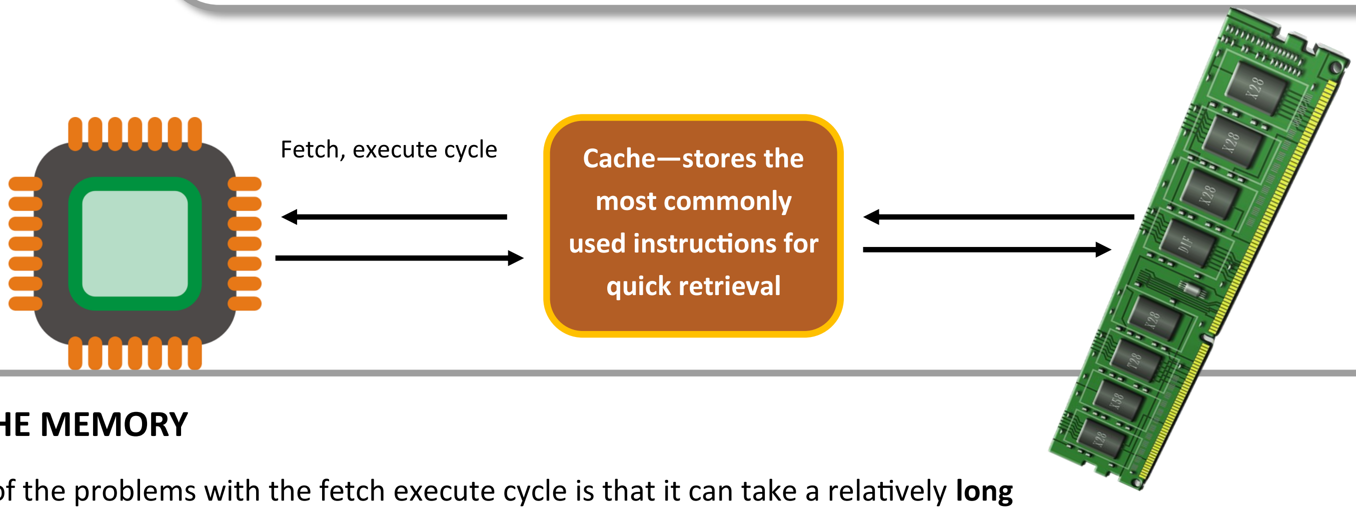
1. Stands for **Random Access Memory**
2. Stores **instructions and data** for **programs that are currently in use**
3. **Volatile**—when the power is switched off all its contents are lost
4. Two types:
   - **DRAM (dynamic RAM)**—less expensive, not as fast, needs constant refreshing. Used for the main RAM in your computer.
   - **SRAM (static RAM)** - much more expensive, faster, doesn't need lots of refreshing. Used for cache (see below).





ROM

1. Stands for **Read Only Memory.**
2. Stores **instructions needed to boot up the computer** including the **BIOS.**
3. **Non-volatile**—keeps its contents when the power is switched off.
4. Originally Read Only meaning data could not be written to by the user—however over the years different types of ROM have been developed that allow the user to write some data PROM, EPROM, EEPROM.



Fetch, execute cycle

Cache—stores the most commonly used instructions for quick retrieval

CACHE MEMORY

One of the problems with the fetch execute cycle is that it can take a relatively **long time** for the data and instructions to be fetched from RAM.

Modern CPUs combat this by using cache memory. This is **super fast** memory that is very **close to the CPU**. It stores the **most commonly used instructions** so that they can be **retrieved much faster** than if they were in RAM. This increases the speed of the computer. The **more cache** you have, the more instructions can be stored, and the **better the performance** of your computer.

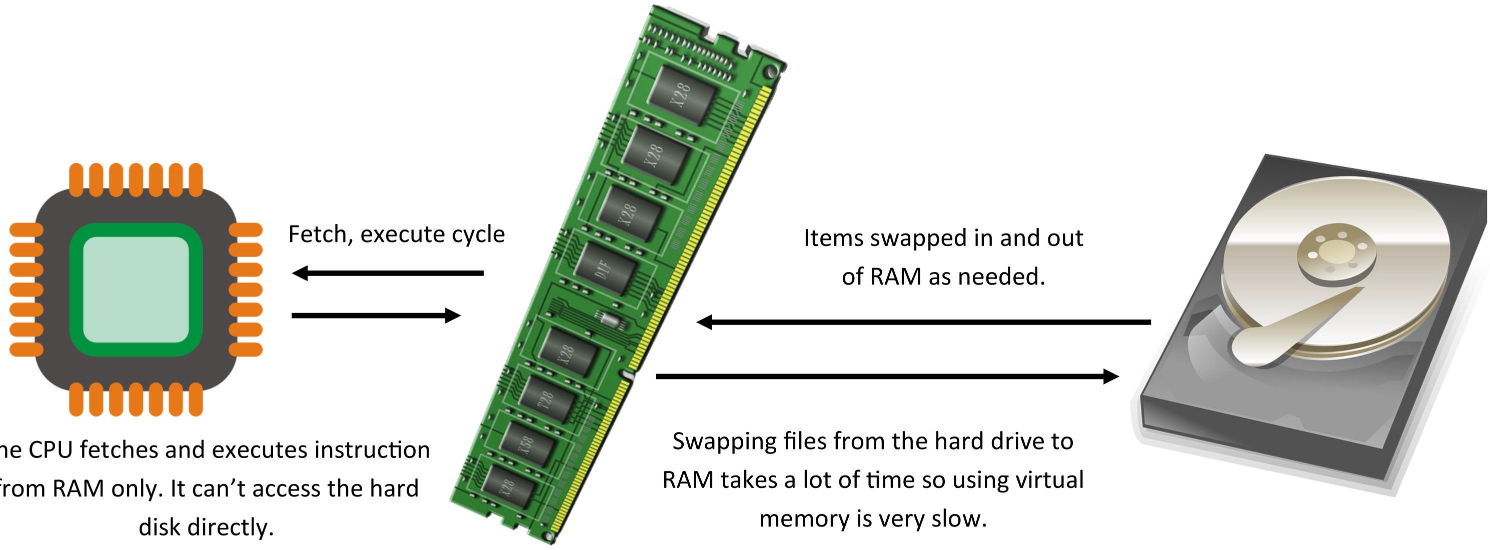
VIRTUAL MEMORY

Often there isn't enough space in RAM for all the programs that are currently being run.

The operating system can use a special section of the hard drive to deal with the overflow if necessary. This is called a **page file** and the process is known as **virtual memory**.

Data and instructions **must be in RAM** to be processed by the CPU so they need to be swapped in and out from the hard drive before they can be processed.

This means that although there is more overall space, using virtual memory is **much slower** than using RAM.



Fetch, execute cycle

The CPU fetches and executes instruction from RAM only. It can't access the hard disk directly.

Items swapped in and out of RAM as needed.

Swapping files from the hard drive to RAM takes a lot of time so using virtual memory is very slow.

MODERN ROM IS FLASH MEMORY!

Advances in ROM technology now mean that ROM can be made to be fully rewritable. This is called flash memory.

Flash memory is useful as it is very fast compared to a hard disk drive and can be used as **secondary storage** in USB memory sticks, SD cards and solid state drives. (see the next topic).

Should ROM still be called Read Only Memory? You decide….

Secondary Storage

Secondary storage uses **magnetic**, **optical** or **flash** technology.

It **cannot be directly accessed by the CPU** and data must be **copied into RAM** first.

Secondary storage stores data **permanently**.

Magnetic Storage

A type of storage that uses lasers a magnet to make a magnetised segment on a disk platter.

Includes hard disk drives and the outdated floppy disk.

Hard disk drives feature in most modern computers as they offer a lot of storage at a cheap price and are relatively fast.

Optical Storage

A type of storage that uses lasers to burn marks in a reflective disc.

There are three types: CD-ROM, DVD-ROM and Blu-Ray ROM.

Often used whenever something cheap to produce and portable is needed. Also, most people have access to the equipment to read the discs.

Flash Storage

A type of storage that uses electricity to open and close gates on a circuit board.

Includes USB memory sticks, SD cards and solid state drives.

Very fast, portable and not affected by moving parts. This technology is slowly overtaking the storage world as it becomes cheaper and cheaper.

UNITS OF DATA

Unit	Abbreviation	Number of Bytes	Notes
Bit		1/8	either a 0 or 1
Nibble		1/2	e.g. 1010
Byte		1	e.g. 11001100
Kilobyte	KB	1,000	written as 1KB
Megabyte	MB	1,000,000	or 1000KB
Gigabyte	GB	1,000,000,000	or 1000MB
Terabyte	TB	1,000,000,000,000	or 1000GB
Petabyte	PB	1,000,000,000,000,000	or 1000TB

CAPACITY—how much data the media can store. The higher the capacity the better.

A typical SD card might hold 32GB. A hard drive might be about 2TB. Old floppy disks were 1.44MB.

ACCESS SPEED—how quickly the device can read and write data.

Old floppy disks were very slow as are tape drives.

Optical drives are quite slow.

Hard drives are pretty fast.

Solid state drives are very fast.

PORTABILITY—can the device be carried around easily?

Internal hard disk drives can't be carried around easily. Neither can solid state drives.

Optical disks, flash memory sticks and SD cards are very portable.

DURABILITY—is the device easy to damage?

Internal hard disk drives and optical discs are very fragile.

Flash memory is much more durable.

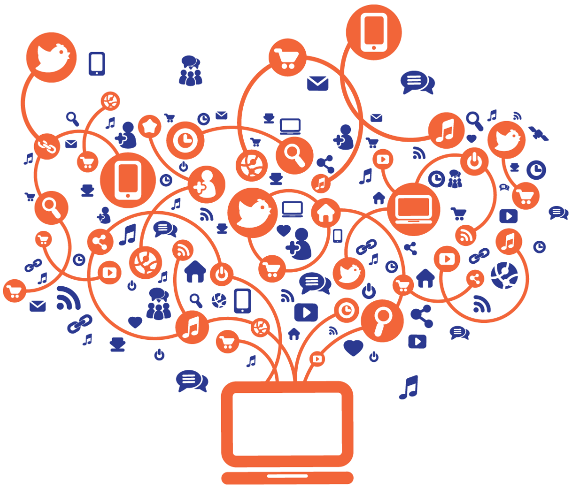
RELIABILITY—how long does it go before it starts to break?

Most storage devices are quite reliable and will suit most uses.

However, flash memory degrades over time and eventually wears out.

Optical discs can't be rewritten forever.

Magnetic storage like hard disks last a very long time.



Data Representation

Why is binary used?

Binary is used as it only has two possible values 0 and 1. This is to represent the **transistor switches** that exist in the CPU which can either be ON or OFF. The CPU can only work with binary so all code has to be translated into binary machine code.

Converting to and from binary

The key to converting to and from binary is writing out the column headings first. Always remember the **smallest number goes on the right!**

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

32 + 16 + 4 + 2 = 54

The best place to practice binary conversions is at www.learncomputing.org/quiz.php

Why is hexadecimal used?

Binary can be difficult to work with and it is **easy to make a mistake**. Hexadecimal is less prone to errors and it is **very easy to convert between binary and hex** so lots of computer scientists prefer using it. You can see hex references in colour codes and memory addresses.

Converting to and from hex

The key to converting to and from hex is writing out the column headings **and** the numbers 1-15 with their hex equivalent. Do this in the exam! This will prevent you making any mistakes and you won't lose any marks.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

You can also practice hex conversions at: www.learncomputing.org/quiz.php

You will need to be proficient at:

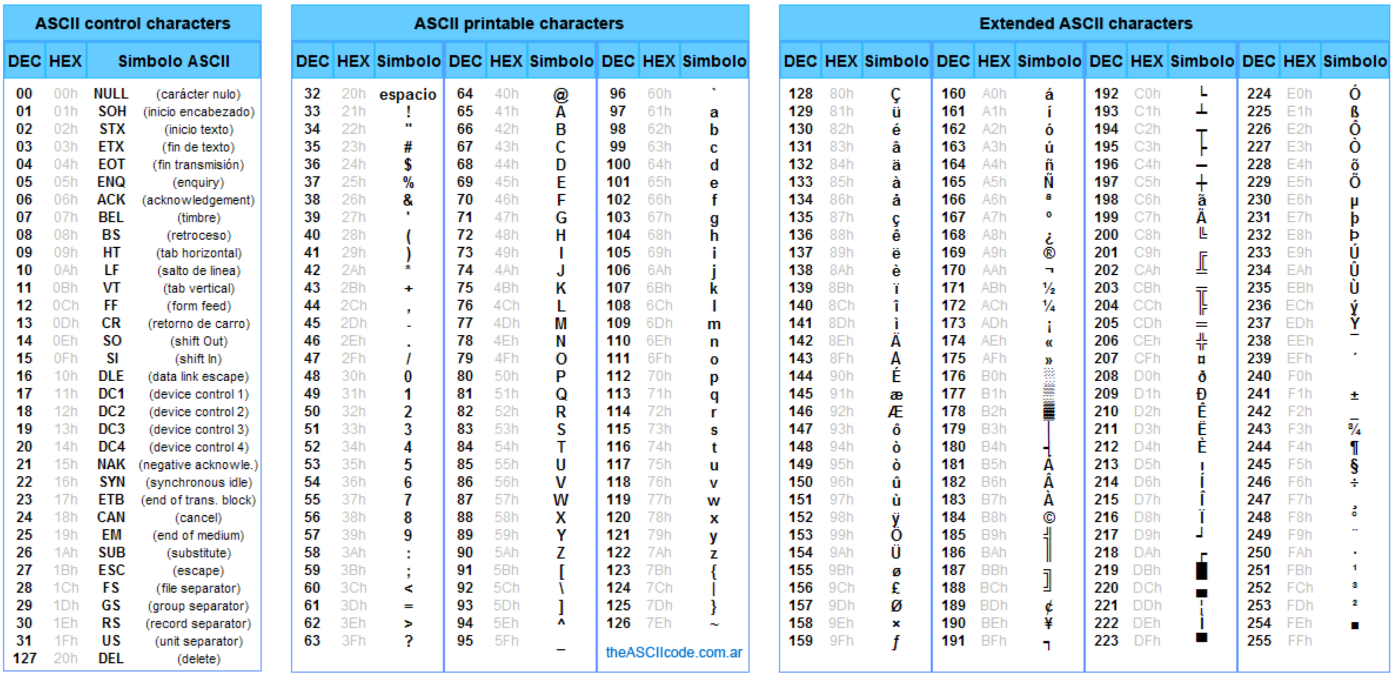
- Converting from denary to binary and back again
- Converting from denary to hexadecimal and back again
- Converting from binary to hexadecimal and back again
- Adding two binary numbers
- Binary shifts

Characters

Characters like letters, numbers and symbols need to be stored in binary just like everything else in a computer. The way this is done is simply just to give each letter or symbol a unique binary number. Of course, there are lots of different ways this could be done. Each one is called a **character set**. The two varieties you need to know are ASCII and Unicode.

ASCII

The American Standard Code for Information Interchange. This character set uses 8 bits to represent characters meaning there are 256 possible combinations. This is only enough to cover English letters and a few extra symbols. Each character is given a **unique binary number**.



ASCII control characters

DEC	HEX	Simbolo ASCII	
00	00h	NULL	(carácter nulo)
01	01h	SOH	(inicio encabezado)
02	02h	STX	(inicio texto)
03	03h	ETX	(fin de texto)
04	04h	EOT	(fin transmisión)
05	05h	ENQ	(enquiry)
06	06h	ACK	(acknowledgement)
07	07h	BEL	(timbre)
08	08h	BS	(retroceso)
09	09h	HT	(tab horizontal)
10	0Ah	LF	(salto de linea)
11	0Bh	VT	(tab vertical)
12	0Ch	FF	(form feed)
13	0Dh	CR	(retorno de carro)
14	0Eh	SO	(shift Out)
15	0Fh	SI	(shift In)
16	10h	DLE	(data link escape)
17	11h	DC1	(device control 1)
18	12h	DC2	(device control 2)
19	13h	DC3	(device control 3)
20	14h	DC4	(device control 4)
21	15h	NAK	(negative acknowle.)
22	16h	SYN	(synchronous idle)
23	17h	ETB	(end of trans. block)
24	18h	CAN	(cancel)
25	19h	EM	(end of medium)
26	1Ah	SUB	(substitute)
27	1Bh	ESC	(escape)
28	1Ch	FS	(file separator)
29	1Dh	GS	(group separator)
30	1Eh	RS	(record separator)
31	1Fh	US	(unit separator)
127	20h	DEL	(delete)

ASCII printable characters

DEC	HEX	Simbolo	DEC	HEX	Simbolo	DEC	HEX	Simbolo
32	20h	espacio	64	40h	@	96	60h	`
33	21h	!	65	41h	A	97	61h	a
34	22h	"	66	42h	B	98	62h	b
35	23h	#	67	43h	C	99	63h	c
36	24h	$	68	44h	D	100	64h	d
37	25h	%	69	45h	E	101	65h	e
38	26h	&	70	46h	F	102	66h	f
39	27h	'	71	47h	G	103	67h	g
40	28h	(	72	48h	H	104	68h	h
41	29h	)	73	49h	I	105	69h	i
42	2Ah	*	74	4Ah	J	106	6Ah	j
43	2Bh	+	75	4Bh	K	107	6Bh	k
44	2Ch	,	76	4Ch	L	108	6Ch	l
45	2Dh	-	77	4Dh	M	109	6Dh	m
46	2Eh	.	78	4Eh	N	110	6Eh	n
47	2Fh	/	79	4Fh	O	111	6Fh	o
48	30h	0	80	50h	P	112	70h	p
49	31h	1	81	51h	Q	113	71h	q
50	32h	2	82	52h	R	114	72h	r
51	33h	3	83	53h	S	115	73h	s
52	34h	4	84	54h	T	116	74h	t
53	35h	5	85	55h	U	117	75h	u
54	36h	6	86	56h	V	118	76h	v
55	37h	7	87	57h	W	119	77h	w
56	38h	8	88	58h	X	120	78h	x
57	39h	9	89	59h	Y	121	79h	y
58	3Ah	:	90	5Ah	Z	122	7Ah	z
59	3Bh	;	91	5Bh	[	123	7Bh	{
60	3Ch	<	92	5Ch	\	124	7Ch	|
61	3Dh	=	93	5Dh	]	125	7Dh	}
62	3Eh	>	94	5Eh	^	126	7Eh	~
63	3Fh	?	95	5Fh	_			

theASCIIcode.com.ar

Extended ASCII characters

DEC	HEX	Simbolo	DEC	HEX	Simbolo	DEC	HEX	Simbolo	DEC	HEX	Simbolo
128	80h	Ç	160	A0h	á	192	C0h	└	224	E0h	Ó
129	81h	ü	161	A1h	í	193	C1h	┴	225	E1h	ß
130	82h	é	162	A2h	ó	194	C2h	┬	226	E2h	Ô
131	83h	â	163	A3h	ú	195	C3h	├	227	E3h	Ò
132	84h	ä	164	A4h	ñ	196	C4h	─	228	E4h	õ
133	85h	à	165	A5h	Ñ	197	C5h	┼	229	E5h	Õ
134	86h	å	166	A6h	ª	198	C6h	ã	230	E6h	µ
135	87h	ç	167	A7h	º	199	C7h	Ã	231	E7h	þ
136	88h	ê	168	A8h	¿	200	C8h	╚	232	E8h	Þ
137	89h	ë	169	A9h	®	201	C9h	╔	233	E9h	Ú
138	8Ah	è	170	AAh	¬	202	CAh	╩	234	EAh	Û
139	8Bh	ï	171	ABh	½	203	CBh	╦	235	EBh	Ù
140	8Ch	î	172	ACh	¼	204	CCh	╠	236	ECh	ý
141	8Dh	ì	173	ADh	¡	205	CDh	═	237	EDh	Ý
142	8Eh	Ä	174	AEh	«	206	CEh	╬	238	EEh	¯
143	8Fh	Å	175	AFh	»	207	CFh	¤	239	EFh	´
144	90h	É	176	B0h	░	208	D0h	ð	240	F0h	
145	91h	æ	177	B1h	▒	209	D1h	Ð	241	F1h	±
146	92h	Æ	178	B2h	▓	210	D2h	Ê	242	F2h	‗
147	93h	ô	179	B3h	│	211	D3h	Ë	243	F3h	¾
148	94h	ö	180	B4h	┤	212	D4h	È	244	F4h	¶
149	95h	ò	181	B5h	Á	213	D5h	ı	245	F5h	§
150	96h	û	182	B6h	Â	214	D6h	Í	246	F6h	÷
151	97h	ù	183	B7h	À	215	D7h	Î	247	F7h	¸
152	98h	ÿ	184	B8h	©	216	D8h	Ï	248	F8h	°
153	99h	Ö	185	B9h	╣	217	D9h	┘	249	F9h	¨
154	9Ah	Ü	186	BAh	║	218	DAh	┌	250	FAh	·
155	9Bh	ø	187	BBh	╗	219	DBh	█	251	FBh	¹
156	9Ch	£	188	BCh	╝	220	DCh	▄	252	FCh	³
157	9Dh	Ø	189	BDh	¢	221	DDh	¦	253	FDh	²
158	9Eh	×	190	BEh	¥	222	DEh	Ì	254	FEh	■
159	9Fh	ƒ	191	BFh	┐	223	DFh	▀	255	FFh	

Unicode

As ASCII is only real good if you are an English speaker, there used to be lots of different character sets all over the world for countries with different alphabets e.g. Greece, Russia, China etc.

This got to be too complicated so computer scientists invented a character set to include all languages in. It is called Unicode and it uses **up to 32-bits** for each character. As there are more bits, there are more possible combinations and there are up to 4,294,967,296 possible characters. This is enough for all languages on Earth with quite a few left over for spare.

You can see the full Unicode table at: https://unicode-table.com/en/

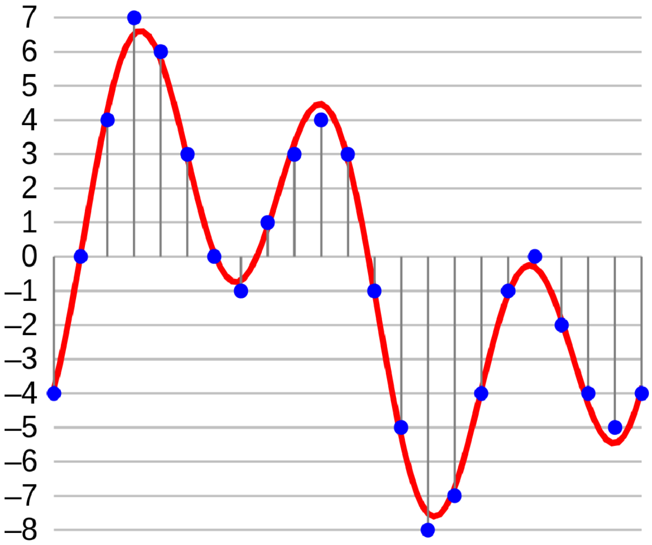
Sound

Sound needs to be converted to binary to be used and stored in a computer system.

To turn sound into binary we need to **sample** it.

An analogue sound wave is taken and the **amplitude** (height) of the wave is measured at regular intervals. This is converted into a binary number.

SAMPLING FREQUENCY



The more often the amplitude is measured, the better the quality of the sound.

Increasing the sampling frequency makes the sample more true to the original but increases the file size.

BIT RATE

This refers to the number of bits of data taken during each sample.

The higher the bit rate, the closer to the original the sample will be but the file size will be higher.

Images

0000	0000	0001	0001	0000	0000
0000	0000	0001	0001	0000	0000
0010	0010	0001	0001	0010	0010
0010	0010	0001	0001	0010	0010
0000	0000	0001	0001	0000	0000
0000	0000	0001	0001	0000	0000

Images need to be converted into binary to be stored in a computer. A common way of doing this is using a **bitmap**.

Bitmap images are made up of **pixels**. For each pixel a binary number is stored that represents a colour.

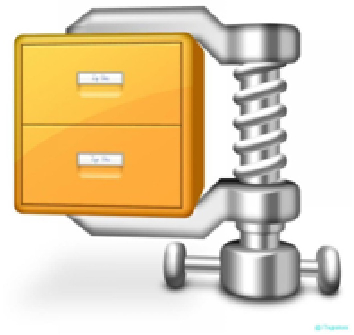
Resolution: The number of pixels in an image, often given as a height and width e.g. 1920x1080. The more pixels there are, the more detailed the image will be, but the higher the file size will be.

Colour depth: The number of bits used to store the colour value e.g. 8-bits, 16-bits. The more bits used, the more colours are available in the image but the higher the file size will be.

Metadata: This is data that goes at the start of an image file that tells you about the file. It might say the resolution, the colour depth, the geo location of where the picture was taken, the device it was taken on. It will **not** say the file size.

Don't forget, you can play around with bitmap images at www.learncomputing.org/bitmap.php

Compression



Often, we might want to make a file smaller. This could be:

- To save storage space
- To transmit it quicker (e.g. over the internet)

Compressing a file will make it smaller. There are two types:

LOSSY COMPRESSION

Makes a file smaller but at the cost of losing some of the data. This type of compression is used when it doesn't matter if a little bit of data is lost for example in a picture file, sound file or video file.

LOSSLESS COMPRESSION

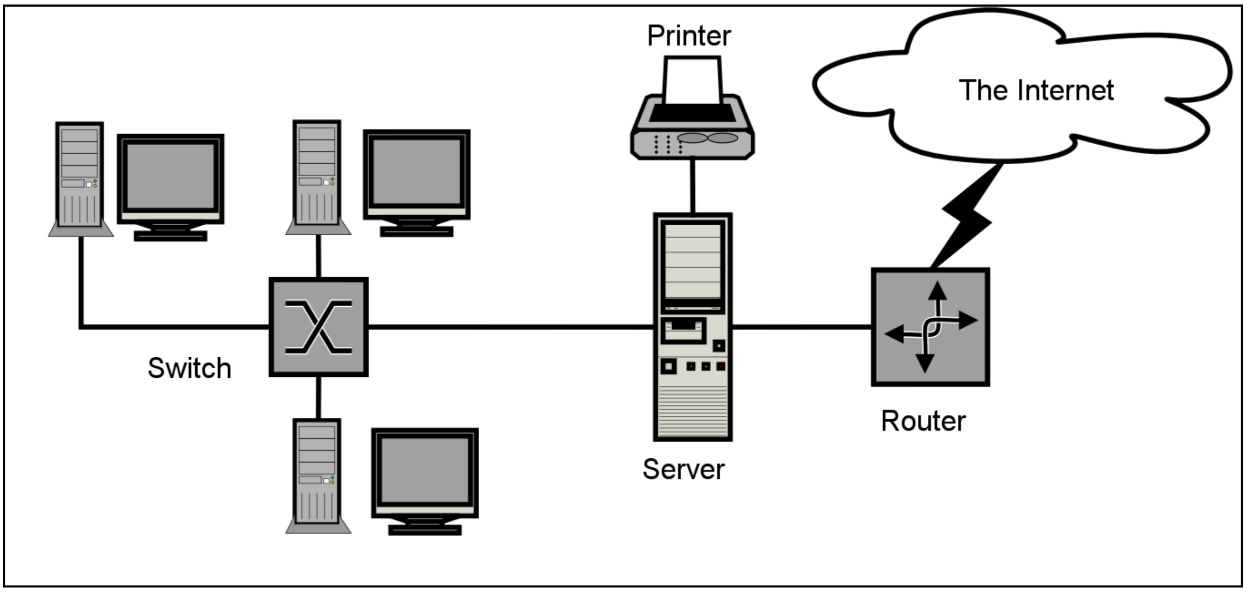
Makes a file smaller but without losing any data. This isn't as effective as lossless compression but can be used when it wouldn't be appropriate to lose any data. For example, you wouldn't want to compress a text file and lose some letter or words so you might use lossless compression for this.

Wired and Wireless Networks

A network is when **two or more computers are connected together**. This is often a good idea because:

- Files can be shared.
- **Resources** like printers and scanners can be shared.
- Buying software for multiple computers is often cheaper (**site license**).
- You can manage **users** and **security centrally.**

However, you can choose to not network your computers. This is called a **standalone environment**. Not having a network is more secure and cheaper to set up but doesn't give you any of the benefits above.



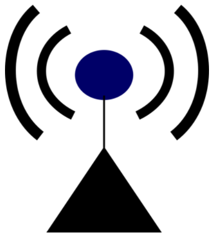
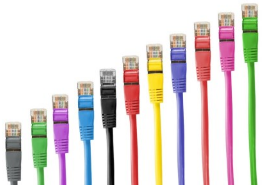
A network can have different sizes.

LAN – local area network

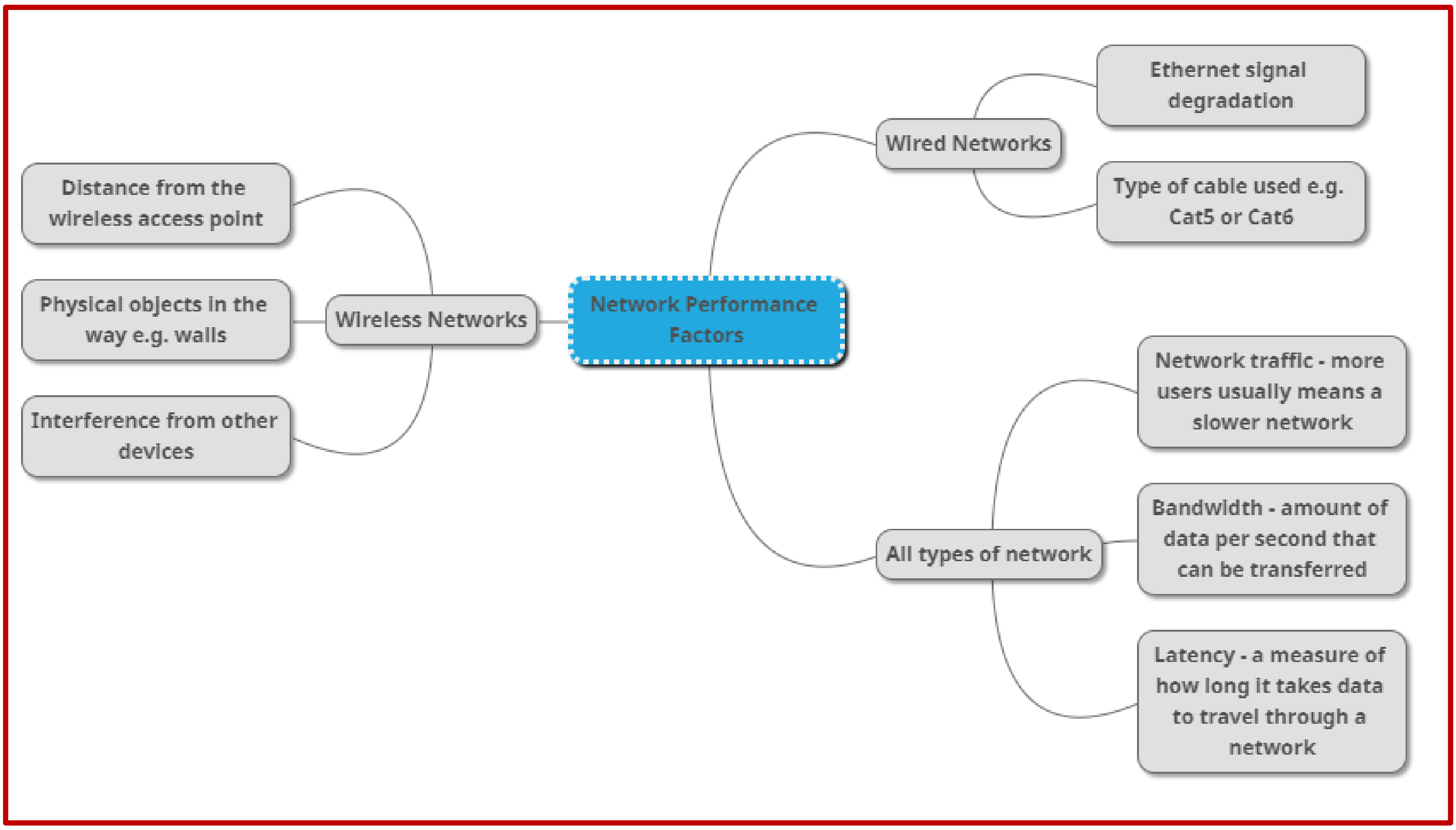
WAN – wide area network

	Advantages	**Disadvantages**
LAN	Quick and easy to set up	Small area only
	Cheap to set up	Relatively few computers / users
	Cheap to maintain	
	Relatively fast	
WAN	Can be any size – even global	More expensive to set up
	Allows many more computers / much more intricate and detailed	Needs ongoing maintenance
		Needs specialised equipment and expertise
		Slower

NETWORK HARDWARE

				
Wireless Access Point	*Router*	*Switch*	*Network Interface Card (NIC)*	*Transmission Media*
Lets a device connect to a LAN using WiFi.	Connects two networks together, usually a LAN to the internet	Intelligently decides where data travels to in a network so each device gets the data it needs	Lets a computer connect to a network using a wire.	Refers to the cabling used to connect the network together and includes Ethernet cable, coaxial cable

NETWORK PERFORMANCE FACTORS



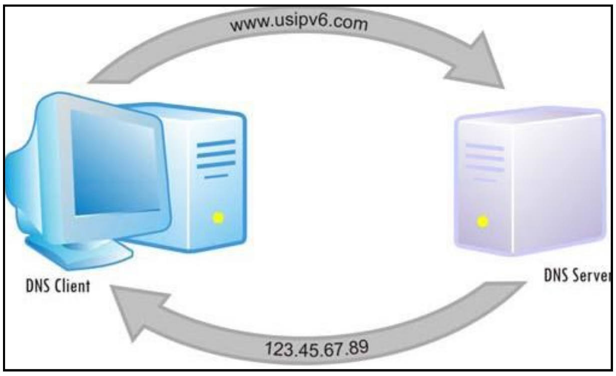
- Network Performance Factors
  - Wireless Networks
    - Distance from the wireless access point
    - Physical objects in the way e.g. walls
    - Interference from other devices
  - Wired Networks
    - Ethernet signal degradation
    - Type of cable used e.g. Cat5 or Cat6
  - All types of network
    - Network traffic - more users usually means a slower network
    - Bandwidth - amount of data per second that can be transferred
    - Latency - a measure of how long it takes data to travel through a network

THE INTERNET

The internet is a very large WAN. In fact it is a collection of networks that span the entire world.

Key terms:

DNS – Domain Name System – the system that converts a web page's name (also know as URL e.g. amazon.co.uk) into its corresponding IP address.

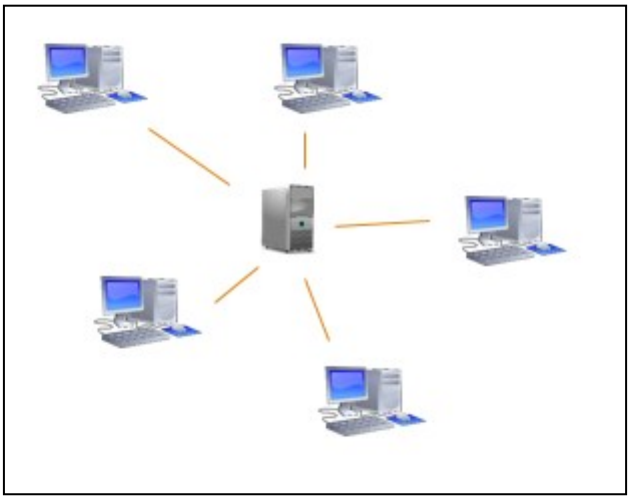


Hosting – the process of storing a web page on a server so that it can be accessed on the World Wide Web.

The Cloud – a term used for storage that can be accessed using the internet.

STAR NETWORK

In a star network all computers are connected directly to a central server or to a switch.



Advantages

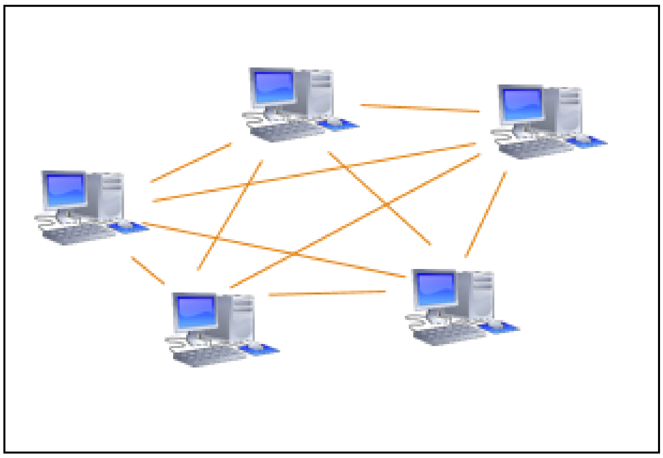
The network can be managed centrally and it is easy to add more computers.

If one computer breaks the network still runs.

Disadvantages

If the server breaks no computers will work.

Needs specialist equipment (switch)



MESH NETWORK

In a mesh network all computers are connected to every other computer in the network. This means all computers are the same importance.

Advantages

Very robust and reliable way to cable a network.

Not reliant on a server. If one computer breaks the rest are fine.

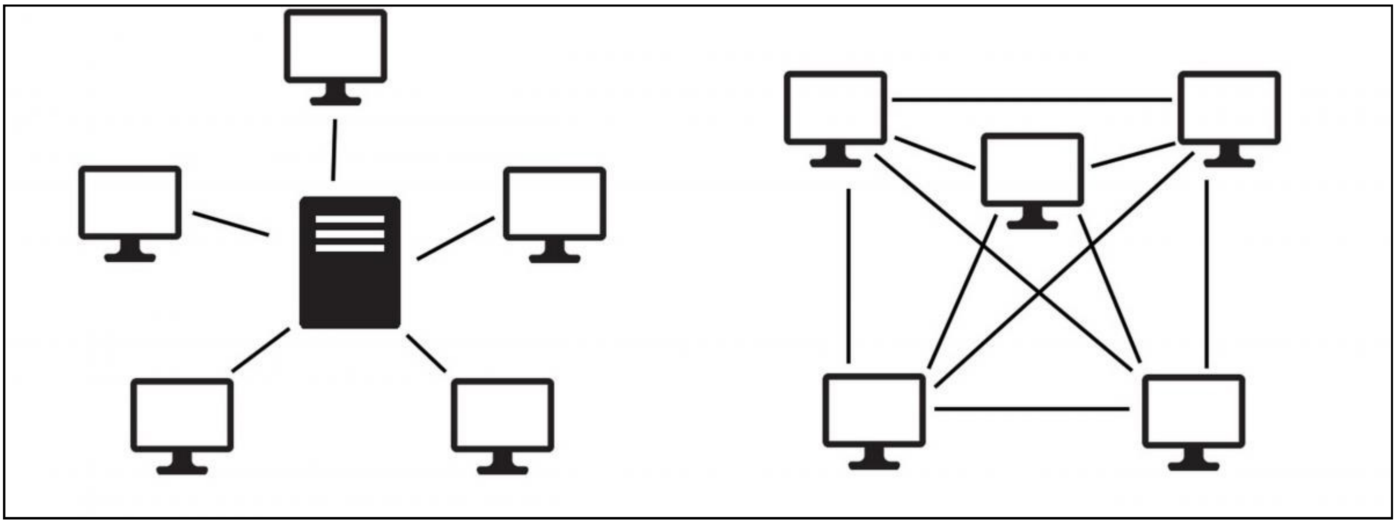
Disadvantages

Requires a lot of cable to set up – this is expensive.

CLIENT SERVER VS PEER TO PEER

Client server involves having one centralised computer (a server) that does most of the processing and stored most of the data. The client computers connect to the server when needed.

In peer-to-peer all the computers have the same importance and all share processing and storage.



	Advantages	**Disadvantages**
Client Server	Files are stored centrally – easy to manage.	Needs a specialist network operating system.
	Backups and security controlled centrally – more secure.	You often have to employ a network manager (costs money).
	You can have levels of access to control data.	You need to buy a server and other expensive equipment.
Peer to Peer	No need for a network operating system.	Files are stored on individual computers so it can be harder to find things.
	Much easier to set up – no high-level IT knowledge needed.	Everybody has to be responsible for not bringing a virus in.
	If one computer fails then the network can carry on.	No levels of access – less security.

Network Topologies, Protocols and Layers

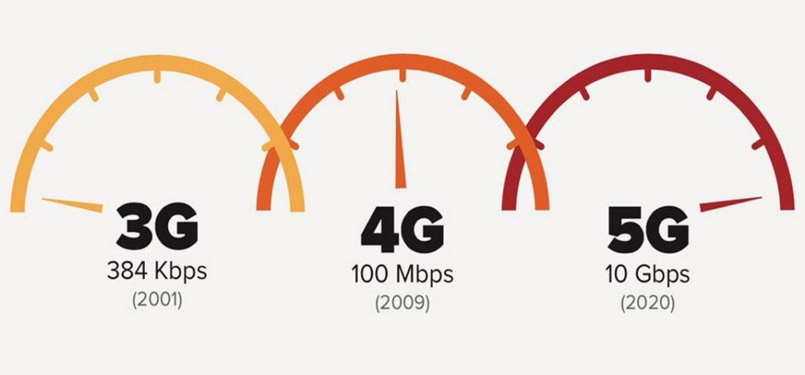
WI-FI

A standard for connecting computers together into a wireless network by **sending data across radio waves**. The acronym doesn't stand for anything—it is just a brand name.

To connect to Wi-Fi you will need a **wireless access point**.

3G / 4G / 5G

This type of connection uses **mobile phone masts** that are dotted around the countryside to beam radio waves to your phone. You will need to pay a phone network to have this privilege. Each generation includes increased speed and performance with 5G currently being the best available.



ETHERNET

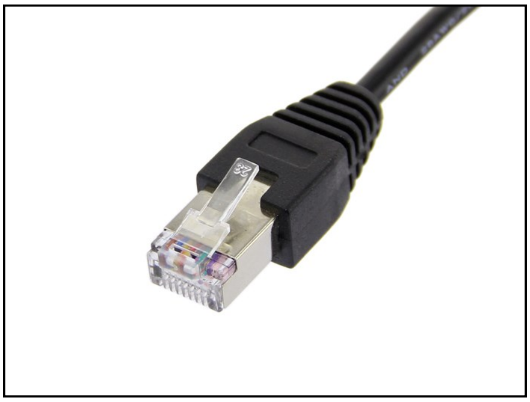
Ethernet is a **protocol** that governs the transmission of data between devices. It uses **cables to transmit the data in a LAN**.

Ethernet is useful for connecting devices in close proximity. After 100m the **signal degrades** and becomes unusable. This can be extended with range boosters.

Ethernet uses **broadcast addressing**.

This means if a device sends some data it broadcasts it out and all the devices on the network receive it. They then need to decide if the broadcast is for them or not and either read the message or ignore it.

Devices can only send data when there is no other devices transmitting to avoid data becoming jumbled up. An Ethernet system uses **collision detection** to stop these kinds of data collisions.



BLUETOOTH

Bluetooth is a short-range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the ISM bands, from 2.402 to 2.48 GHz, and building personal area networks (PANs).

ENCRYPTION

When data is sent across a network, it is often desirable for the information to be kept secret. If a hacker were to intercept the data, this could have negative consequences e.g. bank details could be stolen.

Many systems use encryption. This means **data is scrambled up** so that if it is intercepted it is meaningless. Only the person with the **correct encryption key** can unlock it and read the data.

IP vs MAC ADDRESS

An IP address is given to everything that is **connected to the internet**.

It is a **unique number** that identifies your computer / device and can be used as a way to know where to send data to and where it is sent from.

IP4 addresses involve 4 numbers from 0-255 separated by a dot e.g. 192.168.0.1

IP6 addresses have 8 hex values between 0 and FFFF separated by colons e.g.
2001:db8:3333:4444:5555:6666:7777:8888

There are many more possible combinations of IP6 addresses than IP4 addresses.

A MAC address is a unique number that is **hard wired into every piece of networking equipment**. It does not change.

PROTOCOLS

A protocol is a **set of rules used when transferring data across a network**. You need to learn some of the more common protocols and what they are for.

Protocol	What it stands for	What it does
TCP/IP	Transmission Control Protocol / Internet Protocol	For sending any **data across the internet** Uses layers—see next page
HTTP	Hyper Text Transfer Protocol	For sending and receiving data **about web pages** Has different methods such as GET and POST
HTTP/S	Hyper Text Transfer Protocol Secure	For sending and receiving **encrypted** data about web pages
FTP	File Transfer Protocol	For **sending files** in a **client server** relationship
POP	Post Office Protocol	For **receiving** emails
IMAP	Instant Message Access Protocol	For **receiving** emails and **syncing** emails to the server
SMTP	Simple Mail Transfer Protocol	For **sending** emails

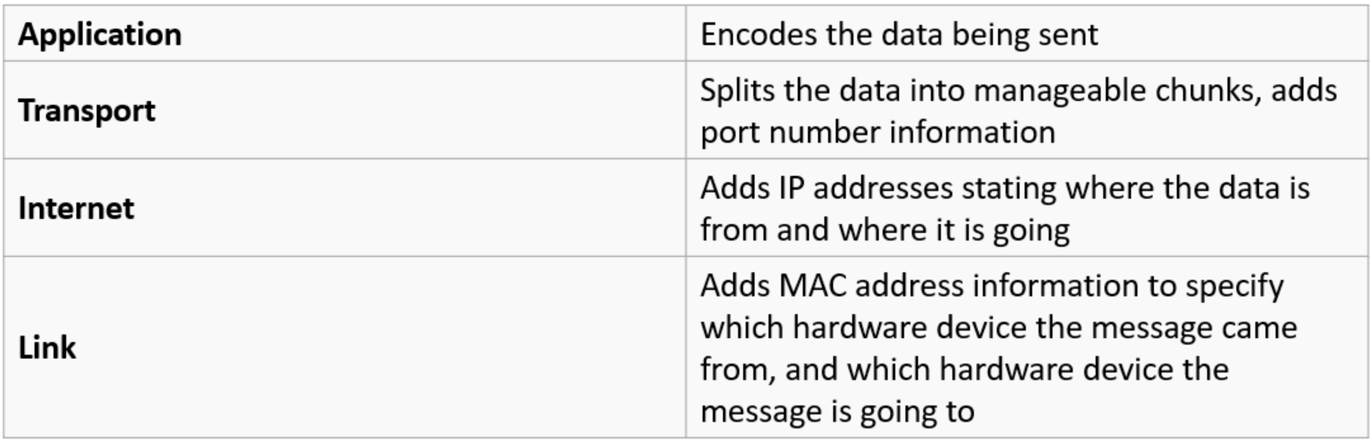
PROTOCOL LAYERS

Protocols are often used together. When this is the case they are divided into separate layers. This is because:

- A layer can be changed or removed without affecting the other layers
- Each layer is self-contained and has its own purpose
- Each layer does not need to consider what the other layers do and can be programmed individually
- Individual protocols are smaller and simpler to manage
- Different layers can interface with different hardware

An example of protocol layers working is the TCP/IP stack. You don't need to memorise this for the exam but it is helpful when understanding how layers work.

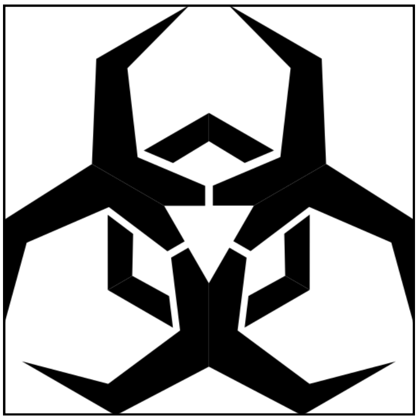
THE TCP/IP STACK



Application	Encodes the data being sent
Transport	Splits the data into manageable chunks, adds port number information
Internet	Adds IP addresses stating where the data is from and where it is going
Link	Adds MAC address information to specify which hardware device the message came from, and which hardware device the message is going to

System Security

MALWARE



Stands for malicious software – it includes any software that has been designed to cause harm to a user or the computer.

Examples are:

- **Virus**: software that copies itself from machine to machine causing harm as it goes.
- **Trojan horse**: malware that is disguised as something beneficial e.g. a game or utility and only once downloaded does it cause damage.
- **Spyware**: malware that watches the keys you press trying to record your passwords and personal information
- **Ransomware**: locks your computer and all the files so you can't access it unless you pay the evil owner a huge sum of cash!

SQL INJECTION

Malicious code is entered into a form on a website that attempts to change the SQL statement that goes to the server.

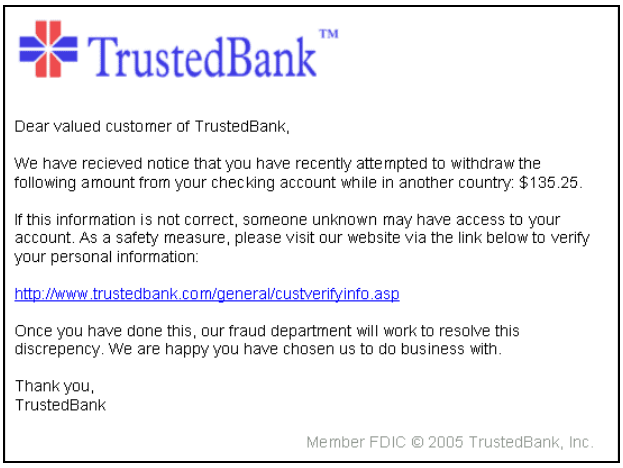
This could mean that the criminal gets unauthorised access to data from the database or could delete / modify the data.

e.g.

Adding ;DROP TABLE Customer to the end of a query string might delete a website's customer data if it wasn't securely protected.

PHISHING

An email is made to look like it comes from a legitimate source such as a bank. The email will try to trick the user into clicking on a link and entering their personal information. This was the hacker can gain access to your secure accounts!



TrustedBank™

Dear valued customer of TrustedBank,

We have recieved notice that you have recently attempted to withdraw the following amount from your checking account while in another country: $135.25.

If this information is not correct, someone unknown may have access to your account. As a safety measure, please visit our website via the link below to verify your personal information:

http://www.trustedbank.com/general/custverifyinfo.asp

Once you have done this, our fraud department will work to resolve this discrepency. We are happy you have chosen us to do business with.

Thank you,
TrustedBank

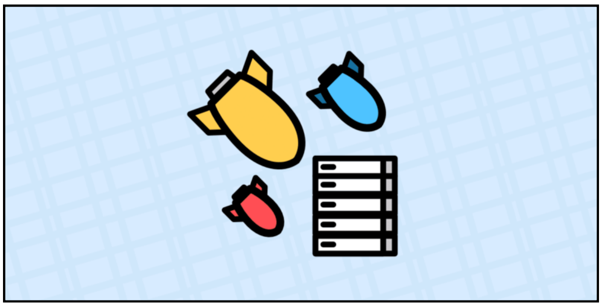
Member FDIC © 2005 TrustedBank, Inc.

BRUTE FORCE ATTACK

One way to try to guess somebody's password is to simply try every single possible combination of passwords available until the correct one is found. This is called a brute force attack.

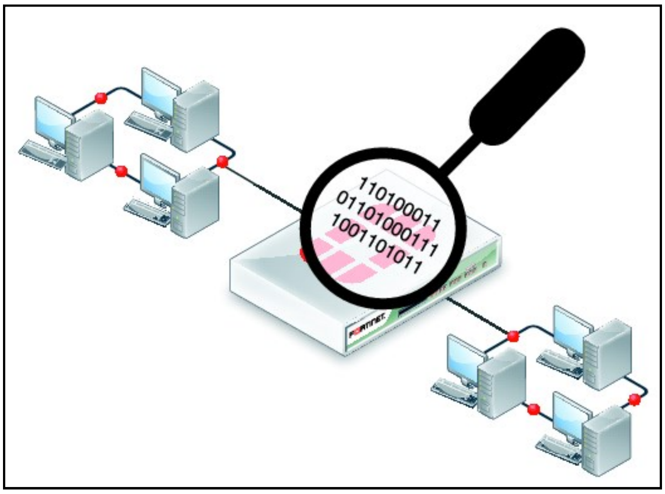
The longer the password and the wider range of characters (e.g. numbers, letters, special characters) the harder it is to do this sort of attack.

DENIAL OF SERVICE ATTACK



A web server is flooded with requests so that it cannot cope with the demand and either shuts down or stops being able to answer the real requests.

DDoS (distributed denial of service attack) is a variant of this and involves the hacker taking over a whole host of computers and using them to perform the attack in unison. This makes it much harder to stop as the attacks are coming from different locations all around the world.



DATA INTERCEPTION AND THEFT

Each time any communication is sent across a network, whether it is a Local Area Network or a Wide Area Network, it is split up into packets and sent by various routes. As they travel from one part of the network to another, they are at risk of being intercepted, read, altered or deleted.

One way data can be intercepted is if someone uses some hijacking software and pretends to be the destination for communications across a network. Another way is for a user to use 'packet sniffing' software and hardware to monitor network traffic and intercept those packets it is interested in. People using packet sniffers are especially looking for plain text files, passwords and set-up information being set across the network, which they can steal, analyse and extract information from.

SOCIAL ENGINEERING

This includes any number of techniques designed to trick people into giving away crucial data or passwords. Effectively this is the same as an old fashioned “con”. Some of the scams available include:

- Pretexting—impersonating a trusted source like a police officer or bank clerk
- Phishing—see above
- Tailgating—looking over someone’s shoulder to see their PIN
- Quid quo pro—phoning up pretending to be from technical support

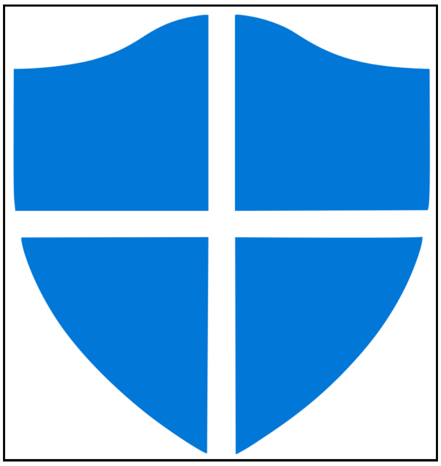
Ways to Protect a System

PENETRATION TESTING

Sometimes called pen testing. This is when a company hires somebody with hacking skills to try to break into their system. If they are successful they can tell the company the weaknesses so that they can fix them and protect themselves from real attacks.

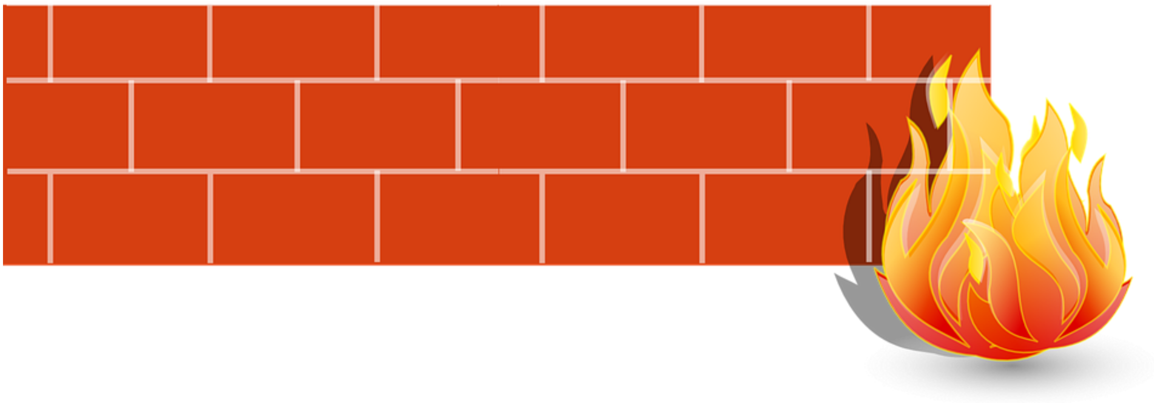
ANTI-MALWARE SOFTWARE

Protection software that stays in the computer's memory. It is constantly scanning the drives and memory for any malicious software. It compares suspicious items with a known database of threats and reports it to you when there is a match. You can then choose to quarantine the file or delete it.



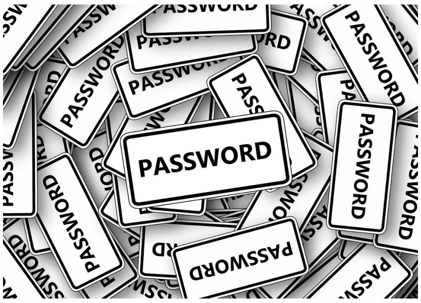
FIREWALLS

Scans files as they come into your system from across a network or the internet. It will let you know if anything looks suspicious and you can set it to block certain types of files or files from certain sources.



USER ACCESS LEVELS

Means that you can allow only partial access to your system to different users. For example, a pupil in a school won't be able to access as many files as a teacher and the teacher won't be able to access as many files as the network administrator.



PASSWORDS

Strong passwords can help to protect against brute force attacks. The longer the password the better and it helps if it contains numbers, a mix of capital and lowercase letters and special characters. Favourite football teams or pet names should be avoided!

ENCRYPTION

Scrambles up data before it is sent across a network or the internet. Only the person who knows the secret encryption key can unscramble it so it doesn't matter if it is intercepted by criminals.

PHYSICAL SECURITY

Quite simply, its much harder to get access to data if there is a wall in the way or it is locked in a safe!

Physical security measures might include keypad entry to server rooms, biometric scanners, guards, locks and many more.

Systems Software

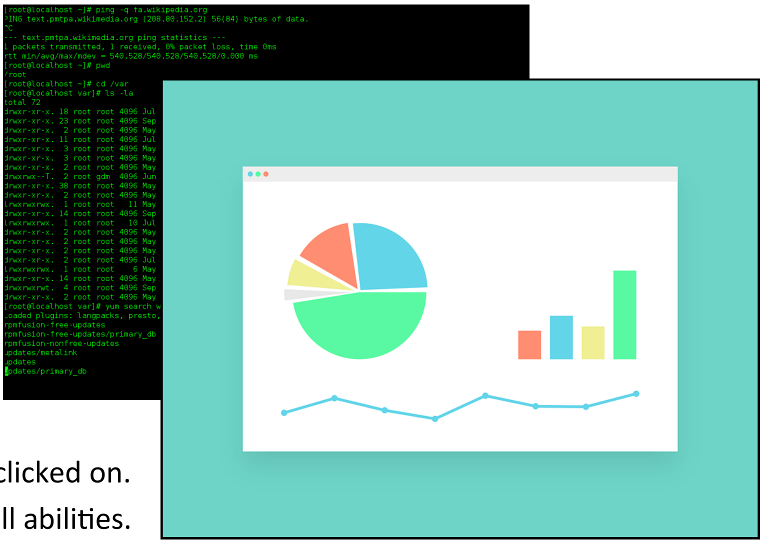
DEFINITION

Systems software provides an interface between the hardware and software and is used to control the hardware.

FUNCTIONS OF AN OPERATING SYSTEM

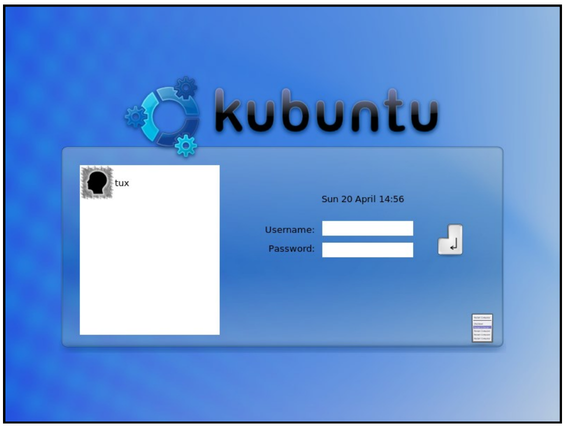
User Interface— This is the part of the OS that you can see. A user interface lets you enter commands and lets the OS display the results of those commands. Two types:

- CLI—Command Line Interface: commands are entered by typing them in. Very fast and powerful but only suitable for expert users.
- GUI– Graphical User Interface: commands are entered using a mouse / touchscreen and icons are clicked on. Slower and less powerful than a CLI but suitable to all abilities.



```
[root@localhost ~]# ping -q fa.wikipedia.org
PING text.pmtpa.wikimedia.org (208.80.152.2) 56(84) bytes of data.
^C
--- text.pmtpa.wikimedia.org ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 540.528/540.528/540.528/0.000 ms
[root@localhost ~]# pwd
/root
[root@localhost ~]# cd /var
[root@localhost var]# ls -la
total 72
drwxr-xr-x. 18 root root 4096 Jul
drwxr-xr-x. 23 root root 4096 Sep
drwxr-xr-x.  2 root root 4096 May
drwxr-xr-x. 11 root root 4096 Jul
drwxr-xr-x.  3 root root 4096 May
drwxr-xr-x.  3 root root 4096 May
drwxr-xr-x.  2 root root 4096 May
drwxrwx--T.  2 root gdm  4096 Jun
drwxr-xr-x. 38 root root 4096 May
drwxr-xr-x.  2 root root 4096 May
lrwxrwxrwx.  1 root root   11 May
drwxr-xr-x. 14 root root 4096 Sep
lrwxrwxrwx.  1 root root   10 Jul
drwxr-xr-x.  2 root root 4096 May
drwxr-xr-x.  2 root root 4096 May
drwxr-xr-x.  2 root root 4096 May
drwxr-xr-x.  2 root root 4096 Jul
lrwxrwxrwx.  1 root root    6 May
drwxr-xr-x. 14 root root 4096 May
drwxrwxrwt.  4 root root 4096 Sep
drwxr-xr-x.  2 root root 4096 May
[root@localhost var]# yum search w
Loaded plugins: langpacks, presto,
rpmfusion-free-updates
rpmfusion-free-updates/primary_db
rpmfusion-nonfree-updates
updates/metalink
updates
updates/primary_db
```

Memory Management—let's memory be shared so more than one process can be stored in RAM at once. This means that modern operating systems are usually **multi-tasking** i.e. they let you run lots of programs at the same time. Memory management also controls the use of **virtual memory** (see memory section).



Peripheral Management– a peripheral is a device you plug into your computer. It might be a mouse, keyboard, scanner, camera or any other. The operating system uses **device drivers** to act as a link between the hardware of the device and the software of the OS.

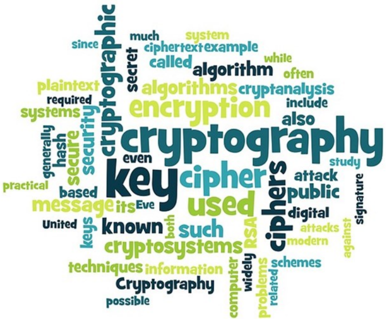
User Management– lets you have different log ins for different users. Each user might have different privileges (user access levels).

File Management– lets you organise your files into folders. Also lets you compress files to make them smaller and there might be some utilities for cleaning up old files.

Utility Software

DEFINITION

Software that fixes problems on your computer or maintains the good working order of your computer.



ENCRYPTION

Encryption takes data and scrambles it up so that it cannot be read.

Only if somebody has the correct password (called the key) can they unscramble the data and read what is inside.

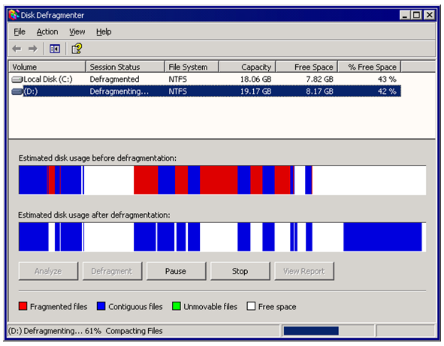
This is particularly useful for sending data across the internet and is used in online shopping to protect credit card details.

DEFRAGMENTATION

When a hard drive writes data it puts it onto the disk in no particularly order.

This can mean that files can get scattered across the disk – they become fragmented.

A defragmenter aims to put all the bits of related files together. This speeds up the hard disk as you don't need to keep going to all four corners to read files that are associated with each other. It can also free up space.



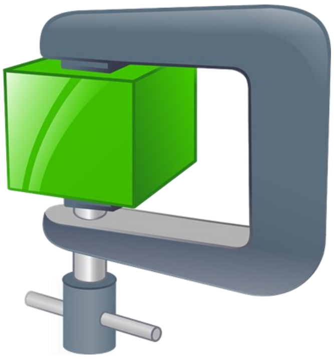
Volume	Session Status	File System	Capacity	Free Space	% Free Space
Local Disk (C:)	Defragmented	NTFS	18.06 GB	7.82 GB	43 %
(D:)	Defragmenting...	NTFS	19.17 GB	8.17 GB	42 %

Estimated disk usage before defragmentation:

Estimated disk usage after defragmentation:

🟥 Fragmented files 🟦 Contiguous files 🟩 Unmovable files □ Free space

(D:) Defragmenting... 61% Compacting Files



DATA COMPRESSION

Makes a file smaller so that it takes up less space and can be transferred faster.

It is possible to compress all the files on your disk. This gives you more space but is slower.

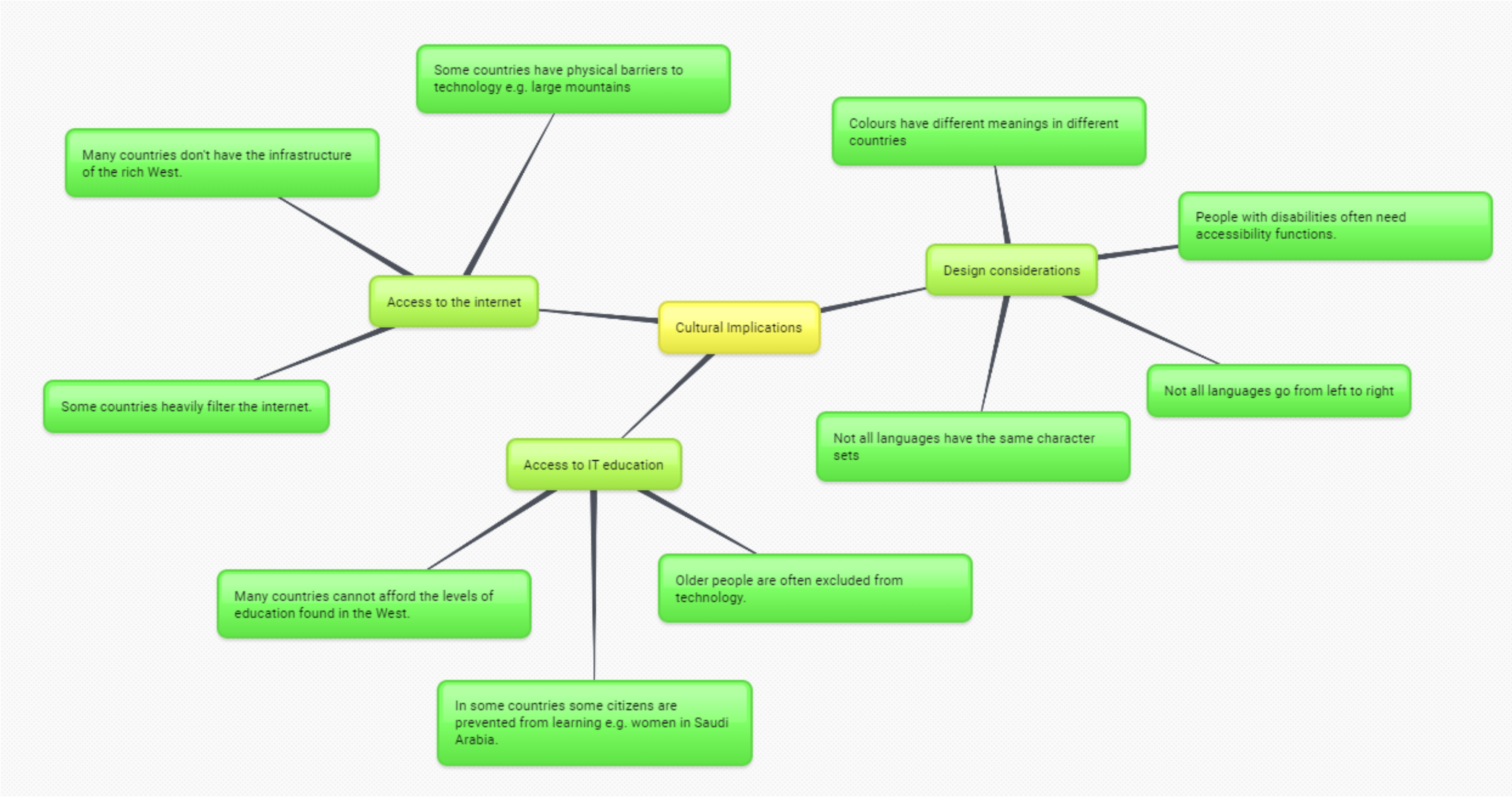
Two types = lossy and lossless.

Ethical, Legal, Cultural and Environmental

ENVIRONMENTAL EFFECTS

GOOD	BAD
Using computers saves paper: • Emails reduce the amount of letters we send • Digital storage reduces the amount of paper files we keep	Computers use energy! Energy means fossil fuels are burned which increase climate change.
Using video conferencing services has reduced the need to travel for meetings	Computers are full of noxious chemicals that cannot easily be disposed of. Most of these chemicals end up in landfill sites damaging the environment for decades to come.
People can now work from home by dialling into their work's server. This reduces commuting and thus reduces	

CULTURAL IMPLICATIONS



Some countries have physical barriers to technology e.g. large mountains

Many countries don't have the infrastructure of the rich West.

Colours have different meanings in different countries

People with disabilities often need accessibility functions.

Design considerations

Access to the internet

Cultural Implications

Some countries heavily filter the internet.

Not all languages go from left to right

Not all languages have the same character sets

Access to IT education

Many countries cannot afford the levels of education found in the West.

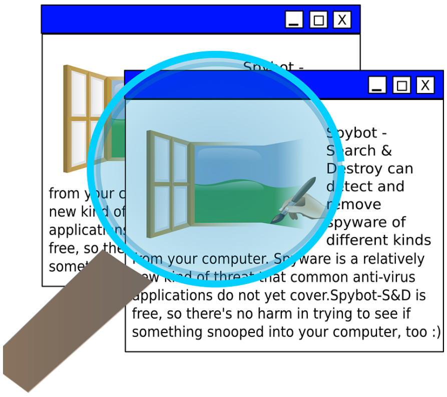
Older people are often excluded from technology.

In some countries some citizens are prevented from learning e.g. women in Saudi Arabia.

LEGAL IMPLICATIONS

LAW	DESCRIPTION	DETAIL
The Data Protection Act 1998	The law that prevents the misuse of your personal information.	8 principles: 1. Data will be processed fairly and lawfully. 2. Data will only be used for the purpose it was gathered for. 3. Data will be adequate, relevant and not excessive. 4. Data will be accurate and up to date. 5. Data will not be held for longer than necessary. 6. Data will be processed with the rights of the data subjects. 7. Companies will protect against unauthorised access to data 8. Data will not be shared outside the European Economic Area.
Computer Misuse Act 1990	The law that stops people causing harm using computers.	Crimes are: Hacking (unauthorised access to a computer system). Creating malware.
Copyright Design and Patents Act 1998	The law that protects published works and makes sure that only their creators get the rewards.	Any work that has been published e.g. book, film, music, software, TV show is covered by copyright law. The law states that the owner of the copyright has the right to be paid for the work they have done. Any copying or redistributing of the work is illegal.
Creative Commons Licensing	A type of license that means the author gives their work away	The creator of a work puts this license on whenever he wants people to be able to freely distribute it without fear of breach of copyright.

PRIVACY


Spybot -
Search &
Destroy can
detect and
remove
spyware of
different kinds
from your computer. Spyware is a relatively
new kind of threat that common anti-virus
applications do not yet cover.Spybot-S&D is
free, so there's no harm in trying to see if
something snooped into your computer, too :)

Privacy is simply the right that all people have to not be watched. Many people feel this right is being eroded away in modern society:

- CCTV cameras are found in most town centres.
- Number plate recognition systems track your car wherever you go.
- Phone GPS systems can track your movements on foot.
- Your ISP can keep records of your internet habits.
- Your phone can be tapped by police under certain circumstances.

Many citizens have tried to combat this by using technologies that mask their IP addresses and encrypt their messages but the government is often pushing for even more control.