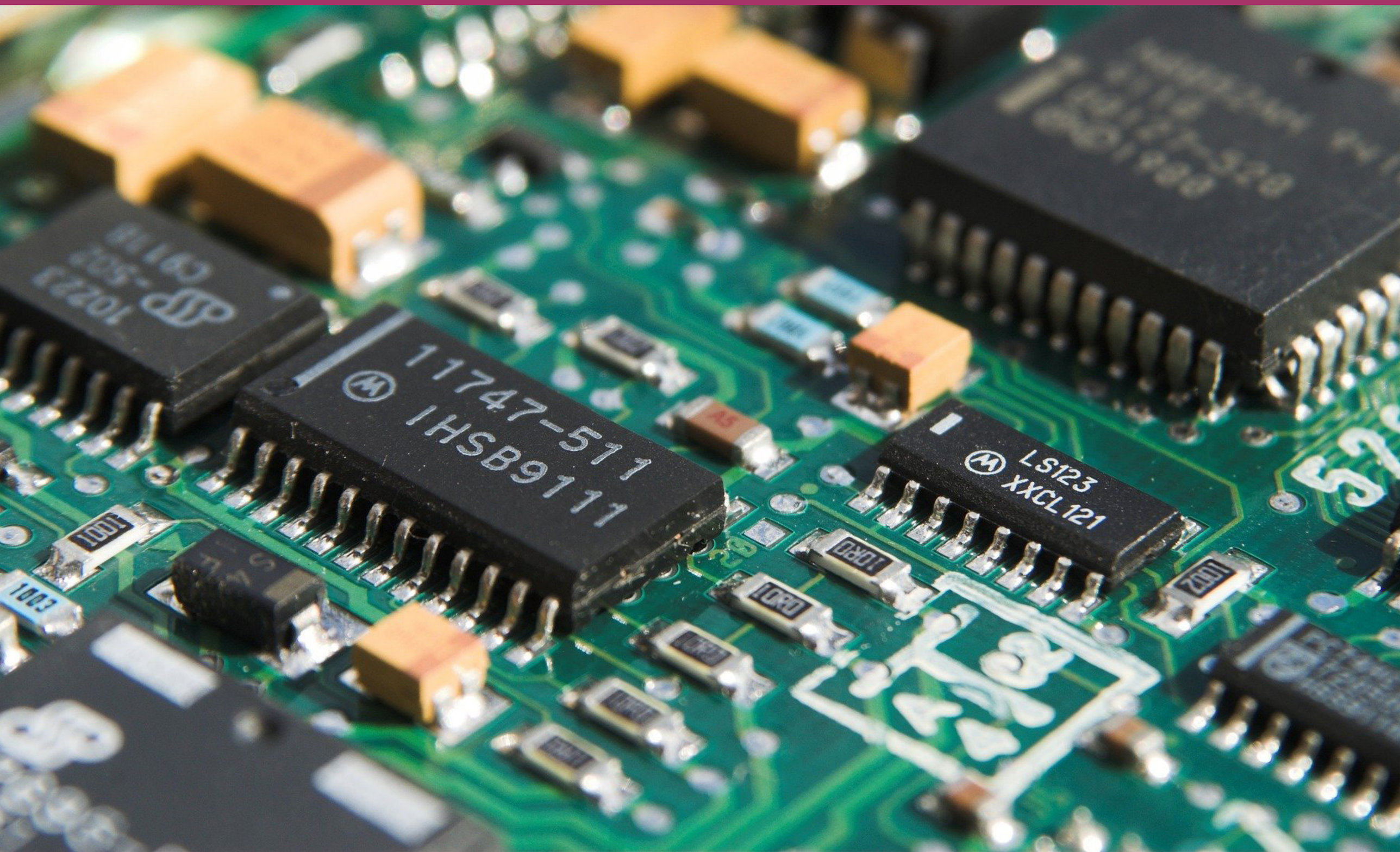
GCSE Computer Science



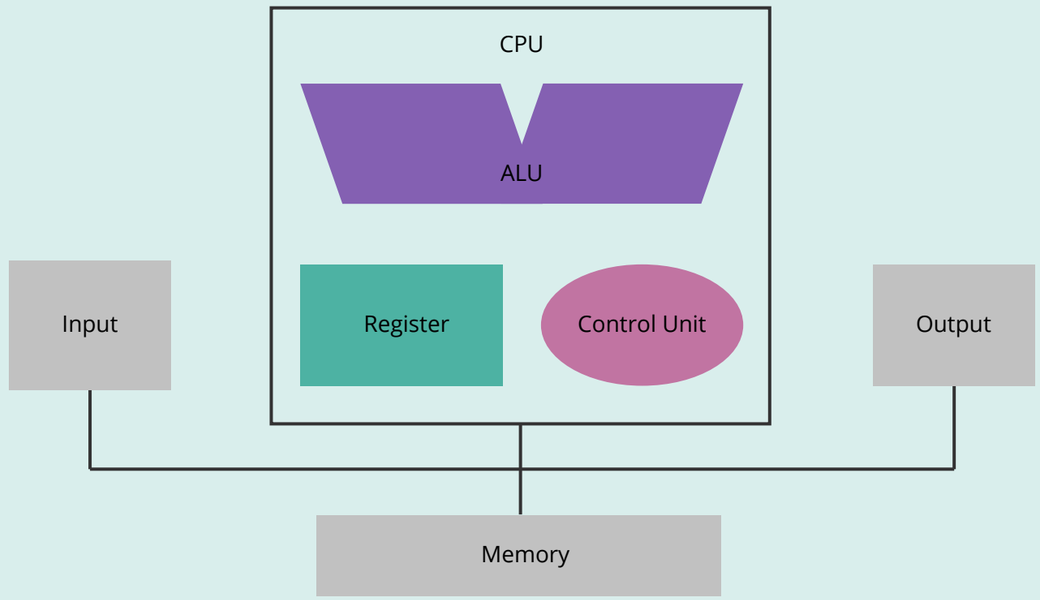
Component 1: Hardware

Key terminology

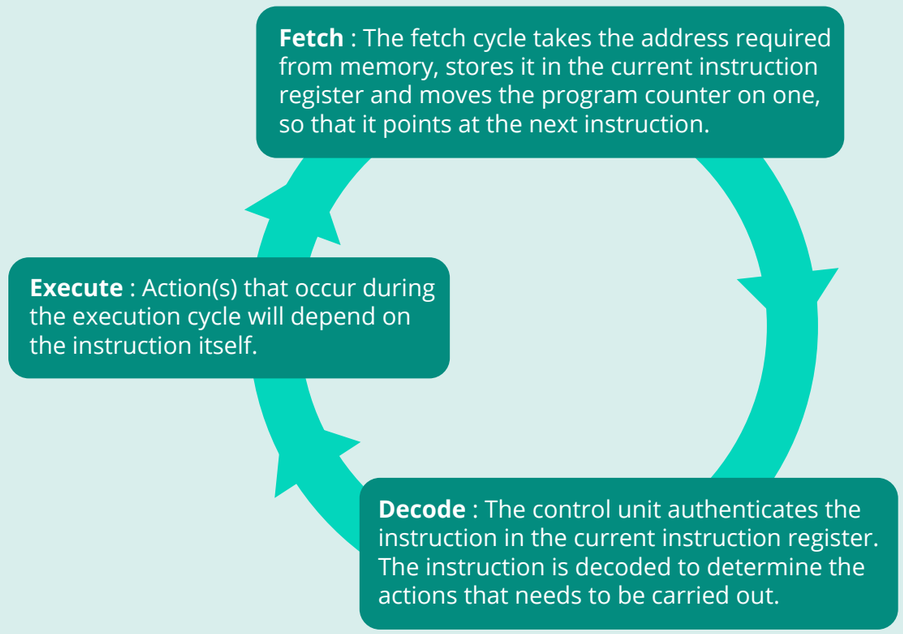
Term	Definition
Central processing unit (CPU)	The main component in a computer for processing data and instructions.
Control unit (CU)	Directs the flow of instructions and/or data and coordinates the other parts of the CPU. It generates clock ticks.
Arithmetic logic unit (ALU)	The ALU performs all the mathematical calculations / logical operations in the CPU.
Cache	Incredibly fast, but very expensive volatile memory used by the CPU.
Registers	Fast access storage locations found on the CPU where data or control information is temporarily stored.
Program counter (PC)	A counter that keeps track of the memory address of the instruction to be executed next.
Current instruction register (CIR)	A temporary holding area for the instruction that has just been fetched from memory.
Accumulator (ACC)	A register for temporary storage of arithmetic and logic data in the CPU.
Memory address register (MAR)	Stores the address in the main memory that is currently being read or written.
Memory data register (MDR)	Stores the data in the main memory that is currently being read or written.
Memory	Used for the temporary storage of currently running programs and data.
Clock speed	The number of FDE cycles that a CPU can carry out per second.
Cores	Some processors have multiple processors (cores) which can work in parallel, sequentially or can multitask.

Central processing unit (CPU)

The typical Von Neumann architecture



The Fetch-Decode-Execute (FDE) cycle



Performance is affected by greater

- cache size
- clock speed
- number of cores.

Cache size

- Can store more data and instructions.
- It can provide instructions and data to the CPU at a much faster rate (than other system memory such as RAM).

Clock speed

- The FDE cycle will run faster, resulting in more instructions being processed.

Number of cores

- More instructions can be processed at the same time.

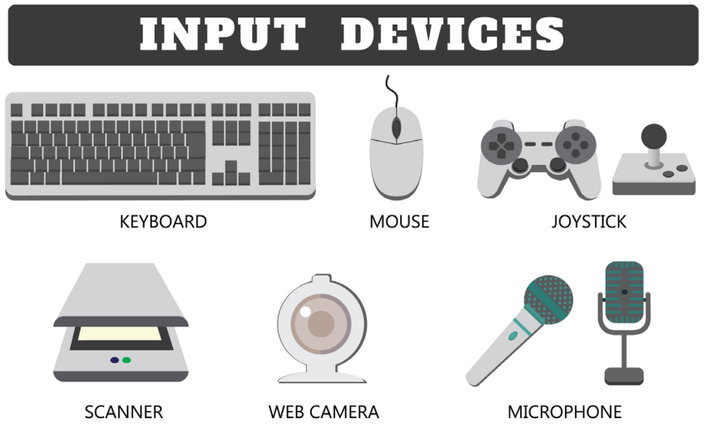
NOTE: Performance may be affected where one core is waiting on the result of another and therefore cannot carry out any more instructions.

Component 1: Hardware

Key terms

Term	Definition
Input	Data is sent to the computer system using a device.
Output	Data is received from the computer system using a device.
Virtual memory	Data that appears to be stored in main memory, but some of is actually held in secondary storage. Data is transferred between the two automatically as required.
Volatile	Stored data is lost when the power is interrupted or switched off.
Permanent	Stored data is kept when the power is interrupted or switched off.

Input and output devices



Primary storage

Summary of the different types of memory:

Type	Cache memory	Read-only Memory (ROM)	Random Access Memory (RAM)	Flash memory	Virtual Memory
Volatile or permanent	Volatile	Permanent	Volatile	Permanent	Volatile
Data can be changed	✓		✓	✓	✓
Relative speed	★★★★★	★★★★	★★★	★★	★
Example use	The temporary storage of frequently accessed data and instructions.	Storing programs such as the system BIOS.	Storing currently running programs and data.	Storing the programs such as the system BIOS.	Compensates for a main memory shortage by temporarily storing data in secondary storage.

Additional hardware components

Graphics Processing Unit (GPU)

Integrated GPU

- Uses the computer's RAM
  Cheaper than installing a dedicated GPU
- Generates less heat and uses less power
- Perfect for general graphics processing such as watching or editing videos and word processing.

Dedicated GPU

- Has its own video memory
- Provides the best visual experience
- Used by people such as professional graphic designers and serious gamers
- Uses more power and require a good cooling system.

Sound cards

- The sound card will convert analogue input signals into digital data and reverse this process for output.

Motherboards

- The motherboard is the main circuit board of the computer.

Component 1: Hardware

Secondary storage

	Functional characteristics	Devices		Capacity	Durability	Portability	Speed	Cost
Solid state	• A non-mechanical design of semiconductor chips • It does not require defragmentation • There are two types of solid state memory NOR and NAND • Both contain cells (transistors) in a grid, but the wiring between the cells differs • If a chain of transistors conducts current, it has the value of 1. If it doesn't conduct current, it's 0.		Flash memory drive	2 GB – 512 GB	★★★★	✓	★★★★	£££
			Solid-state drive	128 GB – 4 TB	★★★★		★★★★	£££
Magnetic	• Each sector can be magnetised as 1 or demagnetised as 0 • Data is read and written using a mechanical arm that has a head at the end • In hard disc drives, a platter is divided into billions of tiny areas. As the disk spins, the arm travels across the disk • Each sector of the platter can store data and the movement of both the disk and the read / write head means that every sector on the hard drive can be reached.		Hard disc drive	250 GB – 16 TB	★		★★★	£££
			Magnetic tape drive		★★	✓	★	£
Optical	• A pit is "burned" with a laser beam into the surface • A pit represents 0 • The lack of a pit (a flat, unburned area on the disc, called a land) represents the number 1 • Data is stored in a continuous spiral.		CD / DVD / Blu-ray Drive	CD: 700 MB DVD: 9 GB BD: 50 GB	★★★	✓	★★	££
Cloud storage	• A technology that allows users to store their data on third-party servers. They can then access that data from many computing devices.			Unlimited		✓		Free / subscription based

Embedded systems

An embedded system is a combination of software and hardware that performs a specific task whereas a general-purpose computer is designed to carry out multiple tasks.

Examples include - MP3 players, mobile phones, video game consoles, digital cameras, DVD players, and GPS. Household appliances, such as microwave ovens, washing machines and dishwashers.

Component 1: Data representation and storage

Key terminology

Term	Definition
Denary	Base 10 number system. Uses digits 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9
Binary	Base 2 number system. Uses digits 0 and 1 only
Hexadecimal	Base 16 number system. Uses digits 0 – 9 and characters A(10), B(11), C(12), D(13), E(14) and F(15) The notation is used as shorthand for binary numbers to avoid errors

Data types

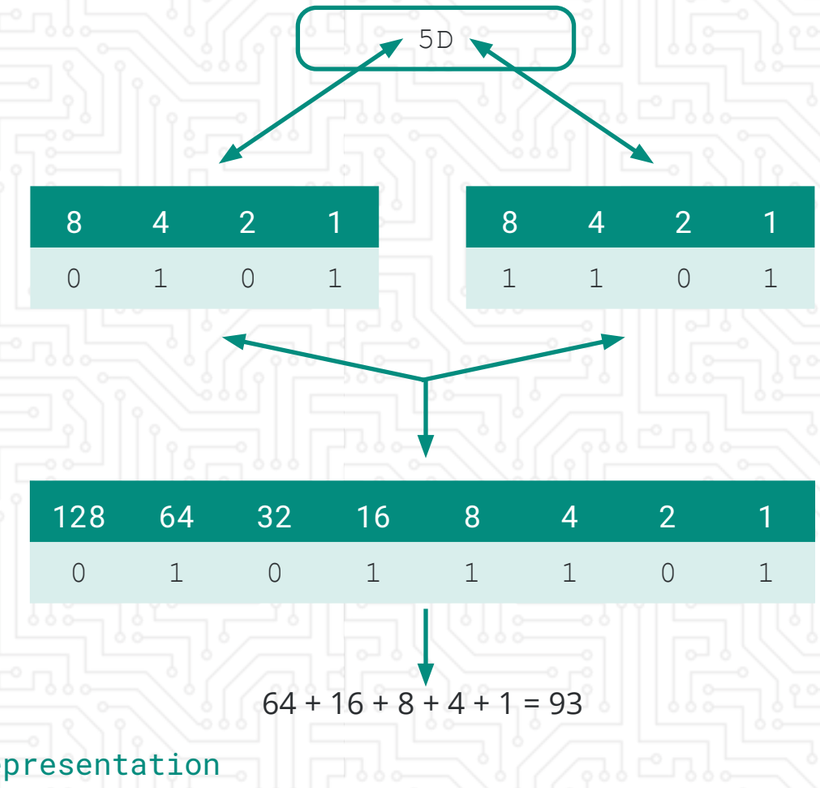
Data type	Description	Examples
Integer	Whole numbers, positive or negative	42, -11, 0
Real	Numbers, including fractions or decimal points	12.9, -17.50, 28.0
Boolean	True or false	1 or 0 TRUE or FALSE
Character	Letter, digit, space, punctuation mark or various other symbols	'A', 'b', '7','?'
String	A sequence of characters	'Computer science'

Representation of numbers

Conversion between denary, binary and hexadecimal:

Hexadecimal

Binary



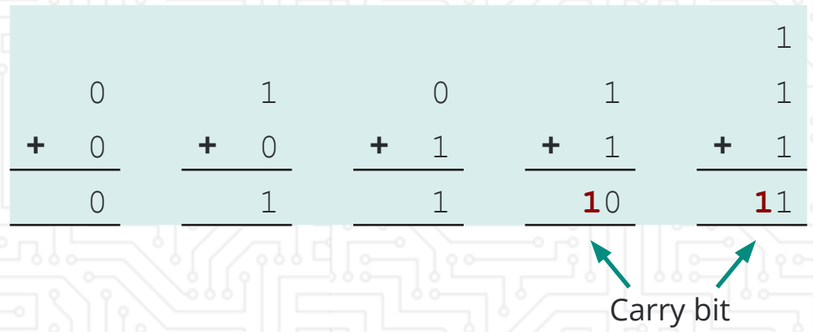
Denary

Sign and magnitude representation

+/-	64	32	16	8	4	2	1
1	0	0	0	1	0	1	0

The most significant bit is used to represent the sign of the number, where 1 means the number is negative and 0 means the number is positive. The number above represents -10_{10}.

Binary addition



Component 1: Data representation and storage

Representation of numbers (continued)

Two's complement representation

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

The most significant bit has a negative value. So to the number above represents -8710 (-128 + 32 + 8 + 1).

Negative numbers can be determined by first writing its positive, flipping each bit and adding 1.

	-128	64	32	16	8	4	2	1
Positive 87_{10}	0	1	0	1	0	1	1	1
Flip the bits	1	0	1	0	1	0	0	0
Add 1								1
	1	0	1	0	1	0	0	1

Overflow

11011001
+ 01010010

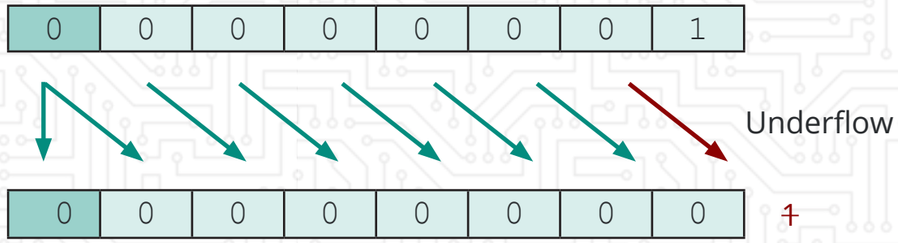
Overflow

~~1~~ 00101011

When the number is too large to be stored by the register, the left-most bit cannot be stored and therefore cannot be counted.

Underflow

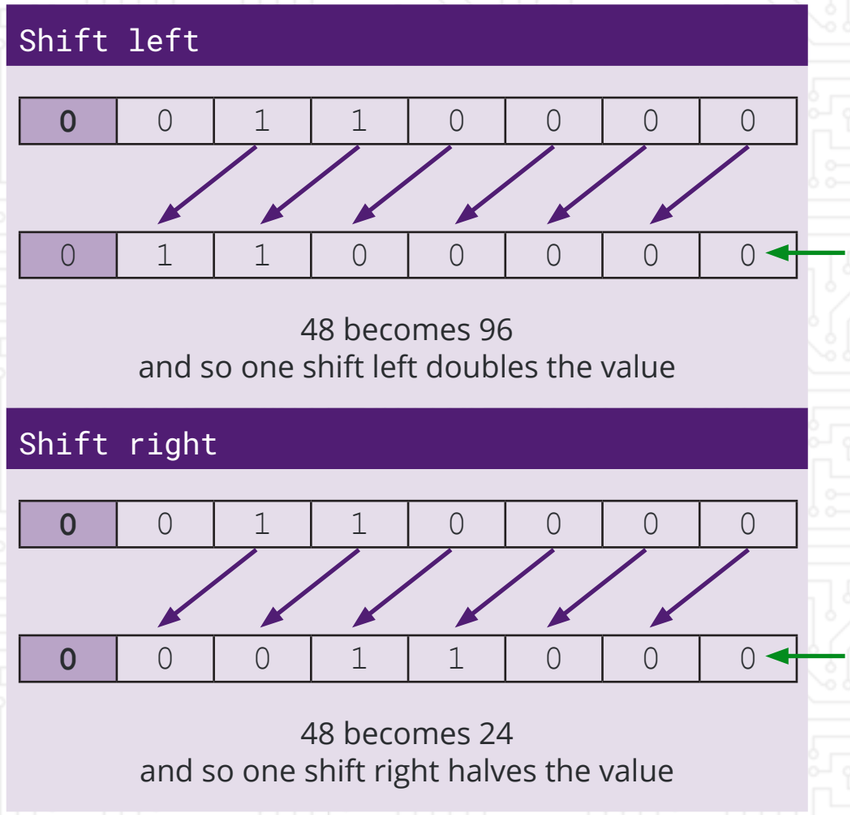
An arithmetic shift right (see right) on the following number (1_{10}) would be divided by half and so should be 0.5_{10}.



When the number is too small to be stored by the register, the right-most bit cannot be stored and therefore cannot be counted.

Arithmetic shift functions

Moving the bits to either the left of the right, doubles (×2) or halves (÷2) the value with each.



Component 1: Data representation and storage

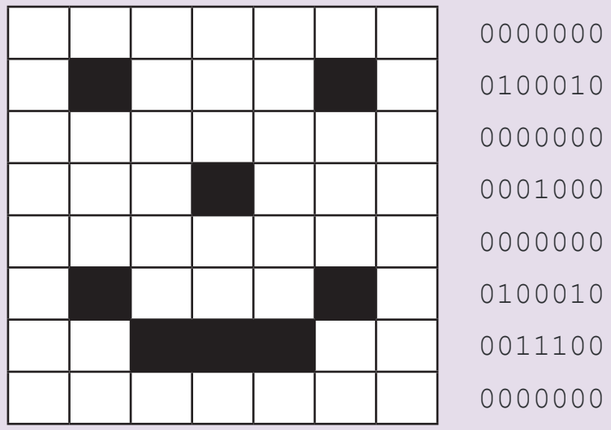
Key terms

Term	Definition
Pixel	A small coloured dot on a computer display (short for picture elements)
Bitmap	Images are stored as an array of pixels
Vector	Images that do not store the data by pixels, but are a set of instructions for drawing a geometric shape
Sample rate	The number of audio samples captured every second
Bit depth	The number of bits available for each clip
Bit rate	The number of bits used per second of audio
Metadata	A set of data that describes and gives information about other data

Representation of graphics and sound

Digital storage of graphics

A black and white bitmap image will store a 1 for a black pixel and 0 for a white pixel.



This bitmap image can be represented using 56 bits (or 7 bytes).

Digital storage of graphics (continued)

A colour bitmap image is stored using a longer binary number that represents how much red, green and blue (RGB) is required in the colour of each pixel to produce different colours.

Colour depth

The more bits in the binary number, the greater the colour depth, which leads to more colours being available.

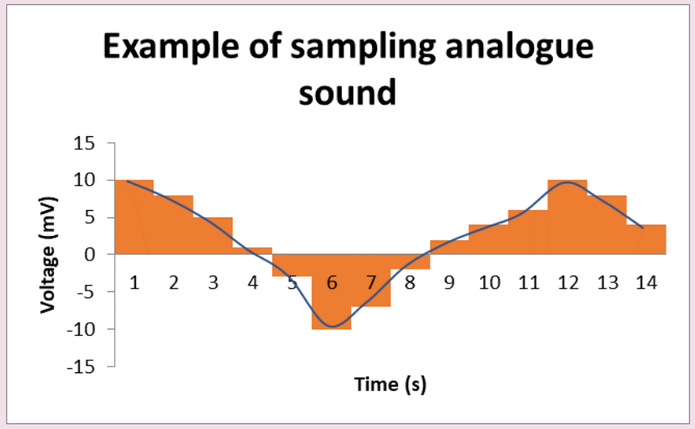
Colour depth	Number of available colours
1 bit	2
2 bits	4
3 bits	8
8 bits	256
16 bits	65,536
24 bits	16.7 million
32 bits	4.3 billion

Resolutions

Resolution is the measure of the quality of graphics. Resolution is expressed in dots per inch (dpi). The higher the dpi, the higher the resolution.

Representation of sound

Sound is converted into a digital signal by a process called sampling. This is where hardware, such as a microphone, measures the level of sound many times per second and records this as binary digits.



The higher the sampling rate, the better the quality, but larger the file size.

Component 1: Data representation and storage

Key terms

Term	Definition
Bit	A binary digit `1` or `0`.
Metadata	A set of data that gives information about other data.
Character	A letter, digit, space, punctuation mark or various other keyboard symbols.
Character set	A table that maps a character with a unique binary number.
Compression	The process of making a file size smaller.
Array	A data structure that can hold a fixed number of data items, which must be of the same data type.

Storage requirements

Unit	Symbol	Value
Bit	b	1 bit
Nybble	-	4 bits
Byte	B	8 bits
Kilobyte	kB	1024 bytes
Megabyte	MB	1024 kB
Gigabyte	GB	1024 MB
Terabyte	TB	1024 GB
Petabyte	PB	1024 TB

Calculating storage requirements

File sizes are calculated as follows:

Graphics: *width* × *height* × *colour depth*

Sound: *channel* × *sample rate* × *bit depth*

Metadata

Examples of metadata used in graphics and sound files:

- Genre: the genre that the sound file belongs to
- Artist: the name of the artist who sang the songs
- Date Created / Year: the date the graphic was taken
- Location: the location where the graphic was taken
- Colour depth
- Dimensions – the width and height of a graphic.

Representation of characters

Characters are stored on a computer system as a binary number using a character set. Examples of character sets include ASCII and Unicode.

A small part of the ASCII character set:

Denary	Binary	Hex	Character
64	1000000	40	@
65	1000001	41	A
66	1000010	42	B
67	1000011	43	C

Character sets allow for meaningful data to be exchanged between different computer systems.

Unicode has combined and replaced many others character sets. It was originally an extension to the ASCII character set, but now contains many of the characters used around the world. Each character requires 2 bytes of storage.

Compression

Lossless compression

Uses an algorithm that compresses data into a form that may be decompressed without any loss of data (recovers all original data).

Lossless data compression works by finding repeated patterns in data and compressing those patterns in an efficient manner.

For this reason, lossless data compression is also referred to as redundancy reduction.

Lossless data compression is ideal for text.

Lossy compression

Compressed files can never be recovered exactly as they were before they were compressed. When compressed files are decompressed they do not give back the original data, i.e. data is lost.

Because lossy compression cannot be decompressed to yield the exact original data, it is not a good method of compression for critical data, such as textual data.

Lossy compression is used to compress multimedia data, such as images, sound and video, for internet streaming.

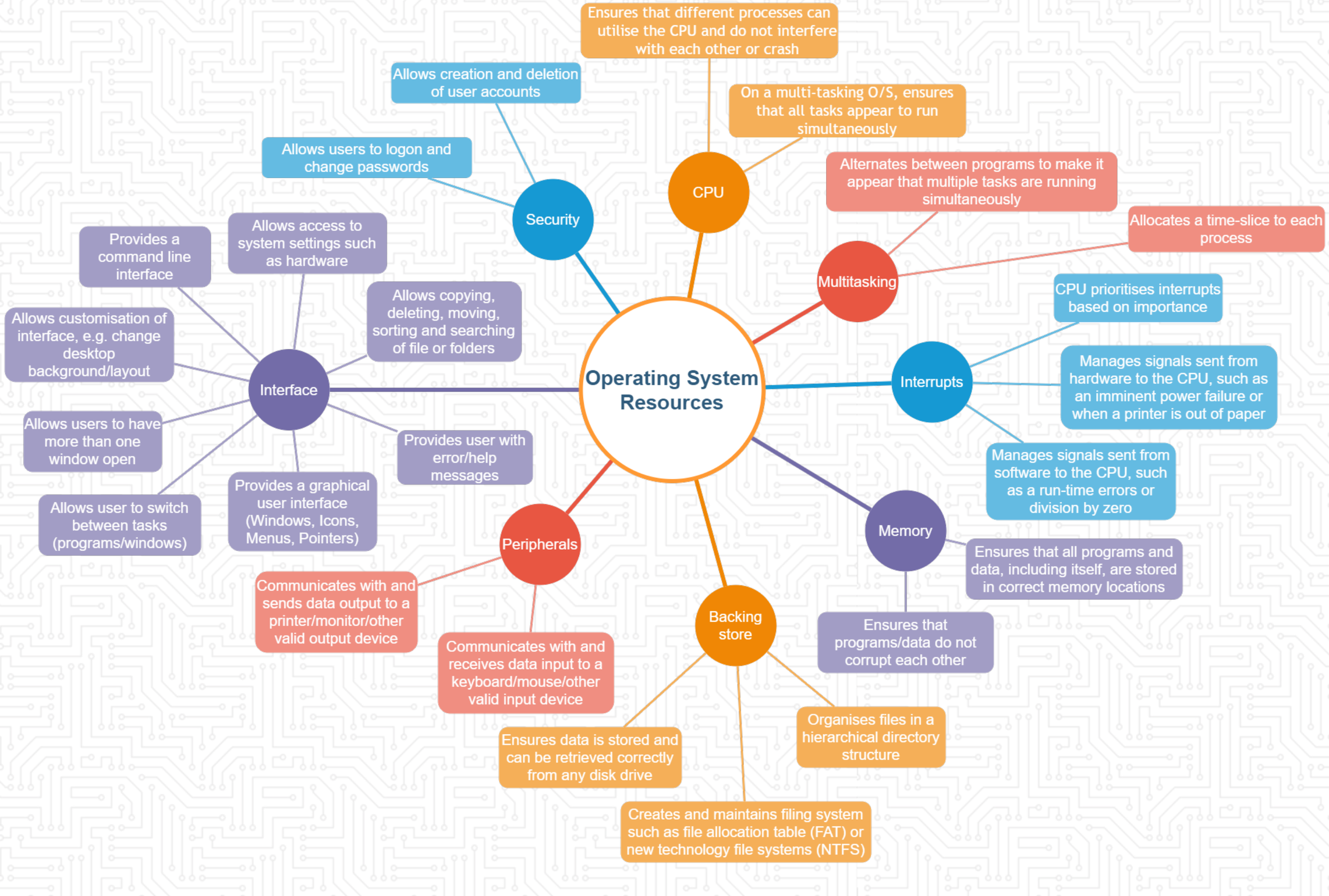
Calculating compression ratios

$$\textit{Compression ratio} = \frac{\textit{Original file size}}{\textit{Compressed file size}}$$

Component 1: Operating systems

The purpose of the operating system

An operating system is software that manages a computer system. The operating system is loaded by the bootstrap loader. One of its primary functions is to manage resources.

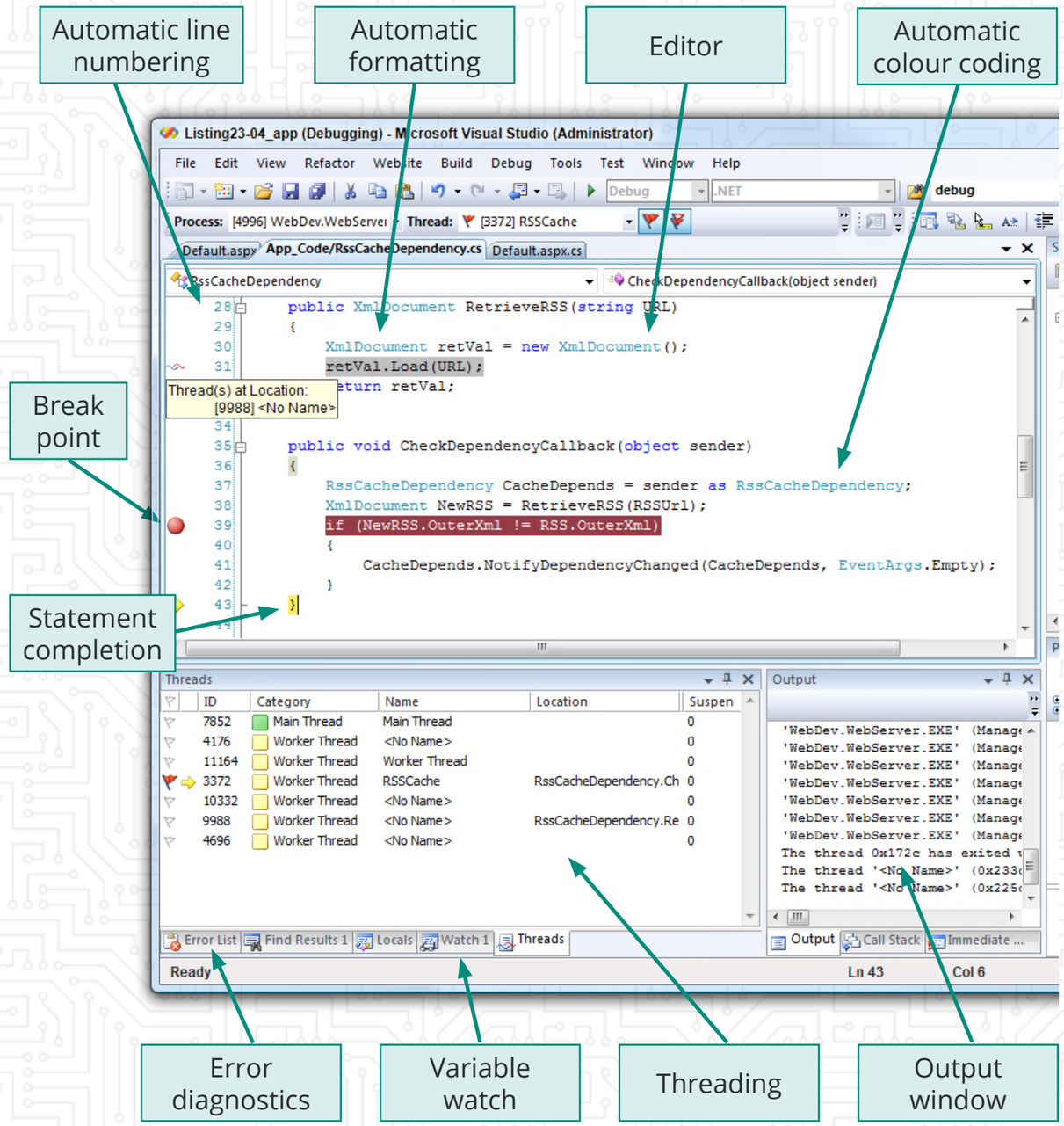


Component 1: Software development

Key terms

Term	Definition
Editor	Allows a programmer to enter, format and edit code.
Automatic formatting	Correctly indents code.
Automatic colour coding	Changes key words, literals and annotation to different colours.
Compiler	Translates source code into executable machine code. Once compiled, a program can be run at any time.
Interpreter	Translates each line/a single line of source code and executes it
Linker	A program which allows previously compiled code, from software libraries, to be linked together.
Loader	A program which loads previously compiled code into memory.
Debugger	A program which helps locate, identify and rectify errors in a program.
Trace	A facility which displays the order in which the lines of a program are executed, and possibly the values of variables as the program is being run.
Break point	Interrupts a program on a specific line of code.
Variable watch	Displays the current value of any variable.
Memory inspector	A facility which will display the contents of a section of memory.
Error diagnostics	Used when a program fails to compile or to run. Error messages are displayed to help the programmer debug.
Syntax error detection	Highlights syntax errors before code is translated.
Routines / subroutines	A sequence of program instructions that performs a specific task.
Library	A collection of commonly used private functions and subprograms, such as square root / saving data to disk.
Statement completion	Auto-completes a statement such as adding an 'end if' to an 'if' statement

Example of an integrated development environment (IDE)



Advantages of using libraries

- Related private functions and subprograms are stored in the same location
- Time is saved as the programmer can simply use the private functions and programs stored in a library
- Subroutines contained in a library have already been tested, so they should work reliably and not need further testing
- Programs will contain less code and will therefore be easier to maintain.

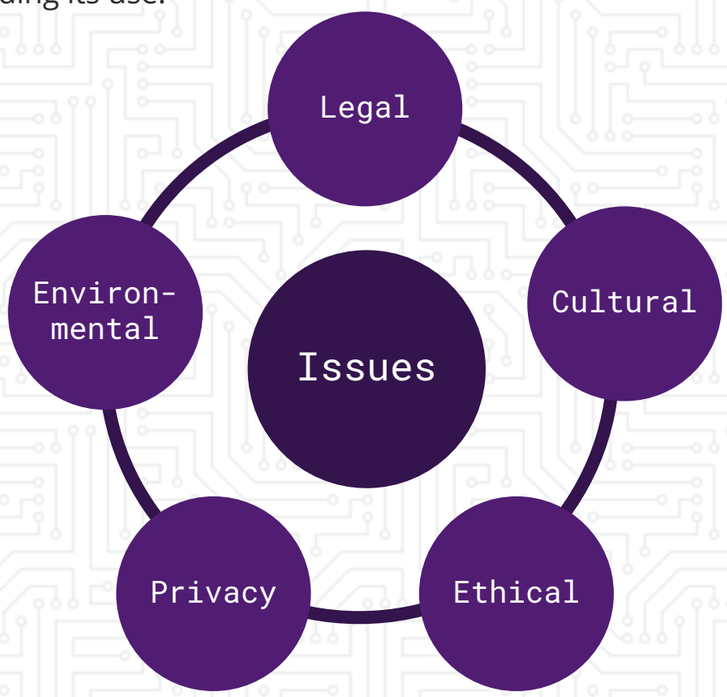
Component 1: Impacts of digital technology on wider society

Key terms

Term	Definition
Legal	Rules which a particular country or community recognises as regulating the actions of its members and which it may enforce by the imposition of penalties.
Cultural	The ideas, customs, and social behaviour of a society.
Ethical	Relating to beliefs about right and wrong and conforming to standards of conduct.
Privacy	An individual's anonymity and how safe they feel in a location.
Environment	The surroundings or conditions in which a person, animal, or plant lives or operates.
Code of ethics / conduct	Defines acceptable behaviour within an organisation.

Impacts

Digital technology increasingly requires us to consider issues surrounding its use.



Legal issues

The following legislation has been put in place to govern the use of computer systems.

Legislation	Overview
The Computer Misuse Act (CMA) 1990	Helps combat issues arising from the misuse of computer systems. The Act makes it an offence to: • access data without permission, e.g. looking at someone else's files • access computer systems without permission, e.g. hacking • alter data stored on a computer system without permission, e.g. writing a virus that deliberately deletes data.
The Freedom of Information (FOI) Act 2000	People have a right to know about the activities of public authorities, unless there is a good reason for them not to have this information. The Act provides public access to information held by public authorities, who are obliged to publish certain information about their activities.
The Regulation of Investigatory Powers Act (RIPA) 2000	Regulates the powers of public bodies to carry out surveillance and investigation. It also regulates the interception of communications. The Act provides clear legal guidelines for organisations, such as the security services and the police, to carry out surveillance and access the digital communications of individuals, such as email, telephone calls, text messages etc.
The General Data Protection Regulation (GDPR) and Data Protection Act (DPA) 2018	The GDPR and DPA applies to all 'personal data'. Personal data is classed as any information relating to a person who can be directly or indirectly identified and so it needs to be protected.
Copyright Designs and Patents Act 1988	This Act gives the authors of any digital software the right to control the ways in which their work may be used.
Creative Commons (CC) Licensing	This license enables the free distribution of copyrighted work. A CC license is used when an author wants to give other people the right to share, use, and build upon a work that they have created.
Telecommunications Regulations Act 2000	This Act gives organisations the right to monitor communications on their own networks. Previously such interception would have been unlawful unless consent had been given by both the sender and the recipient.

Component 1: Impacts of digital technology on wider society

Impacts (continued)

Cultural issues

- The digital divide:
  - The gap between populations that have full access to modern ICT, and those who have restricted access.
  - The divide traditionally exists between those in cities and those in rural areas; between the educated and the uneducated; between socioeconomic groups; and globally, between the more and less industrially developed nations.
- The changing nature of employment:
  - Teleworking – employees working from home
  - Collaborative cloud-based documents enable workers to share documents with their employer
  - Communication can be via email or video conferencing
  - Many technology-based jobs have been moved abroad, where costs are cheaper
  - Automation of processes using technology has led to a fall in manual, low-skilled work, such as warehouse packing
  - More high-skilled work is now available, which includes the maintenance of automated systems.

Ethical issues

- Self-driving cars - making decisions between life or death for its driver and other people
- Artificial intelligence - could the creation of thinking machines raise a host of ethical issues including the potential to harm humans.

Privacy issues

- The use of drones for surveillance
- Tracking people internet usage and information shared with websites visited
- With whom the data and information is shared
- The storage of personal data, including biometric data on a server.

Environmental issues

- Increase in delivery lorries on the road has caused increased congestion and increases in carbon emissions
- Are we a paperless society? More and more paper seem to be consumed affecting rainforests and influencing global warming
- Old computer equipment needs to be disposed of correctly which is expensive. Dumping old computers on landfill sites can cause pollution of toxic substances into the water supply and lead to health problems
- Computer equipment generates heat so many organisations install air conditioning systems leading to increased carbon emissions
- Many computers are left on standby, wasting electricity unnecessarily and increasing carbon emissions
- Mining the rare earth elements required in the manufacture of computers causes pollution
- Global assembly lines and pollution from transportation.

Professional standards

Code of conduct

It is important for employees to conform to professional standards, including formal and informal codes of ethical behaviour.

Each code of conduct is different and usually reflects an organisation's ethos, values and business style. Some codes are short and set out general guidelines, whereas other codes are large documents that include a variety of aspects relating to an organisation's values, ethics, objectives and responsibilities.

Formal codes of ethics are usually enforced by the threat of disciplinary action should the code not be adhered to.

An individual's own personal code

An individual's own personal code often supersedes the bare minimum requirements of an organisation's code. An individual's own personal code will vary from person to person as they choose to act upon their own ethical standards in their everyday actions.