Repetition – *Repeating a set of steps several times.*

Count controlled:

- Repeats the same code a set number of times
- Uses a variable to track how many times the code has been run
- This variable can be used in the loop
- At the end of each iteration the variable is checked to see if the code should be run again
- FOR sets how many times the code should be repeated
- NEXT tells the code to return to the start of the loop
- STEP sets how the variable should increment

Condition Controlled:

- Uses a condition to determine how many times code should be repeated
- While loops will run whilst a condition is met and use the statements WHILE and ENDWHILE
- Repeat loops will run until a condition is met and use the statements REPEAT and UNTIL

Evaluating Fitness for Purpose and Efficiency

Fit for Purpose - meets the original purpose and requirements the code was designed for. Provides the expected outputs. Test tables help to examine the values at each stage and check code is working as expected.

Efficient – the amount of time and resources needed to run a particular program.

Steps which improve efficiency:

- Using repetition (loops) to reduce the amount of code
- Using arrays instead of declaring many individual variables
- Using selection statements which only make comparisons until a solution is reached

Abstraction - *Using symbols and variables to represent a real-world problem using a computer program and removing unnecessary elements*

Advantages:

- Allows the creation of a general idea of how to solve the problem.
- Provides focus on what actually needs to be done.
- Provides a simple view of the problem

Variables - *a box in which data may be stored*

- Different types e.g. string, decimal, etc.
- Allows the program to store data such as an input for later use

Pseudocode

- Uses short English words and statements to describe an algorithm.
- Generally, looks a little more structured than normal English sentences.
- Flexible.
- Less precise than a programming language.

Flowcharts

- Created to represent an algorithm.
- Show the data that is input, and output.
- Show processes that take place.
- Show any decisions and repetitions that take place.
- Lines show flow through the chart.
- Shapes represent different functions

Arrays - *An ordered collection of related dat*

- Each element in the array has a unique index, usually starting at 0
- All elements must be the same type of data
- Arrays are usually a fixed size
- **1 Dimensional arrays** are like a simple list, each element needs a single index number
- **2 Dimensional arrays** are like tables, with each element needing two index numbers
- 2 Dimensional arrays are usually used to store properties of objects, with objects in rows and properties in columns
- Fruits[1] references element 1 in the 1D Fruits array
- Tools[0,2] references element 0,2 in the Tools array

Topic 1 – Computational Thinking

Operators – *Allow us to work with data, to change it and compare it*

Arithmetic Operators

+	Addition
-	Subtraction
*	Multiplication
/	Division
MOD	Modulus (the remainder from a division, e.g. 12 MOD 5 gives 2)
DIV	Quotient (integer division, e.g. 21 DIV 5 gives 4)
^	Exponentiation (to the power of, e.g. 3^3 gives 27)

Comparison Operators

==	Equal to
!=	Not equal to
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to

Boolean Operators

AND - two conditions must be met for the statement to be true

OR - at least one condition must be met for the statement to be true

NOT – inverts the result, e.g. NOT(A AND B) will only be false when both A and B are true

Sequencing - *Breaking down complex tasks into simple steps.*

- The order of steps matter
- Step by step progress through a program
- Benefits
  - Each line follows the next.
  - Can create simple programs very quickly.
  - Easy to follow for a small program.
- Disadvantages
  - Not very efficient.
  - Difficult to follow with large programs.
  - Hard to maintain.

Types of Error

A program with a syntax error will not run. A program with a logic error will run but it will not perform as expected.

Syntax Errors

When the code does not follow the syntax rules of the programming language used. This stops the program from running.

Examples:

- Misspellings or typos
- Using a variable before it has been declared
- Missing or incorrect use of brackets

Logic Errors

The program runs but does not do what it should.

Examples:

- Incorrectly using logical or Boolean operators
- Creating infinite loops
- Incorrectly using brackets in calculations
- Using the same variable name at different points for different purposes

Runtime Errors

Takes place during the running of a program causing it to crash.

- Trying to divide by zero
- Trying to access item 6 in an array of 5 items

Sorting Algorithms

Bubble Sort

1) Take the first element and second element
2) Compare the two
   a) If element 1 > element 2
      i) Swap them over
   b) Otherwise
      i) Do nothing
   c) Move to the next pair in the list
   d) If there are no more elements return to step (1)
   e) Otherwise, return to step (2)
3) Repeat until you have worked through the whole list without making any changes

Merge Sort

1) Split the list into individual elements.
2) Merge the elements together in pairs, putting the smallest element first.
3) Merge two pairs together, putting the smallest first.
4) Keep merging until all pairs are in order.

Searching Algorithms

Linear Search

1) Check the first value
2) If it is desired value
   a) Stop
3) Otherwise check the second value
4) Keep Going until all elements have been checked or the value is found

Binary Search

1) Put the list in order.
2) Take the middle value.
3) Compare it to the desired value.
   a) If it is the desired value.
      i) Stop.
   b) If it is larger than the desired value.
      i) Take the list to the left of the middle value.
   c) If it is smaller than the desired value.
      i) Take the list to the right of the middle value.
4) Repeat step 3 with the new list.

Sub Programs - *Small programs which form part of a larger program.*

Procedures are sets of instructions stored under a single name (identifier).

Functions are like procedures but will always return a value to the main program.

Parameters are values passed into a sub program. These are referred to as arguments when calling the sub program.

Advantages:

- Used to save time and simplify code
- Allows the same code to be used several times without having to write it out each time
- Usually small in size, so easier to write and test.
- Easy for someone else to understand.
- Can be saved separately as modules and used again in other programs.
- Saves time because code that has already been written and tested can be reused

Trace Tables – *a method of recording the values used within an algorithm at each stage of processing to help in troubleshooting*

- Tests algorithms for logic errors which occur when the algorithm is executed.
- Simulates the steps of algorithm.
- Each stage is executed individually allowing inputs, outputs, variables, and processes to be checked for the correct value at each stage.
- A great way to spot errors

Decomposition - *Breaking down large problems into a set of smaller parts.*

There are several different approaches, and not one single right way to do this.

Advantages:

- Smaller problems are easier to solve
- Each part can be solved independently
- Each part can be tested independently
- The parts are combined to produce the full problem.
- Allows each smaller problem to be examined in more detail

Selection

- Allows the program to make decisions
- Uses conditions to change the flow of the program
- Selections may be nested one inside another
- IF statements perform comparisons sequentially and so the order is important
- SELECT CASE has less typing but is less flexible

Constants – *a fixed value used by the program such as pi*

Allows easy use of fixed values without having to store them in the program

Binary – *A number system made up of 0 and 1 used by computers to store and represent data such as numbers, sound, and graphics*

- Also known as Base 2
- Computers use binary because the CPU contains transistors, which are either on or /off

Hexadecimal – *A number system made up of 16 symbols, 0-9 and the letters A-F.*

- Also known as Base 16
- Useful because large numbers can be represented using fewer digits.
- Easier to understand, write and check than binary.
- Commonly used for colour values and MAC addresses.

ASCII – *American Standard Code for Information Interchange*

- A 7 bit method to represent characters using binary
- 7 bits allows 128 characters.
- The characters are represented in a table, called the ASCII table.
- ASCII characters include control codes, punctuation, upper and lower case letters, numbers.
- Upper and lower case characters have different codes.

Character	Denary	Binary	Hexadecimal
A	65	1000001	41
Z	90	1011010	5A
a	97	1100001	61
z	122	1111010	7A
0	48	110000	30
9	57	111001	39

Binary States – *The number of states which can be represented in a given number of bits using binary*

- To calculate the number of states use the formula 2^n where n is the length of the pattern
- Limits on the number of bits available affect how much data can be stored

Measuring Storage

Size	Unit
8 bits	1 byte
1,024 bytes	~~1 kilobyte - KB~~ 1 Kib
1,024 kilobytes - 1,024 KB	~~1 megabyte - MB~~ 1 Mib
1,024 megabytes - 1,024 MB	~~1 gigabyte - GB~~ 1 Gib
1,024 gigabytes - 1,024 GB	~~1 terabyte - TB~~ 1 Tib
1,024 terabytes - 1,024 TB	~~1 petabyte - PB~~ 1 Pib

Topic 2 – Data

Bitmap Images

Allow computers to represent images in binary.
Images are broken down using a grid.
Each square in the grid is known as a pixel

Colour Depth

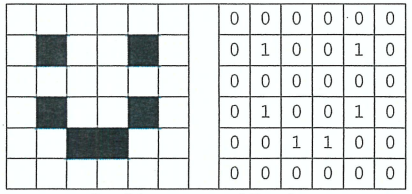
- The more colours an image needs, the more bits per pixel are used.
- The greater the colour depth, the larger the image file will be.
- one bit per pixel (0 or 1) - two possible colours
- two bits per pixel (00 to 11) - four possible colours
- three bits per pixel (000 to 111) - eight possible colours

Resolution

- Higher quality image = higher resolution = more pixels in the same space = smaller pixels.
- Higher resolution = more space needed.
- Calculated by multiplying the width in pixels by the height in pixels.

File Size

The file size of an image can be calculated using the formula :
height in pixels X width in pixels X colour depth per pixel



6 x 6 image, one bit colour
12 pixel resolution, 12 bit file size

Sounds in Binary

Amplitude - The height of the sound wave at the time it was sampled. The higher the amplitude the louder the sound.
Sample Interval – How often (in milliseconds) the sound is sampled
Small sample interval = better quality sound file = larger file.
Sample Rate –we often use the term sample rate instead of sample interval.
The sample rate (in Hz) is the number of samples in one second.

Sample Rate = 1 / Sampling Interval

Small sampling interval = high sample rate = better quality sound file = larger file.
Bit Depth - the number of bits used to record each sample.
Higher bit depth = higher quality audio = larger file size.
Usually 16 bits on a CD and 24 bits on a DVD.

Unsigned and Two's Compliment Integers

Unsigned integers must be positive
Signed integers can be positive or negative

- Both are as accurate
- Both can have overflow errors
- Unsigned integers store more positive values (unsigned is 0 to 255, signed is -127 to 127)

Two's complement

- Used by computers to show negative numbers.
- More effective when performing mathematical operations.
- The bit at the far left of the bit pattern - the most significant bit or MSB - is used to indicate positive or negative and the remaining bits are used to store the size of the number.

Using two's complement for negative numbers

- Find the positive binary value for the negative number.
- Add a 0 to the front of the number, to indicate that it is positive.
- Invert or find the complement of each bit in the number.
- Add 1 to this number.

Converting Between Bases

Binary to Denary

1) Draw your conversion table.

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

2) Write the binary number in the conversion table.
3) Add together all numbers with a 1 beneath them

```
  128
   64
+   8
    4
  204
```

11001100 in binary is 204 in denary

Denary to Binary

1) Draw your conversion table.

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

2) Is the number higher than the first column in the table?
   a) If so, put a 1 in that column and work out the difference.
   b) If not, put a 0 in that column.
3) Repeat the step above with the difference.
4) Keep going until the difference is 0, put a 0 in any empty columns.
5) Read the number from the bottom row of the table.

200 – 128 = **72**

72 – 64 = **8**

8 – 8 = **0**

200 in denary is 11001000 in binary

Denary to Hexadecimal

1) Divide the denary number by 16 and write down both the answer and the remainder. 62 ÷ 16 = 3 R 14
2) Divide the answer by 16 again. Write down both the answer and the remainder. 3 ÷ 16 = 0 R 3
3) Keep going until you reach an answer of 0.
4) Read the remainders from bottom to top. 3 14
5) Convert each remainder to hex. 3E

62 in binary is 3E in hexadecimal

0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

Binary to Hexadecimal

1) Draw two separate conversion tables.
2) Write the binary number across both tables.
3) For each table, add up the numbers which have a 1 beneath them.
4) Convert each number to hexadecimal.

8	4	2	1
0	1	1	0

8	4	2	1
1	1	0	1

4 + 2 = 6   8 + 4 +1 = 13

6   D

01101101 in binary is 6D in hexadecimal

0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

Binary Maths

Addition

- 0 + 0 = 0
- 1 + 0 = 1
- 1 + 1 = 10 (binary for denary 2)
- 1 + 1 + 1 = 11 (binary for denary 3)

Multiplication (using binary shifts)
Move the digits to the left and fill the gaps after the shift with 0.
Move 1 place for X2, 2 places for X4 etc.
Division (using binary shifts)
Move the digits to the right and fill the gaps after the shift with 0.
Move 1 place for X2, 2 places for X4 etc.

Compression

Lossy Compression

- Some data is removed, reducing the amount of data and the size of the file.
- There is a balance to be struck between reducing file size and maintaining quality.
- Images can be compressed by reducing colour depth.
- Audio files can be compressed by reducing the bit depth of the samples.
- Lossy standards include:
  - JPEG file format for images
  - MPEG file format for video and audio
  - MP3 file format for audio

Lossless compression

- Files are reduced in size without the loss of data.
- Lossless compression results in a smaller reduction in file size than lossy compression.
- Lossless compression gives a better file quality that lossy compression
- Lossless standards include:
  - PDF file format for documents
  - GIF file format for images

RAM – Random Access Memory

- Volatile memory – data is lost when the computer is turned off.
- Called random access because data can be directly written to or read from any location.
- Used to hold data and instructions that are currently in use.
- The more RAM a computer has, the more data it can hold simultaneously.

Von Neumann Architecture

Key elements:

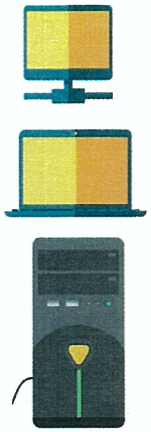
- Data and instructions are stored in binary.
- Data and instructions are stored together in **RAM**.
- Instructions are fetched from **RAM** one at a time in order
- The **CPU** decodes and executes an instruction, before fetching the next instruction
- The cycle continues until no more instructions are available

A CPU using Von Neumann architecture have five special registers

- **Program counter** - holds the memory address of the next instruction to be fetched.
- **Memory address register (MAR)** - holds the address of the current instruction.
- **Memory data register (MDR)** - holds the content at the address held in the MAR.
- **Current instruction register (CIR)** - holds the instruction that is currently being decoded and executed
- **Accumulator (ACC)** - holds the results of processing

The fetch-decode-execute Cycle

1. The memory address held in the program counter is copied into the MAR.
2. The address in the program counter is then incremented - or increased - by one. The program counter now holds the address of the next instruction to be fetched.
3. The processor sends a signal containing the address of the instruction to be fetched along the address bus to the computer's memory.
4. The instruction held in that memory address is sent along the data bus to the MDR.
5. The instruction held in the MDR is copied into the CIR.
6. The instruction held in the CIR is decoded and then executed. The results of processing are stored in the ACC.
7. The cycle then returns to step one.



Programming Languages

Low Level Languages – *very close to computer language, hard for humans to understand*

Machine code

CPUs understands machine code can directly execute it.
Consists of 0s and 1s only.
Very difficult to learn, write and debug.

Assembly Language

Also known as Assembly Code
Uses mnemonics (abbreviations)
Easier for humans to understand and program but still difficult
Must be translated into Machine Code for execution
Commonly used to program device drivers

High Level Languages – *easier for humans to understand, using English like words and phrases.*

Much easier to learn, write and debug.
Examples include Python, Java and C

Developing Robust Software

- What threats will the code face?
- Are security features like usernames and passwords needed?
- How will patches be installed and the code updated?
- Is encryption needed?
- Does the code need to create an audit trail?

Audit Trail - a record of what has been done and who or what did it.

Code Review – a check of code by other programmers.

Topic 3 – Computers

	Compilers	Interpreters
	▪ Translates the whole code in one go into Machine Code. ▪ Optimise the code ▪ Used at the end of development when code is finished ▪ Create error reports and object code	▪ Translate and execute source code ▪ Work line by line. ▪ Syntax is checked ▪ If code is correct it is executed ▪ If code is incorrect interpreting is stopped.
Advantage	▪ Compiled programs run quickly and without needing additional software. ▪ Programs are supplied as executables which cannot be modified. ▪ Optimise code so it runs quickly and uses less memory.	▪ Instructions are executed as soon as they are translated. ▪ Instructions are not stored for later so less memory is needed. ▪ Errors can be quickly spotted.
Disadvantages	▪ Because the source code is translated as a whole, more memory is needed. ▪ Requires a working space for the compiler to perform the translation. ▪ Do not spot errors. ▪ Code must be re-compiled if changed. ▪ Code compiled on one platform will not run on another.	▪ The CPU must wait for each instruction to be translated so execution is slower. ▪ Code is translated each time it is run. ▪ Do not produce an executable file that can be distributed ▪ Do not optimise code.

Embedded Systems

- A small computer which includes hardware and software, designed to control a specific device.
- Forms a part of a larger device such as a washing machine.
- Can perform only a limited number of tasks.
- Have several advantages:
  - Cheaper to design and build.
  - Require less power.
  - Do not need much processing power.

Operating Systems

File management

- Allows users to find and manage data stored by the computer.
- Data is stored in files, within folders, within drives.
- Assigns metadata to files including date created, date modified, last date accessed

Process management

- Allows users to run applications such as web browsers or word processors.
- Multiprogramming enables several programs to run at the same time.
- Each program is made up of instructions. When running, they are called a process.
- Allocates use of the main memory and the CPU between processes.
- A scheduler is used to time the different processes.

Peripheral Management

- Manages input and output between peripherals and a process.
- Data is transferred between input devices, the CPU, and output devices.
- Uses device drivers to communicate with devices.

User Management

- Individual users can be created and deleted.
- Allows more than one person to use a computer with their own files and settings.
- Access levels control user access to systems for security.

Secondary Storage

- Used to store programs and data for longer term when the computer is switched off
- Non-volatile – data is retained with the computer is switched off.
- Not all computers require secondary storage.
- Embedded computers such as a watch do not need to store data when power is turned off.

Magnetic devices

- Use magnetic fields to magnetise individual sections of a spinning disk.
- Each section represents one bit.
- A read/write head moves across its surface.
- Fairly cheap, high in capacity and durable.
- Susceptible to damage if dropped.
- Vulnerable to magnetic fields.

Optical Devices

- Use a laser to scan the surface of a spinning disc.
- The disc surface is divided into tracks, with each track containing flats and hollows.
- The flat areas are known as lands and the hollows as pits.
- Lands reflects the laser light back; pits scatter the beam.
- ROM (Read Only Media) cannot be overwritten. Used for music, films, software and games.
- Read (R) media is blank, can only be written to once, but read many times.
- Read/write (RW) media can be written to more than once.

Solid State Devices

- Use flash memory to store data indefinitely.
- Have faster access times than other devices
- Because they have no moving parts, are more durable.
- More expensive so tend to be smaller in capacity.
- Require little power, so used where battery life is a consideration.
- Portable due to their small size and durability.

Utility Software

File Repair

- Corrupt files can sometimes be repaired.
- Can detect and recover physical errors on the disk and mark damaged sections as unavailable.

Backups

- A copy of data is known as a backup.
- These allow damaged or deleted data to be restored.
- Full backups include every file. This requires a lot of storage and time.
- Incremental backups include new and changed files since the last backup.

Data Compression

- Reduces the size of a file using algorithms.
- Smaller files are easier to transmit.
- Allows more files to be stored in the same space.

Defragmentation

- Files on a disk are broken down into a series of segments.
- When files are deleted, the segments where they were stored are made available for new files.
- The new file may need more segments than the old, and so the segments allocated to it are not together on the disk. This is known as fragmentation.
- A fragmented disk takes longer to read from and write to, making the computer slower.
- Defragmentation software rearranges the segments so that they are stored next to each other.

Anti-Malware

- Protects against viruses, spyware, and other unwanted software.
- Scans the system to identifies potential viruses.
- Will attempt to delete or fix potential threats once they have been identified.
- Runs either when activated or automatically at a specified date and time.

CPU – Central Processing Unit

Control Unit (CU)

Fetches, decodes, and manages the execution of instructions
Issues control signals to control hardware
Moves data around the system

Arithmetic Logic Unit (ALU)

Performs arithmetic and logical operations.
Where calculations are done and where decisions are made.

Registers

Small amounts of high speed memory in the CPU.
Used to store small amounts of data that are needed during processing.

Cache

A small amount of high speed memory In the CPU.
Used to temporarily hold data the CPU will reuse.
Allows for faster processing since as the CPU need not wait for data to be fetched from RAM.

Clock

Used to coordinate all the computer's components.
Sends out a regular electrical pulse to do this.
The frequency of the pulses = clock speed, measured in hertz.
Higher clock speed = greater number of instructions which can be performed at a time.

Buses

High speed internal connections.
Used to send control signals and data between the processor and other components.

- Address bus - carries memory addresses from the CPU to other components.
- Data bus - carries data between the CPU and other components.
- Control bus - carries control signals from the CPU to other components.

Topic 4 – Networks

Advantages and Disadvantages of Networks

Advantages
- Software and files can be shared.
- Hardware such as printers can be shared
- Users can communicate via email, chat, etc.
- Centralised maintenance and updates.
- Centralised security.
- User monitoring.
- Different users can be given different access rights or permissions.

Disadvantages
- Cost, additional equipment is needed.
- Additional management by specialist staff.
- Spread of malware.
- Potential for hacking.

Types of Network

LAN - Local Area Network
- Confined to a single location
- Owned and maintained by a single organisation
- Used by organisation such as schools and small businesses
- Connected by cables or wireless

WAN – Wide Area Network
- Covers a wide geographical area
- Used by organisations with several different sites such as banks or universities
- Allows all the sites to communicate and share data
- Uses national or international long distance media

The Internet
- A vast WAN covering the entire world
- An Internet Service Provider (ISP) provides access to the Internet.
- Routers provide an interface between the Internet and the customer via the ISP.
- Larger, more powerful routers connect the different components of The Internet.

Wired Networking

Using fibre or coper cable to connect devices in the network together.
Fibre cable provides a faster connection and can cover longer distances.
Advantages:
- Faster data transfer
- Less likely to suffer from interference
- More difficult for unauthorised users to intercept data

Disadvantages:
- Expensive to install or reconfigure
- Harder to move devices so less flexible

Wireless Networking

Using radio signals or infrared light to connect devices in a network together.
Advantages
- Devices can easily be added
- Users can move around freely and stay connected

Disadvantages:
- Signals have a limited range.
- Can suffer from electromagnetic interference from other devices.
- Signals can also be blocked by walls or other objects.
- Each wireless access point

The Four Layer TCP/IP Model

Breaks up the process for sending of messages into separate components.
Each component handles a different part of the communication.
Helps to understand the transmission process.
Provides a basis to begin troubleshooting when something goes wrong.
- **Application Layer** – encodes and decodes message using protocols like HTTP or FTP.
- **Transport layer** - breaks down message into pieces called packets. Packets have a packet number. The recipient uses the number to reassemble the packets in the correct order and to see if there are any missing packets.
- **Network layer** - adds the sender and recipient IP address and transmits the message.
- **Data link layer** – provides physical transfer of packets over the network.

Network Protocols

Ethernet - used in wired LANs, covers many standards such as cable types and data transmission speeds.
Wi-Fi - used in wireless LANs.
TCP/IP - Transmission Control Protocol/Internet Protocol. Allows data to be appropriately addressed when transmitting and ensures the integrity of data.
HTTP – Hypertext Transfer Protocol – Web pages
HTTPS - Hypertext Transfer Protocol (Secure) – Secure web pages
FTP – File Transfer Protocol - transmission of files across a network and the internet.
SMTP – Simple Mail Transfer Protocol – Send emails
IMAP – Internet Message Access Protocol – Receive emails
POP3 – Post Office Protocol version 3 – Receive emails

Network Security

Access Control – determines which files, software and systems users have access to.
Users should be restricted to access only the facilities they need for their jobs.
Restrictions limit the actions a user can take, reducing the potential of threats.
Firewall – a tool which monitors traffic going into and out of the network, and either allows or blocks it.
This decision is based on rules, known as the firewall policy.
Can be hardware based or software based.
Hardware firewalls are expensive, but more effective and powerful.
Physical Security - restricting the physical access to important systems and parts of the network.
Important equipment such as servers should be kept in a locked secure room.
Access should only be available to authorised people.
Someone could remove or access the hard disks containing private information or damage equipment.

Identifying Network Vulnerabilities

It is important to identify and fix vulnerabilities before they can be taken advantage of by hackers.
Penetration Testing – determines how resilient a network is against an attack.
Authorised users, sometimes an external company will probe the network for potential weaknesses and attempt to exploit them.
Often carried out using specialist, automated software.
Ethical hacking - attempt to access a network in the same way as a hacker.
They are looking for weaknesses in the security of the network.
Weaknesses can then be fixed.
Might be employed by the business that owns the network being tested or they might work for a security company.

Network Speeds

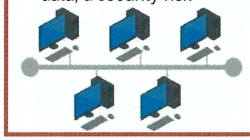
Measured in bits per second.
1 Kbps = 1,000 bits per second
1 Mbps = 1,000,000 bits per second
1 Gbps = 1,000,000,000 bits per second

Working out file transmission speeds
time = size of file (in bits) / network speed (in bits)

Network Topologies

Bus Network
All devices are connected to a single cable (called the bus)
A terminator is at each end of the cable.
Advantages:
- Easy to install extra devices.
- Cheap to install as it doesn't require much cable.

Disadvantages
- If the cable fails or is damaged the whole network will fail.
- Performance becomes slower ad additional devices are connected due to data collisions.
- Each device receives all data, a security risk

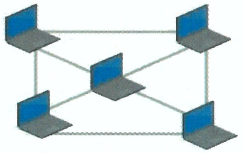


Star Network
All nodes are connected to one or more central switches.
Often used with wireless networks.
Advantages:
- Every device has its own connection so failure of one node will not affect others.
- New devices can be added by simply connecting them to the switch.
- Usually have higher performance as a message is passed only to its intended recipient.

Disadvantages:
- If the switch fails it takes out the whole network.
- Requires a lot of cable so can be expensive.

Mesh Networks
No central connection point, with each device connecting directly to others.
Full mesh networks have every device connected to every other device.
Partial mesh networks have each device connected to several others but not necessarily every other device.
Advantages
- Messages can be received more quickly.
- Messages have many possible routes they can take.
- Multiple connections mean that no device should be isolated
- Each device can talk to more than one node at the same time.
- Devices can be added without interruption.

Disadvantages
- Can be impractical and expensive to setup.
- Require a lot of maintenance



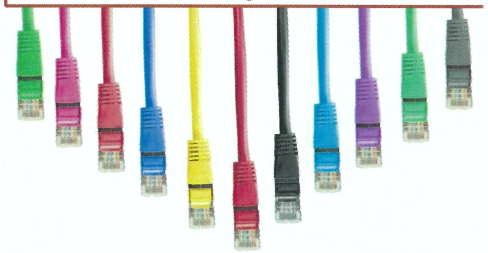
Factors Affecting Network Performance

Bandwidth
- The amount of data that the medium can transfer over a given period of time. Wired networks tend to have more bandwidth than wireless.
- The bandwidth at a Wireless Access Point is shared between all users of that point.
- Different types of traffic have different bandwidth requirements.
- Streaming video requires more bandwidth than sending an email.

Latency
- How long it takes a message to travel across the network.
- Low latency = few delays in transmission, High latency = many delays.
- More delays = longer transmissions.
- Affected by the number of devices on the network and the type of connection.
- Wireless networks usually have higher latency than wired.

Speed
- How fast data can be transferred over the network
- Usually faster for wired connections than wireless.
- Affected by the communication medium used.
- May also be affected by the distance the data must travel, with longer distances resulting in slower speed.

Range
- The physical distance a network can cover.
- Wireless is often used for short range communication.
- Wired is often used for longer distance communication.



Topic 5 – Issues and Impacts

Malware

Viruses
- A program designed to disrupt or damage a computer system.
- May cause the system to stop functioning or loose data.

Worms
- A computer program which makes copies of itself.
- Works by itself rather than attaching to another program.
- Sends out the copies to try and infect other systems.
- Once installed will damage the system or attempt to steal data.

Trojans
- Malicious software hidden in what seems to be a normal program.
- Free games or music often contain trojans.
- Once installed will damage the system or attempt to steal data.

Ransomware
- Encrypts data and demands money to unlock it.
- Leaves systems unusable causing huge organisational impact.

Key Loggers
- Records all keystrokes and activity.
- Capture usernames, passwords, and any other data typed.

Principals of the Data Protection Act 2018

1. Fair, lawful and transparent processing.
   a. Data must only be used for the purposes which it was collected.
   b. The rights of the data subject must be considered.
2. Purpose Limitation.
   a. Data must only be collected for specified defined purposes.
   b. There is an exception for public interest and research
3. Data minimisation
   a. Only the data needed must be held, no more
   b. Must be accurate and relevant.
4. Accuracy
   a. Data must be accurate and kept up to date.
5. Data Retention periods
   a. Data must not be kept for longer than needed.
   b. It may be stored for longer in the case of research but must be anonymised.
6. Data Security
   a. Data must be kept secure against unlawful processing or loss.
7. Accountability
   a. Must be able to prove that data protection methods are sufficient.
   b. Must have appropriate organisational processes.

Hacking

Unpatched or Outdated Software
- Software patches contain fixes for bugs and security flaws.
- Software should include features to automatically apply patches.
- Programmers may stop updating software, leaving it unsupported.
- Hackers take advantage of bugs to gain access to systems.
- Hackers look at patches to see what bugs are fixed and try to exploit them.

Out-Of-Date Anti-Malware
- Anti-malware requires definitions to be kept up to date to be effective.
- Hackers can target systems with outdated anti-malware.

Social Engineering
- Targets people rather than systems.
- Attempt to manipulate people into handing over data.
- Strong policies and user training can help.
- Phishing tries to get people to hand over data using messages which look like they have come from a trusted party.
- Blagging uses a fake story to try and get a person to hand over money or information.
- Shoulder surfing is watching someone enter their password.

Environmental Issues

Energy Consumption
- Computer systems consume huge amounts of energy.
- Computers are becoming more efficient so use less energy.
- We are using computers more than before, meaning higher energy use.

Manufacture
- Building uses up natural resources, which are limited in supply.
- A computer requires 10 x its weight in fossil fuels to make.

Replacement Cycle
- How long is a device designed to be used before it breaks or becomes too old to be used?
- Organisations may set a 3, 5 or 10 year replacement cycle.

Disposal
- Computers contain harmful and so must be disposed of carefully.
- Often sent to countries with lower disposal standards.
- People there will go through waste to find metals they can sell on.
- This exposes them to dangerous chemicals.

Issues with AI, Machine Learning and Robotics

These fields are growing and changing rapidly, bringing up new ethical and legal issues. Often, there is not yet a right or wrong answer, but it is important to consider these issues nevertheless.

Accountability
- All choices have consequences, sometimes significant in legal, financial or safety terms.
- Who is responsible? The person operating the system, the person who produced it, or the system itself.

Legal Liability
- Actions taken by systems may have legal consequences.
- Who should be accountable in these cases? The system owner, the manufacture or the system itself?

Safety
- Ensuring that systems do not cause harm.
- Fail safe processes mean the system will default to a safe state.
- How should a system act in cases where some harm is unavoidable?

Algorithmic Bias
- The design of an algorithm may favour certain groups.
- Should a robot choose to save a young person over an older person?
- Should a self driving car swerve into one person to avoid hitting four?
- Are these things ethical?

Protecting Systems and Data

Anti-Malware
- Scans for, removes, and protects against malicious software.
- Includes anti-virus, anti-phishing, and anti-spyware.
- Can be set to scan manually, at a certain time, or when files are accessed.
- Will attempt to stop malware before it can be installed.
- Scans files against a list of malware (called definitions).
- These definitions must be kept up to date.
- Cannot protect against new malware until definitions are updated.
- Organisations should run this software on their systems and networks.

Encryption
- Changes data so it can't be read by anyone other than the intended recipient.
- Encrypted with an encryption algorithm and decrypted with a decryption algorithm.
- An encryption key is a string of characters used to encrypt data.
- Encrypting data before transmission helps security, as the message cannot be read without the key.
- Data can also be encrypted when stored meaning if the device is stolen the data cannot be read.
- Organisations may be required to use encryption by policies, laws, or contracts.

Acceptable Use Policy (AUP)
- Rules for how systems and networks may be used.
- Users should read and agree before using the system.
- Discourages users from actions which may damage the system.
- Allows the organisation to discipline those who use systems inappropriately.
- Provides clear guidance to users on what they can and cannot do.

Backup and Recovery Procedures
- The process used for backing and restoring.
- Backups allow organisations to recover data which may have been lost or damaged.
- Allows people to have all the information to hand when dealing with an incident.
- It is important that recovery is tested.
- Backups will contain sensitive data, so it is important that they are kept secure.

Ethical and Legal Issues with Personal Data

- Many areas are constantly being debated with people having different views.
- Computer systems hold large amounts of personal data.
- Organisations also collect data such as history of our Internet activity.
- Smart devices collect data such as our voice, video and activity.
- Governments want access to this data to prevent crime. Is this right?
- Should organisations be allowed to collect this much data, and how do they use it?

Ownership
- Who owns data supplied to a company or organisation?
- UK law makes clear that you are the data owner, whilst those who hold the data are data stewards.
- Data Stewards have obligations under law to keep data secure, up to date, and delete it when they no longer need it.
- Right to erasure, allowing us to tell companies to delete data we don't want them to hold.
- There are exceptions to this, such as the Police for crime prevention.

Consent
- Data protection laws require positive consent for data collection.
- Data cannot be collected automatically without consent.
- It is insufficient to use opt out processes, requiring people to tick a box saying they do not want their data to be used.
- Consent must be easy to understand and obvious.

Misuse
- Data can be misused by hackers, phishing scams or viruses.
- Systems should have processes in place to prevent this.

Data Protection
- Data protection law lays out legal rights and responsibilities for data.
- Gives rights to those who own data, and places responsibilities on those who use it.
- UK law is very robust.
- The Data Protection Act 2018 is the UK implementation of the EU GDPR (General Data Protection Regulations)
- Before this, the Data Protection act already provided protection, but it has now been updated to be even more robust.

Using Intellectual Property to Protect Computer Systems

Copyright
- Protection for works such as music, books or software.
- Automatic when work is created and does not need to be registered.
- Does not last forever and will expire.
- Illegal to share or copy without the owner's permission.
- Prevents others from selling copies of the work.

Patents
- Allows someone to register ownership of an invention or process.
- Can apply to different parts of a device or system such as the interface.
- Protects the idea and prohibits people from copying it.

Trademarks
- Protection for a logo, name or phrase.
- Must be registered.
- Allows companies to protect what makes their brand distinctive.
- Provides protection for software names and logos and prevents someone from attempting to sell their own version.
- Also prevents people using names which are too similar and designed to confuse.

Licencing
- Defines how software may be used.
- Prevents people from using the software in a way the owner would not want.
- Proprietary licenses are expensive and must be purchased from a company but are often more secure and include software support and updates.
- Open source licenses are free and available to anybody, but can be less secure and harder to find support for when something goes wrong.