Higher Computing Science
Technical implementation
Summary notes

Input and Output devices

Input devices are used to put data into a computer system.
Output devices feed data back to the user.

Input device examples	Output device examples
Webcam	Printer – laser / inkjet
Microphone	Speakers
Touchpad	Headphones
Keyboard	Monitor – TFT / LCD / LED
Mouse	Projector
Gamepad	
Scanner	

A few devices may be used for both input **and** output (e.g. headset, touchscreen).

Processors

Processor speed is also known as clock speed.
It offers a basic (but unreliable, since there are many other factors to consider) comparison of two processors.

- Processor speeds are measured in **Hertz (Hz).** Modern home computer processors have speeds measured in **Gigahertz (GHz).**

- Small computerised devices (phones, tablets, etc) usually use **ARM processors** – lower power consumption but poorer performance.

- Larger devices (laptops, desktops, etc) use **x86 processors** (manufactured by Intel or AMD) – higher power consumption and better performance.

- **Multi-core processors** have more than one processor on a single chip - this generally means better performance than a single processor, although it can depend on the software being used. The number of processors contained in a multi-core processor is typically referred to as the number of cores and these can be either **physical** or **virtual**.

Memory

- The contents of **RAM (Random Access Memory)** are constantly changing, data can be read from and written to RAM. Data in RAM is **volatile** which means it the contents lost when there is no power (i.e. the computer is switched off). RAM is used to hold all the programs which are currently running on your computer, including the operating system.

- The contents of a **ROM (Read only Memory)** chip cannot be changed. Data in ROM is permanent, even when the computer is switched off. ROM is used to store programs such as the bootstrap loader (loads up the operating system when you turn the computer on).

- **Cache memory** is very fast memory located on the processor chip itself. It is used to store instructions which are used frequently. It is often categorised by level (L1, L2, L3 etc.) which denotes the performance of the cache memory and how close it is to the processor.

  Cache memory uses a form of memory called **static RAM** where the contents do not need to be constantly updated, unlike the dynamic RAM used in main memory. As a result, fetching instructions from cache is faster than fetching them from RAM so cache memory can help improve the performance of the system.

Operating Systems

The operating system is the software which controls the entire operation of the computer. This includes all applications and background processes. It has several key tasks:

File management
Keeps track of data stored on backing storage devices, locates files, allocates space for new files.

Memory management
Keeps track of data stored in RAM, allocates free space to software which is running, ensures programs don't clash.

BIOS (Basic Input Output System) – Input/Output management
Handles the input and output devices connected to the system, transfers data to and from devices.

User interface (interpreting user commands)
Provides a method of communication between the user and the computer. Most modern user interfaces are graphical, relying on windows, icons, menus and pointers (i.e. WIMP).

Resource allocation
Describes the combination of managing processes and memory management to ensure that applications have adequate processor time and can be allocated sufficient storage in RAM as necessary.

Trends in operating system design
OS design aims for simplicity. Most users want clear user interfaces, suitable for touchscreen devices, and don't need to know about the tasks the OS carries out in the background.

Web operating systems take the idea of cloud storage a step further, allowing users to access the same desktop and applications no matter where they are.

Licensing

Licensing restrictions tell the user the rules for use of the software.

- **Single licence** – Software can only be used on one machine, or possible on several machines but only by one specific user.
- **Multi-user licence** – Software may be used on multiple machines or by multiple users.
- **Site licence** – Authorises the software to be used on every machine within a single location (e.g. school or office complex).
- **Freeware** – Can be used and distributed by anybody without restriction.
- **Shareware** – May be limited by a trial period before full version must be purchased or may be a crippled version offering limited functionality.

Proprietary vs Open source

- **Proprietary software** – any software where the source code belongs to the creators and is not freely available. The software itself may be paid or free to use, but it cannot be modified in any way.

  Advantages of proprietary software may include the inclusion of advanced features, the ease of use (i.e. it may be more suitable for novice users) and the support offered by the developer. However, it can be expensive and may not be customisable to the needs of the user.

- **Open source software** – free to use and distribute, the source code is available for use and modification by anybody. It can be used for any purpose.

  Advantages of open source software may include the customisation of the software and its capabilities to suit the needs of the user, the fact that it is free to use and the ability to promote collaboration and sharing between users.

Portability

- Portability refers to the ease with which software can be altered to work on a different platform.
- Portable software can easily be adapted to run on a different platform, saving the expense of rewriting code and creating a wider market for the developers.

Storage devices

Storage capacities and costs of backing storage devices are always changing but you should have a rough idea of typical capacities and pros/cons of each.

Trends in storage

- Cloud storage is becoming more and more popular, as users access data on the move from a variety of devices.
- Cost per GB of storage is decreasing. Users now demand larger amounts of storage space so they can store higher quality video, audio and graphics.
- Solid state devices are replacing hard discs as the main storage device for systems. However, SSD is still more expensive per GB than a conventional magnetic hard disk drive.
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Capacity of storage is measured using the following units:

Bits (b)	A single binary digit, 1 or 0.
Bytes (B)	8 bits (e.g. 01001100)
Kilobytes (KB)	1024 bytes
Megabytes (MB)	1024 KB
Gigabytes (GB)	1024 MB
Terabytes (TB)	1024 GB
Petabytes (PB)	1024 TB

Device	Type	Typical capacity	Features
Internal hard disk drive	Magnetic	Up to 2TB	Large capacity, relatively cheap per GB. The built-in storage in most desktop and laptop computers.
External hard disk drive	Magnetic	Up to 2TB	Large capacity, relatively cheap per GB, portable.
Magnetic tape	Magnetic	Several TB	Relatively cheap per GB, high capacity, slow but ideal for back-ups of large amounts of data.
CD-ROM CD-R CD-RW	Optical	700-800MB	CD-R can record to once then finalised, CD-RW can be re-written over and over. Can store any data but typically used for music.
DVD-ROM DVD-R DVD-RW	Optical	4.7GB/8.5 (dual layer)GB	DVD-R can record to once then finalised, DVD-RW can be re-written over and over. Can store any data but typically used for films.
Blu-ray Disc (BD) BD-R BD-RE	Optical	25 GB/50 GB(dual layer)	BD-R can record to once then finalised, BD-RE can be re-written over and over. Can store any data but typically used for HD films + lots of extras.
USB flash drive	Solid state	Up to 128 GB, but can be as high as 1TB	Very portable, relatively expensive per GB compared to other devices. Physically robust as it contains no moving parts.
SD card	Solid state	16 GB or 32 GB but can be as high as 2 TB	Very portable, relatively expensive per GB compared to other devices. Physically robust as it contains no moving parts.
Cloud	Web-based	Virtually limitless	Files stored securely on a remote computer, accessible from anywhere with an internet connection, vast amounts of storage potentially available. Small amounts of free storage readily available but usually requires a monthly fee for more.

- Most backing storage devices and other peripherals connect to the computer using the USB interface, although there are other possibilities such as FireWire or Thunderbolt. Interfaces are often compared in terms of their **data transfer rate** - USB 2.0 and USB 3.0 are faster versions of USB.

- **Distributed storage** – data is stored at multiple network nodes. This means it can be accessed from any of the locations, offering improved availability and performance. However, in order to keep the data up-to-date at all locations, additional software is required to replicate changes at all locations.

- **Offline storage** – also known as removable storage, this refers to any storage device which must be physically connected by a user to access the content (e.g. flash drives, DVDs, etc).

- **Cloud storage** - relies on using lots of servers in various locations to store data. The servers store user files that can then be accessed by a user on any device that is connected to the internet.

  Costs – potential to be cheaper than offline storage as no requirement to purchase or maintain hardware. However often uses a subscription service so can become expensive over time, especially if a lot of storage is required.

  Accessibility – users can access data from any location using a supported device (e.g. netbook, tablet, smartphone). This also encourages collaborating as files can easily be shared between users. However, files require an active internet condition to be accessed and any interruptions in service could mean data is complete inaccessible.

  Maintainability – many cloud services provide an automatic back up of data, reducing the need for the user to purchase hardware or requiring knowledge of how to create back ups. Also changes or updates to files will be maintained across devices. However users also have less control of security measures in place to protect their data.

Backup systems and strategies

All organisations have backup strategies in place to prevent accidental loss of data.

Full backup strategy

- Backs up **all** the data on the system, regardless of previous back ups..
- Most reliable recovery of data as everything has been backed up.
- Time consuming and can quickly use up the available backing storage space.

Differential backup strategy

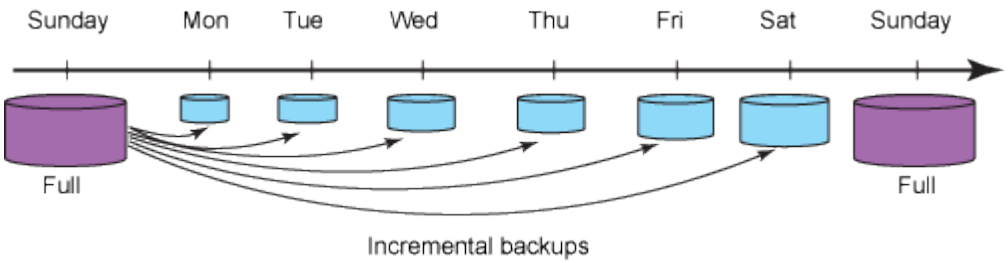
- Backs up all data which has changed or been created since the last **full backup**.
- Faster than a full back up and requires less storage space.
- Takes longer to locate data for recovery as not all may be required.

Incremental backup strategy

- Backs up all data which has changed or been created since the last back up of any kind. This is the preferred modern backup strategy.
- Faster than other backup strategies and requires the least storage space.
- Can take longer to locate data for recovery.

Scheduling backups

The process of creating backups can be scheduled to take place at certain times or certain frequencies. In many cases the most efficient method is to use a combination of back up strategies at different intervals. For example:



Full back up strategy – could be carried out at the start or end of every week (e.g. Monday/Sunday). This ensures that there is always a copy of all data that with one week that can be retrieved.
Differential backup strategy -could be scheduled for every 2 or 3 days. This ensures that most of the data that has changed since the last full back up can be retrieved reliably.
Incremental backup strategy – may take place every day or 12 hours. Only changes to data since last backup of any kind are stored which means backups should be quick and require less storage.

Cloud systems

Different levels of security and management are required depending on the cloud computing model chosen by an organisation.

Public system

- Available to the general public.
- Relatively cheap, often free or on a pay per GB basis.
- Easily accessible.
- Relatively insecure.
- Can't be customised to an organisation's specific needs.

Private system

- Maintained by the organisation which uses the cloud.
- Relatively expensive as the organisation must set up and maintain the system.
- Not a quick, easy option.
- Can be customised to the organisation's specific needs.
- Improved security, only available to members of the organisation.

Hybrid

- Combines a private cloud with a public cloud.
- Less important data, such as archives, could be stored on the public cloud for less expense.
- A private cloud could be used to store only the more important data, as this will come at a greater cost.

Networking and connectivity

Cloud-based services

Cloud service providers often offer more than just storage for your data. Cloud based services refer to any services which you can access on demand from anywhere on the internet. Some examples of cloud based services include Microsoft Office 365, Adobe Creative Cloud, Google Apps and Apple iCloud.

Uses of cloud-based services:

- **Data storage** - allows users to upload files that they can access again from any connected internet ready device, not just the device used to upload the files. Users login and are then given access to files. Any changes are saved on the cloud and are evident in real time. Storage capacities vary from provider to provider and many data storage providers also have subscription models to allow for storage of more files. This can be customised to suit the individual needs of the user.
- **Mail services –**many large organisations (e.g. schools, hospitals, government and council offices) traditionally used internal mail servers to facilitate use of e-mail. In this case e-mails were stored on a server that could be accessed from within the organisation. However there has been a gradual move towards cloud based email systems which is accessed through an internet connection. All features of the e-mail system run via a web browser and this has the advantage of allowing access on a range of devices.
- **Software updates** – cloud services can help ensure that users will always have access to the most up to date versions of software. This is because software systems that run in browser through the cloud are updated regularly and automatically by the cloud provider. Similarly, many of these systems allow employees to download their own version of the software for use at home (Office 365 is an example of this). Links to the software to be downloaded will always be compatible with the cloud based system and are generally kept up to date a lot more often than standalone versions.

Web hosting services

Web hosting allows individuals or companies to store the files and content for their website on an external server. Web hosting companies can also provide templates that can be used by clients when creating their website and usually offer extensive technical support. This allows an organisation to populate a website with content without needing to have knowledge of HTML, CSS, JavaScript and server-side languages. Examples of companies offering this are GoDaddy, Weebly and WordPress.

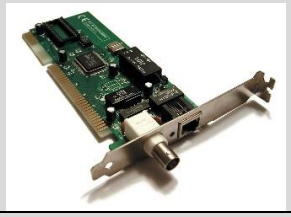
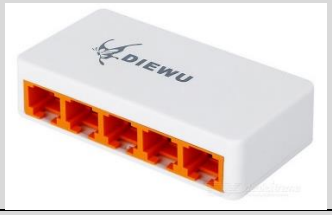
Network hardware and transmission media

Transmission media refers to the way in which computers are connected together.

Wired connections	Use copper cables to connect computers. They can be expensive, depending on quality, but they have a fairly high bandwidth.
Optical connections	Use fibre-optic cables to connect computers. They are more expensive than copper cables but have a much higher bandwidth and are less prone to electrical interference.
Wireless connections	Use radio waves and microwaves to connect computers. This may be cheaper than buying cabling and means computers can be moved easily. However, bandwidth is usually lower and the connection is less secure as the signal can be received by anybody within range.

Network hardware devices

There are four pieces of hardware commonly used to ensure that data can be transferred on a computer network:

Network interface card 	Essential hardware that allows the computer system to connect to the network. The card can either support wired, wireless or both types of connection. Each device on the network has a unique address known as a MAC address. This is used to identify the device on the network.
Router 	A router is used to link devices together on a network. It contains a modem which allows it to connect to external networks (e.g. the internet). Routers possess all the features of a switch and can route network traffic accordingly.
Hub 	A hub will take data that it receives and will send/broadcast this data to every device that it is connected to. This is inefficient as sending data to all connected devices increase the amount of network traffic and reduces performance. Hubs are generally cheaper than routers or switches.
Switch 	A switch is similar to a hub and allows data to be sent around a network. However a switch is more efficient than a hub as it uses MAC addresses to make sure that data packets are only sent to the device that needs or requested the data. This reduces the amount of network traffic and leads to improved performance.