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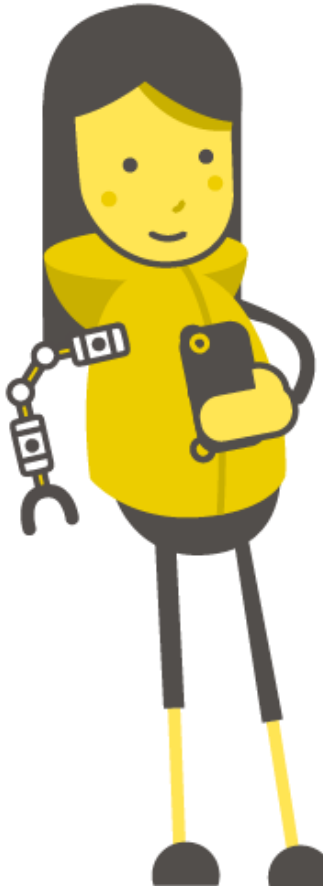
Operating Systems



Hardware vs. Software

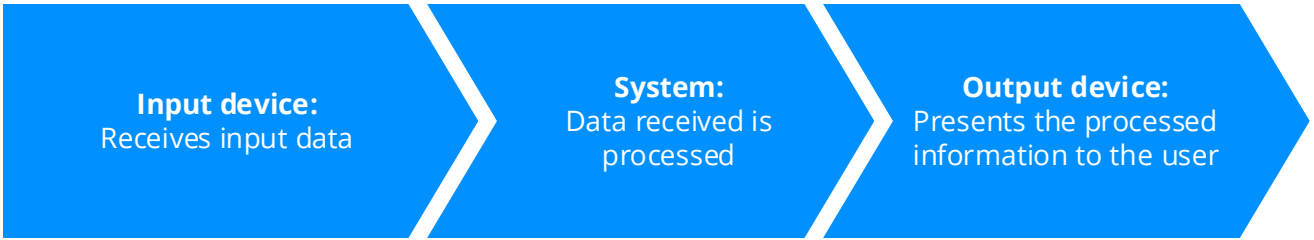
Hardware vs. Software

The physical components of the computer is hardware. For example: monitor, keyboard, mouse, etc.

The programs that run on the computer is software.

Both hardware and software, work together for smooth functioning of the computer.

All components communicate with system using inputs and outputs.



How hardware and software work together

Software

System Software

Responsible for running hardware and managing computer systems

- Operating system
- Device drivers
- Utility software
- Etc.

Application Software

Enables user to perform a specific task

- Word processor
- Web browser
- Video conferencing
- Etc.

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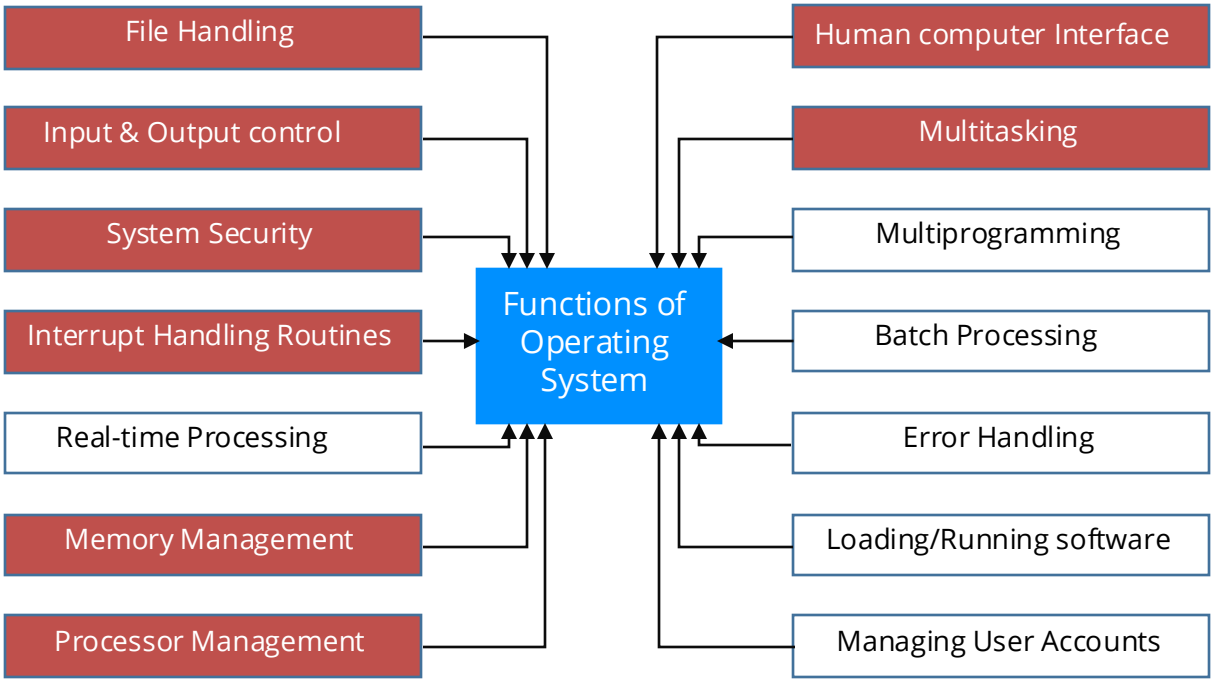
What is an Operating System?

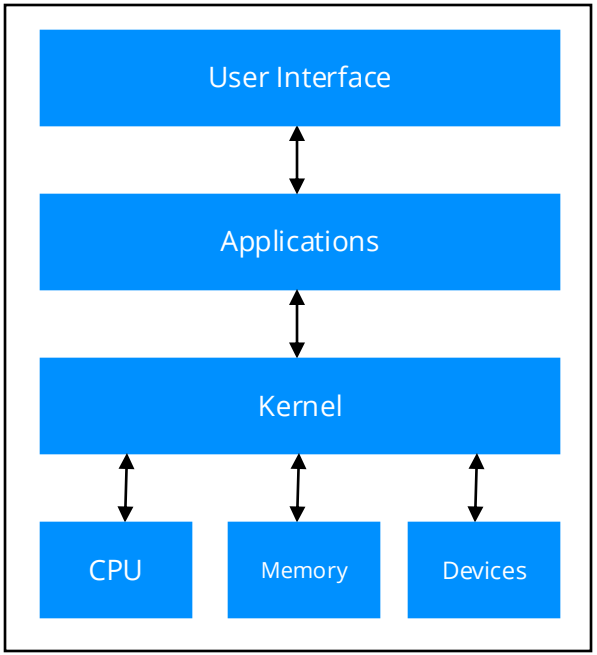
What is an Operating System?

- Manages the software and hardware that make up the computer system
- Acts as an interface between the user and important applications for managing the computer
- It is software that runs in the background of a computer system
- Some computer systems, such as gaming consoles, have unique operating systems
- Windows, Mac OS X, Linux and iOS are a few examples of operating systems


File Handling
Input & Output control
System Security
Interrupt Handling Routines
Real-time Processing
Memory Management
Processor Management
Functions of Operating System
Human computer Interface
Multitasking
Multiprogramming
Batch Processing
Error Handling
Loading/Running software
Managing User Accounts

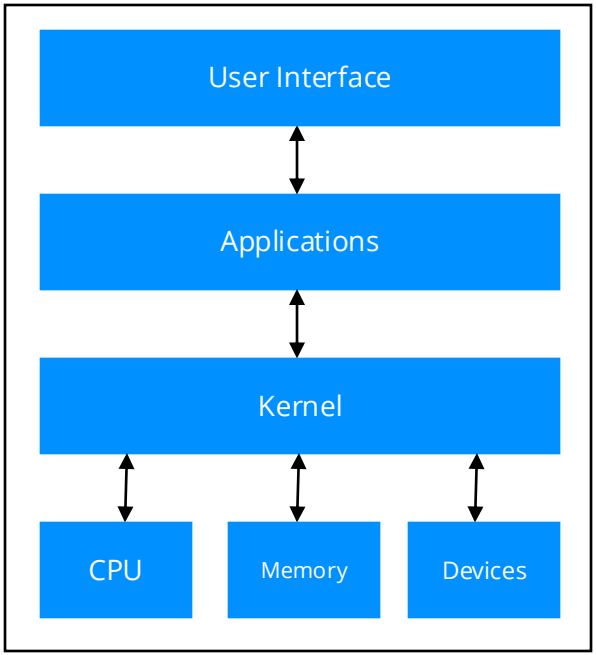
Layers in operating systems

- The communications between hardware and applications is processed through an OS
- An operating system is structured in the form of layers
- The user interfaces with the installed applications
- These applications interact with the kernels of the OS



Layers in operating system

- Kernels are the control centre of the operating system
- Resources are allocated according to priority of requests
- The central processing unit (CPU), memory and other hardware are the resources required to process a request
- The response of the OS is obtained through the UI



User Interfaces

Interfaces

There are a few types of interfaces:

- Menu Driven
- Command Line
- Graphical
- Mobile

Menu Driven Interface

https://www.bbc.co.uk/bitesize/guides/zwb4jxs/revision/2

Menu Driven Interface

Simple Menu

- User offered a simple menu from which to choose an option.
- One menu often leads to a further menu.
- Part of the screen may have an instruction followed by a number of options to choose from.

Full Screen Menu

- Takes up the entire screen.

Menu Bar

- Set of options at the top of the screen. When an option is chosen a drop-down menu may be offered.
- Easy to use and the user does not have to remember sets of commands.
- User friendly – can often guess your way around the options.
- Can be irritating if there are too many.

Command Line Interface

A command-line interface (CLI) allows the user to interact with the computer by typing in commands. The computer displays a prompt, the user keys in the command and presses enter or return

- Commands must be typed correctly and in the right order or the command will not work
- Experienced users who know their commands can work very quickly without having to find their way around menus
- Command driven programs do not need the memory and processing power of the latest computer and will often run on lower spec machines.

Graphic User Interface

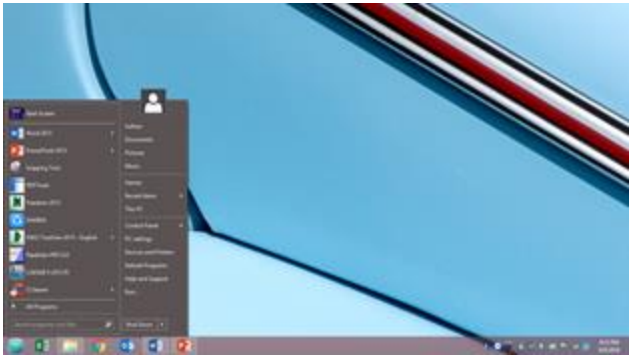
Graphical user interface (GUI) provides users with an interactive environment based on icons, menus and tiles

- Much easier to use for beginners
- Enable you to easily exchange information between software using cut and paste or drag and drop
- Use a lot of memory and processing power.
- Can be slower than a command line interface if you are an expert user
- Can be irritating to experienced users when simple tasks require a number of operations

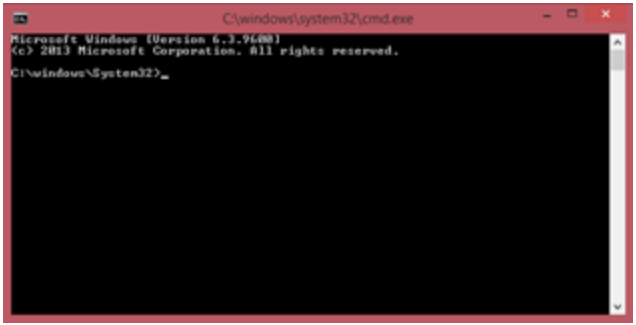
Mobile user interface (MUI) falls under the umbrella of GUIs but is optimised for smaller screens and touch interaction

Human-Computer Interface

Graphical User Interface (GUI)



Command Line Interface (CLI)

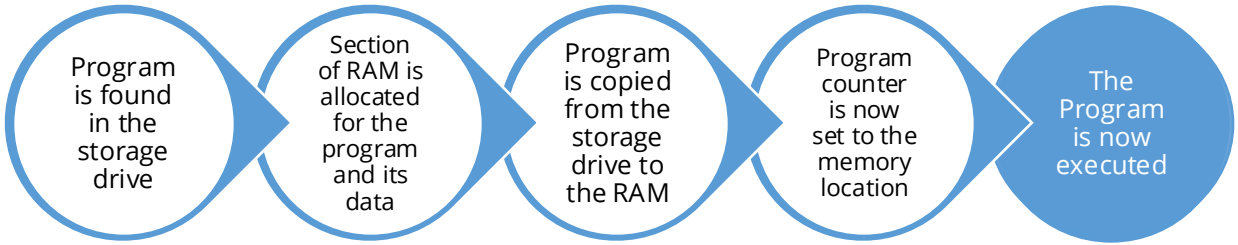


GUI Vs. CLI

CPU Management

Managing the CPU

To run a piece of software, the OS finds the program in the storage drive, loads it to the main memory and instructs the CPU to start executing the program from the beginning



Multitasking

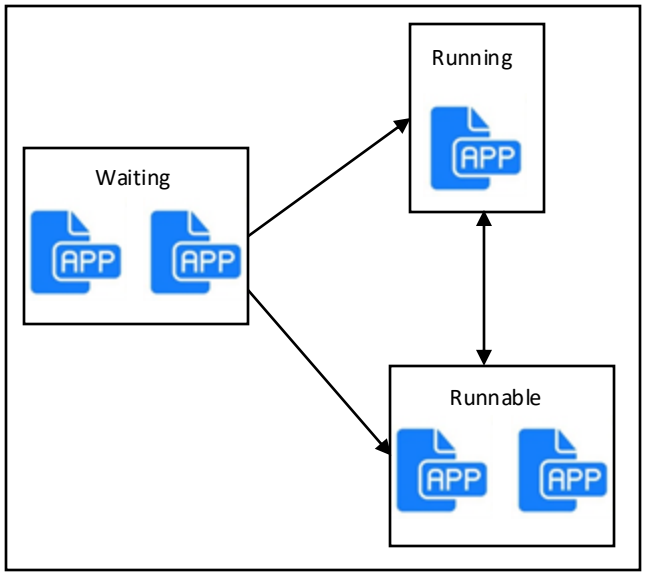
Multitasking

An OS can run multiple programs at the same time

Multiple programs can be copied to RAM at the same time, but only one program is processed at a particular instant

The programs could be in any of the following three states: Running, waiting and runnable

Multitasking

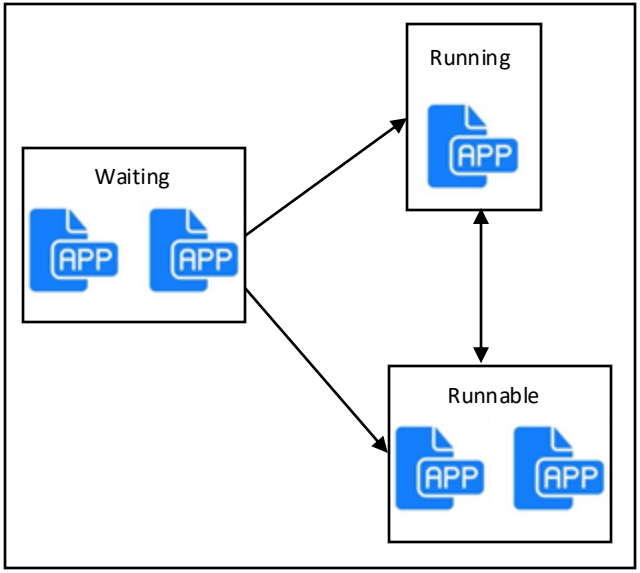


- CPUs are extremely fast and can swap between various processes
- The OS controls the CPU and decides which process should be executed at a particular time
- When a process is being run by a CPU, the other processes are put on hold in a waiting state

Multitasking

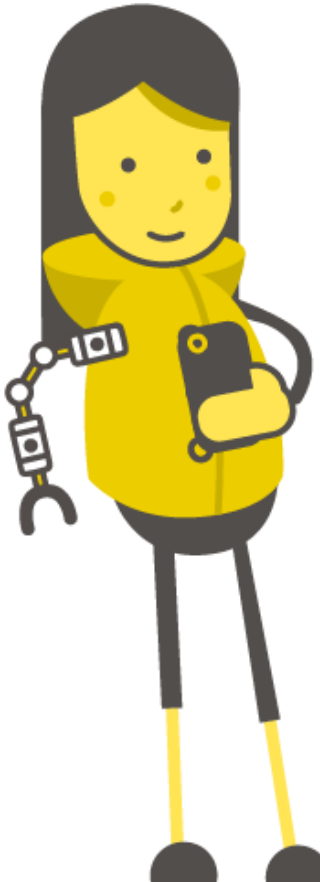
The CPU is switched from running to a runnable process if:

- The running process is interrupted by an external event
- The running process is taking longer than its allocated time.



Multitasking: Scheduling

- Scheduling is to determine how the processes are run and swapped
- The operating system may choose the shortest job first or it may choose the one with the longest waiting time first
- This is managed by the operating system
- This is very important for efficient and fair processing of all processes



Memory Management

Memory Management

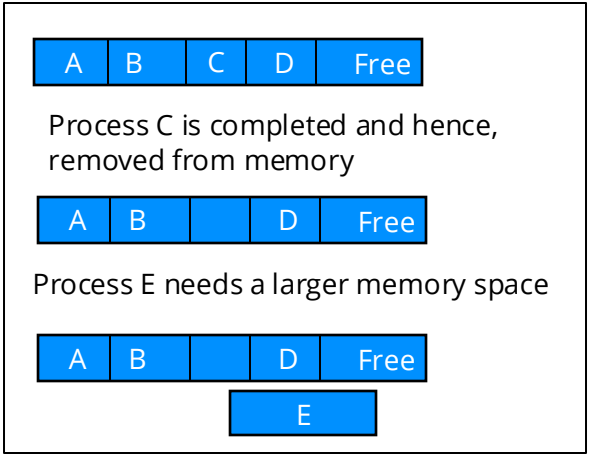
- The memory is shared efficiently between the processes
- When multiple processes are being run, the OS makes sure that each process has its data and instructions stored in a different memory location
- Hence, the processes do not interfere with each other
- In cases where processes need to share some data, these data are stored in a shared location.

Allocating Memory to a New Process

Consider four process running at the same time and being allocated memory A, B, C and D

Look at the scenario shown

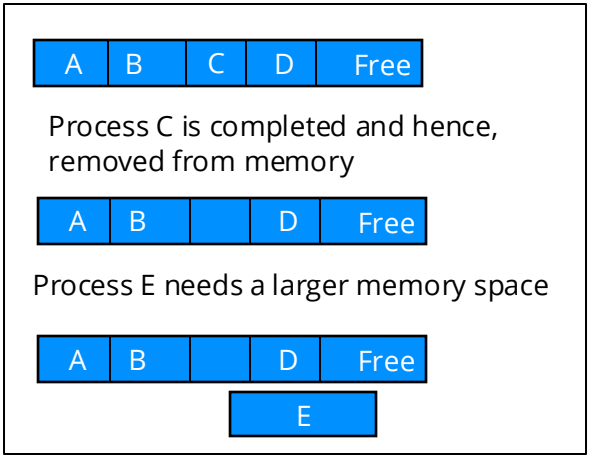
How can memory space be allocated for process E?



Allocating Memory: Segmentation

The memory required from process E is split into two parts, as shown

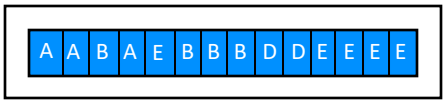
This way of splitting memory and allocating it to a process is called **segmentation**



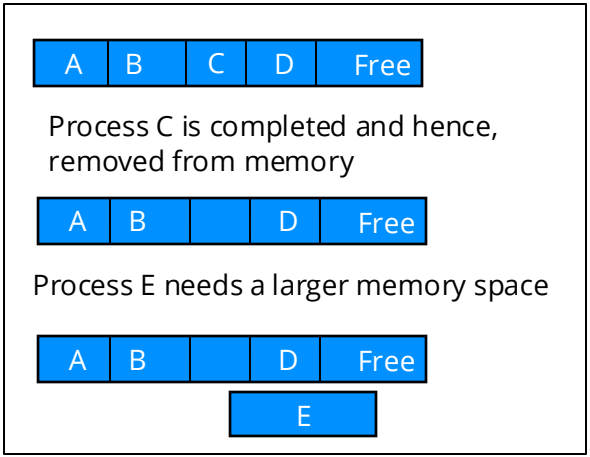
Allocating Memory: Paging

Memory can also be split into equally sized blocks called **pages**

Mappings of which process is allocated to which page is maintained in a table



An operating system may use both segmentation and paging to manage memory



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Managing Peripherals

Control of I/O Devices

Peripheral devices are controlled using protocols and device drivers:

Protocol:

- The peripheral devices connected to the computer are programmed with machine code
- This code describes the way data is to be transferred between the device and the computer

Device drivers:

- A device driver manages the connection with a peripheral device
- Handles the different requests between a computer and a device
- Defines the processes to store the outgoing data and incoming messages

Device Drivers

- When the device is idle for more than a specified time, the driver puts the device into sleep mode
- An OS is equipped with generic device drivers but some devices require the installation of its device drivers
- A single driver is enough to control multiple peripherals using the same protocol
- In cases where multiple peripherals are connected, the data related to each device is stored in a different location to make sure that the processes do not interfere with each other

Backing Store Management

Backing Store

The backing store is the data managed by the system – **file handling** and **file maintenance**

The OS manages the backing store by loading, saving and organising data

Suitable management require files to be stored in an organised, hierarchical structure

Data storage within the file structure is kept efficient through methods such as defragmentation (**more on this later**)

File management systems

In order to access a file, the OS needs to know the location of the file

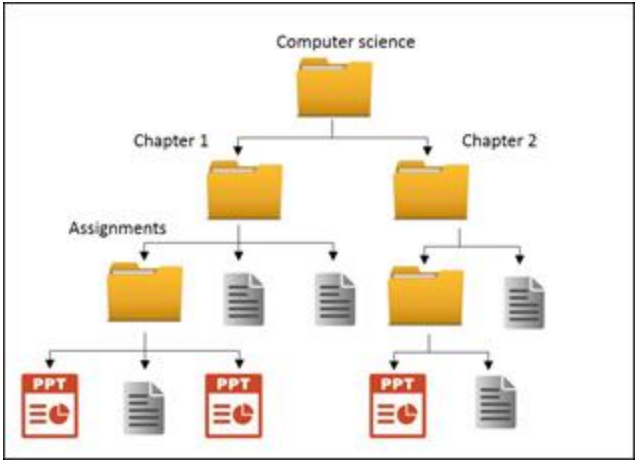
To retrieve data from the file, an OS needs to know:

- the organisation structure
- amount of data in the file
- protocol needed to communicate with the file system

Windows File Explorer

Each file in a folder has a unique name and the OS maintains a look-up table that contains the information about the location of all the files.

Files are stored in a hierarchical system.



Interrupts & Buffers

What is an Interrupt?

An interrupt is a signal sent from a device or software to the processor

The processor will temporarily stop its current process and will service the interrupt signal

For example: When paper is jammed in a printer, the CPU prompts the user to check the status

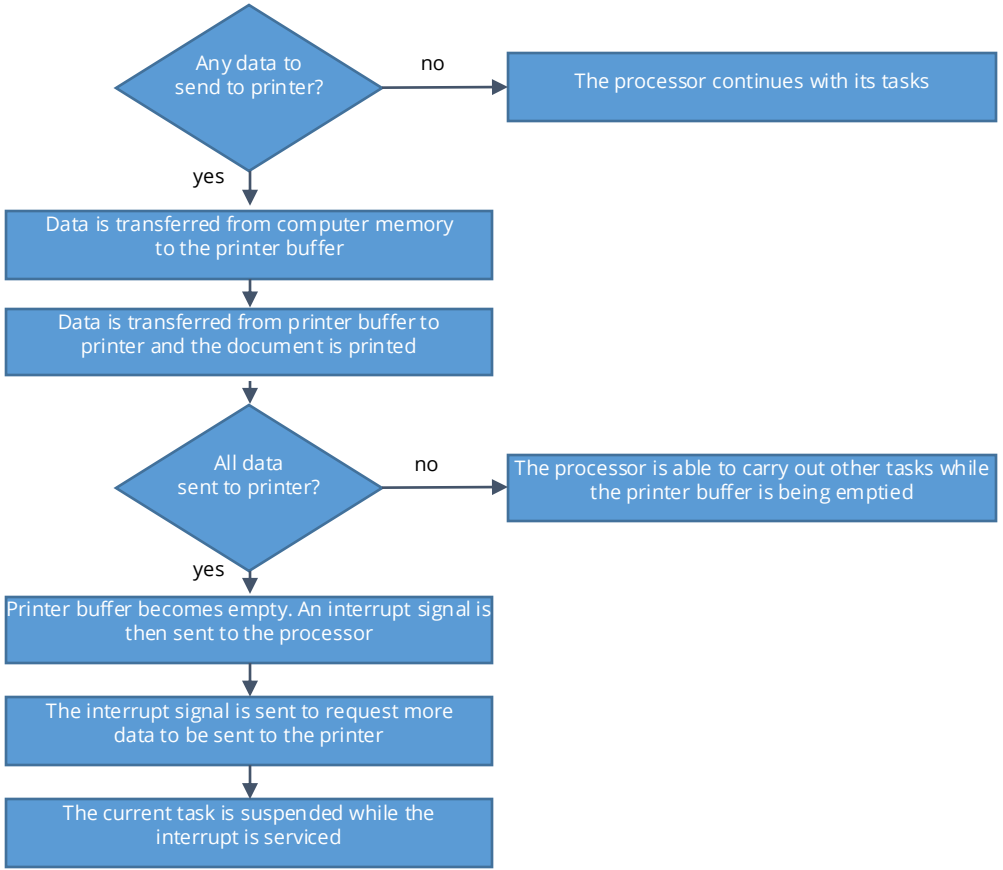
What is a Buffer?

Hardware devices operate at a much lower speed compared to that of the processor

If the processor is sending data to an output device, it needs to wait for the hardware to complete its operation

Buffers are temporary memory areas, which hold the data for the output hardware

Buffers are used to speed up the processor's operation.

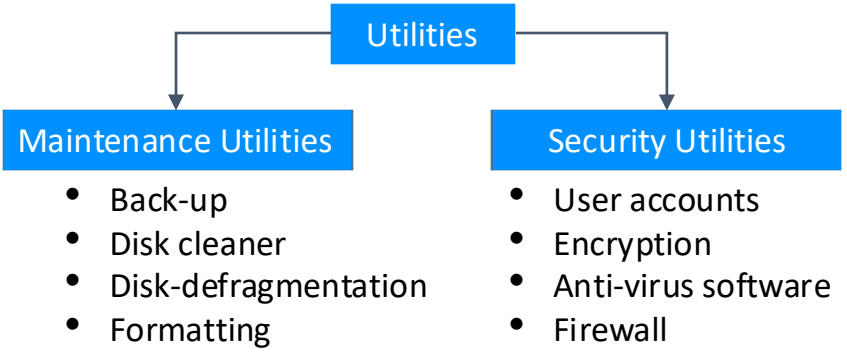


Buffers and interrupts are used together for the standard computer functions.

Utilities

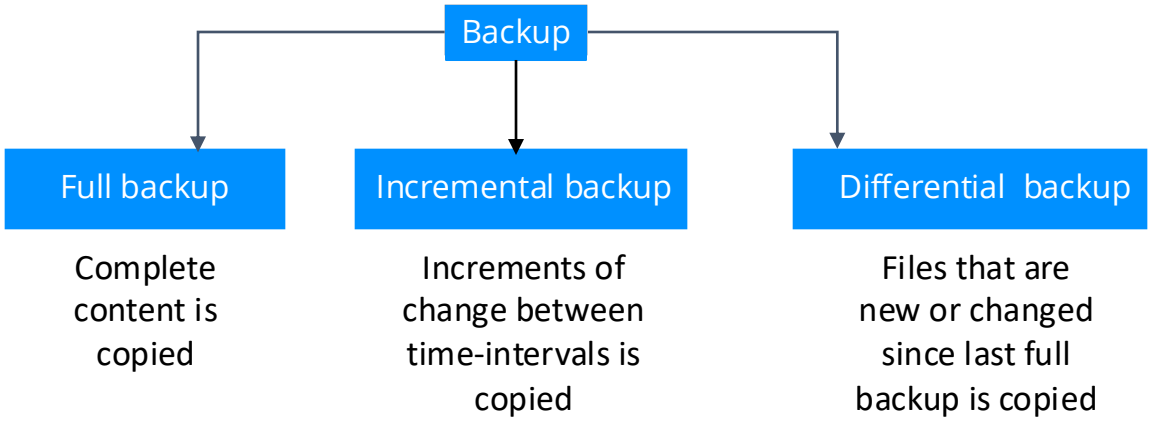
Utilities

Utilities are programs that are installed in a system alongside the operating system



Maintenance Utilities: Backup

- To make the system reliable, a copy of all data and files is stored in a separate server or storage drive
- This protects the data from being lost due to failure
- Backup is also useful when the data is accidentally overwritten



Maintenance Utilities: Backup

Full backup

- A copy of all the contents of a system is made at one or more specific point(s) in time.
- Unchanged data is also copied to the backup.
- Slowest and requires a larger space compared to other methods.
- Faster restoration.

Incremental backup

- Stores an initial back first and then, backups at more intervals of time.
- Unchanged data is not copied to the backup.
- Faster and requires less space than other methods.
- Slower restoration because many restore points may be accessed.

Differential backup

- Only saves those files that are new or are changed since the last full back-up procedure.
- Faster than full backup procedure but is slower than incremental backup procedure.
- Space required to perform differential backup is more than that of incremental backup.
- Restoration process is faster than incremental backup but is slower than full backup.

Maintenance Utilities: Disk-cleaner

A storage drive is divided into clusters

A look-up table for all files with their addresses is present in the drive

When a file is deleted, its address from the look-up table is also deleted. Now, the address is free to be used for another file

Commercially available disks cleaners identify and remove the unused, temporary and cached files to make more free space on the disk.

Maintenance Utilities: Disk-Defragmentation

When many small files are deleted, small parts of all clusters are free for usage

If a large file needs to be stored, this file is fragmented into smaller parts and can then be stored in many small clusters

When this large file is accessed, the read-write head has to move many times and the time taken to access this data increases

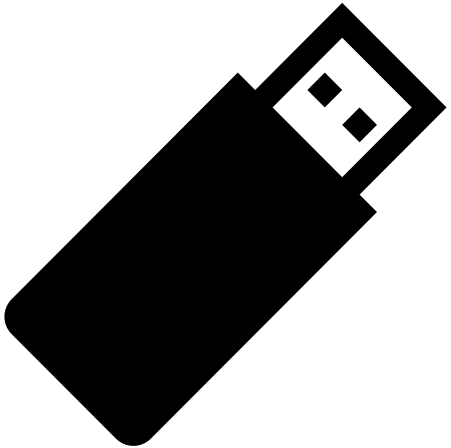
Therefore, a utility software disk-defragmenters are used that reassembles the fragments and the file appears in continuous sequences of clusters

Also, the free space now appears as a separate sequence of clusters

Maintenance Utilities: Formatting

Storage devices need to be formatted to be compatible with the OS

When a storage device is connected to an OS, the device is formatted automatically



Security utilities

User accounts

User accounts are provided to authorise access to important files and documents

These accounts ask for a password

The system is now protected from unauthorised access

Encryption

Data is encrypted when it is stored or when it is sent over a network

This is done to protect the data from unauthorised access

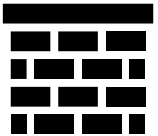
Security utilities

Anti-virus software

Anti-virus software detects malware and blocks its operation

This type of software safely removes any file that could be a threat to the system

Firewall



Firewalls establish a barrier between a trusted internal network and untrusted external networks

They prevent unauthorised web users and malicious software from gaining access to private networks connected to the internet

Legal, Ethical & Privacy Considerations

Legal, Ethical & Privacy

Data Protection Laws

• Laws like the General Data Protection Regulation (GDPR) and DPA (2018). Developers of the OS must follow these laws by ensuring their operating systems store and process personal data securely

Cybercrime and Hacking

• Security features in operating systems are designed to prevent cybercrime. Weak security can leave systems vulnerable to attacks by hackers

• Operating systems have firewalls and antivirus tools to stop hackers from accessing your computer

Legal, Ethical & Privacy

User Privacy

- Operating systems collect data for various reasons. Without proper security, this data can be exposed
- They should be transparent about what data is collected and why. The operating system should ask for your permission before using your data and keep that information private

Security Vulnerabilities

- If security vulnerabilities are not fixed, it could lead to data theft, financial loss, or other damages
- It is the responsibility of developers to regularly update and patch these vulnerabilities to keep users safe

Legal, Ethical & Privacy

Encryption and Access Controls

- Crucial security features in operating systems to protect sensitive data from being accessed by unauthorised users.
- Developers must balance security and privacy when designing encryption systems. Data must be secure, while also considering how law enforcement or authorities might need access in extreme cases.

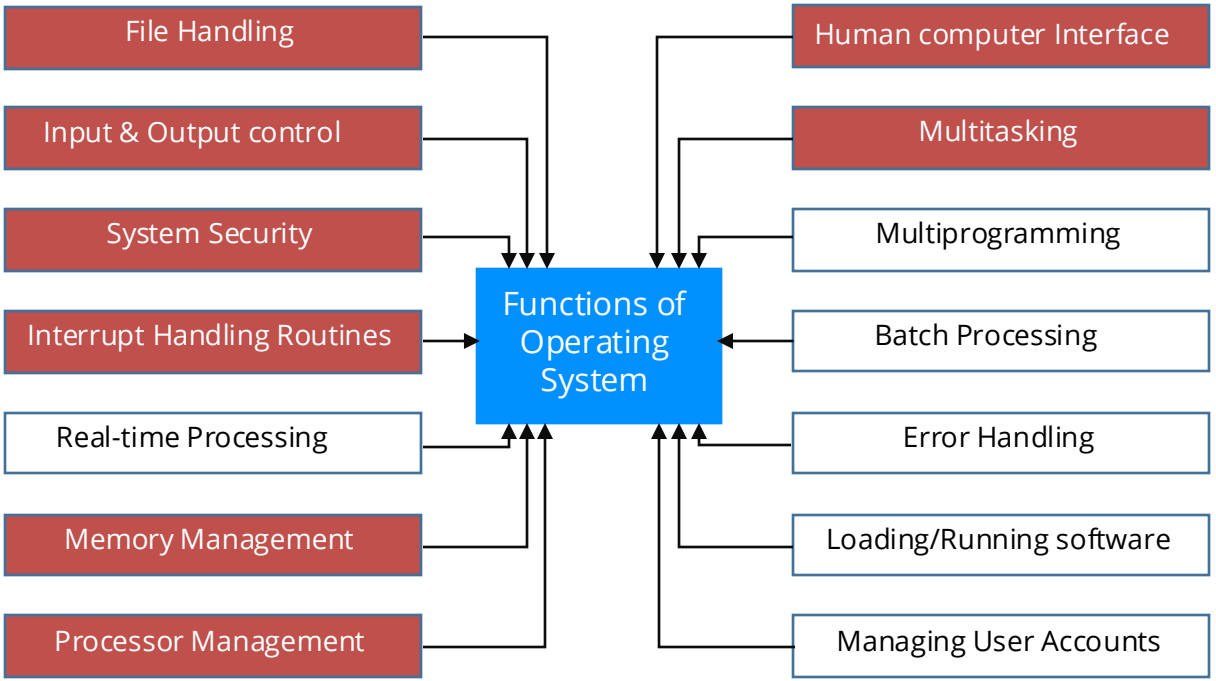
Security for Vulnerable Users

- Vulnerable users, such as the elderly, are more likely to fall victim to cyberattacks, scams, or data breaches, so the operating system needs extra safeguards.
- Developers have an ethical responsibility to ensure security features are easy to use and effective for all types of users, especially those who may not fully understand complex security settings.

Legal, Ethical & Privacy

Transparency and Trust

- Users need to trust that the operating system is keeping their data safe and using it responsibly.
- It is unethical for companies to hide how they collect or use data, or to create "backdoors" in the operating system that allow secret access to data.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