A-level
Computer Science

Systems software

Lesson Objectives

Students will learn about:

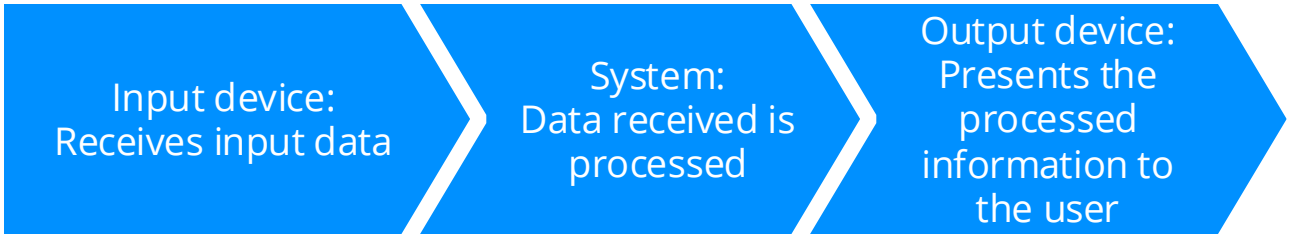
- Hardware vs. software (types)
- Operating systems
- Utility software

1.

Content

Hardware vs. software

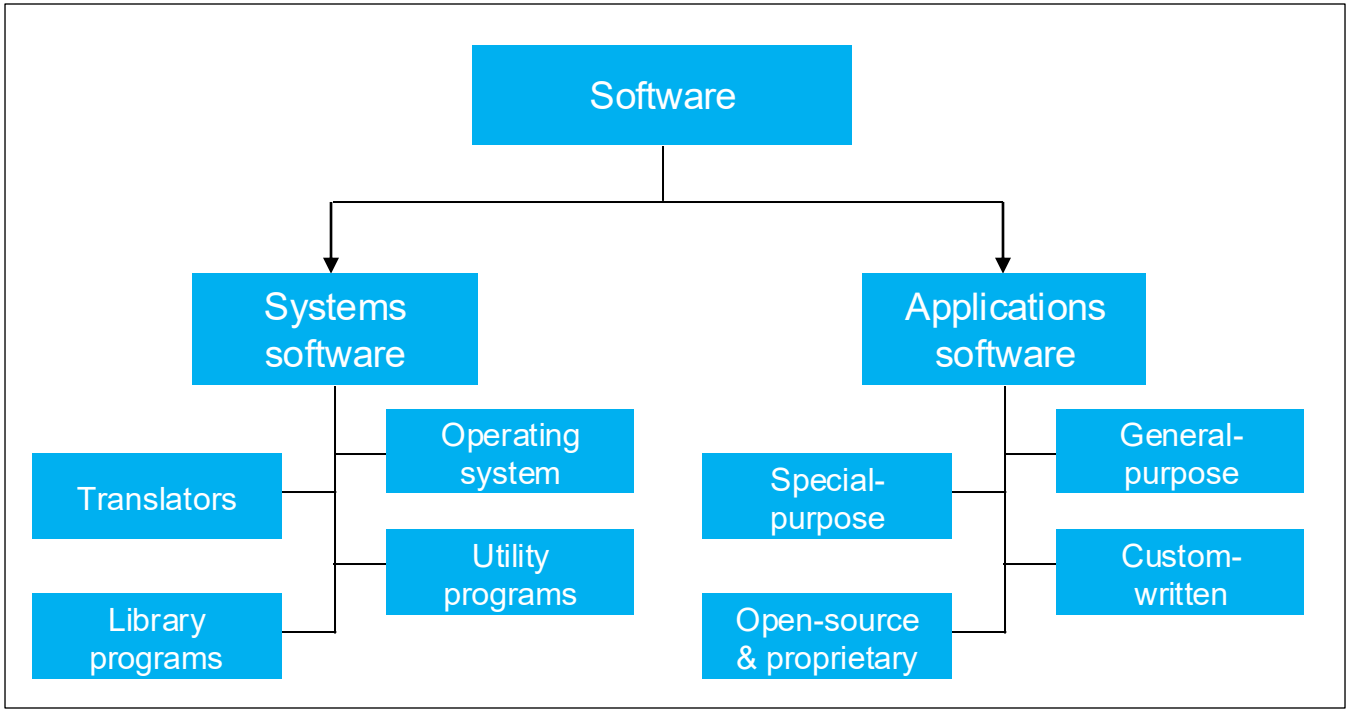
- The physical components of the computer is hardware. For example: monitor, keyboard, mouse, etc.
- The programs that run on the computer is software.
- Both hardware and software work together for smooth functioning of the computer.
- All components communicate with the system using inputs and outputs.



Software

There are two types of software:

- **System software**: System software is responsible for running hardware and managing computer systems.
  - For example: Operating system, device drivers, utility software, etc.
- **Application software**: Application software enables the end user to perform a specific task.
  - For example: A word processor allows the user to store text and simple images, and a web browser displays web pages.


Software
Systems software
Applications software
Operating system
Translators
Utility programs
Library programs
Special-purpose
General-purpose
Custom-written
Open-source & proprietary

Operating system

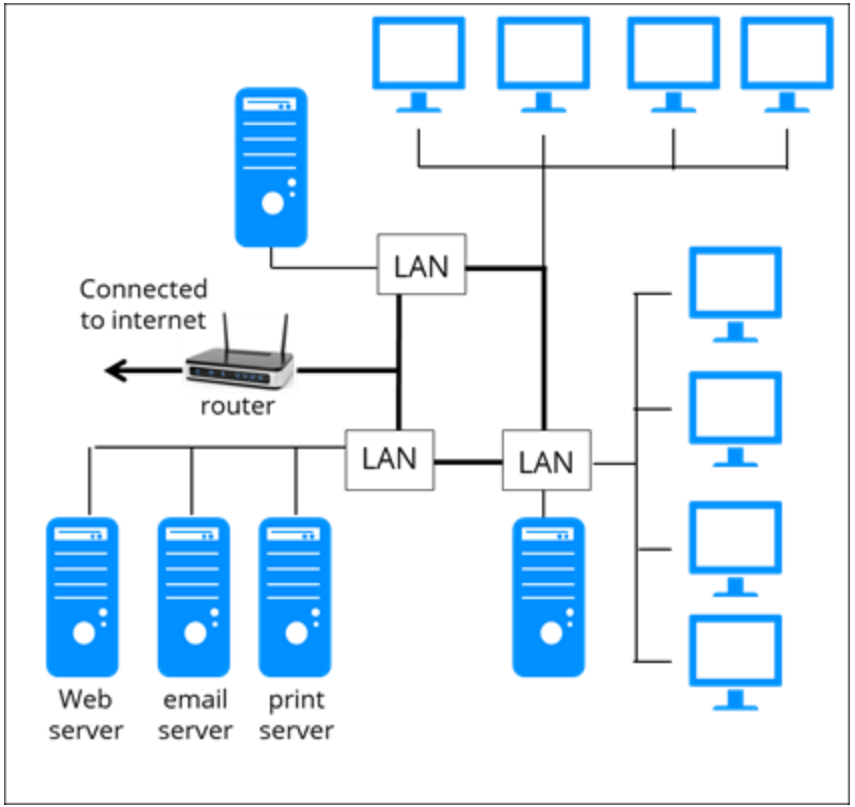
What is an operating system?

- Manages the software and hardware that make up the computer system.
- Windows, Mac OS X, Linux and iOS are a few examples of operating systems.
- The need of OS:
  - Acts as an interface between the user and important applications for managing the computer.
  - Provide background of application software

Types of OS

Distributed operating system

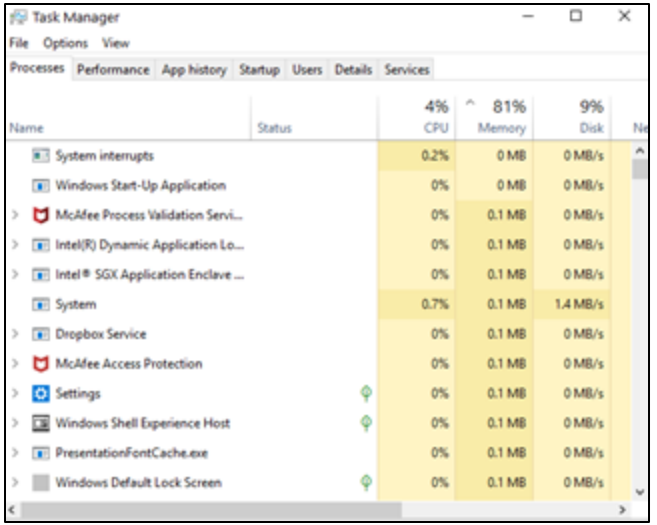
- Offers a parallel processing system by sharing the load over multiple servers that are interlinked.
- A job is divided into simple tasks and each task is sent to a computer in the network.
- For a user, it appears as if the job is processed in a single system.



Types of OS

Multi-tasking system

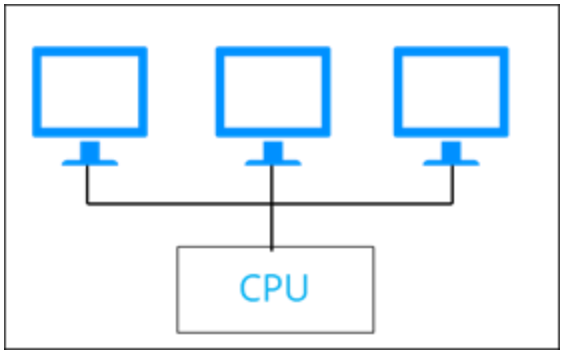
- Are used in laptops and personal computers, wherein multiple processes run simultaneously.
- The processor switches between processes and it appears to a user that all processes are running simultaneously.
- The task manager of Windows operating system lists the current processes running in a system.



Types of operating system

Multi-user, multi-tasking system

- Based on time-sharing and implements efficient processor scheduling algorithms to divide the time between multiple users.
- Each user is allocated a time slice in a Round Robin. The number of time slices may vary in some systems depending on the priority of tasks.
- In this system, numerous terminals are connected to a single mainframe system.



Types of operating system

Embedded operating system

- Embedded computers are designed to perform a dedicated function within a large mechanical or electrical system.
- Operating system for embedded system offers minimal control features to the user and has a limited RAM space.
- No permanent storage is provided.
- Embedded system accepts input from the sensors, processes it and sends output to control devices.

Types of operating system

Real-time operating system

- Critical systems are systems that must be highly reliable, as their failure may have a great impact on human lives.
- For example, temperature control of nuclear reactors and air traffic control.
- These systems are designed to work on numerous input data simultaneously with less response time.
- These systems are designed to be fault-tolerant and fail-safe.

Types of operating system

Real-time operating system

- Fault tolerance is a property that enables a system to operate properly even if the system undergoes one or more failures.
- When a system gracefully fails, that is, operates at a reduced level after some component failures, is called a fail-safe system.
- RTOS also implements redundancy. Redundancy is the duplication of critical parts of a computer system to improve reliability. If the primary system fails, the backup or reserve system steps in.

OS for mobile and handheld devices

- Windows phone, Apple iOS and Android are widely used operating systems for phones.
- Provide a graphical user interface only.
- They are smaller versions of desktop operating systems, which allows a user to listen to music, watch movies, read eBooks, play games, browse the Internet, and check emails.

Apple iOS


FaceTime
Saturday
25
Calendar
Photos
Camera
Contacts
Clock
Maps
Home
Videos
Photo Booth
Notes
Reminders
iTunes Store
App Store
iBooks
Settings

Android


12:25
Finder search
Samsung
Google
Microsoft Apps
Play Store
Samsung Members
Facebook
Spotify
Camera
Gallery
Clock
Galaxy Store
Contacts
Settings
Calendar
Calculator
Play Music
Samsung Notes
WhatsApp
Evernote
Hotlink RED
Lazada
Messenger
Slack
Home
Carousell
YT Music

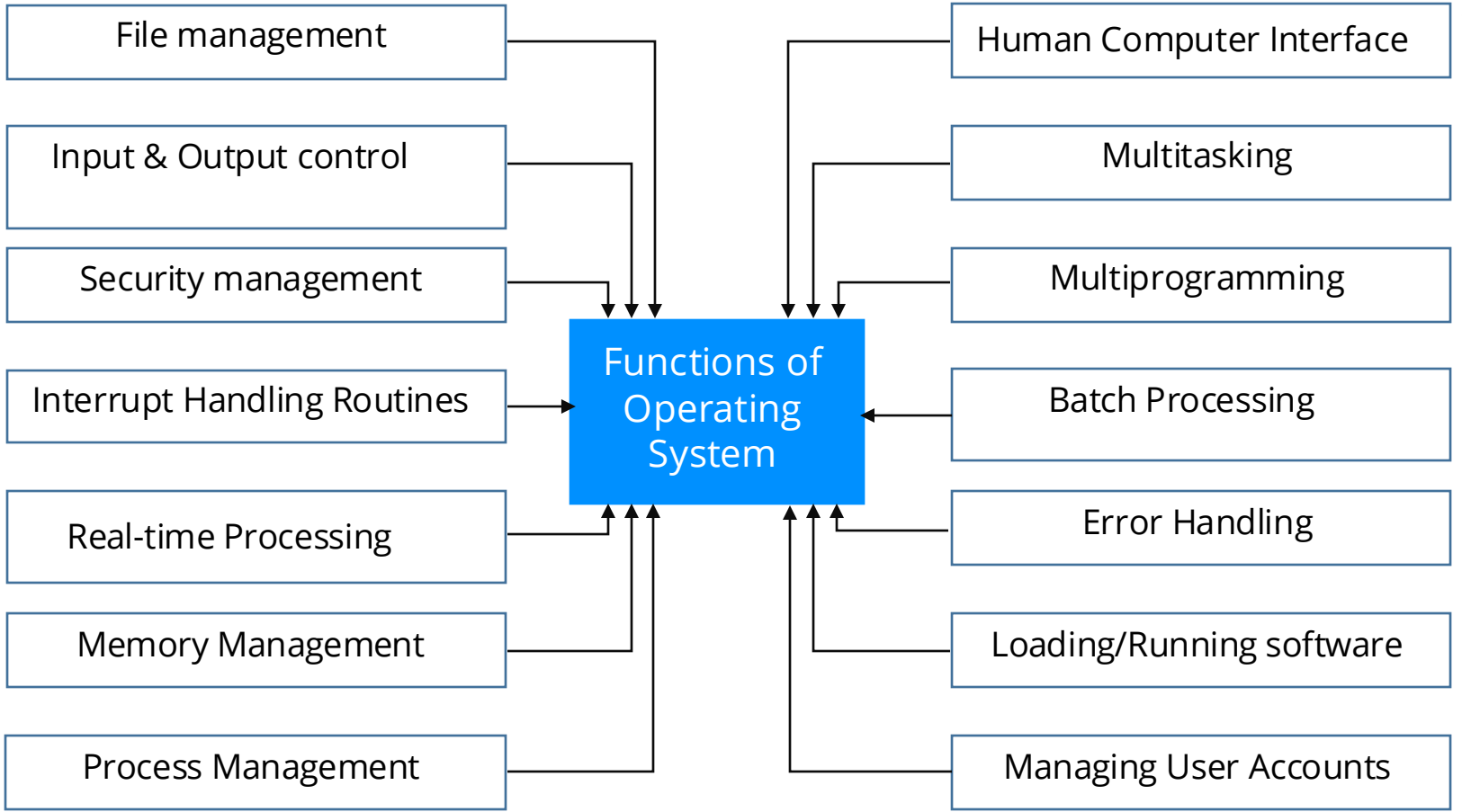
OS for mobile and handheld devices

Smartphones use two types of operating system:

- The main system that is responsible for user interface
- A real-time OS that is responsible for hardware operations and radio
    - The RTOS is a delicate system that is vulnerable to security threats.

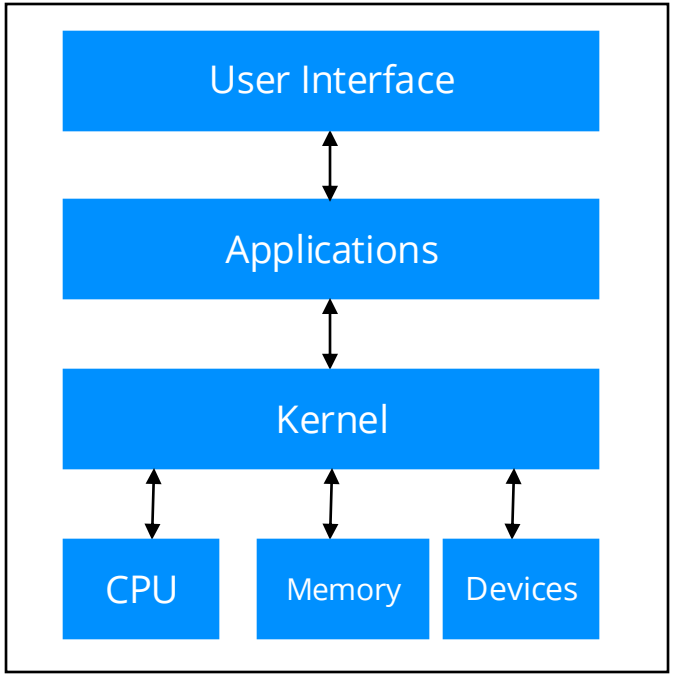
Functions of operating systems

- Human-computer interface.
- Multitasking.
- Loading and running of applications and software.
- Error handling.
- Batch processing.
- Interrupt handling routines.
- Real-time processing.
- **Process management.**
- Multiprogramming.
- **Memory management.**
- **Hardware management**
- **Security management.**
- **File management**


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

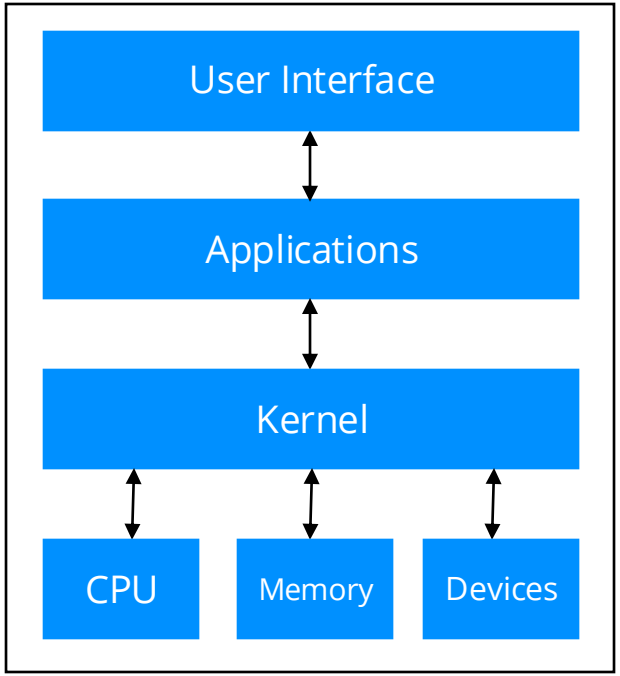
Layers in operating systems

- The communications between the hardware and applications are processed through an operating system.
- An operating system is structured in the form of layers, as shown in the figure.
- The user interfaces with the applications installed in the system.
- These applications interact with the kernels of the operating system.



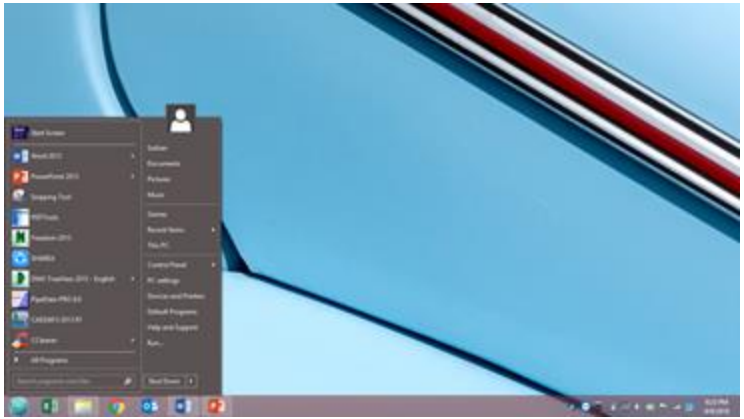
Layers in operating system

- Kernels are the control centre of the operating system.
- According the priority of the requests, the resources are allocated.
- The central processing unit (CPU), memory and other hardware devices are the resources required to process a request from an application.
- The response of the operating system is obtained by the user though the user interface.

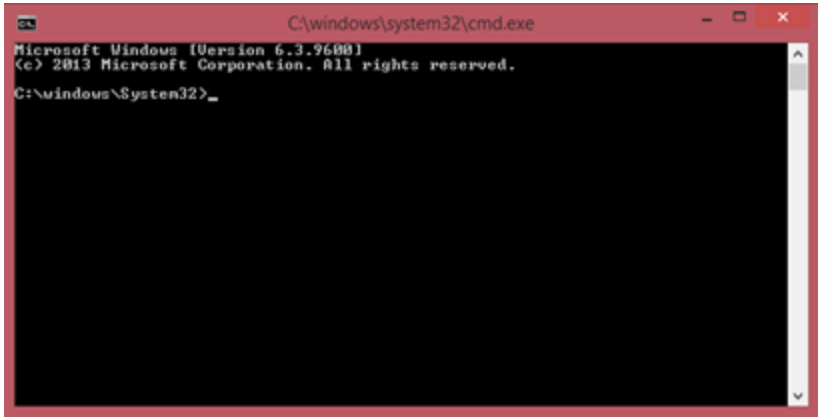


Human-computer Interface

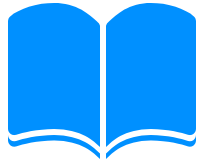
Graphical User Interface (GUI)



Command Line Interface (CLI)



Human-computer Interface



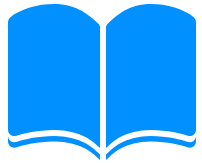
Graphical User Interface (GUI):

- Users are provided with an interactive environment based on icons, menus and tiles.
- Example: Smartphones are an example of a GUI where users interact through a touchscreen.
- In computer systems, users interact with a GUI through a mouse and keyboard.

Command Line Interface (CLI):

- A command-line interface is a non-graphical user interface where the user interacts with a text-only service.
- Example: The feedback from the OS is also text information. The user needs to know the various commands to interact with the OS using a CLI.

Human-computer Interface



Graphical User Interface (GUI):

Pros:

- Easy to use
- Don’t require users to remember commands

Cons:

- Slower than CLI
- Limited options to do

Command Line Interface (CLI):

Pros:

- CLI is faster, more flexible and uses less memory compared to a GUI.
- not restricted to a number of pre-determined options.

Cons:

- Users must remember commands

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.

Memory management

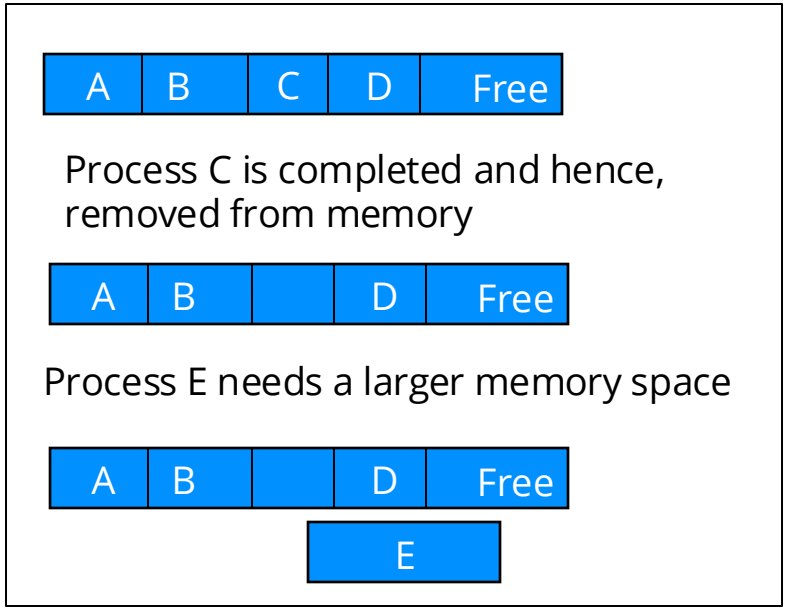
- Memory organization:
  - determine how computer memory is allocated and deallocated when a number of applications are running simultaneously
- Memory Optimization:
  - determines how much memory is allocated to an application, and how the memory can be split up
- Memory protection:
  - ensures that two competing applications cannot use the same memory locations at the same time

Allocating memory to new process

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

Look at the scenario shown.

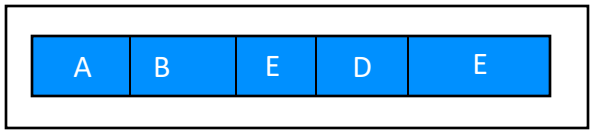
How can memory space be allocated for process E?

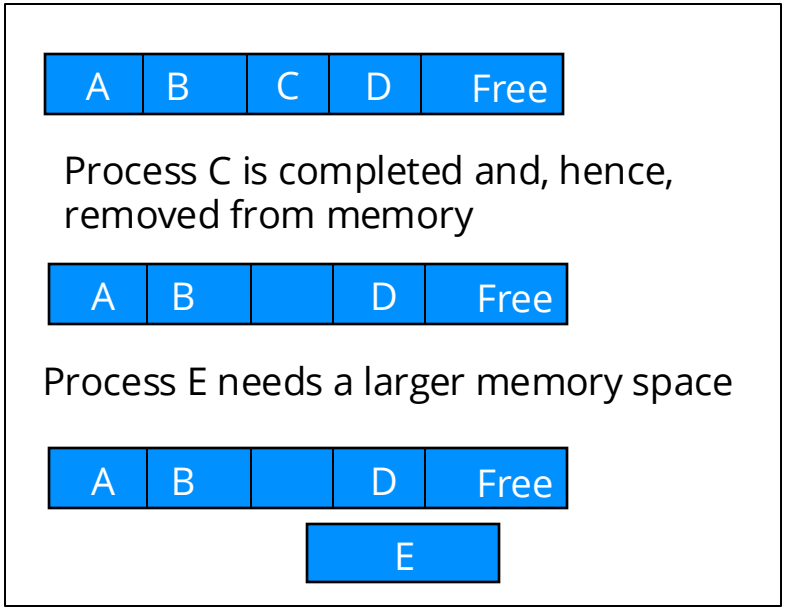


Allocating memory to new process: Segmentation

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.**

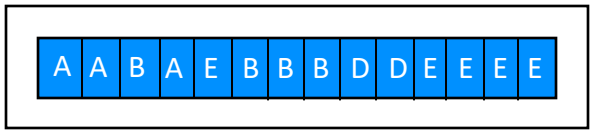




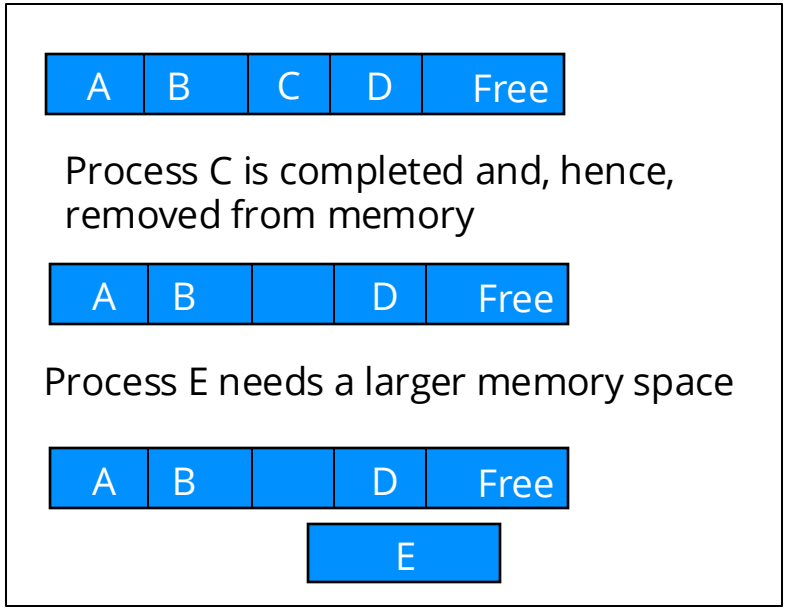
Allocating memory to new process: Paging

Alternatively, the memory can also be split into equally sized blocks called **pages.**

The information of which page is allocated to which process is maintained in a table.



An operating system may use both of these methods to manage memory.



Hardware management

- Control the input and output (peripheral) devices
- Using protocols and device drivers.
- Functions:

- Communicating with all input and output devices.
- Translating data from a file into a format that the input/output device can understand.
- ensuring each hardware resource has a priority so that it can be used and released as required.

Hardware management

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 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.

File management

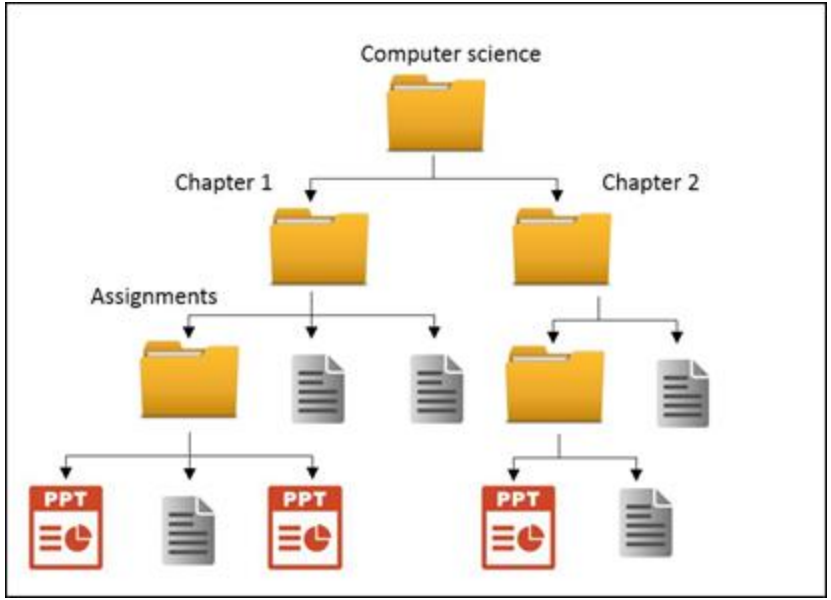
- Mange file system and access to it
- Functions:
  - defining the file naming conventions
  - performing specific tasks, such as create, open, close, delete, rename,...
  - maintaining the directory structures
  - ensuring access control mechanisms are maintained
  - specifying the logical file storage format (FAT or NTFS...)
  - ensuring memory allocation for a file by reading it from the HDD/SSD and loading it into memory.

File management

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

File management systems: Windows file explorer

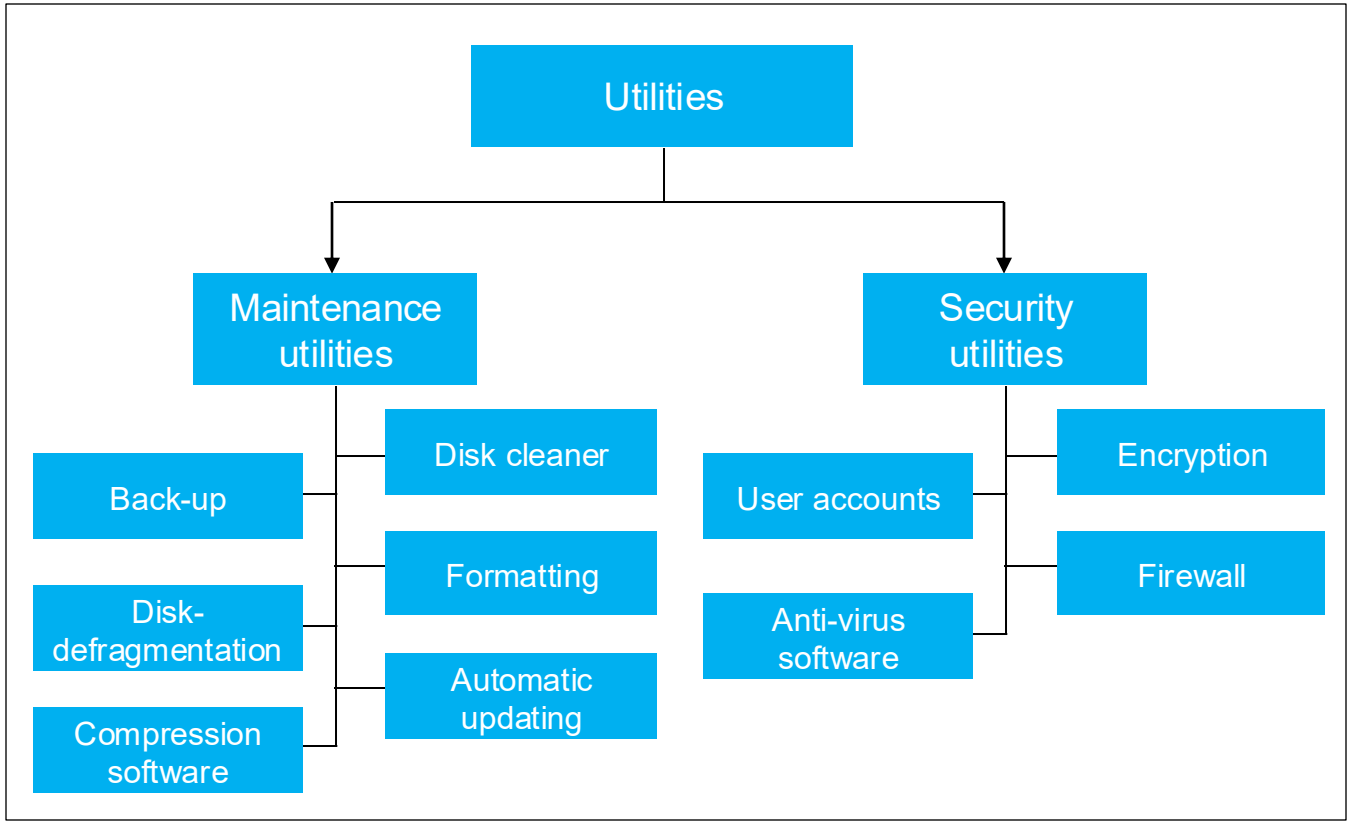
- Each file in a folder has a unique name and the OS maintains a look-up table that contains the information about the location of all the files.
- Files are stored in a hierarchical system.



Utility software

Utilities

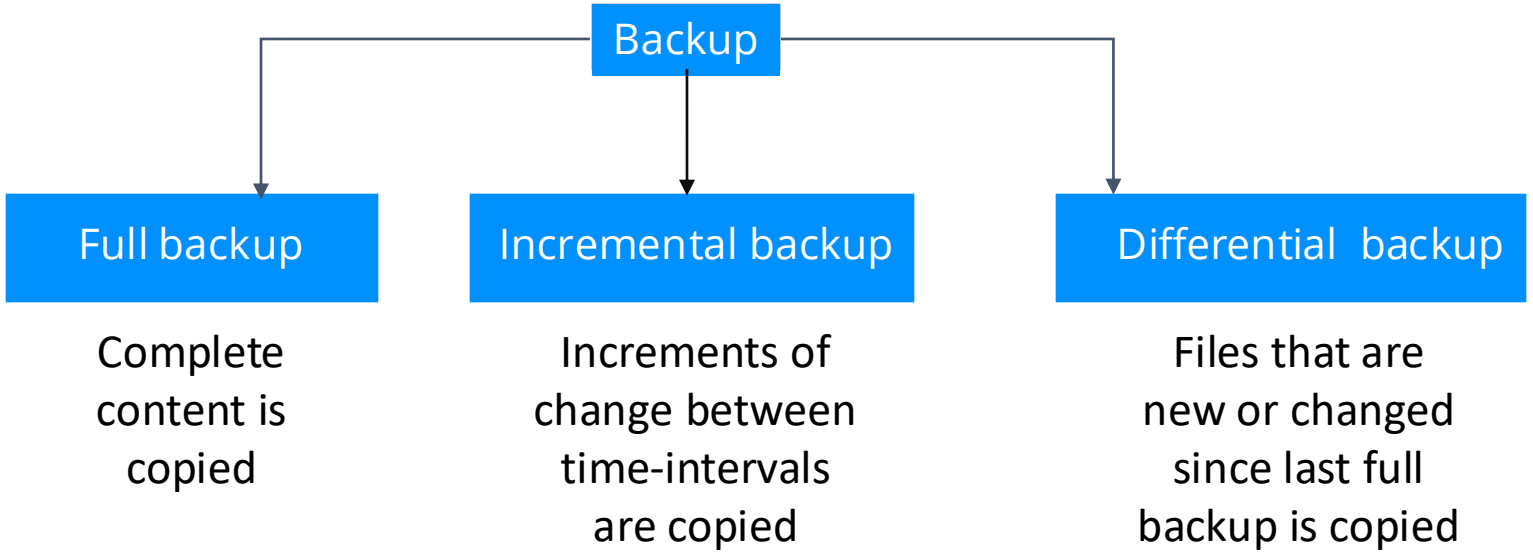
- Utilities are programs that are installed in a system alongside the operating system.
- Perform a limited range of functions.
- Some of these programs are installed automatically with an operating system.


Utilities
Maintenance utilities
Security utilities
Back-up
Disk cleaner
Disk-defragmentation
Formatting
Compression software
Automatic updating
User accounts
Encryption
Anti-virus software
Firewall

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



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 backup 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 an incremental backup procedure.

Space required to perform a differential backup is more than that of incremental backup.

The restoration process is faster than incremental backup but is slower than a full backup.

Maintenance utilities: Disk-cleaner

- A storage drive is divided into clusters.
- A look-up table for all files with their addresses are 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 disk cleaners identify and remove the unused, temporary and cached files to make 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: Disk formatter

- 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.

Maintenance utilities: Automatic updating

- The developers of an operating system constantly work to improve its performance, security and eliminate bugs.
- Updates of the latest utility programs are installed on the computer.
- Automatic updating features in firewalls and anti-virus software identifies and quarantines new viruses and threats.
- Application software must be updated regularly so that bug fixes can be added.

Maintenance utilities: Compression software

- Software such as WinZip enables us to compress files.
- Compressing files reduces the memory occupied and thus, makes the transfer of files over the internet faster.
- Email services have restrictions on the size of the file attached.
- Compression enables us to send larger files through email and reduces the upload and download time of a file.

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:

The 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 the malware and blocks its operation.

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

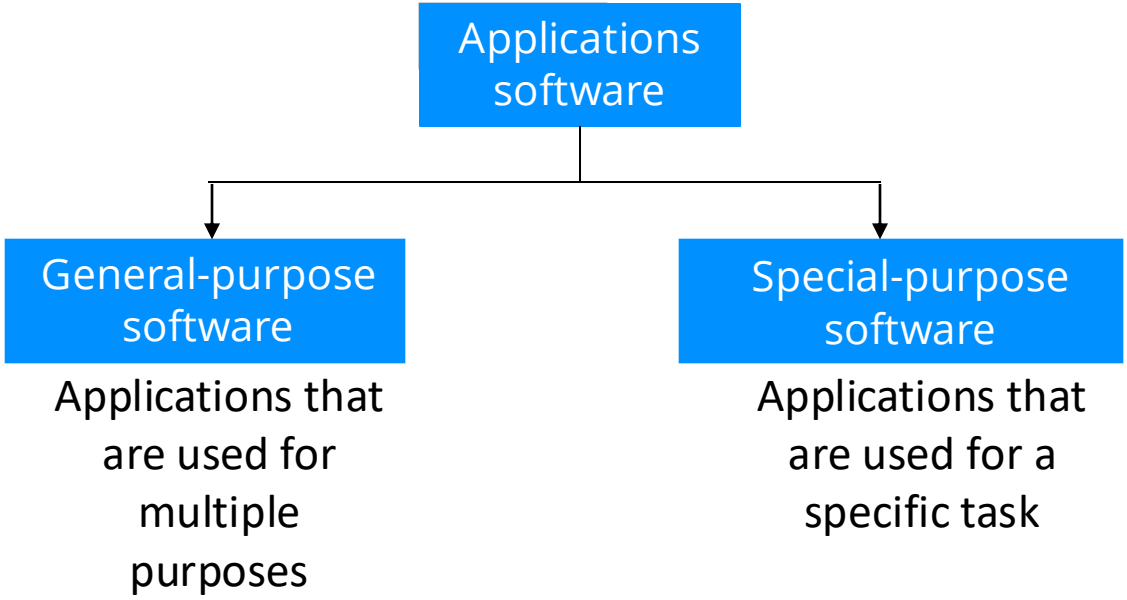
Firewall:

A firewall establishes a barrier between a trusted internal network and untrusted external networks.

It prevents unauthorised web users and malicious software from gaining access to private networks connected through the Internet.

Operating system

Applications software



Applications software

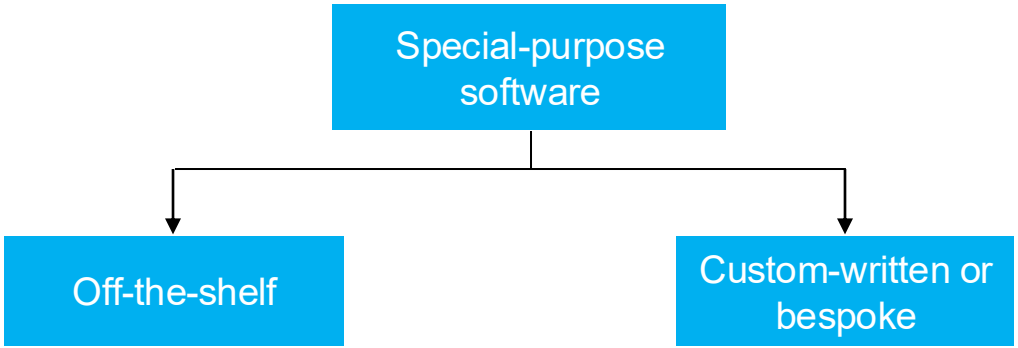
General-purpose software

A spreadsheet is an example of general-purpose software which enables the user to store and manage data, perform calculations or create graphs.

Special-purpose software

A web browser such as Google chrome is an example for special-purpose software which is specifically used for visiting webpages.

Types of special-purpose software



Special-purpose software

Off-the-shelf software

- Ready to use software.
- A large amount of users which reduces its cost.
- Some of the features may not be used.
- Well-documented and tested with all parameters before its release.

Custom-written software

- Developed by a team of programmers specifically for an organization.
- Comparatively expensive.
- Does not have any unwanted feature.
- Special features may also be added.
- Some errors may surface during its usage.

Open-source and proprietary software

Open-source software

Developed under open standards.

Its source code is freely available to users.

This software is regularly updated by developers. Developers may distribute their updates for little or no cost.

For example Mozilla Firefox

Proprietary software

Copyrighted software was written by organisations trying to make a profit.

The source code of the software is not distributed among users.

Organisations provide timely updates, fix bugs and improve the software.

Producers of this type of software are Microsoft, Adobe and Apple

Proprietary software	Open-source software
Source code is not available to users	Source code is available to users
Users are charged	Available for no cost
Users cannot modify the software	Users may modify software according to their needs
Each computer needs a specific licence	Can be installed on multiple computers
Owner of the software takes complete responsibility	No one takes responsibility for failures
Support from organisation in commercial form and through community	Only community support is available

Program Libraries

Program libraries

- **Program libraries** are pre-written subroutines
  - Used in software development to save considerable development time
- **Library program:** programs stored in library for future use by other programmers
- **Library routine:** subroutines stored in library to use in other software

Program libraries

- **Benefits**
  - Don’t need to rewrite and test many routines every single time => saving time and cost
  - Leads to modular programming
  - allows continuity with other games that may form part of a whole range
  - allows the maintenance of a ‘corporate image’ in all the software being developed by a particular company

Program libraries

- **Two type of libraries:**
  - **Dynamic**: software being developed is not linked to the library routines until actual run time => Dynamic link library (DLL)
  - **Static**: linked to executable code in the library at the time of compilation➔ the library routines would be embedded directly into the new program code.

Program libraries

- **Dynamic Link Library**
  - library routines would be stand-alone files only being accessed as required by the new program
    → available to several applications at the same time.
  - library routines are not loaded into RAM until required,
    → memory is saved, and software runs faster.

Program libraries

Pros:

- the executable code of the main program is much smaller
- Unnecessary to recompile the main program if any changes are made to the DLL files
- A DLL can be made available to a number of applications at the same time

--> save memory and execution time

Program libraries

Cons:

- all DLL files need to be available at run time otherwise error messages or software crash
- Any DLL linking software in the main program needs to be available at run time
- if a DLL file havs been changed this could lead to unexpected results or even crashing of main program
- malicious changes to DLL files could present a risk to the main program

Let’s review some concepts

System software

Responsible for running hardware and managing computer systems.

For example, operating system, device drivers, utility software, translators and library programs.

Special-purpose software

Applications that are used for a specific task.

Types: Off-the-shelf & Custom-written or bespoke software.

Utilities

Utilities are programs that are installed in a system alongside the operating system and performs limited range of functions.

Types: Maintenance & security utilities.

Open-source software

Open-source software is developed under open standards and its source code is freely available to users.

Applications software

A type of software designed for the end user.

Three types: General-purpose software, special-purpose software and custom-written software.

Proprietary software

Software is written by organisations trying to make a profit. These applications are copyrighted, and the source code of the software is not distributed among users.

3.

End of topic questions

End of topic questions

1. Define the following terms and state examples for each:
   a) System software
   b) Application software
2. What is the category application software classified into?
3. Why is enabling automatic updating in software important?
4. What is the function of disk-defragmenter?
5. What is the function of a firewall?

End of topic questions

6. What are the advantages of custom-written software over off-the-shelf software?
7. What are the advantages of off-the-shelf software over custom-written software?
8. What is the difference between open-source and proprietary software?

End of topic questions

1. What are the two types of user-interfaces provided by operating systems?
2. How does an operating system execute multiple programs at the same time? Explain using a diagram.
3. What are the two ways in which an operating system allocates memory to a new process?