

# Information Technology Essentials — Lecture 07

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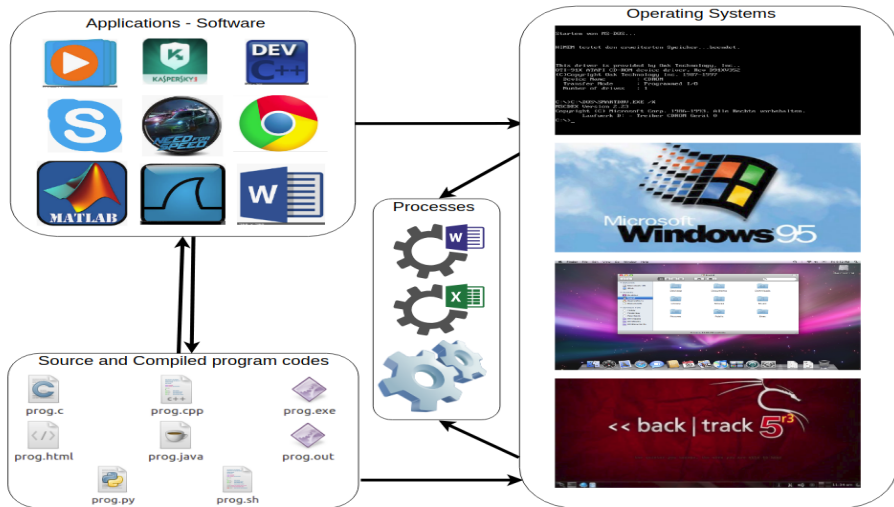


# Operating Systems

# What is an Operating System?



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# What is an Operating System?

## Definition

It is a set of programs (called modules) that cooperate for the good management and use of computer resources.

These modules can be classified into two classes, primary and secondary. The primary modules constitute the kernel of an operating system.

### • Primary modules (Kernel):

- Process management.
- Memory management module.
- File system module.
- Interrupt handling module.
- Other?

### • Secondary modules:

- Drivers.
- Networking module.
- Security management module.
- The Shell
- Others?

# What is an Operating System?

## Primary modules (Kernel):

- Process management module. Responsible for creating, executing, and terminating processes. It includes a process scheduler, that decides which process will run next and when it should be stopped, based on a scheduling algorithm, e.g., FIFO, SJF, STRF, RR, and PR.
- Memory management module. Decides where to load a process in the memory (RAM) and how to keep track of each portion of the memory. It allocates and frees space in the central memory — RAM.
- File system module. Keeps track of files, their identity, type, how they are stored, and where. Also, how the hard drive is logically structured (file systems: NTFS, FAT16, FAT32, EXT4, etc).
- Interrupt handling module. Handles interrupts: hardware (e.g., network traffic, keystrokes, mouse, etc), exception (e.g., division by 0, overflow, etc), and system calls (e.g., read and write on I/O devices).

# What is an Operating System?

## Secondary modules:

- Drivers. These are system programs that interface between the operating system and certain hardware devices, e.g., advanced keyboard, network cards, printer, graphical card, etc.
- Networking module. It implements a list of functions and services, called communication protocols (e.g., TCP/IP protocol suite), to allow inter/inner-computer communication.
- Security management module. Provides security services, such as encryption, authentication, data integrity, and availability.
- The Shell. Is the program that implements the interface of interaction, either as command-line interface (CLI) and/or a graphical user interface (GUI), between the user and the kernel. In the GUI-Shell, users can run programs by clicking and executing them, whereas in CLI-Shell, programs are run by executing commands (e.g., `kill -9 pid`).

# What is an Operating System?

The operating system provides a set of services to both computer users and user programs through its modules:

- It provides computer users with a set of services to:
  - Execute their programs.
  - Exploit computer resources in an efficient way.
  - Make programming tasks easier for developers.
  - Present a virtual machine.
- It provides user programs with an environment for their execution.



# What is an Operating System?

## Definition

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**Computer Resources.** There are two types:

- **Physical Resources.** It includes all hardware components that programs use for their execution.
  - CPU: The processor, used to execute instructions.
  - Memory (RAM): Used to store programs and their data.
  - I/O devices: Used to perform input and output operations.
- **Logical Resources.** It includes the non-hardware components that a computer manipulates.
  - Software and programs: Run on a computer.
  - Files: Are data structures. They have extensions docx, pdf, png, cpp, py, class, jpeg, exe, h, so, out, iso, pptx, mp4, ...
  - Process: Instance of a program being executed.
  - Network connection: connections with other computers.
  - System and user variables: shared memory locations.

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# Which Services does an Operating System Provide?

*Services provided by the operating system to the users ({programs}):*

**User Interface.** Could be a Batch Interface<sup>1</sup> [1945-1968], a CLI (Command Line Interface)[1969-] or GUI (Graphical User Interface) [1970-].

**Program Execution.** Programs need to be loaded into the main memory and get executed till completion. The operating system ensures that.

**I/O Operations.** Running programs may require I/O operations, the operating system provides special functions to talk to I/O devices.

**File System Manipulation.** Programs may need to manipulate files. The operating system provides special functions for such manipulations.

**Communication.** Programs may need to communicate with each other, locally (e.g., pipes & shared memory) or remotely. The OS provides special functions to guarantee a safe, secure, and reliable communication.

# Which Services does an Operating System Provide?

**Error Detection.** The operating system needs to detect and correct errors when they occur during programs execution (e.g., device failure). For each type of error, the operating system takes the appropriate action.

*Services provided by the operating system to the users and system itself:*

**Resource Allocation.** The operating system ensures that resources are shared in an optimal manner among multiple users and jobs.

**Accounting.** The operating system keeps track of which user uses how much and what kind of resources for accounting and statistics.

**Protection and Security.** The operating system provides certain security services to its users (or processes) to preserve their security and privacy.

## Types of Operating Systems

# Types of Operating Systems (Terminology)

**Multiprogramming Systems.** These are systems that can load multiple programs onto the central memory at a time.

**Single-tasking Systems.** These are systems that can only load one single program (+ OS) onto the central memory at a time, e.g., MS-DOS.



**Time-sharing Systems.** A.k.a., multitasking systems, are multiprogramming systems that switch between processes when their time slice is up, e.g., GNU/Linux, macOS X, and Windows (since Windows 95 & NT).



# Types of Operating Systems (Terminology)

**Embedded OSs.** Designed for embedded devices (e.g., TinyOS, LiteOS). Embedded systems rely on it (firmware) to perform its dedicated function (e.g., Washing machine, robot, drone, router, vehicules, etc).



**Real-time OSs.** Designed for critical industrial facilities. Some real-time operating systems are used in embedded systems (e.g., spacecraft).



**Firmware.** Is a low-level (written in assembly or machine code) single-purpose program that is embedded in computer systems (in their ROM, EPROM, or EEPROM).

# Types of Operating Systems (Terminology)

**Distributed OSs.** Designed for distributed infrastructures (e.g., Inferno, Plan 9 by Bell Labs, Solaris Sun Microsystems, and IBM AIX).



**Network OSs.** Designed for networks administration and management (e.g., Windows NT, 2000-2022 server or Red Hat Enterprise Linux).

**Mobile OSs.** Designed for mobile devices — smartphones, PDAs, etc (e.g., Windows Mobile, Android, iOS, Symbian OS, BlackBerry OS, etc).



# How Does an Operating System Start?

To launch the OS, the **kernel** needs to be located and loaded into the memory then executed (Booting the system is loading the **kernel**):

- It is performed by a dedicated program known as the bootstrap loader (e.g., GRUB in GNU/Linux) generally loaded by the BIOS<sup>2</sup>.
- When the computer starts/reboots, the CPU instruction register is loaded with a predefined memory location (bootstrap first instruction) to start the execution.
- The bootstrap loader loads the kernel into memory and executes it (we say, the system is running).
- The bootloader also performs diagnostic tasks, e.g., it determines the state of the machine (hardware) and devices.



# Operating Systems (Exercise)

- What is a Kernel of an operating system?
- Which module of the operating system is responsible for managing the execution of programs and which one is responsible for managing Internet connections?
- Which module of the operating system provides the user with a GUI or CLI to interact with the operating system to run programs and software?
- Provide three examples of hardware resources and logical resources.
- Which module of the operating system is responsible for encrypting folders and files and which one is responsible for organizing the storage of files in HDD?
- Give one example of an interrupt.

- End.