

Introduction to the GNU/Linux Operating System

Objectives: In this chapter, you will learn to :

- Describe the characteristics and possible architectures of an operating system
- Trace the history of UNIX and GNU/Linux
- Choose a Linux distribution adapted to your own needs
- Explain the philosophy of free and open-source software
- Discover the usefulness of the shell

What is an Operating System?

Linux, UNIX, BSD, VxWorks, Windows, and macOS are all operating systems.

An **operating system**, or **OS** for *Operating System*, is a set of programs designed to establish a link between the various **hardware resources**, **applications**, and the **user**.

Role & Operation:

- **Manage the processor:** that is, manage the allocation of the CPU among different applications using a scheduling algorithm.
- **Manage memory:** that is, manage the memory space allocated to each application and, when applicable, to each user.
- **In case of insufficient physical memory (RAM):** the operating system can create a memory area on the hard disk, called **virtual memory**.
- **Manage input/output:** that is, manage program access to hardware resources through device drivers.
- **Manage application execution:** that is, ensure the proper execution of applications by assigning them the necessary resources for correct operation, and also allow the termination of an application that is no longer responding, for example.
- **Manage files:** that is, manage reading and writing operations in the file system, as well as file access permissions for users and applications.

UNIX / GNU/Linux Overview:**History:****UNIX:**

- **1964–1968:** MULTICS (MULTiplexed Information and Computing Service) is developed for MIT, Bell Labs (AT&T), and General Electric.
- **1969:** After Bell and General Electric withdrew from the project, two developers (Ken Thompson and Dennis Ritchie), later joined by Brian Kernighan, found MULTICS too complex and began developing UNIX (UNiplexed Information and Computing Service).
Originally written in assembly language, UNIX was later rewritten in the B language and then in C (1971).
Because UNIX was developed in 1970, the reference date (epoch) for UNIX/Linux systems is January 1, 1970.
- UNIX is an open and evolving operating system that played a major role in computing history. It served as the basis for many systems such as GNU/Linux, BSD, macOS, etc.
- UNIX is still widely used today (HP-UX, AIX, Solaris, etc.).

GNU Project:

1984: Richard Matthew Stallman launched the GNU project (GNU's Not Unix), aiming to create a free and open Unix-like operating system. Key tools include the GCC compiler, Bash shell, Emacs editor, etc.

GNU is a Unix-type operating system. Many GNU software packages are released under the GNU Project.

1990: The GNU kernel, GNU Hurd, was launched (before Linux).

MINIX

1987: Andrew S. Tanenbaum developed MINIX, a simplified UNIX system for teaching operating systems. He made its source code available.

Linux

1991: Finnish student Linus Torvalds created an operating system for his personal computer and named it Linux. He published version 0.02 on Usenet, and other developers contributed.

The name Linux is a play on *Linus* and *UNIX*.

1993: Debian distribution was created. It is a non-commercial, community-based distribution suitable for servers and personal computers. Debian is the base of many distributions such as Mint and Ubuntu.

1994: Red Hat created a commercial Linux distribution and is now a major GNU/Linux distributor. It supports Fedora and previously CentOS Linux.

1997: KDE desktop environment was created (Qt, C++).

1999: GNOME desktop environment was created (GTK+).

2002: Arch Linux was created, featuring a rolling-release model.

2004: Ubuntu was created by Canonical (Mark Shuttleworth), based on Debian and including both free and proprietary software.

2021: Rocky Linux was created, based on Red Hat.

Naming Dispute:

Although people commonly say *Linux*, Linux is strictly a kernel. The GNU project's contribution must not be forgotten, hence the preferred term **GNU/Linux**.

Market Share:

Despite its widespread presence, GNU/Linux remains relatively unknown to the general public. Linux is found in smartphones, TVs, routers, etc.

- About **70% of websites** run on GNU/Linux or UNIX servers
- Linux runs on **over 82% of smartphones**
- Linux powers **100% of the world's top 500 supercomputers** since 2018

System Architecture:

- **Kernel:** Core of the GNU/Linux system, manages hardware resources
- **Shell:** Interprets user commands and executes them
 - Main shells: Bourne, C shell, Korn shell, Bash
- **Applications:** Web browsers, word processors, spreadsheets, etc.

Key Characteristics:

1. Multitasking

- Simultaneous execution of multiple programs
- CPU time sharing via scheduler
- Better fault isolation
- Performance decrease if overloaded

2. Multi-user

Multiple users can work simultaneously, each with their own account, memory space, and permissions.

3. Multiprocessor

Linux runs on multiprocessor and multicore systems.

4. Multiplatform

Runs on PCs, servers, smartphones, embedded systems, routers, TVs, appliances, etc.

5. Open

Uses standards such as POSIX, TCP/IP, NFS, Samba.

UNIX / Linux Philosophy

- The UNIX/Linux philosophy
- Everything is a file.
- Portability.
- Do one thing at a time and do it well.
- KISS: Keep It Simple and Stupid.
- ‘UNIX is a simple operating system, but you have to be a genius to understand the simplicity.’ (Dennis Ritchie)
- ‘UNIX is user-friendly. However, UNIX doesn't really specify with whom.’ (Stephen King)

GNU/Linux Distributions

A GNU/Linux distribution is a complete software set built around the Linux kernel, including package management tools.

Distributions may be:

- Community-based (Debian, Rocky Linux)
- Commercial (Red Hat, Ubuntu)

They may target beginners (Ubuntu, Mint), advanced users (Arch, Gentoo), servers (Debian, Red Hat), or desktops (Fedora).

Desktop Environments

Examples: GNOME, KDE, LXDE, XFCE.

They are modern and comparable to Windows or macOS interfaces.

Free / Open Source

Proprietary systems require paid licenses.

GNU/Linux promotes free software.

Free ≠ Free of charge

- **Open Source:** Source code is available and modifiable
- Free software is always open source, but open source is not always free (GPL freedoms differ)

GPL (General Public License)

GPL guarantees intellectual property while allowing modification, redistribution, and resale, provided source code is included.

It ensures:

- Freedom to run the program
- Freedom to study and modify it
- Freedom to redistribute copies
- Freedom to improve and share improvements

Areas of Use

GNU/Linux excels in:

- Servers
- Security systems
- Mainframes
- Embedded systems

Linux can do almost everything, explaining the large number of distributions.

The Shell

Overview

The shell is a command-line interface allowing users to interact with the operating system. It remains essential on systems without GUIs.

It is a full scripting language supporting:

- Loops
- Conditions
- Variables
- Automation (backups, user creation, monitoring)

Common shells:

- **sh**, the POSIX-compliant shell
- **csh**, a shell using syntax similar to the C language
- **bash**, Bourne-Again Shell, the Linux shell

Features

- Command execution (checks the command entered and executes it).
- Input/output redirection (sends data to a file instead of displaying it on the screen).
- Connection process (manages the user's connection).
- Interpreted programming language (allows the creation of scripts).
- Environment variables (access to information specific to the system currently in operation).

Test Your Knowledge

1. An operating system is a set of programs that manages a computer's resources:
 - True
 - False

2. The operating system is responsible for:
 - Managing physical and virtual memory
 - Allowing direct access to hardware devices
 - Delegating task management to the processor
 - Collecting information about programs used or currently running

3. Among the following personalities, which ones participated in the development of UNIX:
 - Linus Torvalds
 - Ken Thompson
 - Lionel Richie
 - Brian Kernighan
 - Andrew Stuart Tanenbaum

4. The original nationality of Linus Torvalds, creator of the Linux kernel, is:
 - Swedish
 - Finnish
 - Norwegian
 - Flemish
 - French (obviously)

5. Among the following distributions, which is the oldest:
 - Debian
 - Slackware
 - Red Hat
 - Arch

6. Is the Linux kernel:

- Multitasking
- Multiuser
- Multiprocessor
- Multicore
- Multiplatform
- Open

7. Is free software necessarily open-source?

- True
- False

8. Is open-source software necessarily free software?

- True
- False

9. Among the following options, which one is not a shell:

- Jason
- Jason-Bourne shell (jbsh)
- Bourne-Again shell (bash)
- C shell (csh)
- Korn shell (ksh)