###### Chapter 1

###### Introducing Operating Systems

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| At a Glance |

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##### Overview

To understand an operating system is to begin to understand the workings of an entire computer system, because the operating system software manages each and every piece of hardware and software. In the pages that follow, students will explore what operating systems are, how they work, what they do, and why.

##### Learning Objectives

After completing this chapter, the student should be able to describe:

* How operating systems have evolved through the decades
* The basic role of an operating system
* How operating system software manages its subsystems
* The role of computer system hardware on the development of its operating system
* How operating systems are adapted to serve batch, interactive, real-time, hybrid, and embedded systems
* How operating systems designers envision their role and plan their work

##### Teaching Tips

# What Is an Operating System?

1. Point out that every computer system consists of software (programs) and hardware.

1. A computer system typically consists of software (programs) and hardware (the tangible machine and its electronic components). Note that the operating system software is the chief piece of software, the portion of the computing system that manages all of the hardware and all of the other software.

# Operating System Software

1. Provide an outline of the following essential managers of an operating system: Memory Manager, Processor Manager, Device Manager, and File Manager.
2. Discuss the importance of the user interface. Note that this communication mechanism allows users to interact directly with the operating system. Review Figure 1.1 to reinforce the abstract view of how the user interface interacts with the four essential managers in a non-networked environment.
3. Explain that each manager works closely with the other managers and performs a unique role. Use the examples on page 6 of the text and Figure 1.2 to clarify this point. There are four main tasks each manager performs:

* Monitor its resources continuously
* Enforce the policies that determine who gets what, when, and how much
* Allocate the resource when appropriate
* Deallocate the resource when appropriate

1. Note that the vast majority of major operating systems today, incorporate a Network Manager to coordinate the services required for multiple systems to work cohesively together.

Main Memory Management

1. Describe the role of the Memory Manager and explain how it allocates and deallocates memory.
2. Introduce the terms **Random Access Memory (RAM), Read- Only Memory (ROM**), and **firmware**. Use Figure 1.4 to aid the discussion.

Processor Management

1. Explain that an important function of the Processor Manager is to keep track of the status of each job, process, thread, and so on.
2. Discuss the Processor Manager’s role as a traffic controller.

Device Management

1. Discuss the role of the Device Manager.
2. Note that good device management requires that this part of the operating system uniquely identify each device, start its operation when appropriate, monitor its progress, and finally deallocate the device to make the operating system available to the next waiting process.

File Management

1. Describe the various management roles of the File Manager.
2. Discuss access control as it relates to file management.

Network Management

1. Describe the roles of the Network Manager.
2. Point out that regardless of the size and complexity of the network, these operating systems must be prepared to properly manage the available memory, CPUs, devices, and files.

User Interface

1. Describe the functions of a user interface.
2. Introduce the terms **graphical user interface (GUI)** and **command line interface**. Use Figure 1.6 to aid the discussion.
3. Discuss the evolution from typed commands to graphical user interfaces. Use Figures 1.6 and 1.7 to aid the discussion.

**Cooperation Issues**

1. None of the elements of an operating system can perform its individual tasks in isolation; each must also work harmoniously with every other manager. Use the example on pages 11-12 to discuss the actions that occur when someone chooses a menu option to open a program.

Cloud Computing

1. Introduce the term cloud computing. Use Figure 1.8 to aid the discussion.
2. Note that regardless of where the resource is located (in the box, under the desk, or the cloud, the role of the operating system is the same) to access those resources and manage the system as efficiently as possible.

##### Quick Quiz 1

1. Which of the following are essential managers of every operating system? (Choose all that apply.)

a. Memory Manager

b. System Manager

c. Directory Manager

d. Process Manager

Answer: a and d

1. The term \_\_\_\_ is used to describe the programming code that is used to start the computer and perform other necessary tasks.

Answer: firmware

1. (True or False) The contents of ROM are volatile, meaning that they are erased when the power is turned off, unlike the contents of RAM.

Answer: False

1. \_\_\_\_ is the practice of using Internet-connected resources to perform processing, storage, or other operations.

Answer: Cloud computing

# An Evolution of Computing Hardware

1. Provide an outline of the essential hardware components found in computers, explaining the basic functions of each. This includes main memory, also known as random access memory (RAM); the various input/output devices (I/O devices); and the central processing unit (CPU). Storage devices may also be considered at this time.
2. Use Table 1.1 to explore a brief list of platforms and a few of the operating systems designed to run on them.
3. Explain that in 1965, Intel executive Gordon Moore observed that each new processor chip contained roughly twice as much capacity as its predecessor (number of components per integrated function), and that each chip was released within 18–24 months of the previous chip. Use Figure 1.9 to aid the discussion.

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| ***Teaching***  ***Tip*** | For additional information on the basics of computer hardware, refer students to the following Web site: <http://www.computernetworkingnotes.com/computer-hardware/review.html> |

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| ***Teaching***  ***Tip*** | For additional information on Moore’s law, refer students to the following Web site: <http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html> |

# Types of Operating Systems

1. Provide an outline of the different categories of operating systems, including **batch**, **interactive**, **real-time**, **hybrid**, and **embedded systems**. Mention that each category is distinguished by response time and how data is entered into the system.
2. Provide students with an overview of batch systems. Point out that in the past, such systems relied on a stack of cards or tape for input, and efficiency was measured in throughput.
3. Discuss the characteristics of interactive systems. Note that these systems offered huge improvements in response over batch-only systems with turnaround times in seconds or minutes instead of hours or days.
4. Real-time systems are used in time-critical environments where reliability is critical and data must be processed within a strict time limit. Note that there are two types: hard and soft systems.
5. Provide students with an overview of hybrid systems. Point out that a hybrid system takes advantage of the free time between high-demand usage of the system and low demand times
6. Introduce the concepts of networks and network operating systems. Use Figure 1.10 to aid the discussion.
7. Provide students with an overview of embedded systems, which are computers placed inside other products to add features and capabilities. Note that operating systems for embedded computers are very different from those for general computer systems. Each one is designed to perform a set of specific programs, which are not interchangeable among systems.

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| ***Teaching***  ***Tip*** | For additional information on real-time operating systems, refer to the following Web site: <http://www.ni.com/white-paper/3938/en> |

# Timeline of Operating Systems Development

1. Begin this section by explaining that the evolution of operating system software parallels the evolution of the computer hardware they were designed to control.

## 1940s

1. Mention that the machines from this era were poorly utilized, i.e., the CPU processed data and made calculations for only a fraction of the available time. Basically, early programs were designed to use the resources conservatively at the expense of understandability.
2. Review Figure 1.11 and discuss the origins of the term computer “bug.”

## 1950s

1. Outline two major improvements that were widely adopted: computer operators were hired to facilitate each machine’s operation and job scheduling was instituted.
2. Discuss various factors that helped improve the performance of the CPU, such as the increase in the speed of I/O devices, the introduction of “blocking” to improve storage, and the introduction of control units and buffers.

## 1960s

1. Provide students with an overview of third-generation computers dated from the mid-1960s. Point out that they were designed with faster CPUs, but their speed caused problems when they interacted with the relatively slow I/O devices. Explain how the concept of multiprogramming helped solve this problem and discuss the mechanism of its implementation.
2. Use examples to explain the concepts of passive multiprogramming and active multiprogramming. Point out the disadvantages of passive multiprogramming and how these were overcome by active multiprogramming.

## 1970s

1. Note that during the late 1970s, computers had faster CPUs, thus creating a disparity between their rapid processing speed and slower I/O time. Multiprogramming schemes to increase CPU use were limited by the physical capacity of main memory.
2. Discuss how the concept of virtual memory solved the physical limitation issue.

## 1980s

1. Discuss the various developments in the 1980s, such as improved cost/performance ratio of computer components, greater flexibility of hardware, and the introduction of the concept of firmware.
2. Point out that the evolution of personal computers and high-speed communications sparked the move to distributed processing and networked systems, enabling users in remote locations to share hardware and software resources.
3. Provide students with an overview of distributed operating systems.

## 1990s

1. Point out that the demand for Internet capability in the mid-1990s sparked the proliferation of networking capability. The World Wide Web, conceived by Tim Berners-Lee, made the Internet accessible by computer users worldwide. Use Figure 1.12 to aid the discussion.
2. Be sure to note that increased networking also created increased demand for tighter security to protect hardware and software.
3. Point out that the decade also introduced the proliferation of multimedia applications demanding additional power, flexibility, and device compatibility for most operating systems.

**2000s**

1. The new century emphasized the need for improved flexibility, reliability, and speed. The concept of virtual machines was expanded to allow computers to accommodate multiple operating systems that ran at the same time and shared resources.
2. Introduce the term virtualization.
3. Note that processing speed enjoyed a similar advancement with the commercialization of multicore processors, which can contain two to many cores. Use Figure 1.13 to aid the discussion.

**2010s**

1. Increased mobility and wireless connectivity spawned a proliferation of dual-core, quad-core, and other multicore CPUs with more than one processor (also called a core) on a computer chip. Discuss the driving force behind this innovation.

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| ***Teaching***  ***Tip*** | For additional information on the history of operating systems, refer to the following Web site: <http://www.osdata.com/kind/history.htm> |

**Role of the Software Designer**

1. The people who write operating systems are faced with many choices that can affect every part of the software and the resources it controls. Before beginning, designers typically start by asking key questions, using the answers to guide them in their work.
2. Point out that no single operating system is perfect for every environment. Some systems can be best served with a UNIX system, others benefit from the structure of a Windows system, and still others work best using Linux, Mac OS, or Android, or even a custom-built operating system.

##### Quick Quiz 2

1. \_\_\_\_ allows separate partitions of a single server to support a different operating system.

Answer: Virtualization

1. \_\_\_\_ was developed in the late 1970s and allowed portions of multiple programs to reside in memory at the same time.

Answer: Virtual memory

1. \_\_\_\_ are computers that are physically placed inside the products in which they operate to add very specific features and capabilities.

Answer: Embedded systems

1. \_\_\_\_ allow users to manipulate resources that may be located over a wide geographical area.

Answer: Networks

##### Class Discussion Topics

1. Discuss the primary design features of current operating systems and the security implications.
2. Ask students to discuss the security measures that they would take to protect hardware and software.

##### Additional Projects

1. Submit a two-page report that discusses the requirements of operating systems for use in embedded computers. Be sure to cite your sources.
2. Submit a two-page report that discusses the advantages and disadvantages of cloud computing and the security risks involved. Be sure to cite your sources.

##### Additional Resources

1. Windows Products and Technologies History:

<http://www.ibtimes.com/microsoft-windows-30-short-history-one-most-iconic-tech-products-ever-2194091>

1. History of UNIX: <https://www.bell-labs.com/usr/dmr/www/hist.html>

1. The untold story behind Apple's $13,000 operating system: <https://www.cnet.com/news/the-untold-story-behind-apples-13000-operating-system/>

**Key Terms**

* **batch system:** a type of computing system that executes programs, each of which is submitted in its entirety, can be grouped into batches, and is executed without external intervention.
* **central processing unit (CPU):** a component with circuitry that controls the interpretation and execution of instructions. See also *processor.*
* **cloud computing:** a multifaceted technology that allows computing, data storage and retrieval, and other computer functions to take place via a large network, typically the Internet.
* **Device Manager:** the section of the operating system responsible for controlling the use of devices. It monitors every device, channel, and control unit and chooses the most efficient way to allocate all of the system’s devices.
* **embedded system:** a dedicated computer system that is often part of a larger physical system, such as a jet aircraft or automobile. Often, it must be small, fast, and able to work with real-time constraints, fail-safe execution, and nonstandard I/O devices.
* **File Manager:** the section of the operating system responsible for controlling the use of files.
* **firmware:** software instructions, or data, that are stored in a fixed or “firm” way, usually implemented on some type of read-only memory (ROM).
* **hardware:** the tangible machine and its components, including main memory, I/O devices, I/O channels, direct access storage devices, and the central processing unit.
* **hybrid system:** a computer system that supports both batch and interactive processes.
* **interactive system:** a system that allows each user to interact directly with the operating system.
* **kernel:** the primary part of the operating system that remains in random access memory (RAM), and is charged with performing the system’s most essential tasks, such as man-aging main memory and disk access.
* **main memory (RAM):** the memory unit that works directly with the CPU, and in which the data and instructions must reside in order to be processed. Also called primary storage, RAM, or internal memory.
* **Memory Manager:** the section of the operating system responsible for controlling the use of memory. It checks the validity of each request for memory space, and if it’s a legal request, allocates the amount of memory required to execute the job.
* **multiprogramming:** a technique that allows a single processor to process several pro-grams residing simultaneously in main memory, and interleaving their execution by overlapping I/O requests with CPU requests.
* **Network Manager:** the section of the operating system responsible for controlling the access to, and use of, networked resources.
* **network:** a system of interconnected computer systems and peripheral devices that exchange information with one another.
* **operating system:** the primary software on a computing system that manages its resources, controls the execution of other programs, and manages communications and data storage.
* **process:** an instance of execution of a program that is identifiable and controllable by the operating system.
* **processor:** (1) another term for the CPU (central processing unit); (2) any component in a computing system capable of performing a sequence of activities. It controls the interpretation and execution of instructions.
* **Processor Manager:** a composite of two submanagers, the Job Scheduler and the Process Scheduler, that decides how to allocate the CPU.
* **RAM:** short for random access memory. See main memory.
* **real-time system:** a computing system used in time-critical environments that require guaranteed response times. Examples include navigation systems, rapid transit systems, and industrial control systems.
* **server:** a node that provides clients with various network services, such as file retrieval, printing, or database access services.
* **storage:** the place where data is stored in the computer system. Primary storage is main memory. Secondary storage is nonvolatile media, such as disks and flash memory.
* **user interface:** the portion of the operating system that users interact with directly—is one of the most unique and most recognizable components of an operating system.