COM1013
INTRODUCTION TO COMPUTER SCIENCE

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CHAPTER

3

Operating Systems

In this chapter we study operating systems, which are software packages that coordinate a computer's internal activities as well as oversee its communication with the outside world. It is a computer's operating system that transforms the computer hardware into a useful tool. Our goal is to understand what operating systems do and how they do it. Such a background is central to being an enlightened computer user.

Operating system: Definition

An operating system (OS) is the software that controls the overall operation of a computer.

An operating system provides

- the means by which a user can store and retrieve files,
- the interface by which a user can request the execution of programs, and
- the environment necessary to execute the programs requested.

Today's Popular OSs

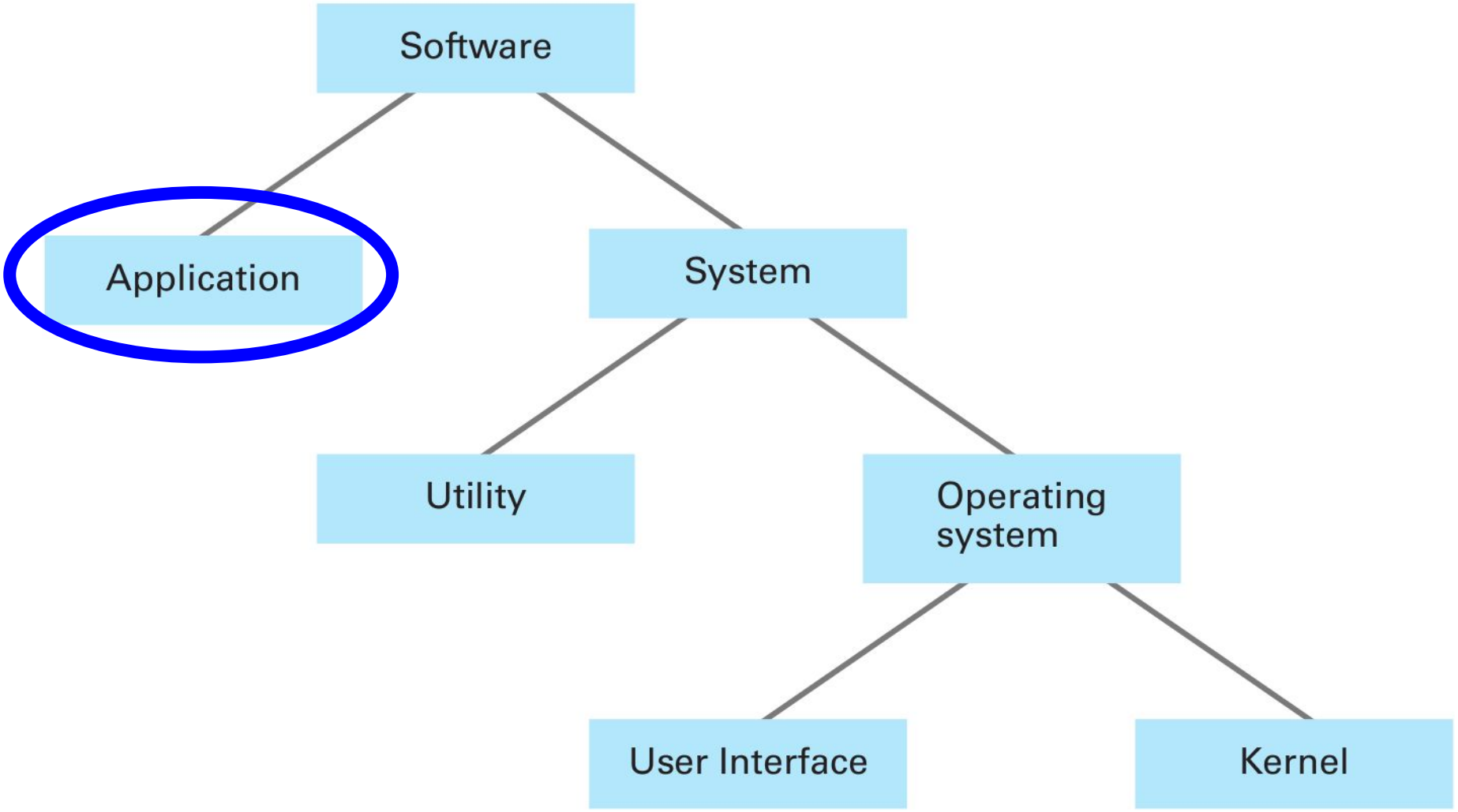
Windows; Microsoft

UNIX

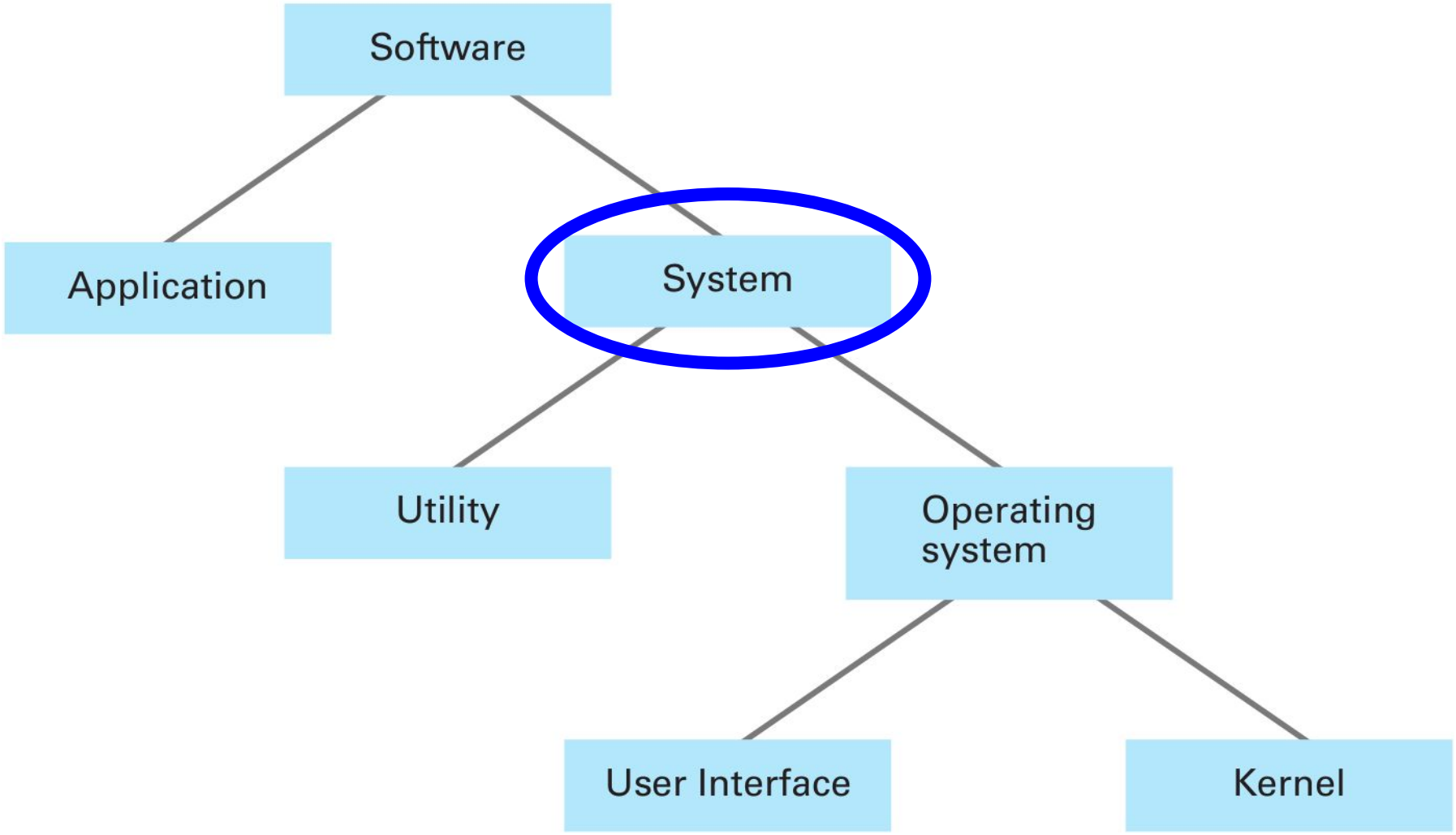
UNIX distrubution OSs:

- Mac OS; Apple
- Solaris; Oracle
- Ubuntu; Canonical Ltd.
- Pardus; Scientific and Technological Research Council of Turkey (TÜBİTAK)

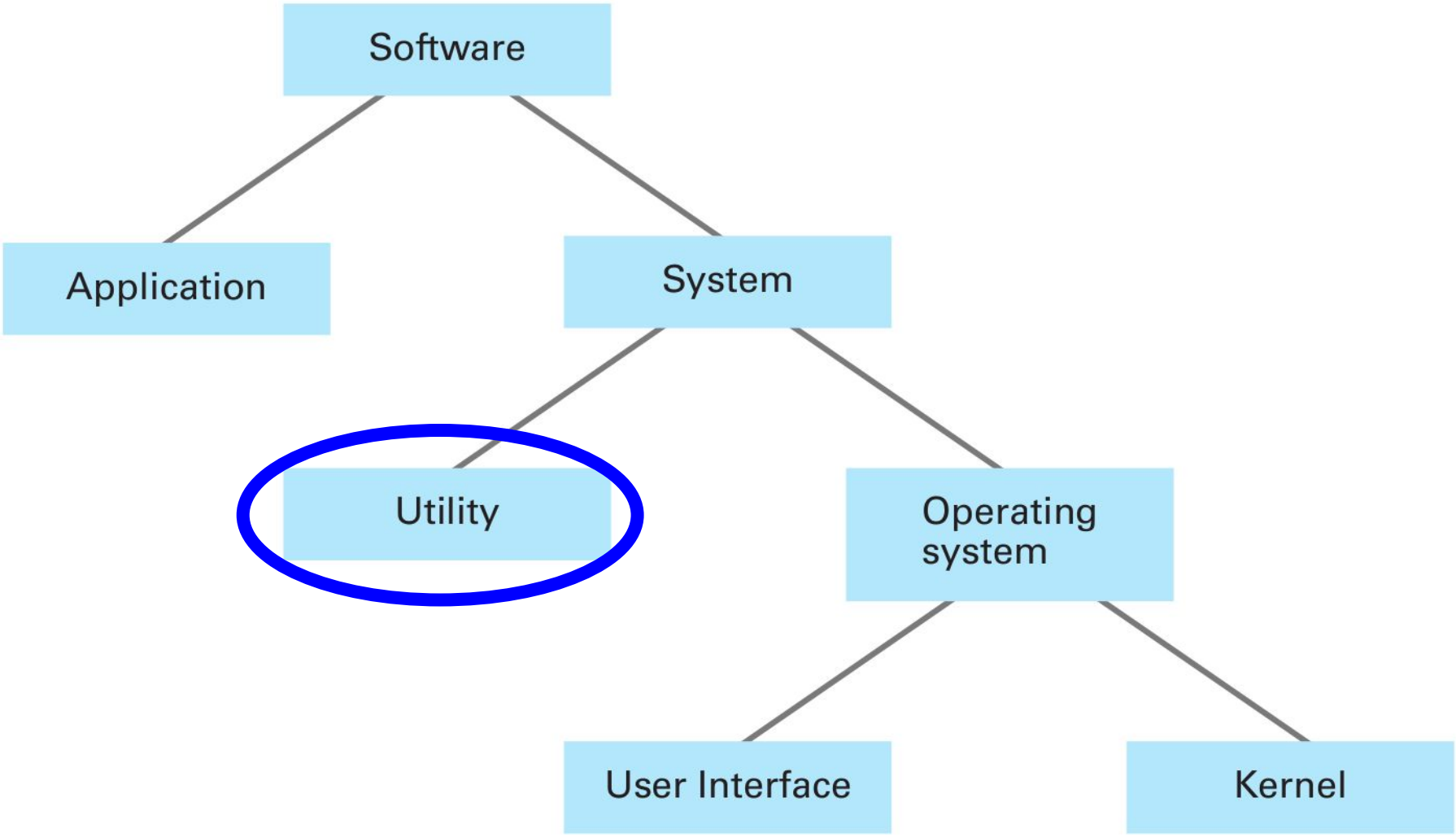
Software classification



Software classification



Software classification



User Interface

An operating system must be able to communicate with users.

The portion of an operating system that handles this communication is often called the **user interface**.

Older user interfaces: **shells**

More modern systems perform this task by means of a graphical user interface (**GUI**).

- Mouse operations
- Window manager

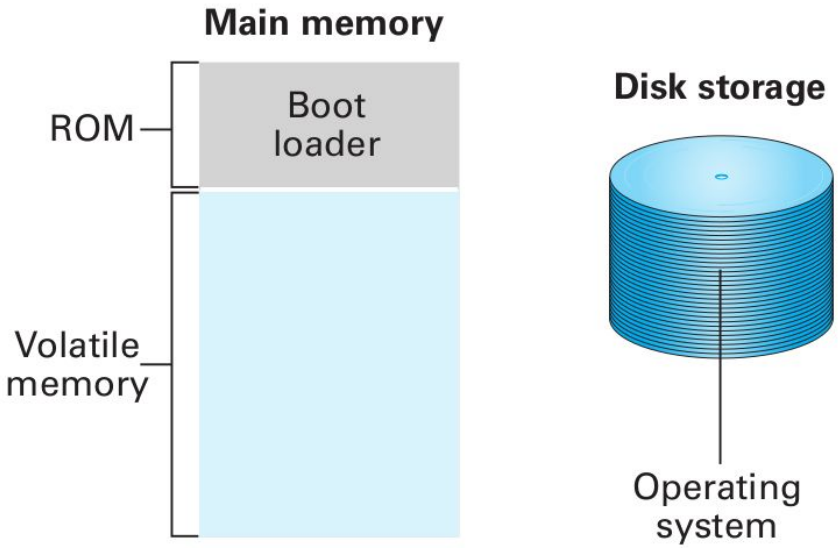
Kernel

The set of software components that perform the very basic functions required by the computer installation

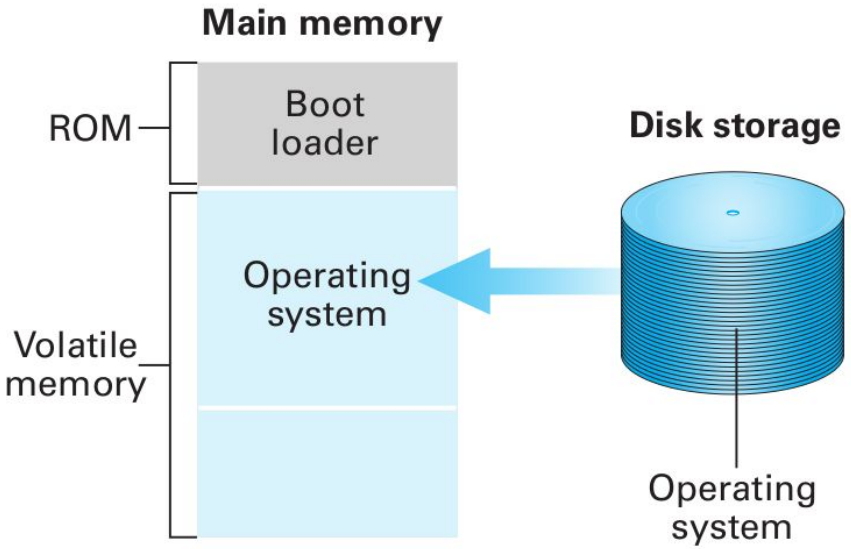
- Basic kernel components include
  - File manager
  - Device drivers
  - Memory manager
  - Scheduler and dispatcher

Boot strapping

How the operating system gets started?



Step 1: Machine starts by executing the boot loader program already in memory. Operating system is stored in mass storage.



Step 2: Boot loader program directs the transfer of the operating system into main memory and then transfers control to it.

Coordinating the Machine's Activities

How an operating system coordinates the execution of application software, utility software, and units within the operating system itself.

The Concept of a Process

Distinction between a program and the activity of executing a program

Program: static set of directions

Process: dynamic activity whose properties change as time progresses

- Current status of the activity, the process state
  - The current position in the program being executed (the **value of the program counter**) as well as the **values in the other CPU registers** and the associated **memory cells**

The Concept of a Process

Each musician is playing only **ONE** instrument.

Unlike a musician, typical **time-sharing/multitasking computers** are running many processes, all competing for the computer's resources.

- **Task of the operating system:** to manage these processes so that
  - Each process has the resources that it needs,
  - Independent processes do not interfere with one another,
  - Processes that need to exchange information are able to do so.

Process Administration

The tasks associated with coordinating the execution of processes are handled by the scheduler and dispatcher within the operating system's kernel.

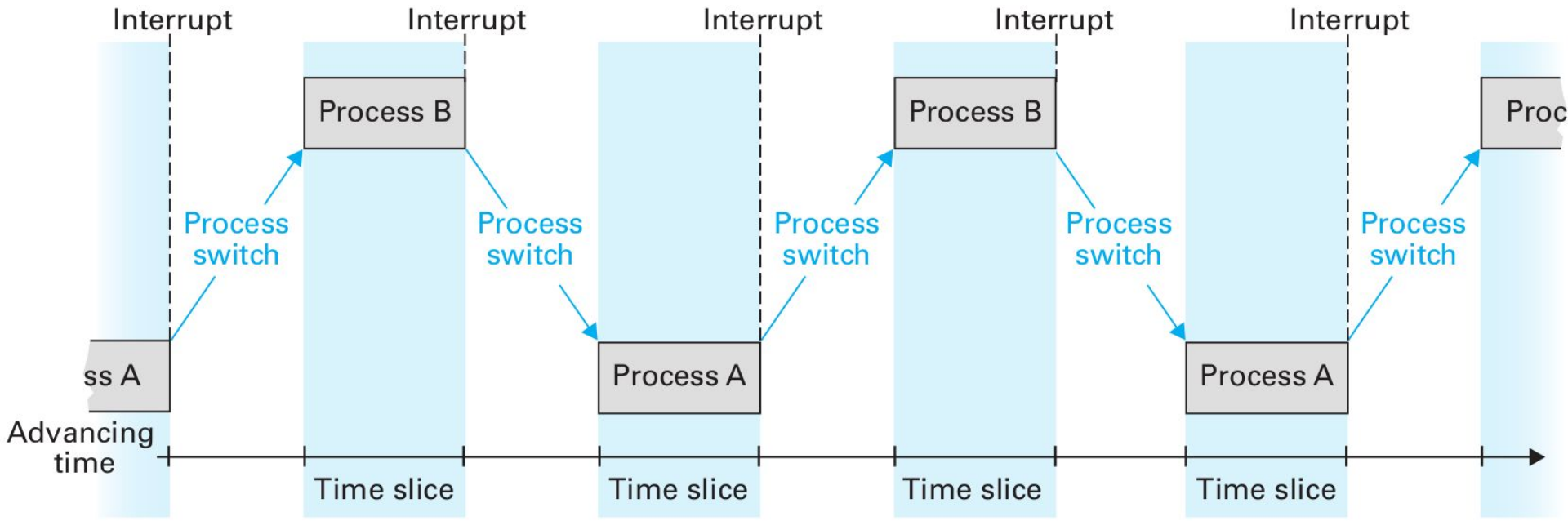
- The scheduler
  - maintains a record of the processes present in the computer system,
  - introduces new processes to this pool, and
  - removes completed processes from the pool.
  - Thus when a user requests the execution of an application, it is the scheduler that adds the execution of that application to the pool of current processes.

To keep track of all the processes, the scheduler maintains a block of information in main memory called the **process table.**

Each time the execution of a program is requested, the scheduler creates a new entry for that process in the process table.

Process Administration

- The dispatcher
  - Divides time into short segments, each called a time slice and then
  - switches the CPU's attention among the processes as each is allowed to execute for one time slice
  - Called **a process switch**

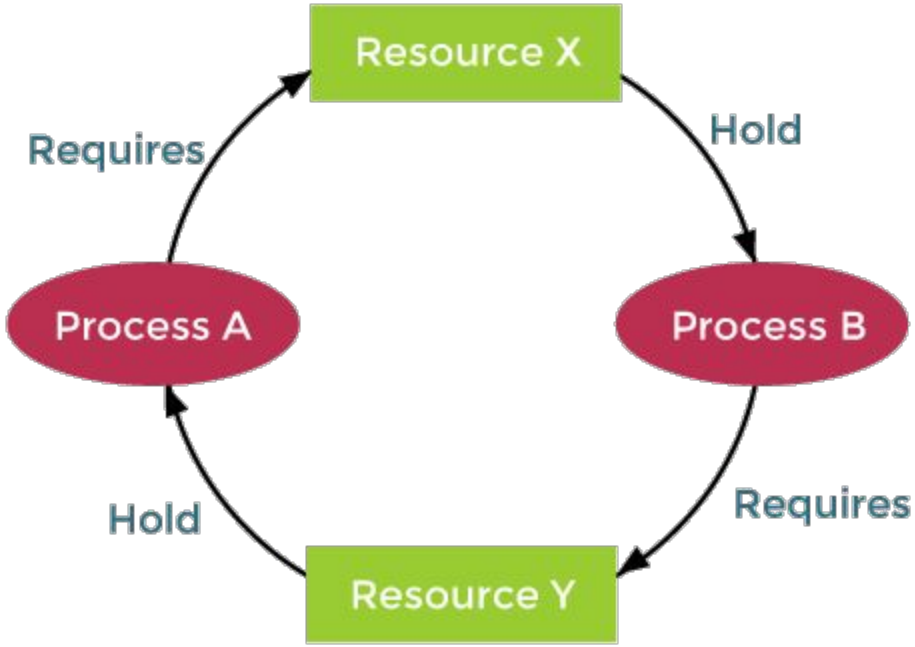


Handling Competition Among Processes

An important task of an operating system is the allocation of the machine's resources to the processes in the system.

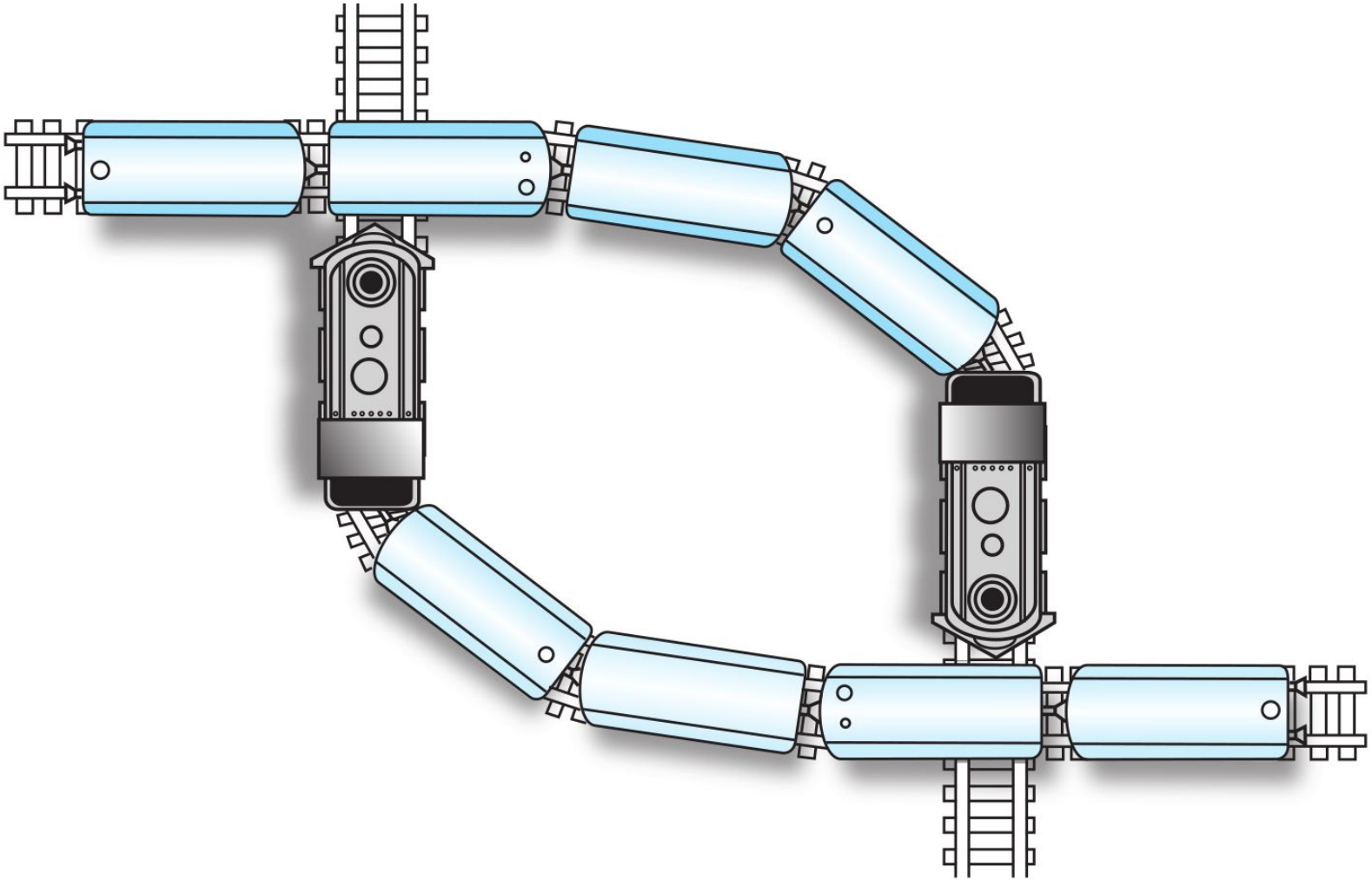
Resource allocation problems may occur

- Deadlock



Deadlock

A deadlock resulting from competition for nonsharable railroad intersections



Research Themes

Operating system architectures

1. Multics and Unix
   a. “Multics—The first seven years”, Corbató FJ, Saltzer JH, and Clingen CT (1972)
   b. “Protection in an information processing utility”, Graham RM (1968)
   c. “The evolution of the Unix time-sharing system”, Ritchie DM (1984)

Research Themes

Operating system architectures

2. Microkernels
    a. “The nucleus of a multiprogramming system”, Brinch Hansen P (1970).
    b. “Toward real microkernels”, Liedtke J (1996).
    c. “Are virtual machine monitors microkernels done right?”, Hand S, Warfield A, Fraser K, Kotsovinos E, Magenheimer DJ (2005).

Research Themes

Operating system architectures

3. Exokernels
    a. “Exterminate all operating systems abstractions”, Engler DE, Kaashoek MF (1995).
    b. “Exokernel: an operating system architecture for application-level resource management”, Engler DE, Kaashoek MF, O’Toole J (1995).
    c. “The nonkernel: a kernel designed for the cloud”, Ben-Yehuda M, Peleg O, Ben-Yehuda OA, Smolyar I, Tsafrir D (2013).

Research Themes

Storage

4. Log-structured file system
    a. “The Design and Implementation of a Log-Structured File System”, Rosenblum M, Ousterhout J (1992)
    b. “Logging versus Clustering: A Performance Evaluation”, Margo Seltzer, Keith A. Smith

Research Themes

Virtualization

5. Virtual machines and containers
    a. “Xen and the Art of Virtualization”, Barham P, Dragovic B, Fraser K, Hand S, Harris T, Ho A, Neugebauer R, Pratt I, Warfield A (2003)
    b. “Blending containers and virtual machines: A study of Firecracker and gVisor”, Anjali, Caraz-Harter T, Swift MM (2020)

Research Themes

Virtualization

6. Virtual memory and virtual devices
    a. “Memory resource management in VMware ESX Server”, Waldspurger CA (2002)
    b. “Opportunistic flooding to improve TCP transmit performance in virtualized clouds”, Gamage S, Kangarlou A, Kompella RR, Xu D (2011)

Research Themes

7. Distributed systems
    a. “Grapevine: an exercise in distributed computing”, Birrell AD, Levin R, Schroeder MD, Needham RM (1982)
    b. “Implementing remote procedure calls”, Birrell AD, Nelson BJ (1984)
    c. Skim: “Time, clocks, and the ordering of events in a distributed system”, Lamport L (1978)
    d. “Scaling Memcache at Facebook”, Nishtala R, Fugal H, Grimm S, Kwiatkowski M, Lee H, Li HC, McElroy R, Paleczny M, Peek D, Saab P, Stafford D, Tung T, Venkataramani V (2013)
    e. “Millions of Tiny Databases”, Brooker M, Chen T, Ping F (2020)

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