Operating System Overview

Chapter 1.5 – 1.9

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Learning Outcomes

- A high-level understanding of the structure of operating systems, applications, and the relationship between them.

- Some knowledge of the services provided by operating systems.

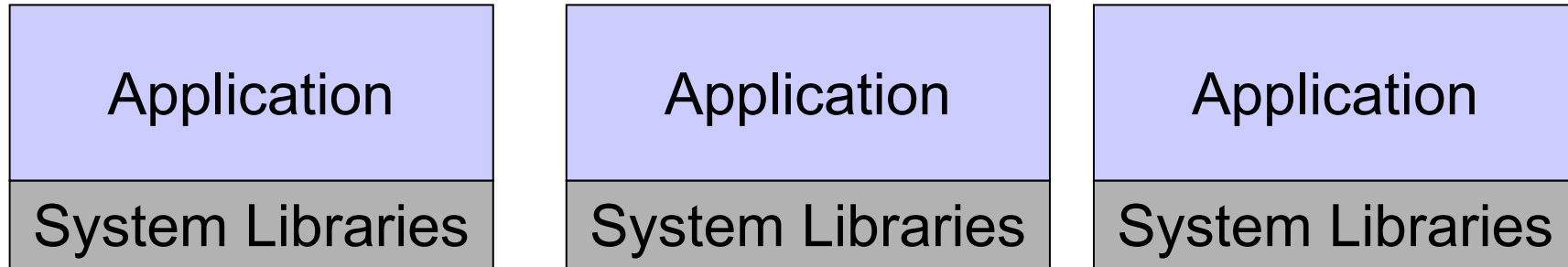- Exposure to some details of major OS concepts.

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Operating System

- A program that controls execution of applications
  - The resource manager
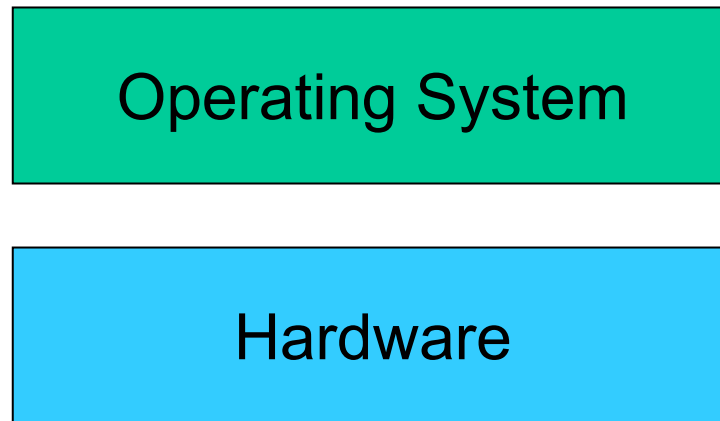- An interface between applications and hardware
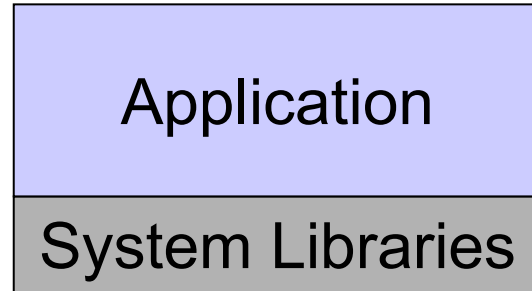 - The extended machine

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Structure of a Computer System

User Mode

Application	Application	Application
System Libraries	System Libraries	System Libraries

- -

Operating System

Kernel
Mode

Hardware

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Structure of a Computer System

User Mode

Application

System Libraries

Kernel Mode

Operating System

Hardware
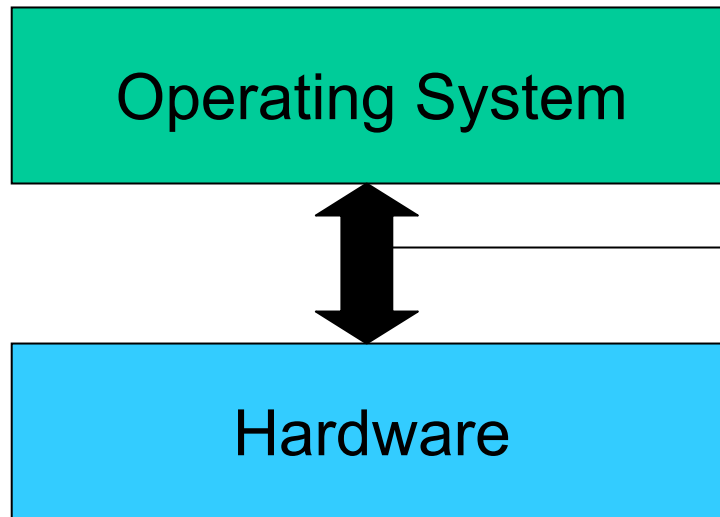
Interacts via load and store instructions to CPU and device registers, and interrupts

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Structure of a Computer System

User Mode

Application

Interaction via function calls to library procedures

System Libraries

Kernel Mode

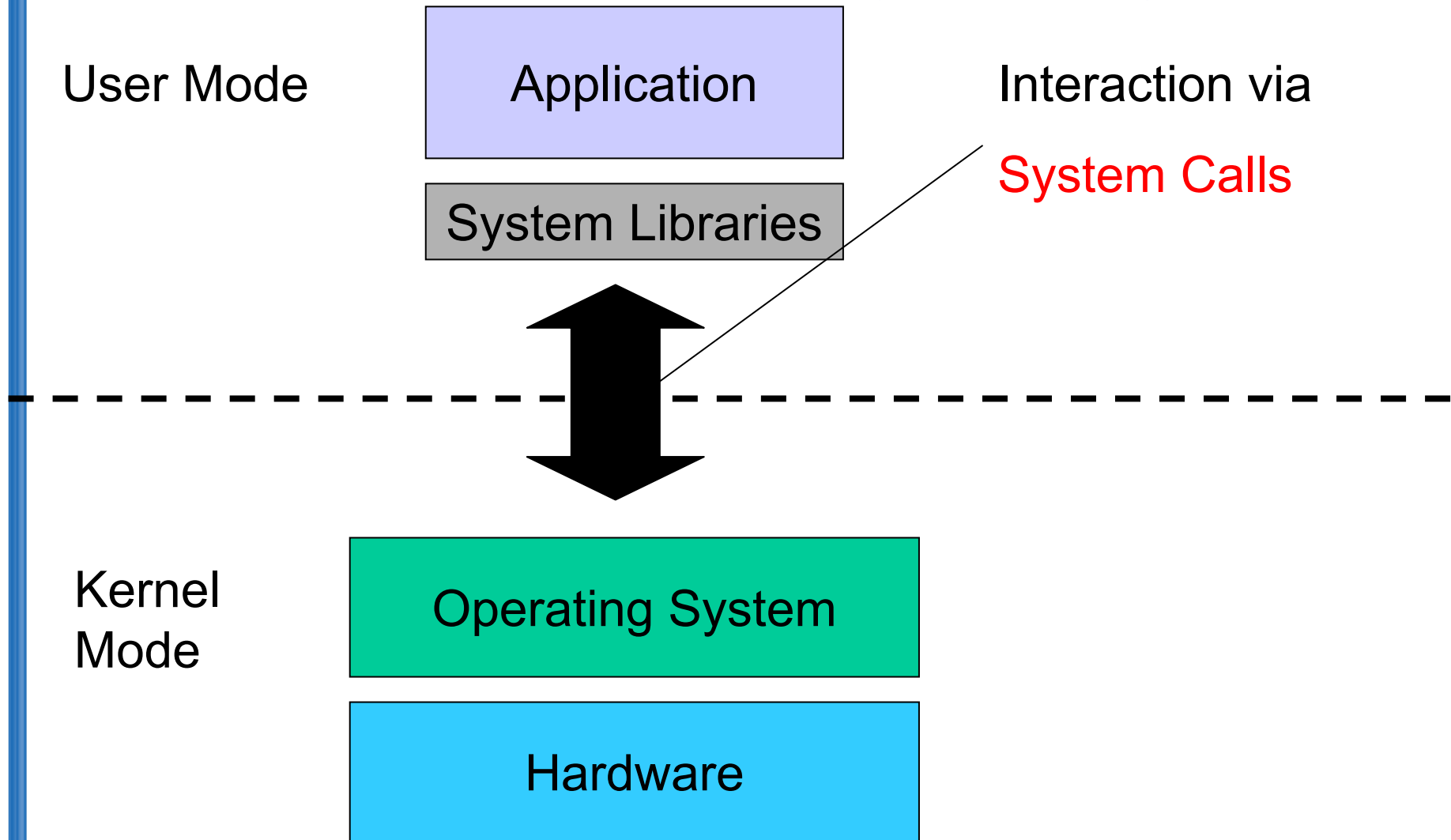Operating System

Hardware

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Structure of a Computer System

User Mode

Application

Interaction via

System Calls

System Libraries

Kernel Mode

Operating System

Hardware

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A note on System Libraries

- System libraries are just that, libraries of support functions (procedures, subroutines)
  - Only a subset of library functions are actually systems calls
    - strcmp(), memcpy(), are pure library functions
    - open(), close(), read(), write() are system calls
  - System call functions are in the library for convenience

Operating System Objectives

- **Convenience**
  - Make the computer more convenient to use
- **Abstraction**
  - Hardware-independent programming model
- **Efficiency**
  - Allows the computer system to be used in an efficient manner
- **Ability to evolve**
  - Permit effective development, testing, and introduction of new system functions without interfering with existing services
- **Protection**

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Services Provided by the Operating System

- Program development
  - Editors, compilers, debuggers
    - Not so much these days
- Program execution
  - Load a program and its data
- Access to I/O devices
- Controlled access to files
  - Access protection
- System access
  - User authentication

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Services Provided by the Operating System

- Error detection and response
  - internal and external hardware errors
    - memory error
    - device failure
  - software errors
    - arithmetic overflow
    - access forbidden memory locations
  - operating system cannot grant request of application

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Services Provided by the Operating System

- Accounting
  - collect statistics
  - monitor performance
  - used to anticipate future enhancements
  - used for billing users

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Operating System Software

- Fundamentally, OS functions the same way as ordinary computer software
  - It is a program that is executed (just like apps)
  - It has more privileges

- Operating system relinquishes control of the processor to execute other programs
  - Reestablishes control after
    - System calls
    - Interrupts (especially timer interrupts)

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Kernel

- Portion of the operating system that is running in *privileged mode*
- Usually resident in main memory
- Contains fundamental functionality
  - Whatever is required to implement other services
  - Whatever is required to provide security
- Contains most-frequently used functions
- Also called the nucleus or supervisor

Major OS Concepts

- Processes

- Concurrency and deadlocks

- Memory management

- Files

- Information Security and Protection

- Scheduling and resource management

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Processes

- A program in execution
- An instance of a program running on a computer
- The entity that can be assigned to and executed on a processor
- A unit of resource ownership
- A unit of activity characterized by a single sequential thread of execution, a current state, and an associated set of system resources
  - Nowadays the execution abstraction is separated out: *Thread*
  - Single process can contain many threads

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Process

- Consist of three segments
  - Text
    - contains the code (instructions)
  - Data
    - Global variables
  - Stack
    - Activation records of procedure
    - Local variables
- Note:
  - data can dynamically grow up
 - The stack can dynamically grow down

Memory
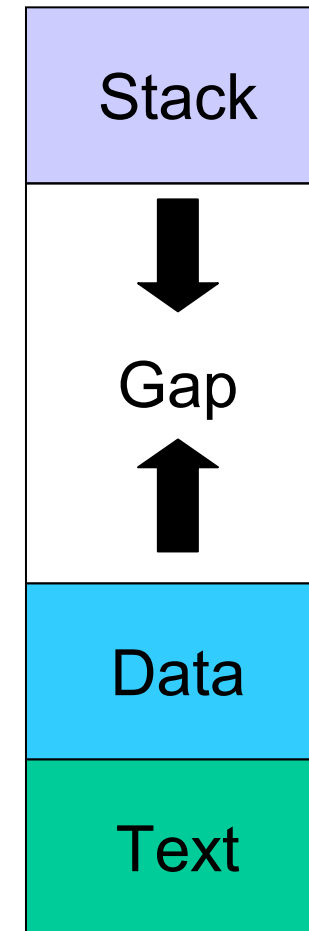
Stack
Gap
Data
Text

Process

- Consists of three components
  - An executable program
    - text
  - Associated data needed by the program
    - Data and stack
  - Execution context of the program
    - All information the operating system needs to manage the process
      - Registers, program counter, stack pointer, etc…
    - A multithread program has a stack and execution context for each thread

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Multiple processes creates concurrency issues

(a)

(b)
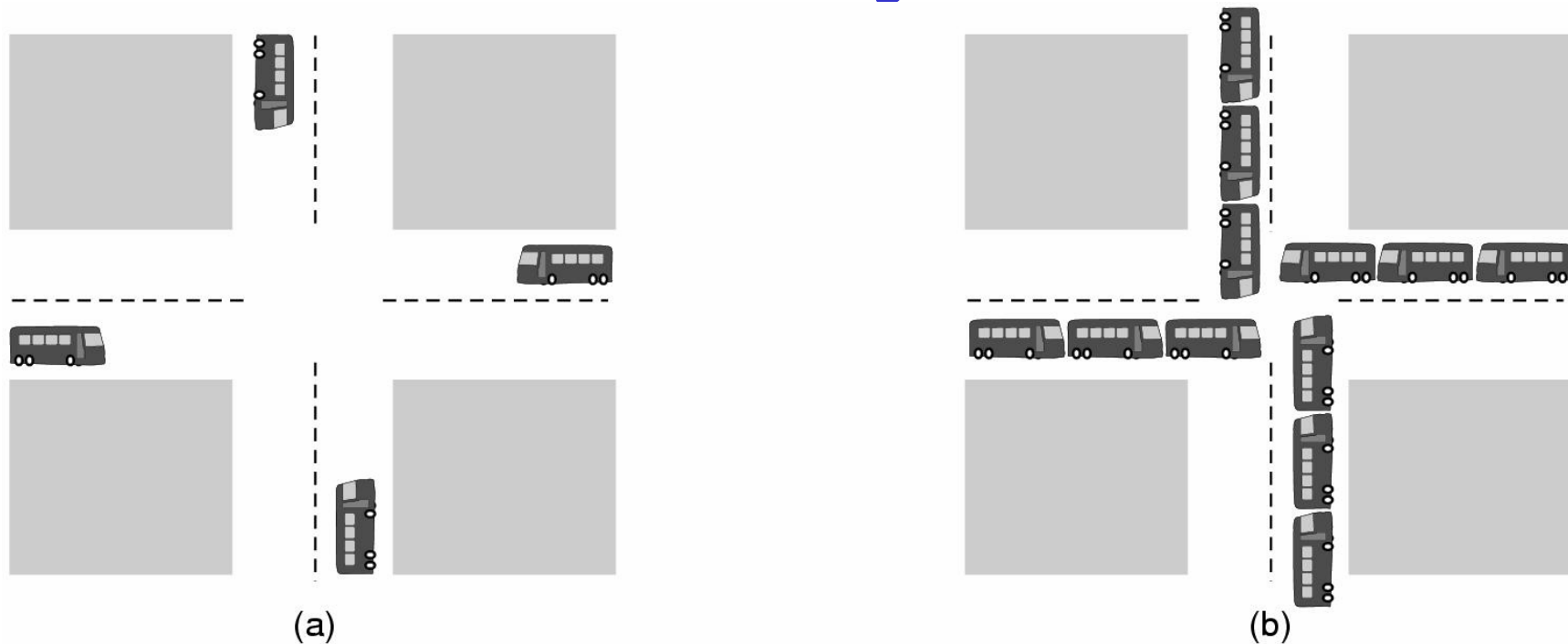
(a) A potential deadlock. (b) an actual deadlock.

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Memory Management

- The view from thirty thousand feet
  - Process isolation
    - Prevent processes from accessing each others data
  - Automatic allocation and management
    - Don't want users to deal with physical memory directly
  - Support for modular programming
  - Protection and access control
    - Still want controlled sharing
  - Long-term storage
  - OS services
    - Virtual memory
    - File system

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Virtual Memory

- Allows programmers to address memory from a logical point of view
    - Gives apps the illusion of having RAM to themselves
    - Logical addresses are independent of other processes
    - Provides isolation of processes from each other
- Can overlap execution of one process while swapping in/out others.

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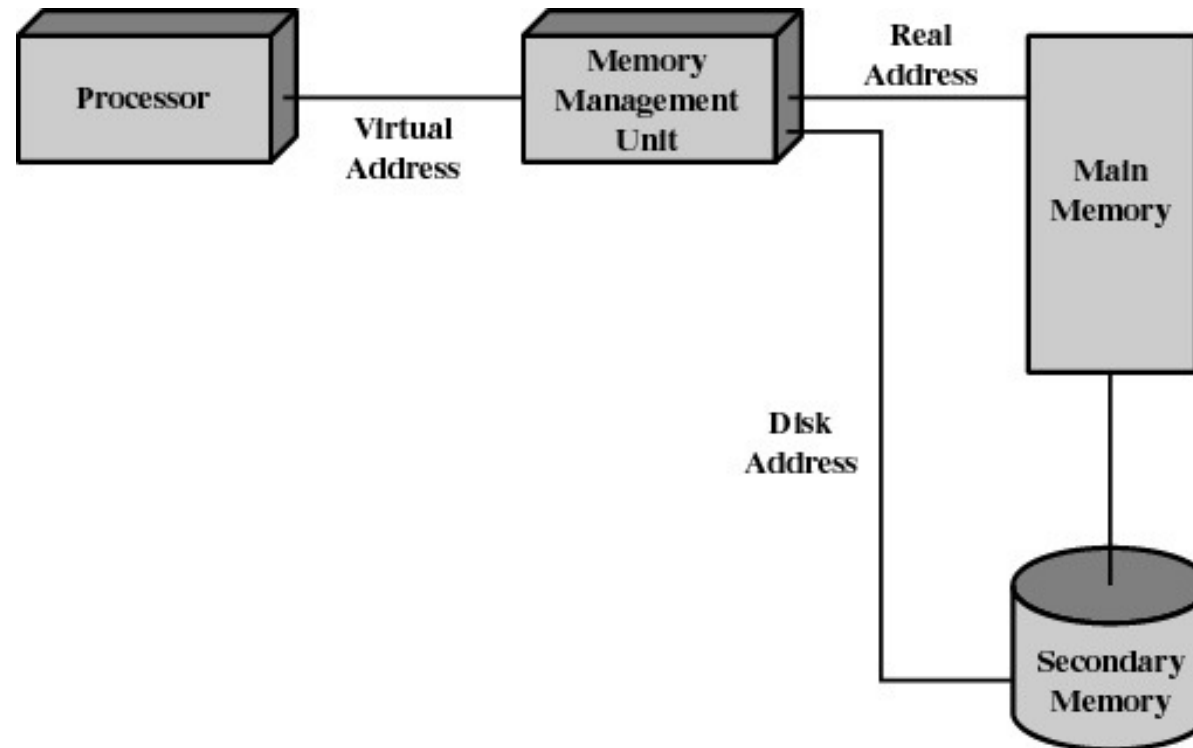NEW SOUTH WALES

Virtual Memory Addressing

Figure 2.10   Virtual Memory Addressing

Paging

- Allows process to be comprised of a number of fixed-size blocks, called pages

- Virtual address is a page number and an offset within the page

- Each page may be located any where in main memory

- A page may actually exist only on disk

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A.1			
	A.0	A.2	
	A.5		
B.0	B.1	B.2	B.3
		A.7	
	A.9		
		A.8	
B.4	B.5	B.6	

Main Memory

Main memory consists of a number of fixed-length frames, equal to the size of a page. For a program to execute, some or all of its pages must be in main memory.

User program A	User program B
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	
8	
9	
10	
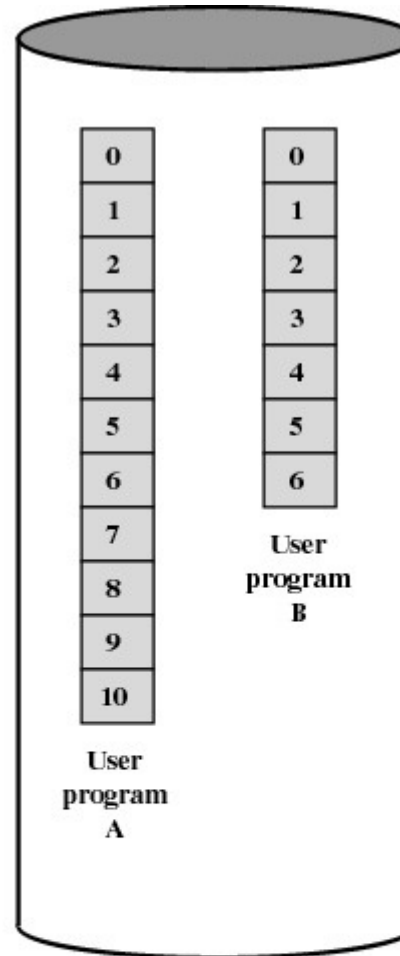
Disk

Secondary memory (disk) can hold many fixed-length pages. A user program consists of some number of pages. Pages for all programs plus the operating system are on disk, as are files.
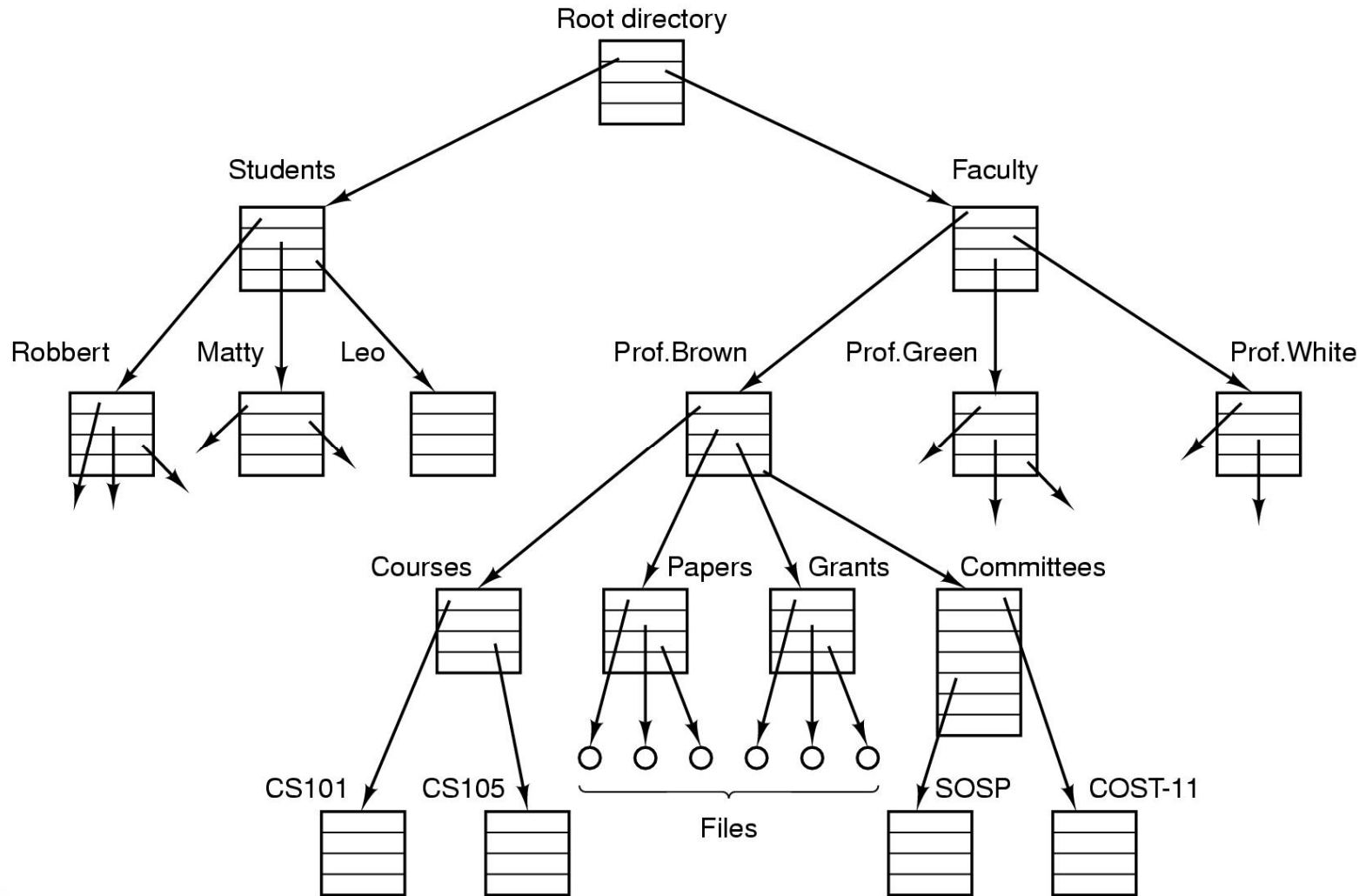
Figure 2.9 Virtual Memory Concepts

File System

- Implements long-term store
- Information stored in named objects called files

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Example File System

Information Protection and Security

- Access control
  - regulate user access to the system
  - Involves authentication
- Information flow control
  - regulate flow of data within the system and its delivery to users

Scheduling and Resource Management

- ## Fairness
  - give equal and fair access to all processes

- ## Differential responsiveness
  - discriminate between different classes of jobs

- ## Efficiency
  - maximize throughput, minimize response time, and accommodate as many uses as possible

Operating System Structure

- The layered approach

  a) Processor allocation and multiprogramming

  b) Memory Management

  c) Devices

  d) File system

  e) Users

 – Each layer depends on the the inner layers
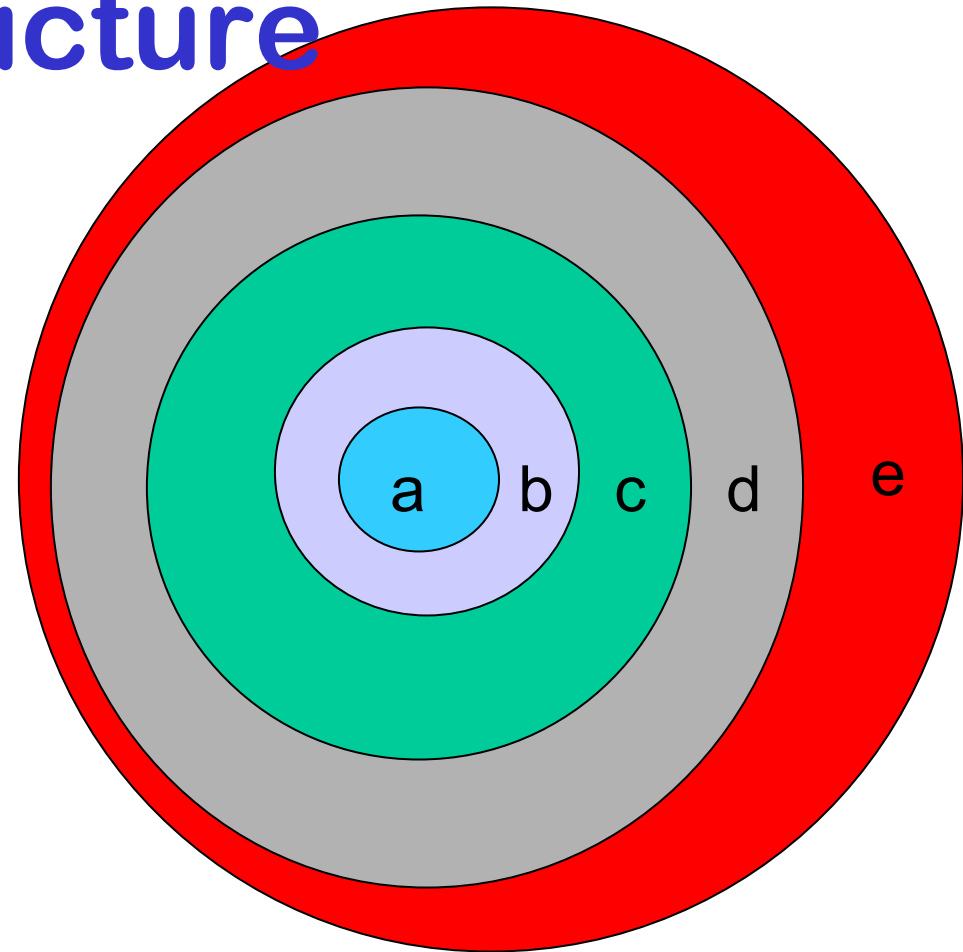
Operating System Structure

- In practice, layering is only a guide
  - Operating Systems have many interdependencies
    - Scheduling on virtual memory
    - Virtual memory on I/O to disk
    - VM on files (page to file)
   - Files on VM (memory mapped files)
    - And many more…

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The Monolithic Operating System Structure

- Also called the "spaghetti nest" approach
  - Everything is tangled up with everything else.
- Linux, Windows, ….

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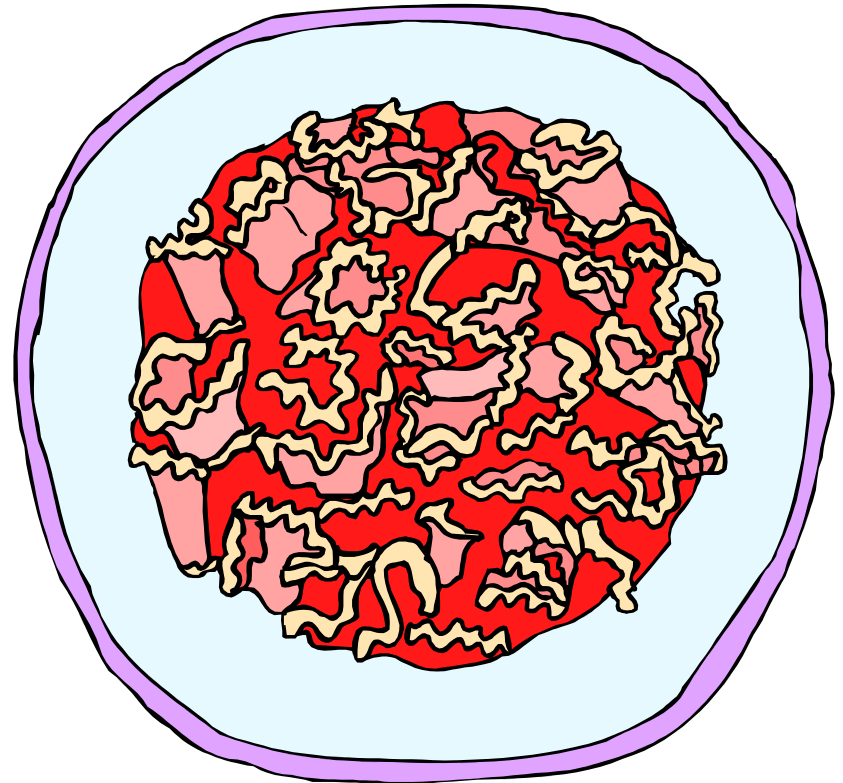
The Monolithic Operating System Structure

- However, some reasonable structure usually prevails

Main procedure

Service procedures

Utility procedures
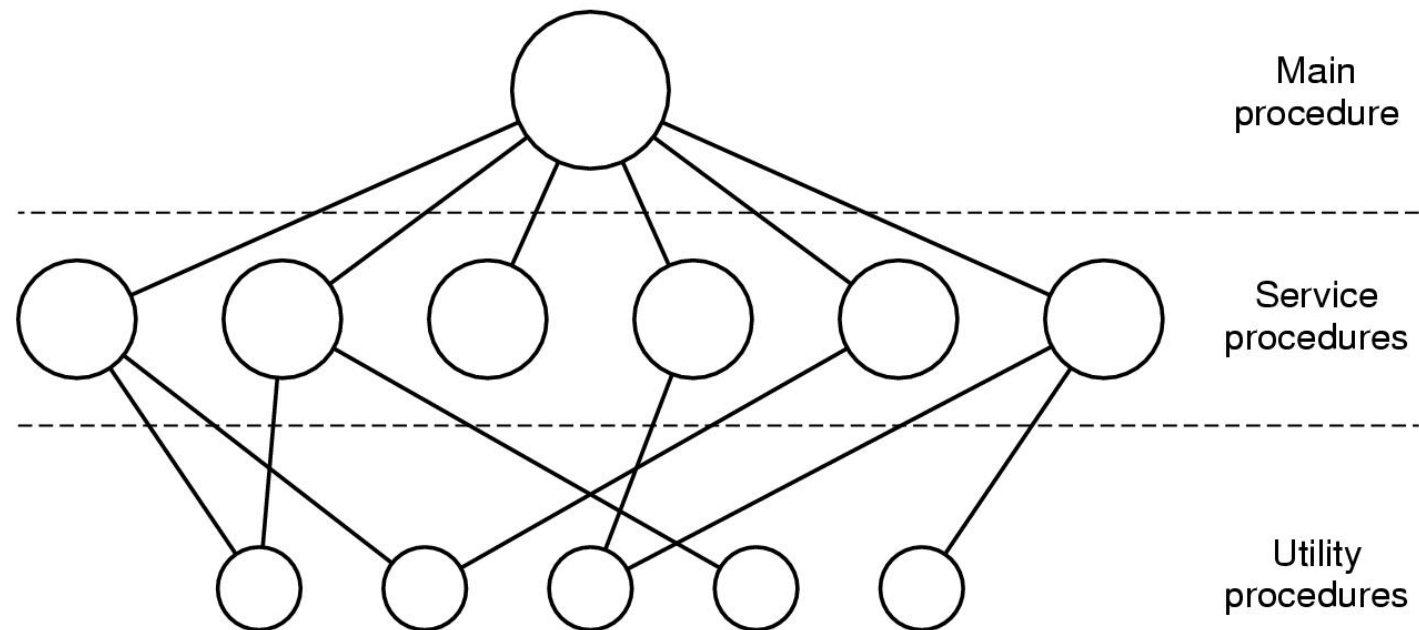
UNIX

- Provides a good hardware abstraction
  - Everything is a file (mostly)
- Runs on most hardware
- Comes with a number of user services and interfaces
  - shell
  - C compiler

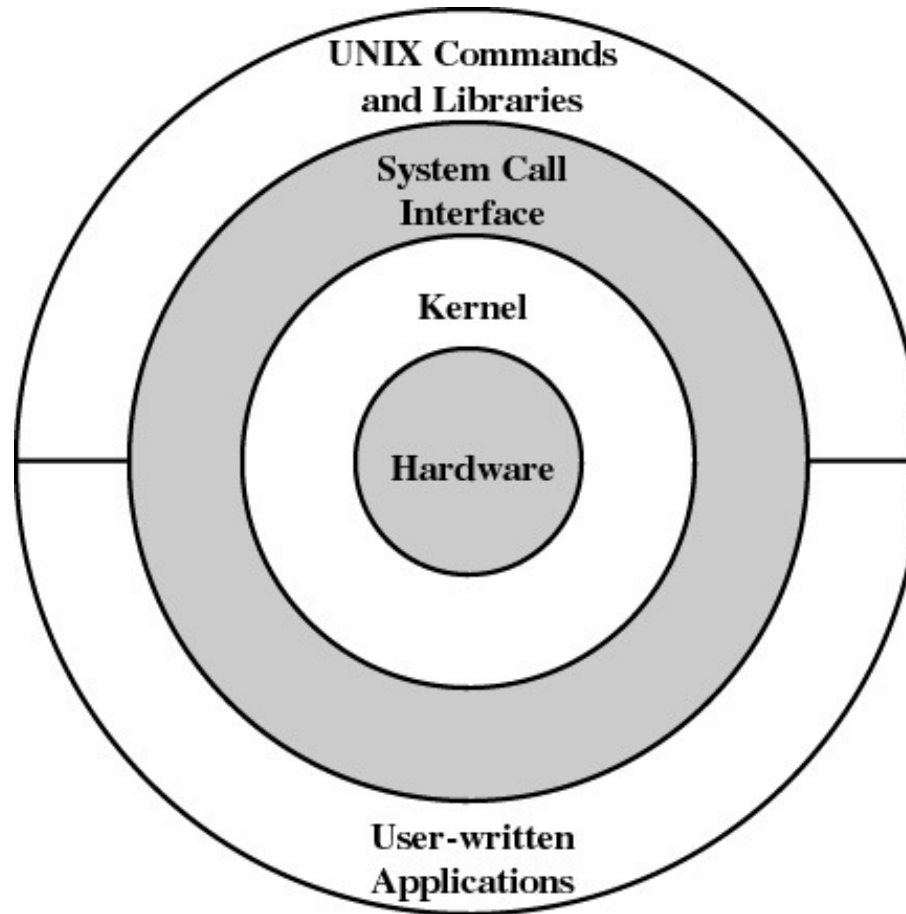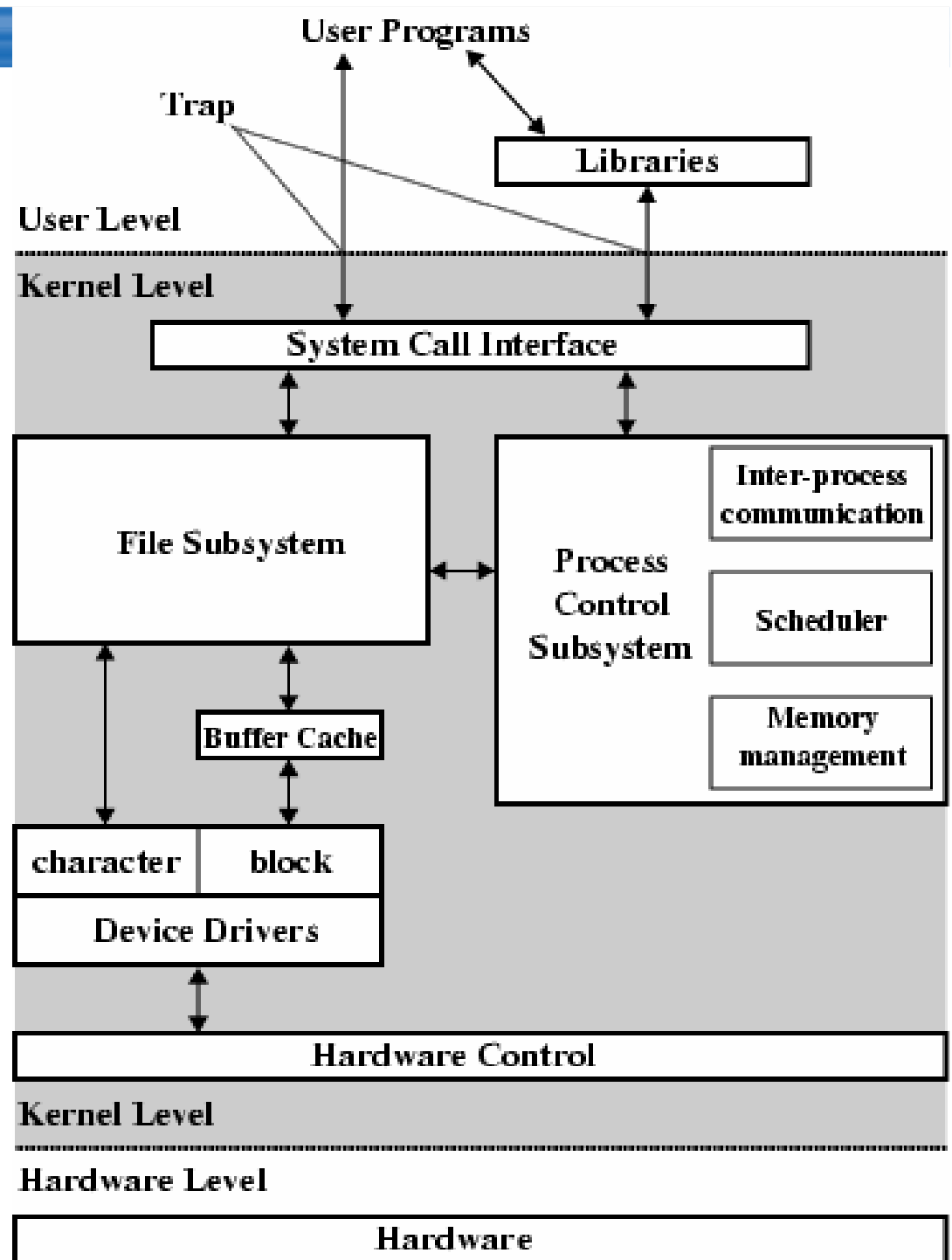# Traditional **UNIX** Structure

Figure 2.15 General UNIX Architecture

Traditional UNIX Kernel

Microkernel-based Systems

- Assigns only a few essential functions to the kernel
  - Address space
  - Interprocess Communication (IPC)
  - Basic scheduling
  - Minimal hardware abstraction
- Other services implemented by user-level servers
- Traditional "system calls" become IPC requests to servers
- Extreme view of a microkernel
  - A feature is only allowed in the kernel if required for security

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