Chap. 2) System Structures

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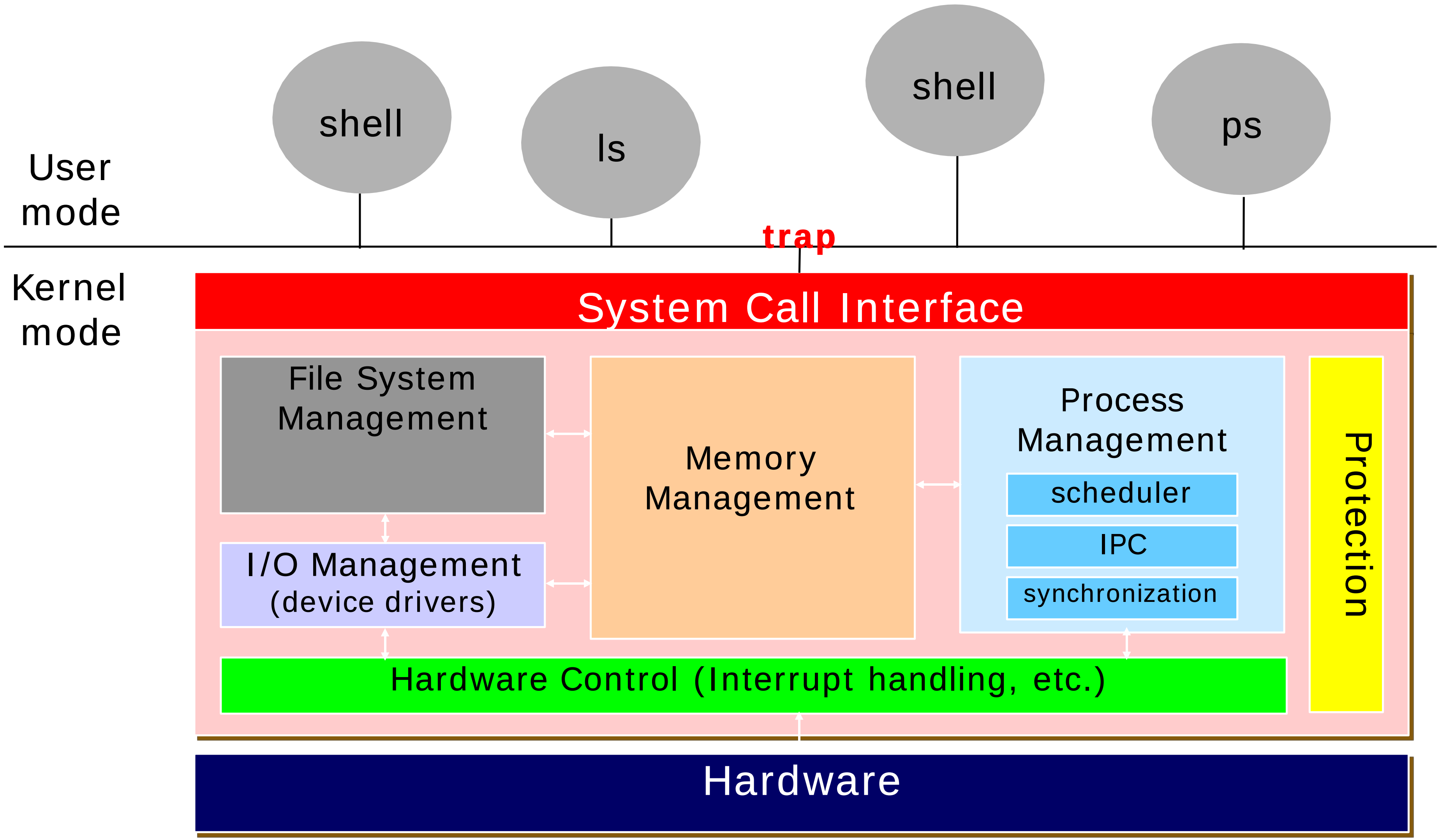
방 재 훈

Common System Components

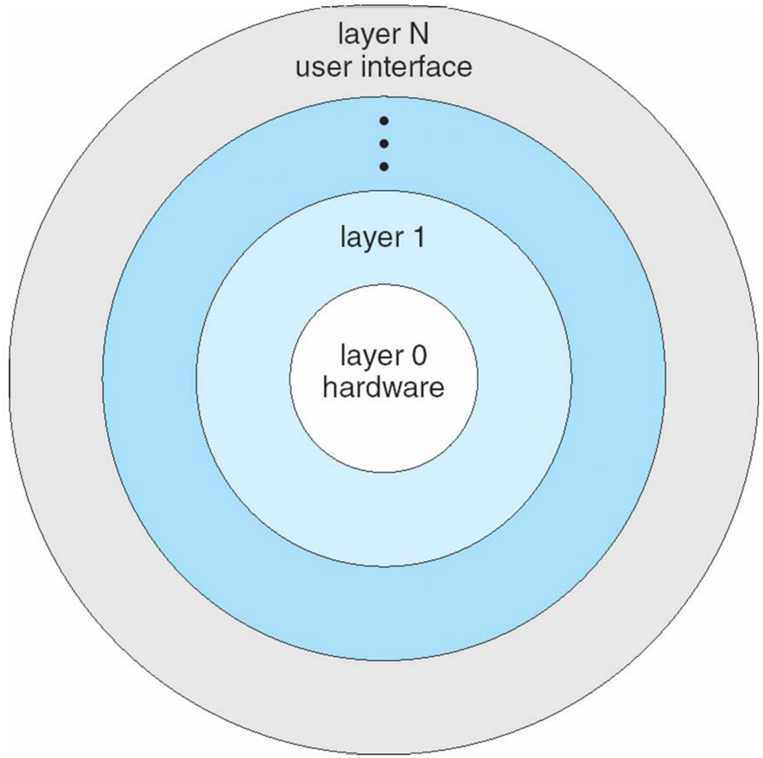
- Process Management
- Main Memory Management
- I/O System Management
- Secondary Storage Management
- File Management
- Networking
- Protection System
- Command-Interpreter System

Operating System Structure



Layered Approach

- The operating system is divided into a number of layers (levels), each built on top of lower layers. The bottom layer (layer 0), is the hardware; the highest (layer N) is the user interface.
- With modularity, layers are selected such that each uses functions (operations) and services of only lower-level layers

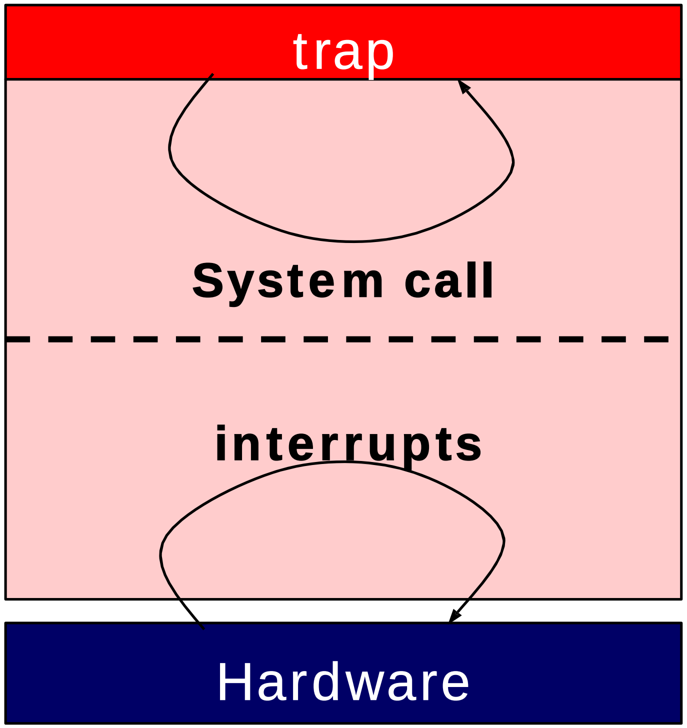


System Calls

	Windows	Unix
Process Control	CreateProcess() ExitProcess() WaitForSingleObject()	fork() exit() wait()
File Manipulation	CreateFile() ReadFile() WriteFile() CloseHandle()	open() read() write() close()
Device Manipulation	SetConsoleMode() ReadConsole() WriteConsole()	ioctl() read() write()
Information Maintenance	GetCurrentProcessID() SetTimer() Sleep()	getpid() alarm() sleep()
Communication	CreatePipe() CreateFileMapping() MapViewOfFile()	pipe() shmget() mmap()
Protection	SetFileSecurity() InitlializeSecurityDescriptor() SetSecurityDescriptorGroup()	chmod() umask() chown()

Taking Control of the System

- Bootstrapping
- System calls
- Interrupts



- Linux Booting Process
  - ✓ The CPU initializes itself and then execute an instruction at a fixed location (0xfffffff0).
  - ✓ This instruction jumps into the BIOS.
  - ✓ The BIOS finds a boot device and fetches its MBR (Master Boot Record), which points to LILO (Linux Loader).
  - ✓ The BIOS loads and transfers control to LILO.
  - ✓ LILO loads the compressed kernel.
  - ✓ The compressed kernel decompresses itself and transfers control to the uncompressed kernel.

Process Management

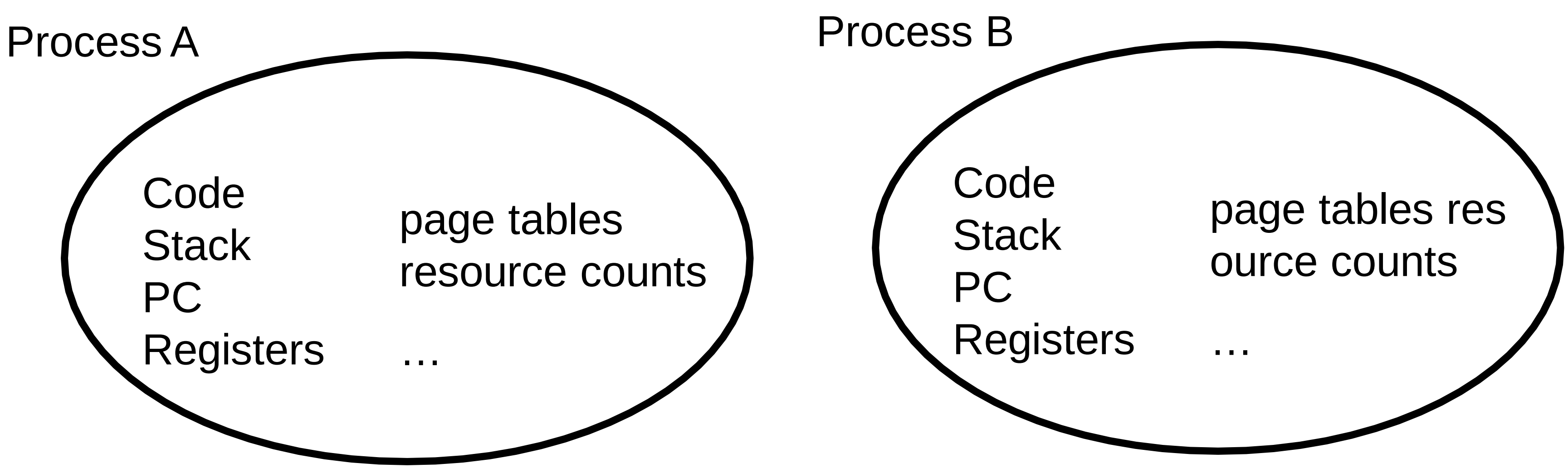
- A *process* is a program in execution
  - ✓ A process needs certain resources, including CPU time, memory, files, and I/O devices, to accomplish its task

- The operating system is responsible for the following activities in connection with process management
  - ✓ Process creation and deletion
  - ✓ process suspension and resumption
  - ✓ Provision of mechanisms for:
    - process synchronization
    - process communication

Program vs. Process

- A <u>program</u> is a passive thing – just a file on the disk with code that is *potentially* runnable

- A <u>process</u> is one instance of a program *in execution*;
  at any instance, there may be many processes running copies of a single program (e.g., an editor): each is a *separate, independent* process



Main-Memory Management

- Memory is a large array of words or bytes, each with its own address
  - ✓ It is a repository of quickly accessible data shared by the CPU and I/O devices

- Main memory is a volatile storage device
  - ✓ It loses its contents in the case of system failure

- The operating system is responsible for the following activities in connections with memory management:
  - ✓ Keep track of which parts of memory are currently being used and by whom
  - ✓ Decide which processes to load when memory space becomes available
  - ✓ Allocate and deallocate memory space as needed

File Management

- A file is a collection of related information defined by its creator
  - ✓ Commonly, files represent programs (both source and object forms) and data
- The operating system is responsible for the following activities in connections with file management:
  - ✓ File creation and deletion
  - ✓ Directory creation and deletion
  - ✓ Support of primitives for manipulating files and directories
  - ✓ Mapping files onto secondary storage
  - ✓ File backup on stable (nonvolatile) storage media

File System

- A convenient abstraction for the secondary storage
  - ✓ Defines logical objects (files, directories)
  - ✓ Defines logical operations

- File
  - ✓ Named collection of persistent information
  - ✓ The basic long-term storage unit

- Directory (folder)
  - ✓ Named file that contains names of other files and metadata about those files

I/O System Management

- The I/O system consists of:
  - ✓ A buffer-caching system
  - ✓ A general device-driver interface
  - ✓ Drivers for specific hardware devices

- *I/O Abstraction*
  - ✓ The OS provides a standard interface between programs and devices
  - ✓ File system, Sockets, I/O devices, etc.

Secondary-Storage Management

- Since main memory (*primary storage*) is volatile and too small to accom modate all data and programs permanently, the computer system must provide *secondary storage* to back up main memory

- Most modern computer systems use disks as the principle on-line storage medium, for both programs and data

- The operating system is responsible for the following activities in connection with disk management:
  - ✓ Free space management
  - ✓ Storage allocation
  - ✓ Disk scheduling

Networking (Distributed Systems)

- A *distributed* system is a collection processors that do not share memory or a clock
- Each processor has its own local memory
- The processors in the system are connected through a communication network
- Communication takes place using a *protocol*
- A distributed system provides user access to various system resources
- Access to a shared resource allows:
  - ✓ Computation speed-up
  - ✓ Increased data availability
  - ✓ Enhanced reliability

Protection System

- *Protection* refers to a mechanism for controlling access by programs, processes, or users to both system and user resources

- The protection mechanism must:
  - ✓ distinguish between authorized and unauthorized usage
  - ✓ specify the controls to be imposed
  - ✓ provide a means of enforcement

Command-Interpreter System

- Many commands are given to the operating system by control statements which deal with:
  - ✓ process creation and management
  - ✓ I/O handling
  - ✓ secondary-storage management
  - ✓ main-memory management
  - ✓ file-system access
  - ✓ protection
  - ✓ networking

- The program that reads and interprets control statements is called variously:
  - ✓ command-line interpreter
  - ✓ shell (in UNIX)

- Its function is to get and execute the next command statement

Command-Interpreter System

- Shell
  - ✓ A particular program that handles the interpretation of users' commands
  - ✓ Helps to manage processes
- Types
  - ✓ A standard part of the OS
    - MS-DOS, Apple II
  - ✓ A non-privileged process
    - sh / csh / tcsh / zsh / ksh on UNIX
  - ✓ No command interpreter
    - MacOS

Operating System Services

- User interface
  - ✓ Command-line interface (CLI) vs. Graphical user interface (GUI)
- Program execution
  - ✓ system capability to load a program into memory and to run it
- I/O operations
  - ✓ since user programs cannot execute I/O operations directly, the operating system must provide some means to perform I/O
- File-system manipulation
  - ✓ program capability to read, write, create, and delete files
- Communications
  - ✓ exchange of information between processes executing either on the same co mputer or on different systems tied together by a network (Implemented via *s hared memory* or *message passing)*
- Error detection
  - ✓ ensure correct computing by detecting errors in the CPU and memory hardware, in I/O devices, or in user programs

Additional Operating System Functions

- Additional functions exist not for helping the user, but rather for ensuring efficient system operations
  - ✓ Resource allocation
    - allocating resources to multiple users or multiple jobs running at the same time
  - ✓ Accounting
    - keep track of and record which users use how much and what kinds of computer resources for account billing or for accumulating usage statistics
  - ✓ Protection
    - ensuring that all access to system resources is controlled

System Calls

- System calls provide the interface between a running program and the operating system
  - ✓ Generally available as assembly-language instructions
  - ✓ Languages defined to replace assembly language for systems programming allow system calls to be made directly (e.g., C, C++)

- Three general methods are used to pass parameters between a running program and the operating system
  - ✓ Pass parameters in *registers*
  - ✓ Store the parameters in a table in memory, and the table address is passed as a parameter in a register
  - ✓ *Push* (store) the parameters onto the *stack* by the program, and *pop* off the stack by operating system

Types of System Calls

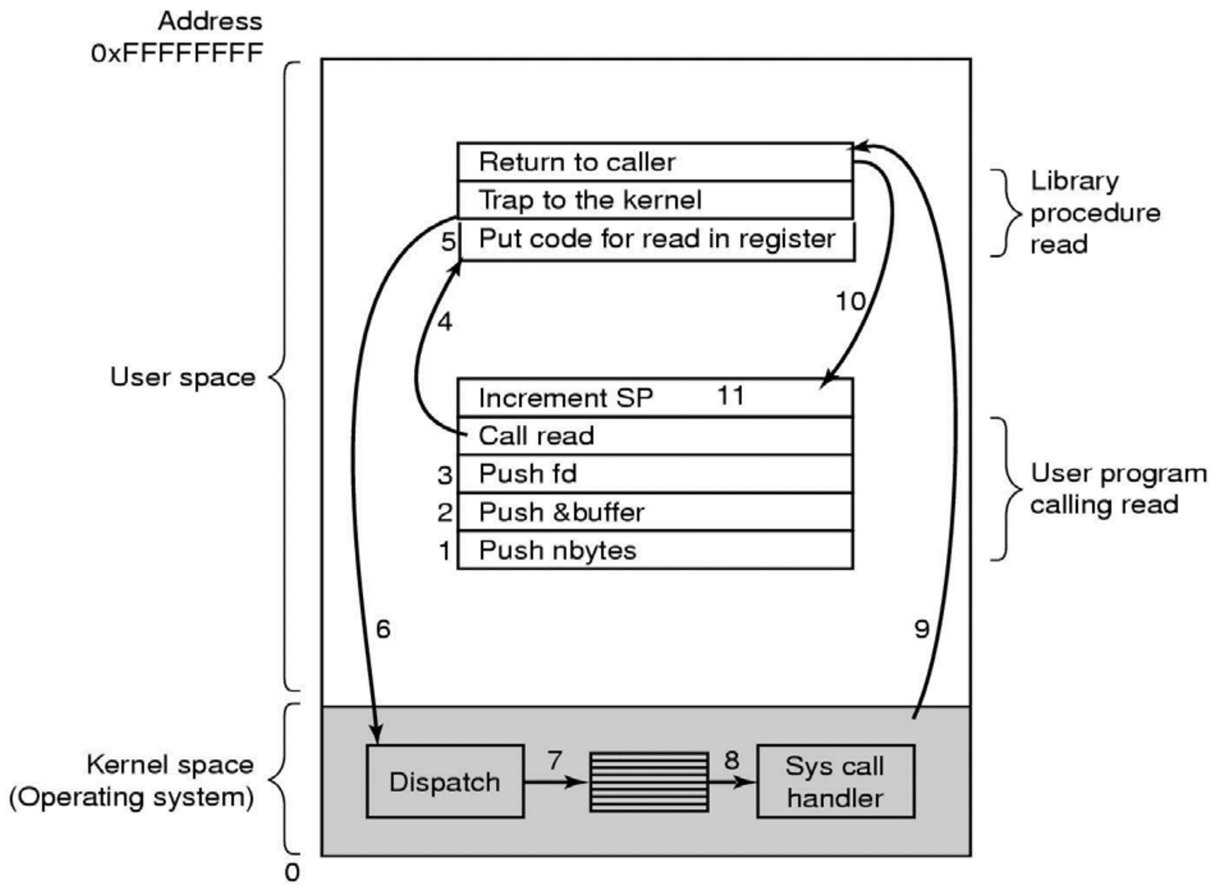
- Process control
- File management
- Device management
- Information maintenance
- Communications

System Calls

Process Management	**fork**	**CreateProcess**	Create a new process
	waitpid	**WaitForSingleObject**	Wait for a process to exit
	execve	**(none)**	CreateProcess = fork + execve
	exit	**ExitProcess**	Terminate execution
	kill	**(none)**	Send a signal
File Management	**open**	**CreateFile**	Create a file or open an existing file
	close	**CloseHandle**	Close a file
	read	**ReadFile**	Read data from a file
	write	**WriteFile**	Write data to a file
	lseek	**SetFilePointer**	Move the file pointer
	stat	**GetFileAttributesEx**	Get various file attributes
	chmod	**(none)**	Change the file access permission
File System Management	**mkdir**	**CreateDirectory**	Create a new directory
	rmdir	**RemoveDirectory**	Remove an empty directory
	link	**(none)**	Make a link to a file
	unlink	**DeleteFile**	Destroy an existing file
	mount	**(none)**	Mount a file system
	umount	**(none)**	Unmount a file system
	chdir	**SetCurrentDirectory**	Change the curent working directory

Invoking a System Call

```
count = read (fd, buffer, nbytes);
```



System Programs

- System programs provide a convenient environment for program development and execution. They can be divided into:
  - ✓ File manipulation
  - ✓ Status information
  - ✓ File modification
  - ✓ Programming language support
  - ✓ Program loading and execution
  - ✓ Communications
  - ✓ Application programs

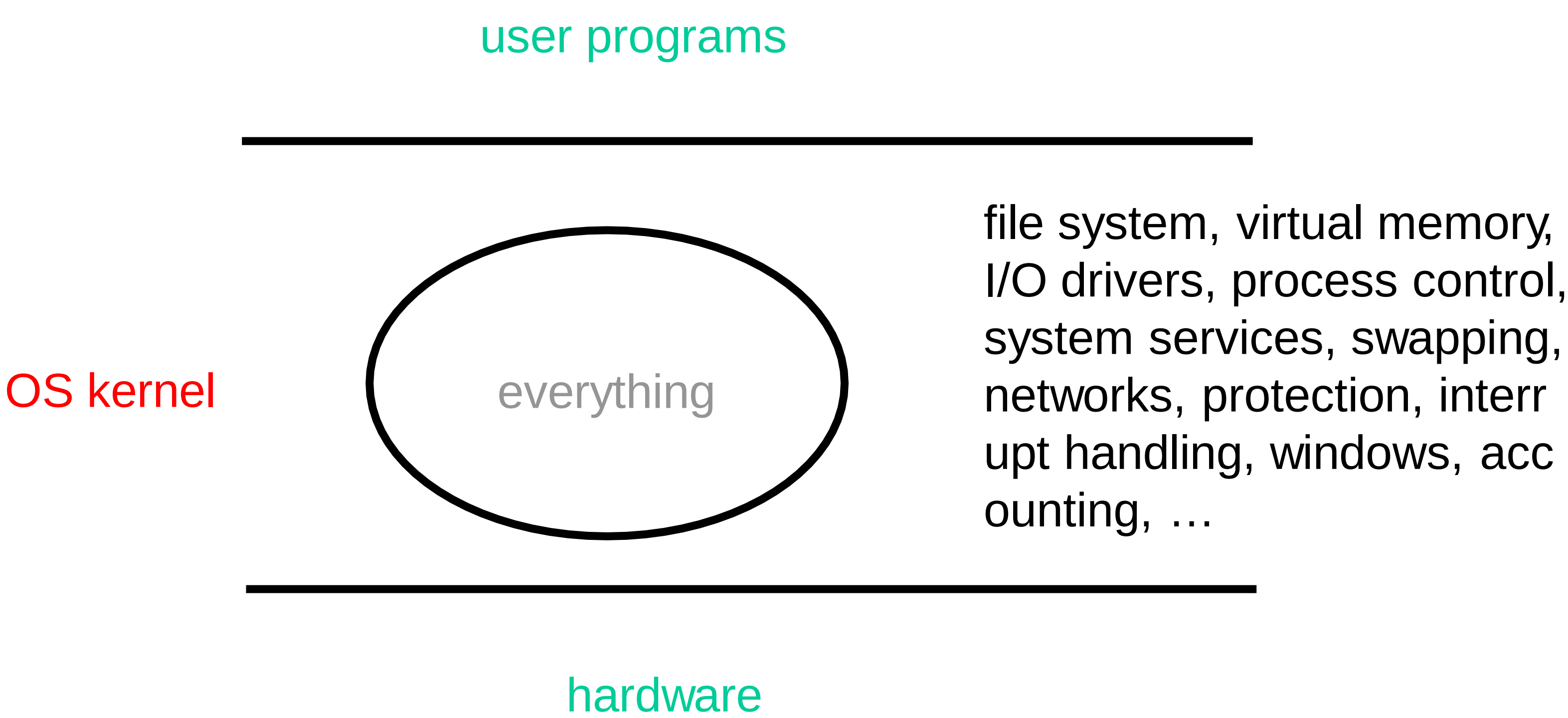
- Most users' view of the operation system is defined by system programs, not the actual system calls

OS Structure

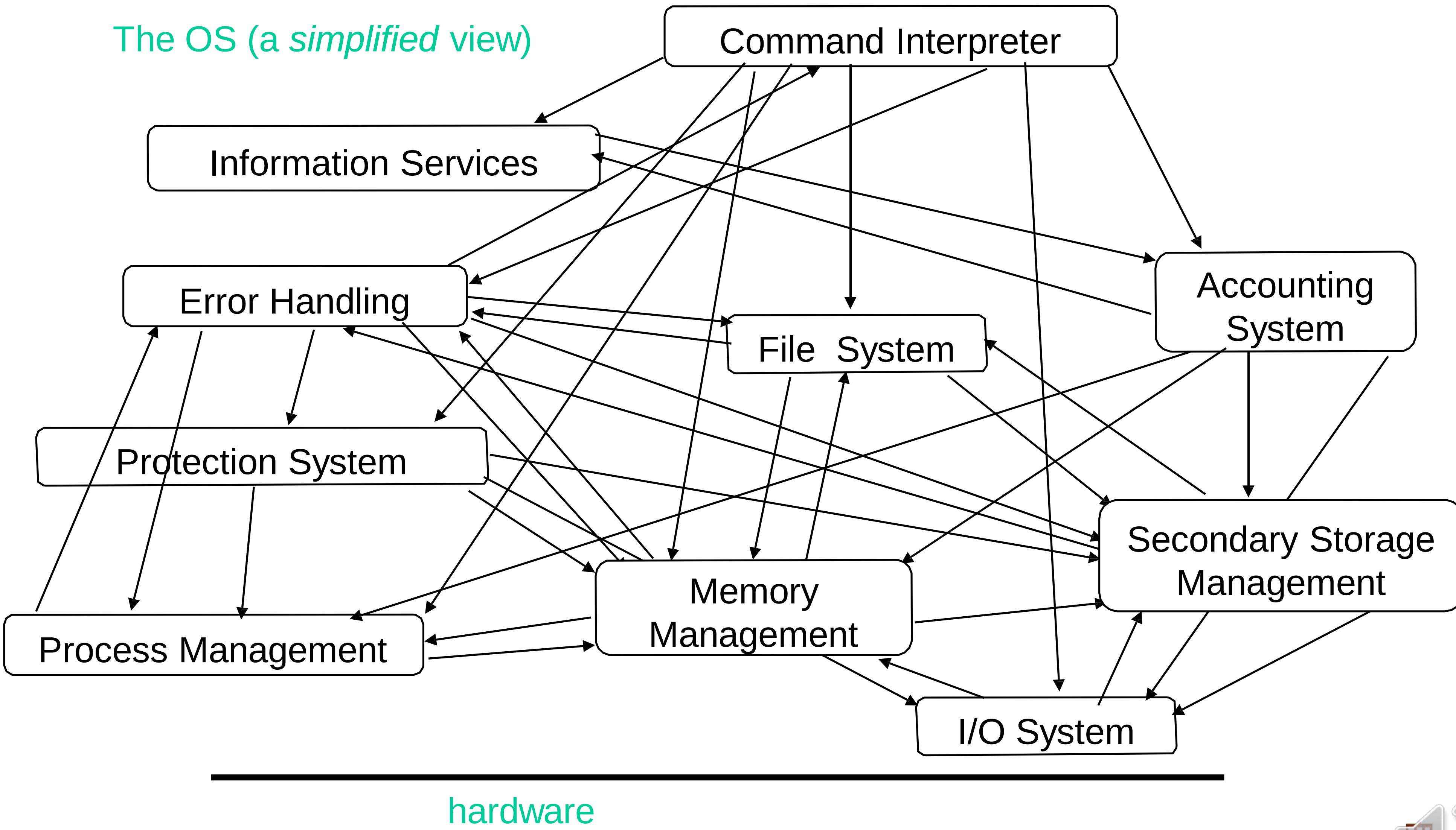
- An OS consists of all of these components, plus lots of others, plus system service routines, plus system programs(privileged and non-privileged), plus …
- The big issue:
  - ✓ How do we organize all of this?
  - ✓ What are the entities and where do they exist?
  - ✓ How does these entities cooperate?
- Basically, how do we build a complex system that's:
  - ✓ Performance
  - ✓ Reliable
  - ✓ Extensible

OS Structure (Cont'd)

- Traditionally, systems such as Unix were built as a *monolithic* kernel:



OS Structure (Cont'd)



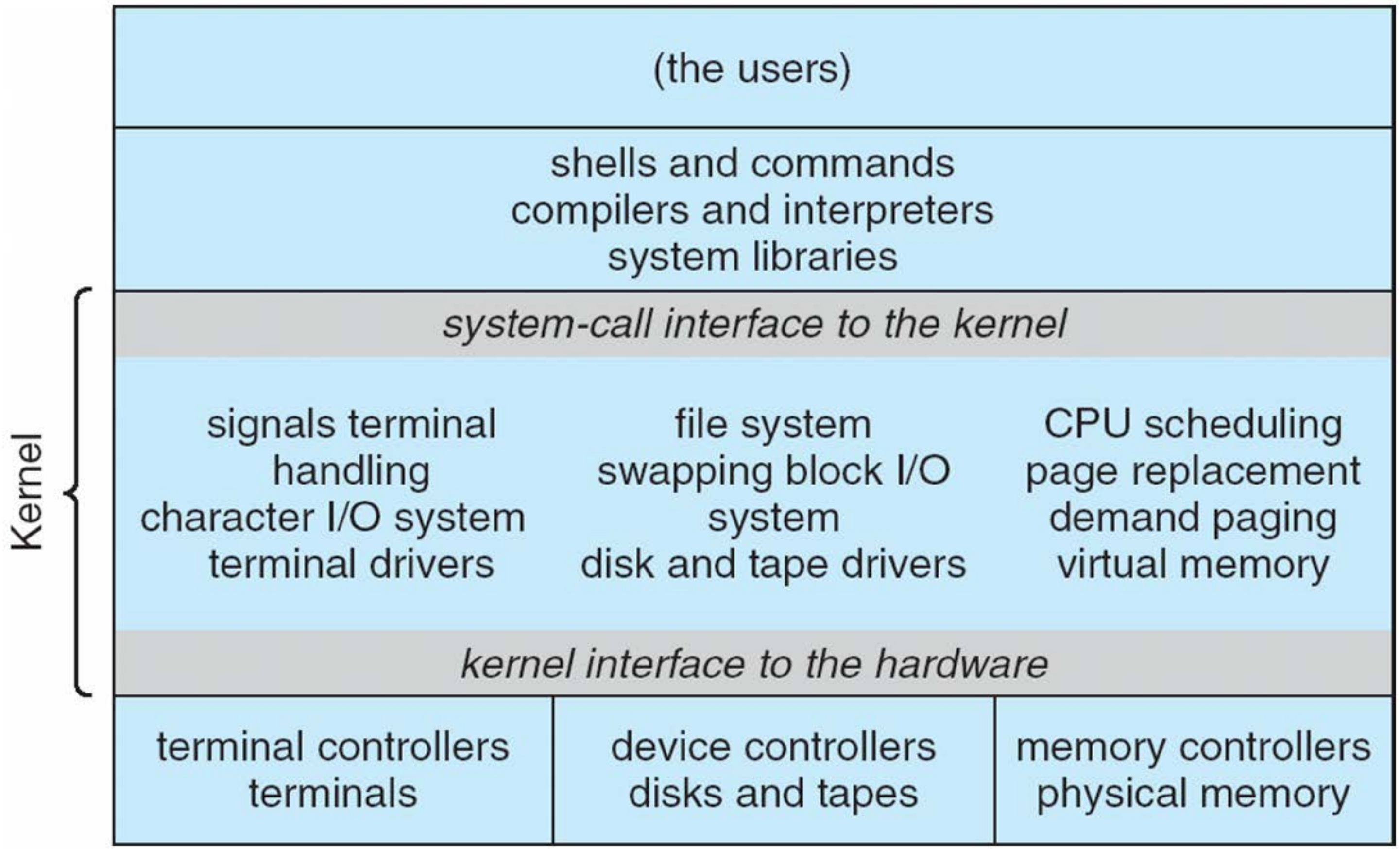
MS-DOS System Structure

- MS-DOS – written to provide the most functionality in the least space
  - ✓ not divided into modules
  - ✓ Although MS-DOS has some structure, its interfaces and levels of functionality are not well separated

UNIX System Structure

- UNIX – limited by hardware functionality, the original UNIX operating system had limited structuring
- The UNIX OS consists of two separable parts
  - ✓ Systems programs
  - ✓ The kernel
    - Consists of everything below the system-call interface and above the physical hardware
    - Provides the file system, CPU scheduling, memory management, and other operating-system functions; a large number of functions for one level

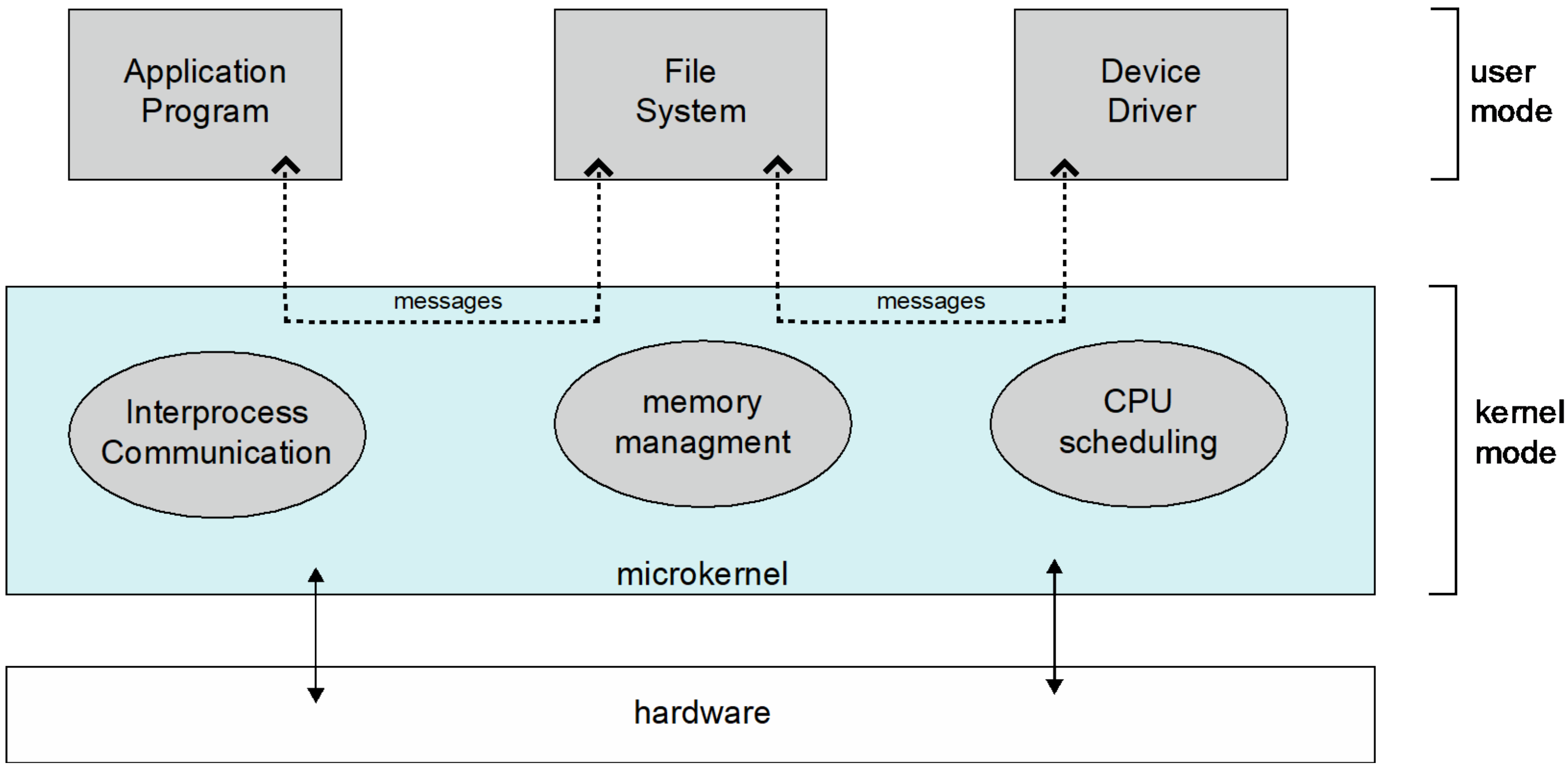
UNIX System Structure (Cont'd)



Microkernel System Structure

- Moves as much from the kernel into "*user*" space
- Communication takes place between user modules using message passing
- Benefits:
  - ✓ easier to extend a microkernel
  - ✓ easier to port the operating system to new architectures
  - ✓ more reliable (less code is running in kernel mode)
  - ✓ more secure

Micro Kernel Structure

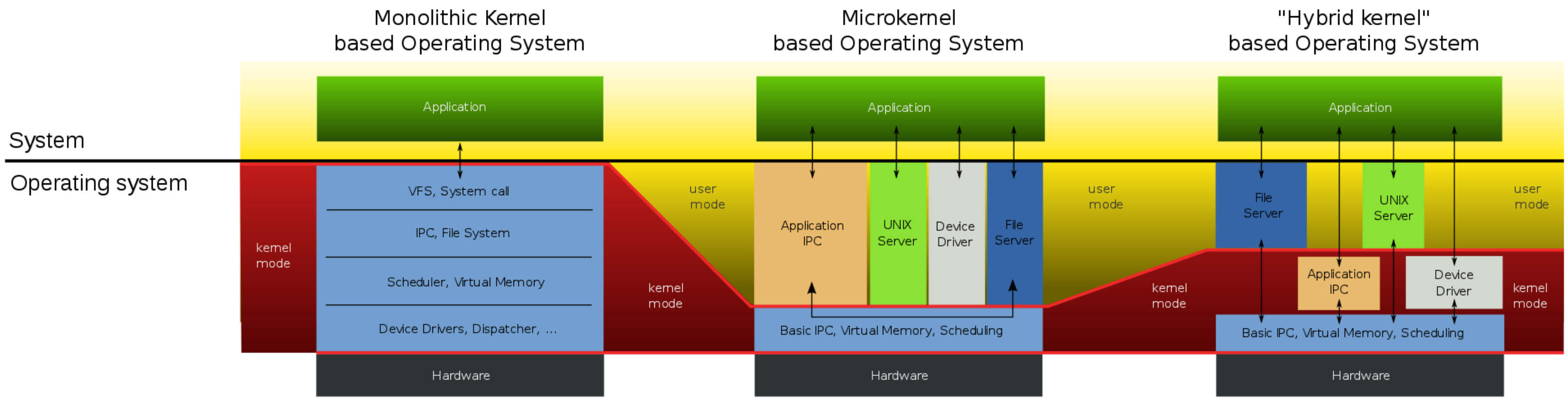


Hybrid Kernel Systems

- Most modern operating systems are actually not one pure model
  - Hybrid combines multiple approaches to address performance, security, usability needs
  - Linux and Solaris kernels in kernel address space, so monolithic, plus modular for dynamic loading of functionality
  - Windows mostly monolithic, plus microkernel for different subsystem personalities

- Apple Mac OS X hybrid, layered, Aqua UI plus Cocoa programming environment

- Below is kernel consisting of Mach microkernel and BSD Unix parts, plus I/O kit and dynamically loadable modules (called kernel extensions)



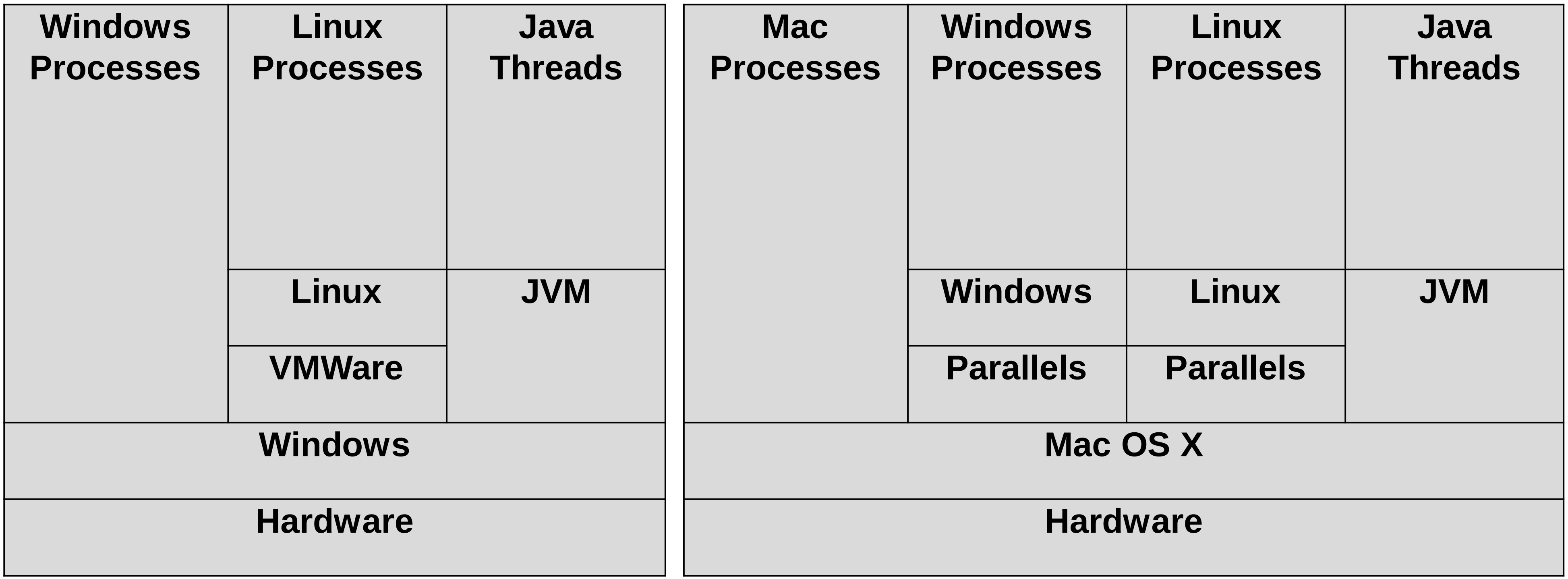
Virtual Machines

- A *virtual machine* takes the layered approach to its logical conclusion
  - ✓ It treats hardware and the operating system kernel as though they were all hardware
- A virtual machine provides an interface *identical* to the underlying bare hardware
- The operating system creates the illusion of multiple processes, each executing on its own processor with its own (virtual) memory

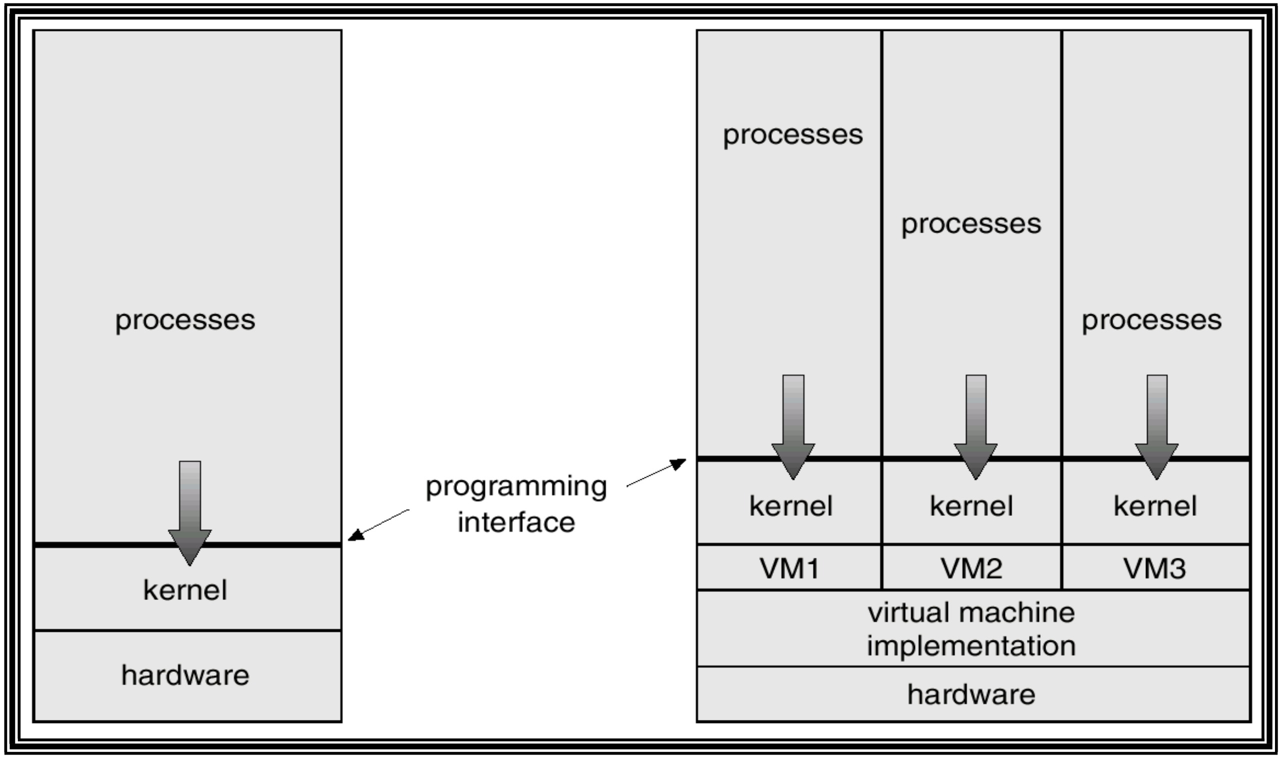
Virtual Machines (Cont'd)

- The resources of the physical computer are shared to create the virtual machines
  - ✓ CPU scheduling can create the appearance that users have their own processor
  - ✓ Spooling and a file system can provide virtual card readers and virtual line printers
  - ✓ A normal user time-sharing terminal serves as the virtual machine operator's console

Virtual Machine Examples



System Models



Non-virtual Machine

Virtual Machine

Advantages/Disadvantages of Virtual Machines

- The virtual-machine concept provides complete protection of system resources since each virtual machine is isolated from all other virtual machines
- This isolation, however, permits no direct sharing of resources
- A virtual-machine system is a perfect vehicle for operating-systems research and development
- System development is done on the virtual machine, instead of on a physical machine and so does not disrupt normal system operation
- The virtual machine concept is difficult to implement due to the effort required to provide an *exact* duplicate to the underlying machine

Java Virtual Machine

- Compiled Java programs are platform-neutral byte-codes executed by a Java Virtual Machine (JVM)

- JVM consists of

  - class loader

  - class verifier

  - runtime interpreter

- Just-In-Time (JIT) compilers increase performance

Summary

- Operating system component
  - ✓ Process management
  - ✓ Main memory management
  - ✓ File management
  - ✓ Secondary storage management
  - ✓ I/O system management
  - ✓ Protection system
  - ✓ Command-interpreter system
  - ✓ Networking system
- Operating system implementation
  - ✓ Monolithic-kernel
    - All the OS components are implemented into one big image
  - ✓ Micro-kernel
    - Only primitive functions are implemented into a small kernel
    - A lot of components are moved from the kernel to user server processes