# 操作系统原理及应用

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# Chapter 2 Operating-System Structures

# Outline

- Operating System Functions
- Operating System Services
- Operating System Interfaces
- Operating System Structure
- Operating System Design and Implementation

# Common Functions of OS

- Process Management
- Main Memory Management
- Secondary-Storage Management
- File Management
- I/O System Management

# Process Management

- A *process* is a program in execution
- System Processes and User Processes
- Activities for process management
  - Process creation and deletion
  - process suspension and resumption
  - Provision of mechanisms for
    - process synchronization
    - process communication
    - Deadlock handling

# Main-Memory Management

- Memory is a large array of words or bytes, each with its own address.
- It is generally the only large storage device that the CPU is able to address and access directly.
- Main memory is a volatile storage device.
- Activities for main-memory management
  - Allocate and deallocate memory space as needed
  - Record the usage of Main-memory

# Secondary-Storage Management

- **Since main memory (*primary storage*) is volatile and too small to accommodate 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.**

# Secondary-Storage Management

- Activities for disk management
  - Free space management
  - Storage allocation
  - Disk scheduling

# File Management (1/2)

- There are different types of physical media to store information. Each of them has its own characteristics and physical organization.
  - Access speed
  - Data-transfer rate
  - Access method (sequential or random)
- Operating System provides a uniform logical view of information storage, i.e., file.

# File Management (2/2)

- A file is a collection of related information (programs and data) defined by its creator.
- Activities for 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

# I/O System Management

- **Hiding the peculiarities of specific hardware devices from the user**
- **The I/O subsystem consists of**
  - **A memory-management component including buffer, caching, spooling**
  - **A general device-driver interface**
  - **Drivers for specific hardware devices**

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# Operating System Services(1/2)

- Services for helping Users
  - 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 (shared memory or message passing)
  - Error detection – ensure correct computing by detecting errors in hardwares or in user programs.

# Operating System Services(2/2)

- Services for ensuring system operations
  - Resource allocation – allocating resources to multiple users or multiple jobs running at the same time.
  - Accounting – keep track of which users use how much and what kinds of computer resources.
  - Protection – ensuring that all access to system resources is controlled and recording all the connections for detection of break-ins.

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# Operating System Interfaces(1/3)

- Interfaces to Users
  - Command-Line Interface – text commands
  - Batch Interface – files including some commands
  - Graphical User Interface – window system
    - Mouse-based window and menu
  - Many systems now include both CLI and GUI interfaces
    - Microsoft Windows is GUI with CLI "command" shell
    - Apple Mac OS X as "Aqua" GUI interface with UNIX kernel underneath and shells available
    - Linux is CLI with optional GUI interfaces (Java Desktop, KDE)

# Operating System Interfaces(2/3)

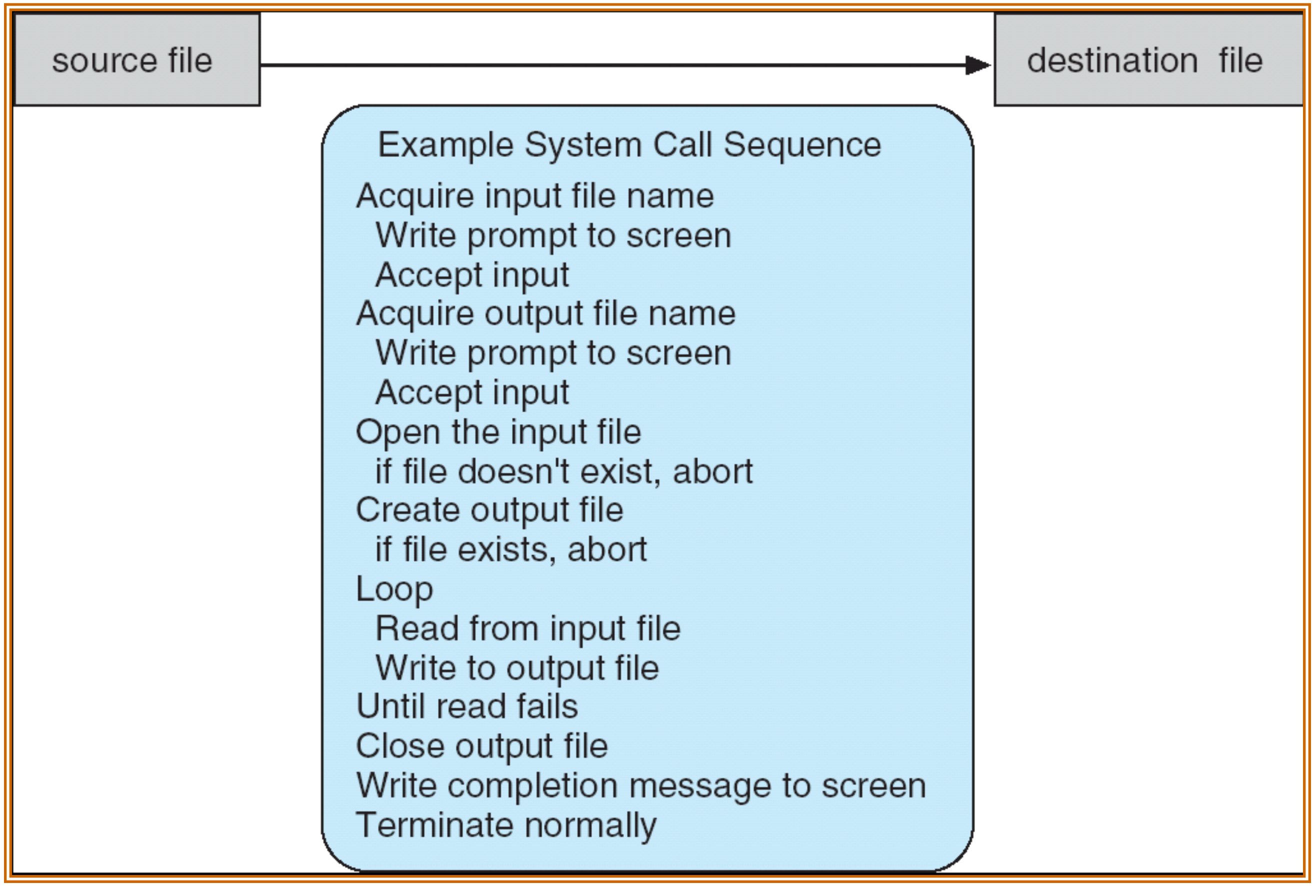
- **Command-line Interpreter (Shell)**
  - **The program that reads and interprets control statements**
  - **DOS OS: command.com**
- **Two ways to implement commands**
  - **Internal Command: The command interpreter itself contains the code to execute the command. (dir, copy)**
  - **External Command: System programs implement most commands. (fdisk, format)**

# Operating System Interfaces(3/3)

- Interfaces to Programs
  - System calls
    - Typically written in assembly-language instructions or a high-level language (C or C++)

# Example of System Calls

- **System call sequence to copy the contents of one file to another file**



# System Call Implementation

- System-call Interface (SCI)
  - Typically, a number associated with each system call
  - System-call interface maintains a table indexed according to these numbers
  - The system call interface invokes intended system call in OS kernel and returns status of the system call and any return values

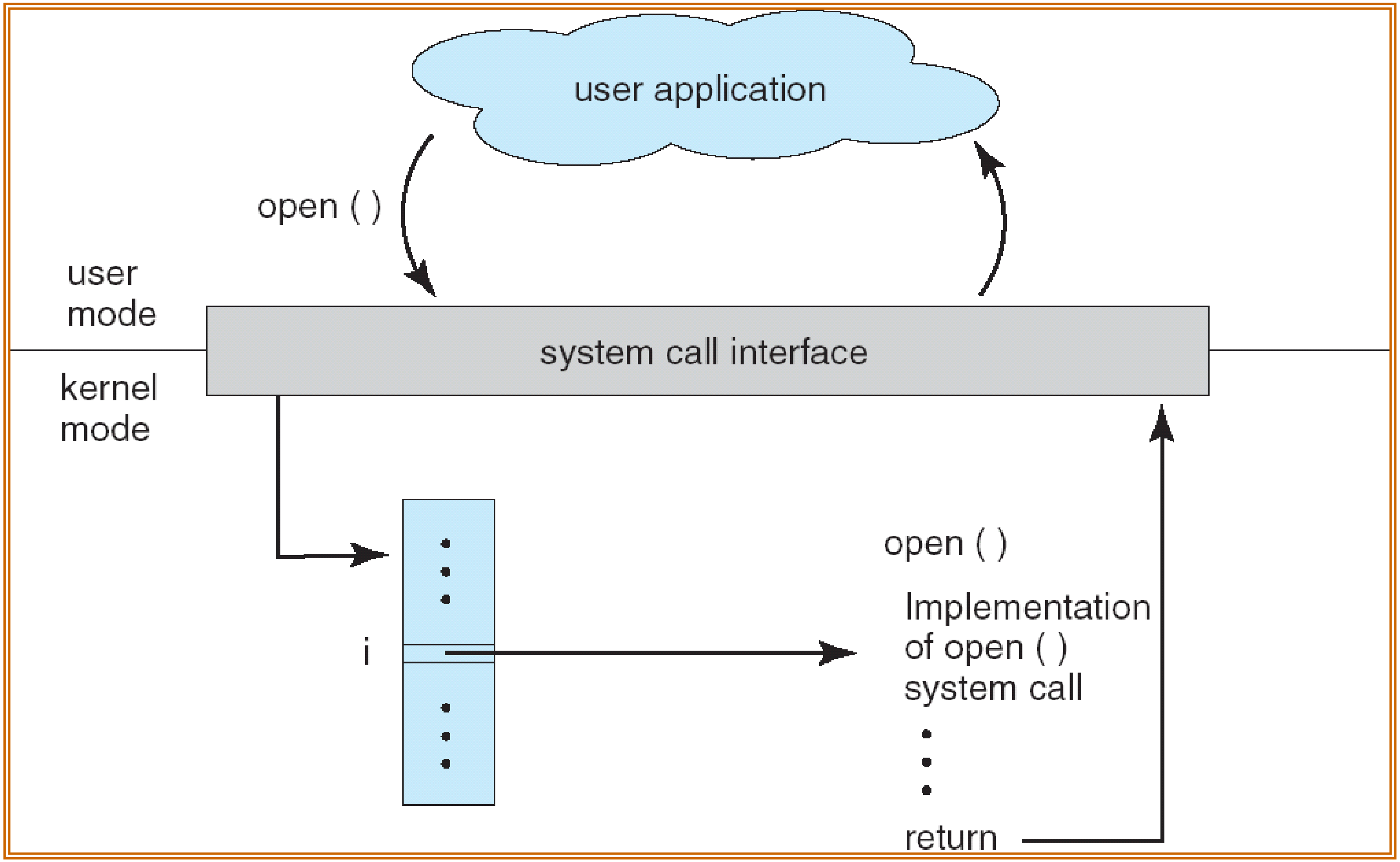
# System Call Implementation

- **Application Programming Interface (API)**
  - **API functions invoke the actual system calls on behalf of the application programmer**
  - **Mostly accessed by programs via a high-level API rather than direct system call use**
  - **Just needs to obey API and understand what OS will do as a result call, most details of OS interface hidden from programmer by API**
  - **APIs are Managed by run-time support library (set of functions built into libraries included with compiler)**

# System Call Implementation

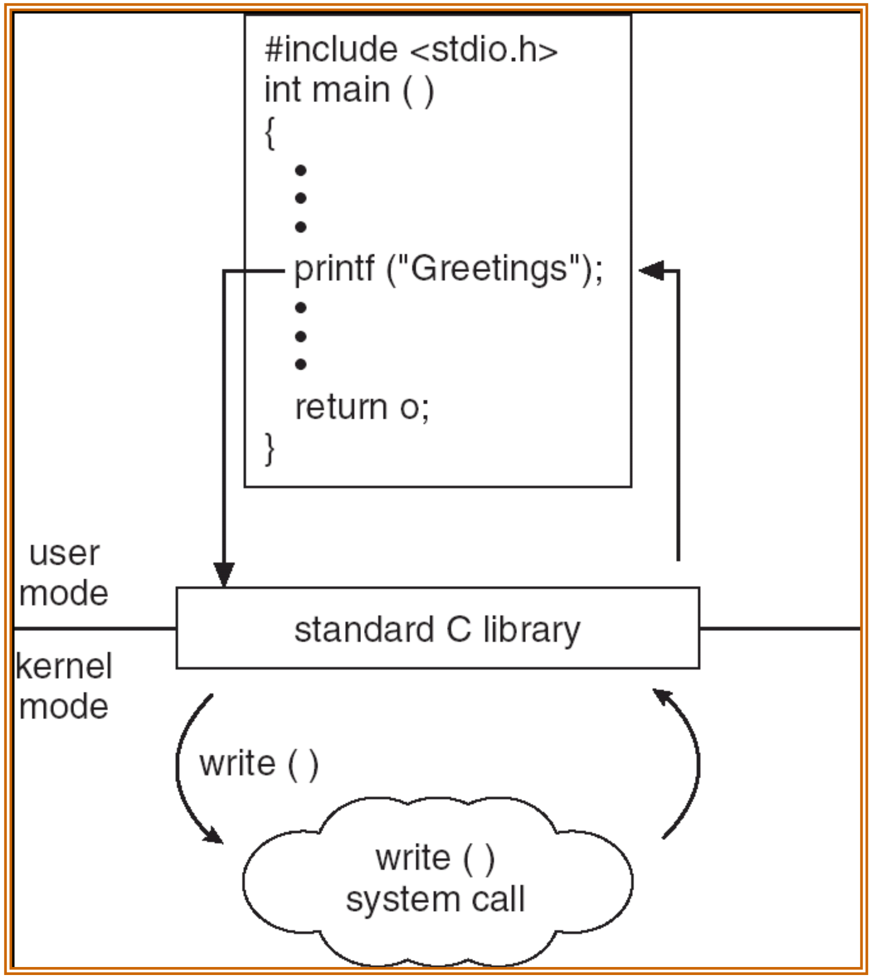
- Three most common APIs
  - **Win32 API** for Windows
  - **POSIX API** for POSIX-based systems (including virtually all versions of UNIX, Linux, and Mac OS X)
  - **Java API** for the Java virtual machine (JVM)

# Relationship between API, SCI, OS



# Standard C Library Example

- C program invoking printf() library call, which calls write() system call



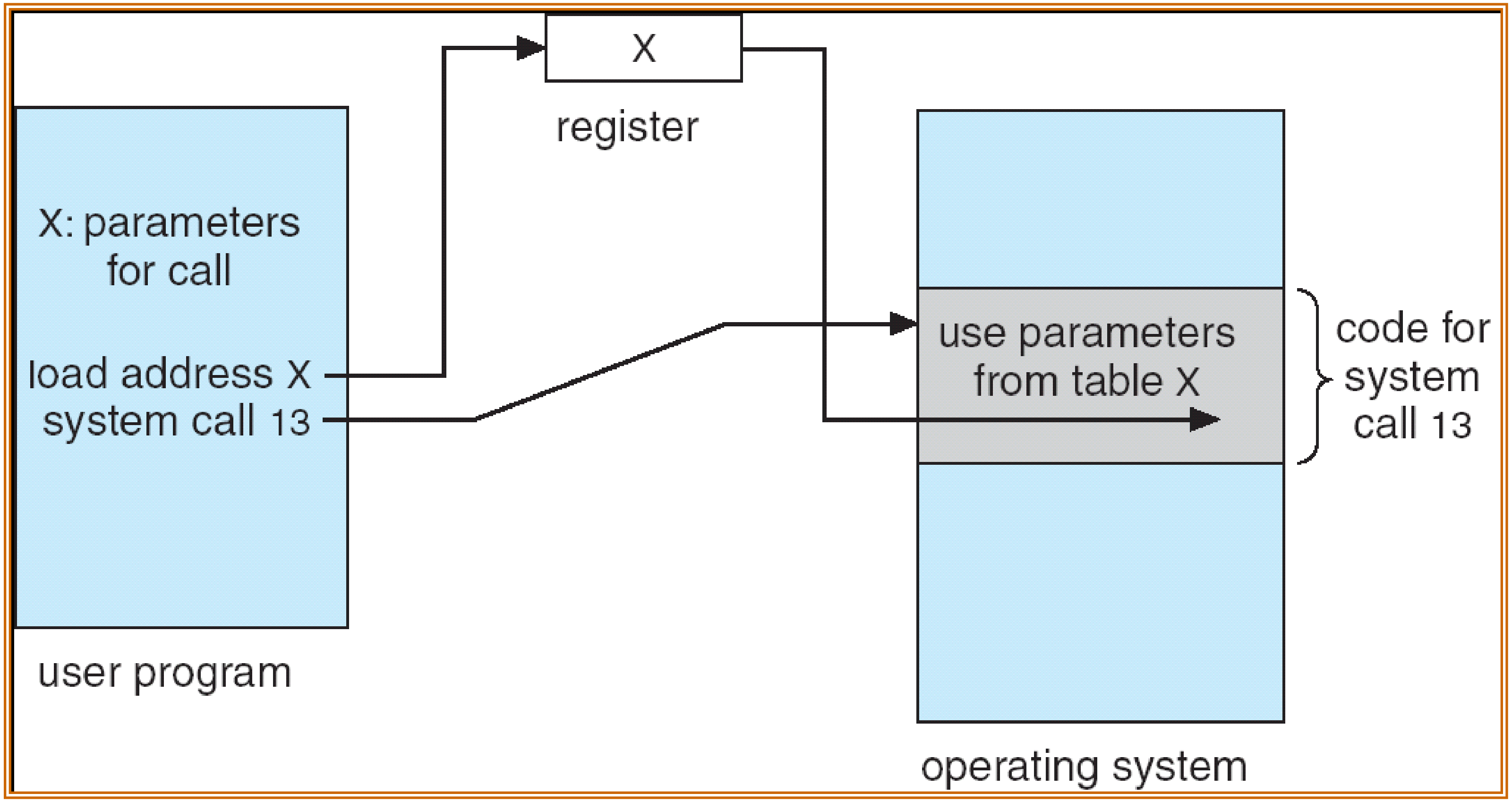
# Discussion

***Why do user use APIs rather than system calls directly?***

# System Call Parameter Passing

- **Often, more information is required than simply identity of desired system call**
- **Three general methods used to pass parameters to the OS**
  - **Simplest: pass the parameters in *registers***
  - **Parameters stored in a *block,* or table, in memory, and address of block passed as a parameter in a register**
  - **Parameters placed, or *pushed,* onto the *stack* by the program and *popped* off the stack by the operating system**

# Parameter Passing via Table



# Types of System Calls

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

# Types of System Calls

- Process control
  - end, abort
  - load, execute
  - create and terminate process
  - get and set process attributes
  - wait for time
  - wait event, signal event
  - allocate and free memory

# Types of System Calls

- File management
  - create and delete file
  - open and close file
  - read, write, reposition
  - get and set file attributes
- Device management
  - request and release file
  - read, write, reposition
  - get and set device attributes
  - logically attach or detach devices

# Types of System Calls

- Information maintenance
  - get and set time or date
  - get and set system data
  - get and set process, file or device attributes
- Communications
  - create and delete communication connection
  - send and receive message
  - transfer status information
  - attach or detach remote devices

# Outline

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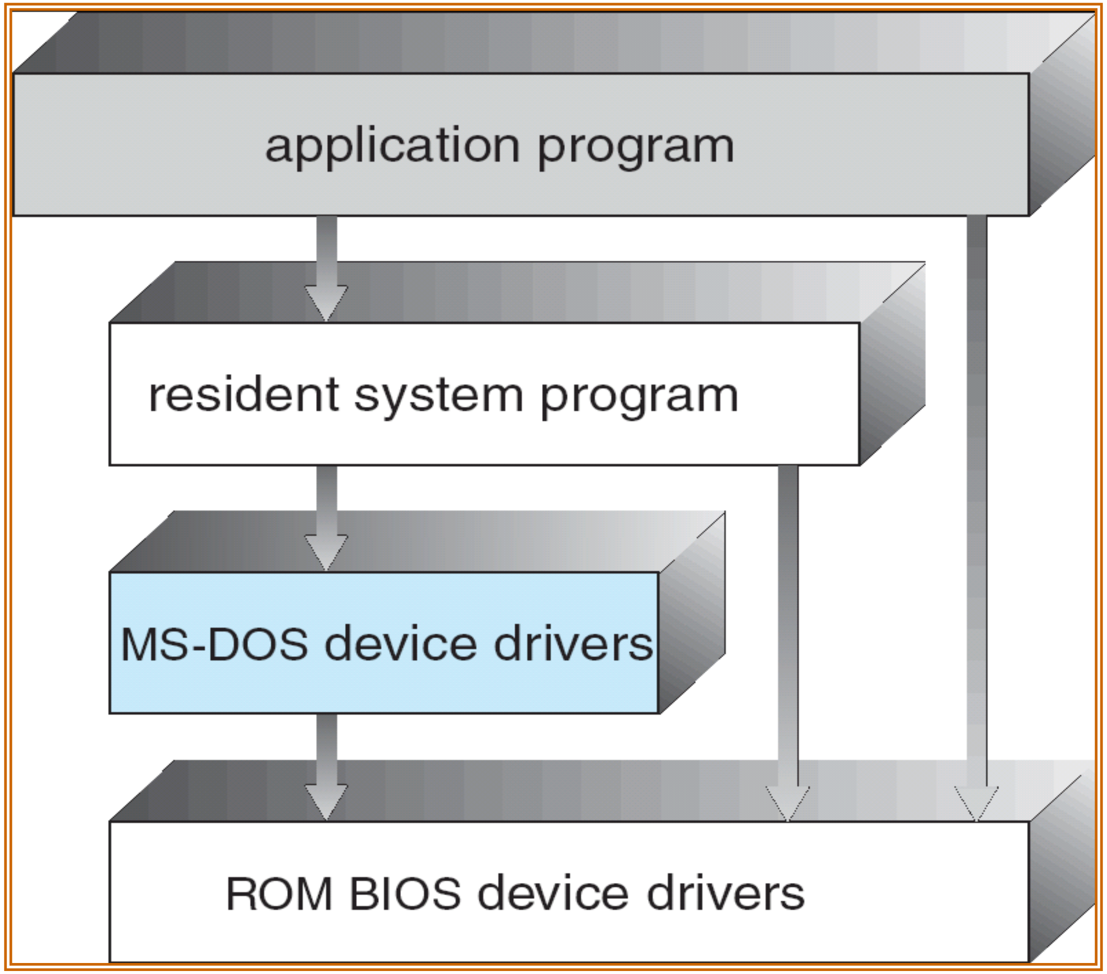
# Operating System Structure

- Simple Structure
- Layered Structure
  - Virtual Machines
- Microkernel Structure
- Modules

# Simple 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**

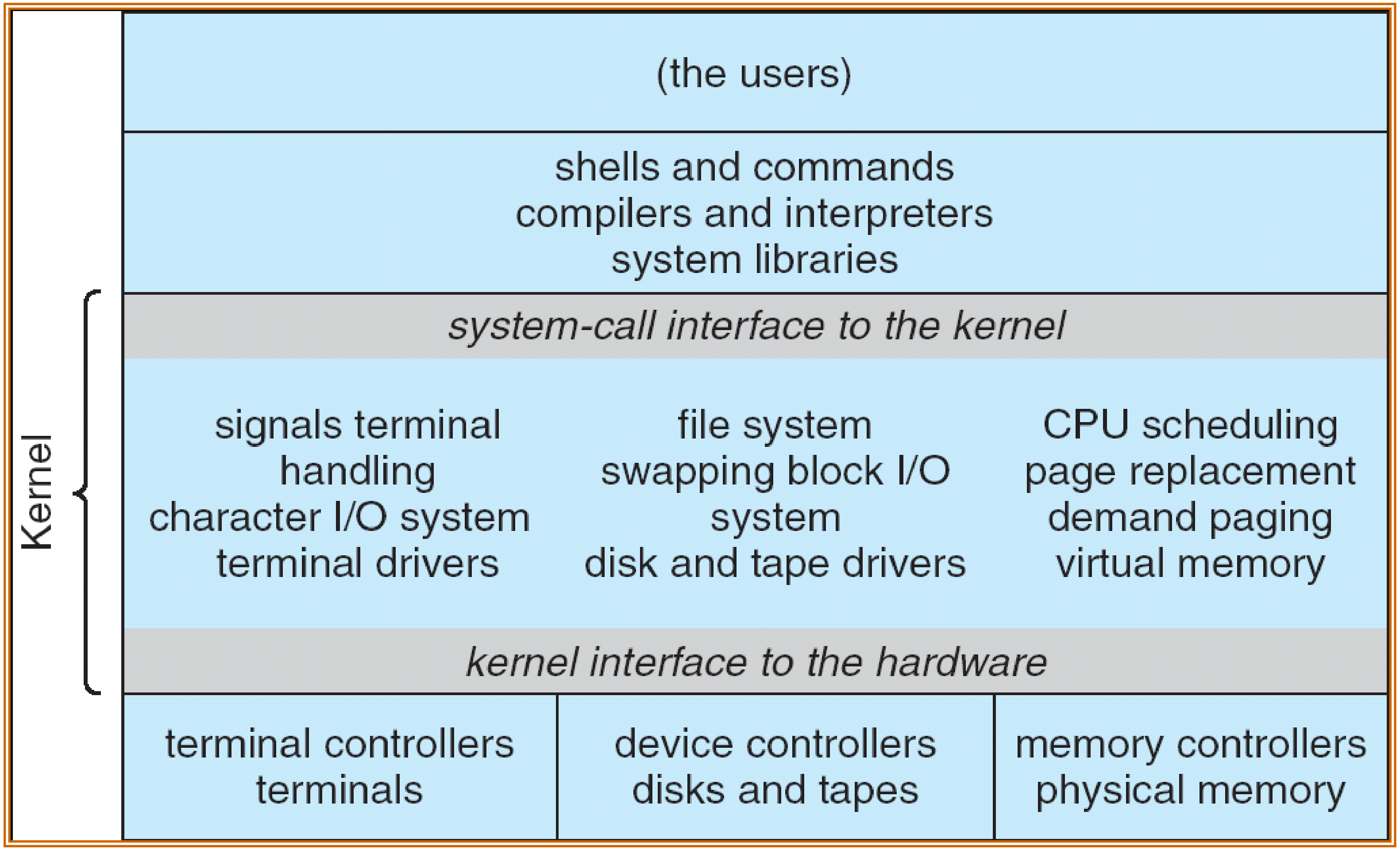
# MS-DOS Layer Structure



# Simple Structure

- Original UNIX
  - Two separable parts
    - Systems programs
    - The kernel: Consists of everything below the system-call interface and above the physical hardware, provides a large number of functions for one level

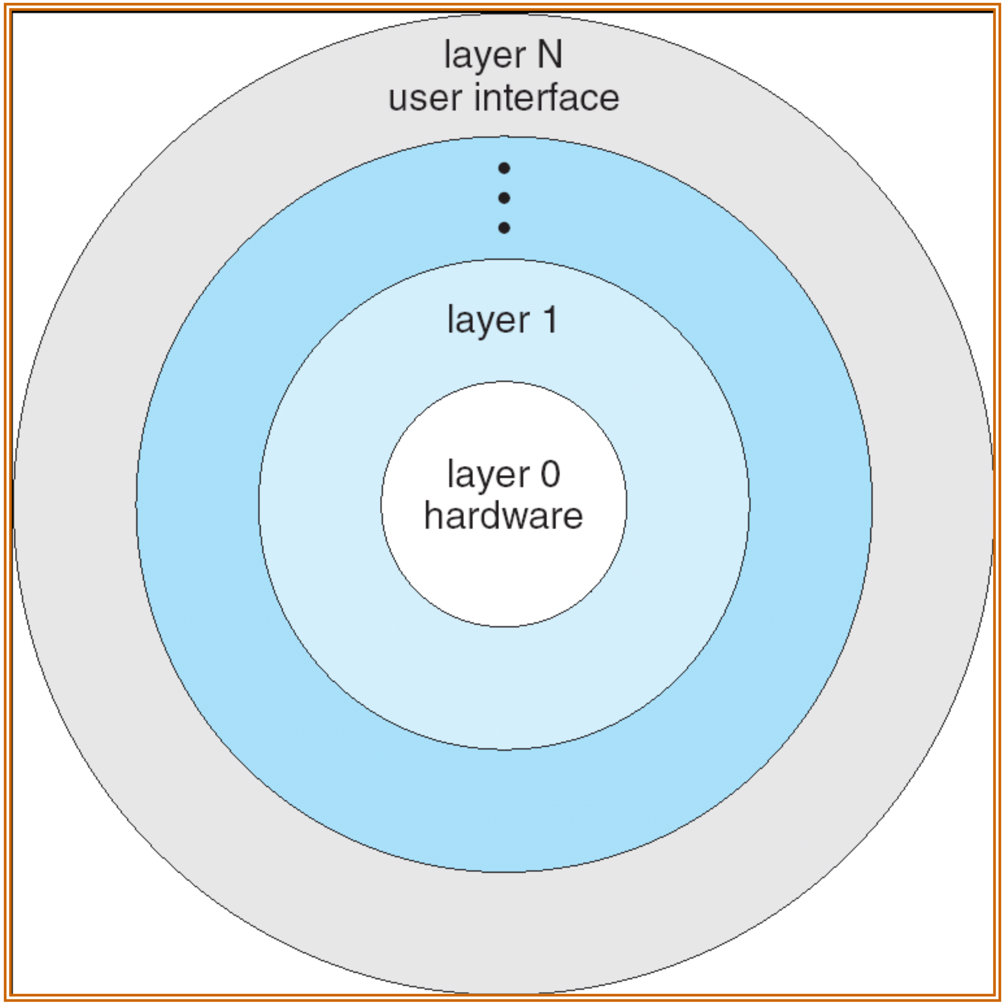
# UNIX System Structure



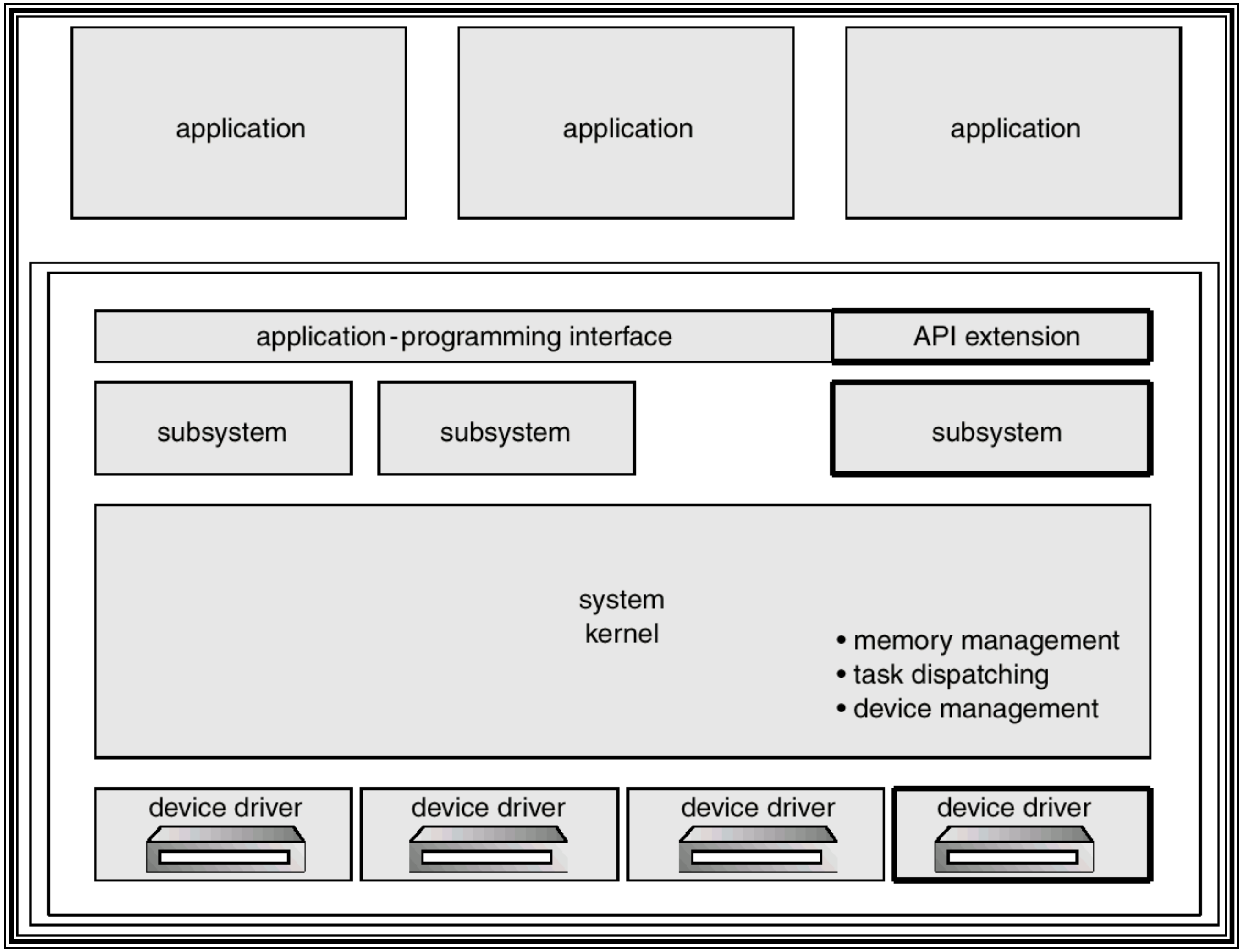
# Layered Structure

- **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**

# Layered Operating System



# OS/2 Layer Structure



# Microkernel Structure

- Moves as much from the kernel into "*user*" space
- Typically, microkernels provide minimal process management, memory management and communication facility
- Communication takes place between user modules using message passing

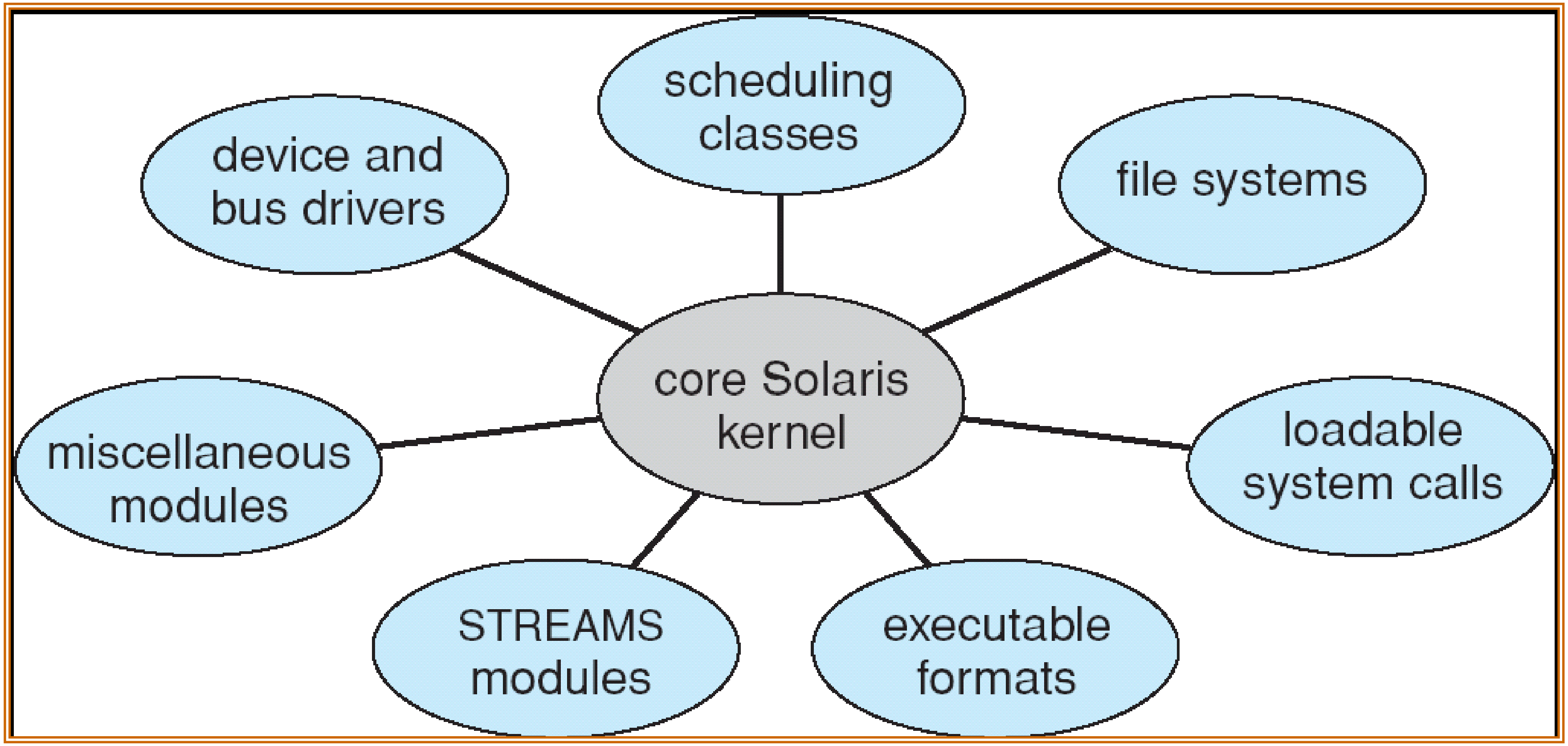
# Microkernel Structure

- Benefits
  - Easier to extend a operating system
  - Easier to port the operating system to new architectures
  - More reliable (less code is running in kernel mode)
  - More secure
- Lacks
  - Performance overhead of user space to kernel space communication

# Modules

- Most modern operating systems implement kernel modules
  - Uses object-oriented approach
  - Each core component is separate
  - Each talks to the others over known interfaces
  - Each is loadable as needed within the kernel
- Overall, similar to layers but with more flexible

# Solaris Modular Approach



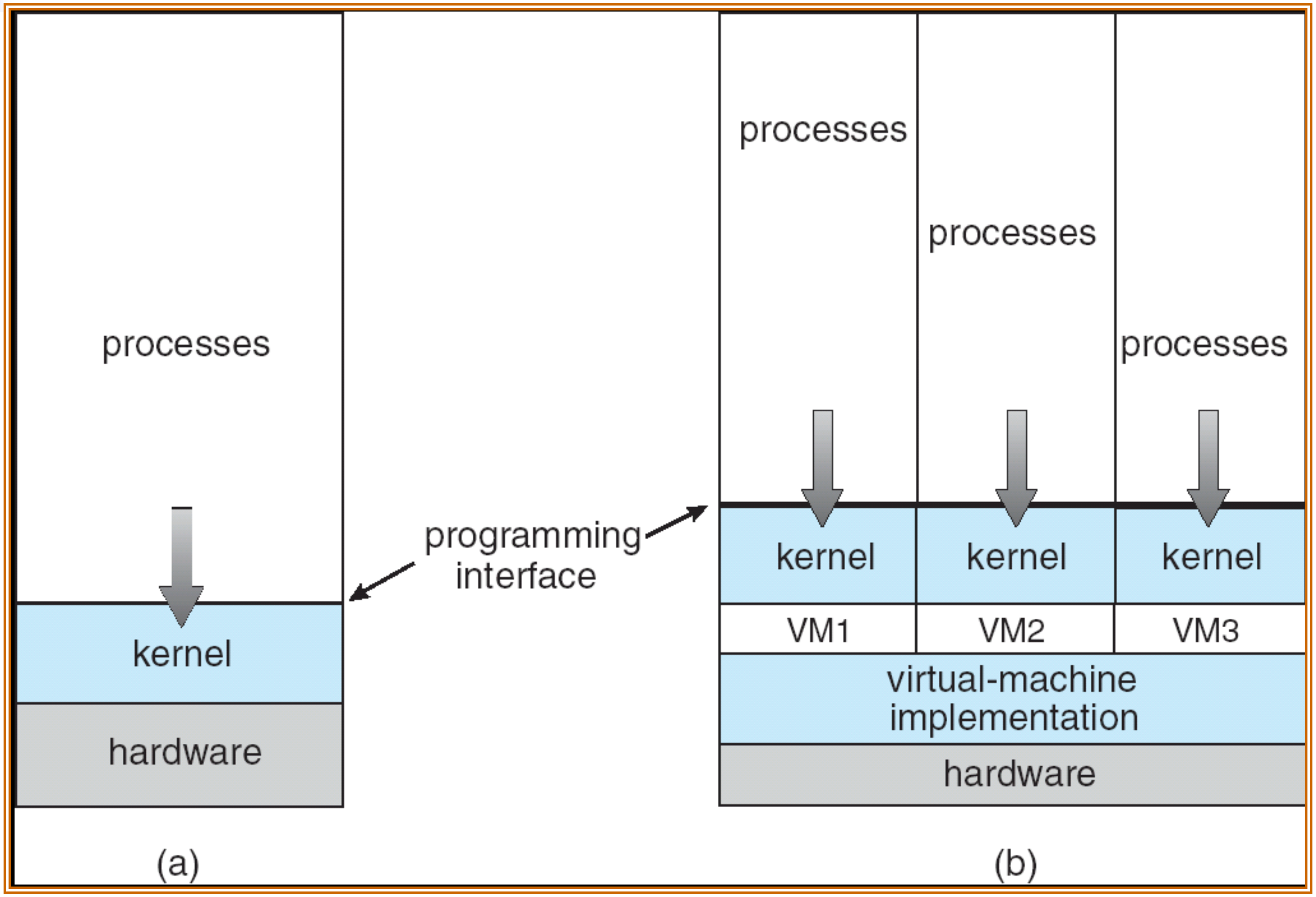
# 作业1

设计操作系统时采用的模块化内核方法和分层方法在那些方面类似？哪些方面不同？

# 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



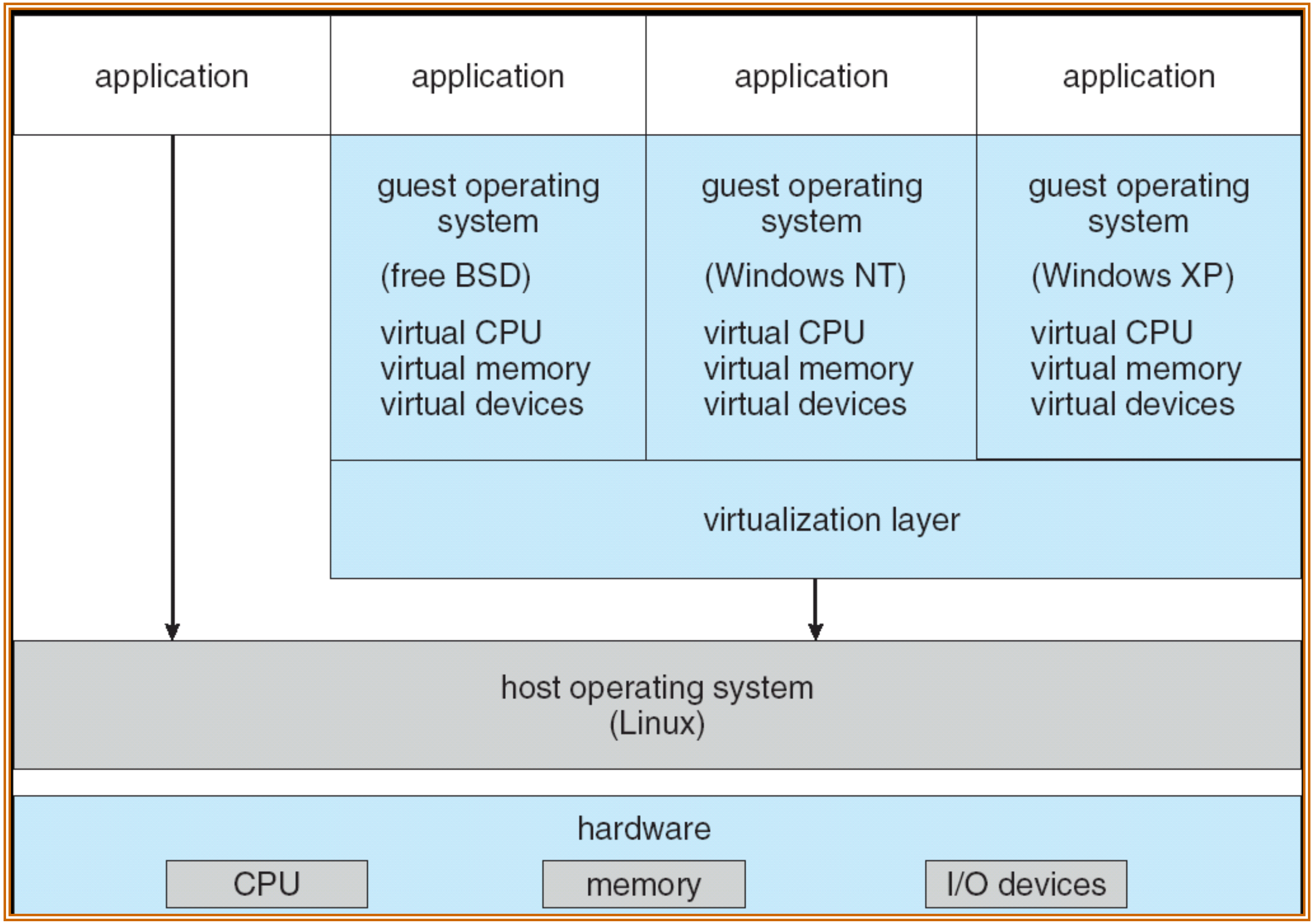
# Virtual Machines

- 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 Machines

- Advantages
  - Providing complete protection of system resources
    - Each virtual machine is isolated from all other virtual machines.  This isolation, however, permits no direct sharing of resources.
  - Being able to share the same hardware yet run different operating systems concurrently
  - A perfect vehicle for operating-systems research and development
    - System development is done on the virtual machine, so does not disrupt normal system operation.

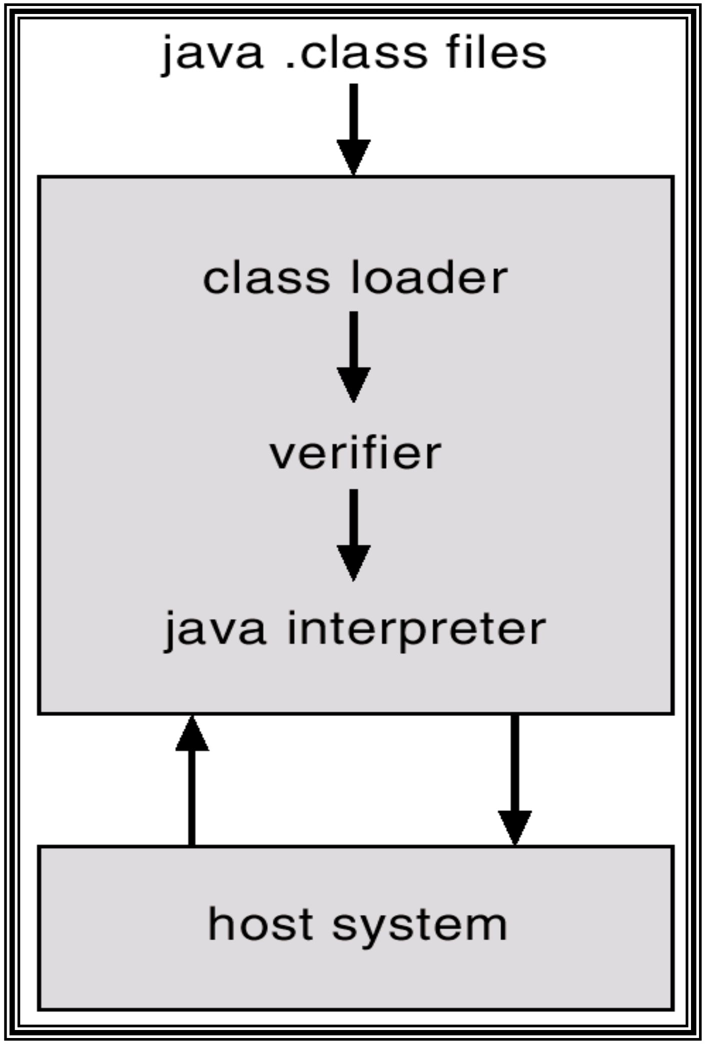
# VMware Architecture



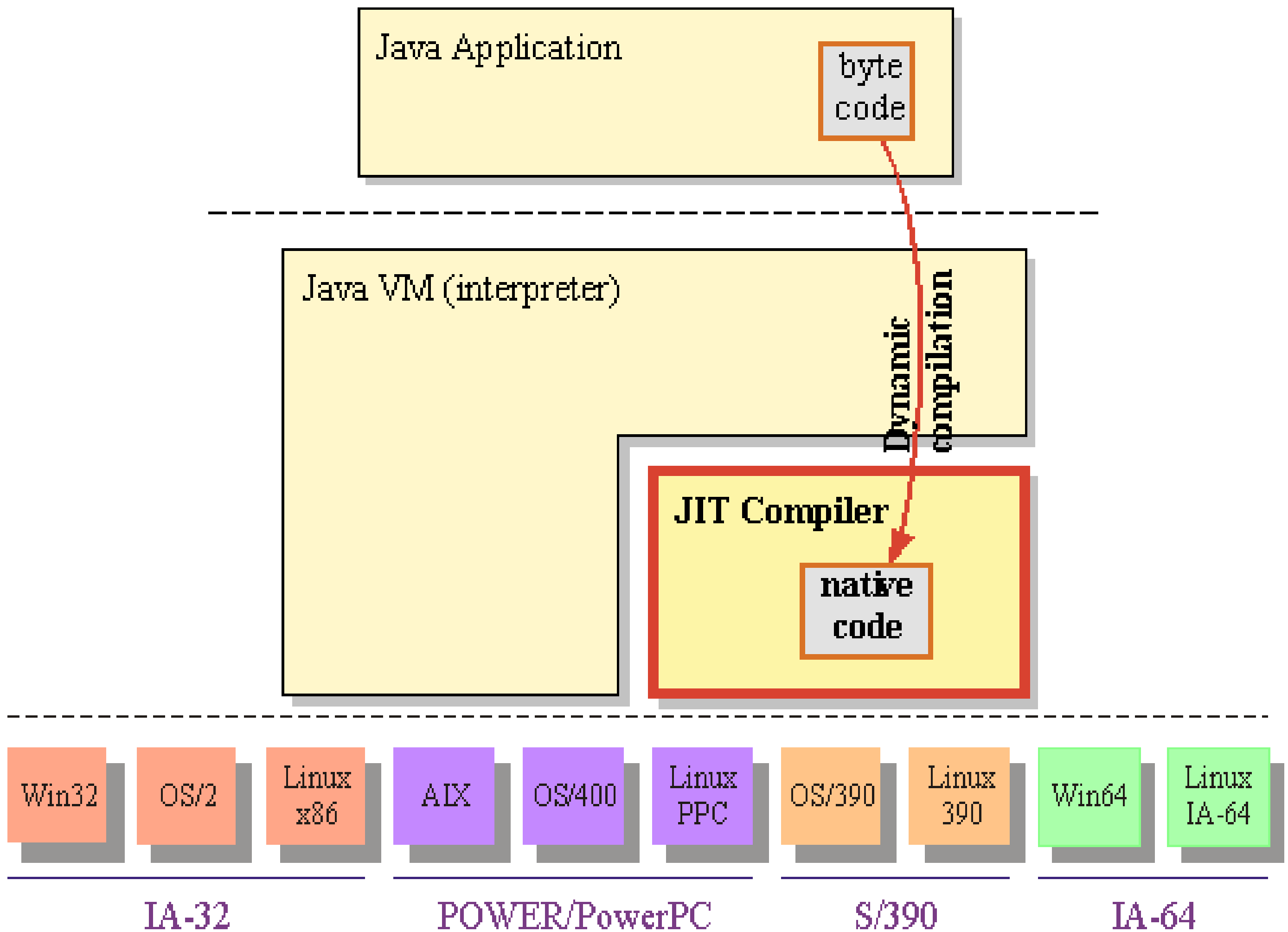
# Java Virtual Machine

- Compiled Java programs are platform-neutral bytecodes executed by a Java Virtual Machine (JVM).
- JVM consists of
  - class loader
  - class verifier
  - runtime interpreter
- Just-In-Time (JIT) compilers increase performance

# Java Virtual Machine



# Java Virtual Machine



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- **Operating System Functions**
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- **Operating System Design and Implementation**

# Operating System Design and Implementation

- Design and Implementation of OS not "solvable", but some approaches have proven successful
- Internal structure of different Operating Systems can vary widely
- Start by defining goals and specifications
- Affected by choice of hardware, type of system

# Operating System Design and Implementation

- Design goals
  - User goals – operating system should be convenient to use, easy to learn, reliable, safe, and fast
  - System goals – operating system should be easy to design, implement, and maintain, as well as flexible, reliable, error-free, and efficient

# Operating System Design and Implementation

- Important principle to separate
  - Policy: What will be done?
  - Mechanism: How to do it?
  - The separation of policy from mechanism is a very important principle, it allows maximum flexibility if policy decisions are to be changed later

# Operating System Design and Implementation

- Written mostly in C or C++
  - Advantage — being far easier to port
  - Disadvantage — reduced speed and increased storage requirements
- Some small sections of assembly code for device drivers and for saving and restoring the state of registers

# Part 1 小结（1/2）

- 操作系统概念（管理各种资源、支持程序运行、方便用户使用的程序集）
- 操作系统的基本目标（方便性与高效性）
- 引导程序、中断、中断处理程序、中断向量
- 存储结构：内存（小、易失）、二级存储（大、非易失）、分层结构
- I/O结构：设备控制器（本地缓冲）、DMA
- 硬件保护：双重模式操作、特权指令、I/O保护、内存保护、CPU保护

# Part 1 小结（2/2）

- 操作系统的发展（大型机（无OS、批处理、多道程序设计（并发性、共享性、虚拟性、异步性）、分时）——桌面——并行（紧耦合）——分布式（松耦合，集群）——专用（实时、手持））
- 操作系统的功能：进程（CPU）管理、内存管理、磁盘管理、文件管理、I/O管理、用户接口
- 操作系统的服务：程序执行、I/O操作、文件系统操作、通信、错误检测与处理、资源分配、统计、保护
- 操作系统的接口：用户接口（CLI、GUI）+程序接口（系统调用（参数传递、类型）、SCI、API）
- 操作系统的结构：简单结构、分层结构（虚拟机）、微核结构（进程管理、内存管理、通信功能）、模块化