



Operating System Concepts

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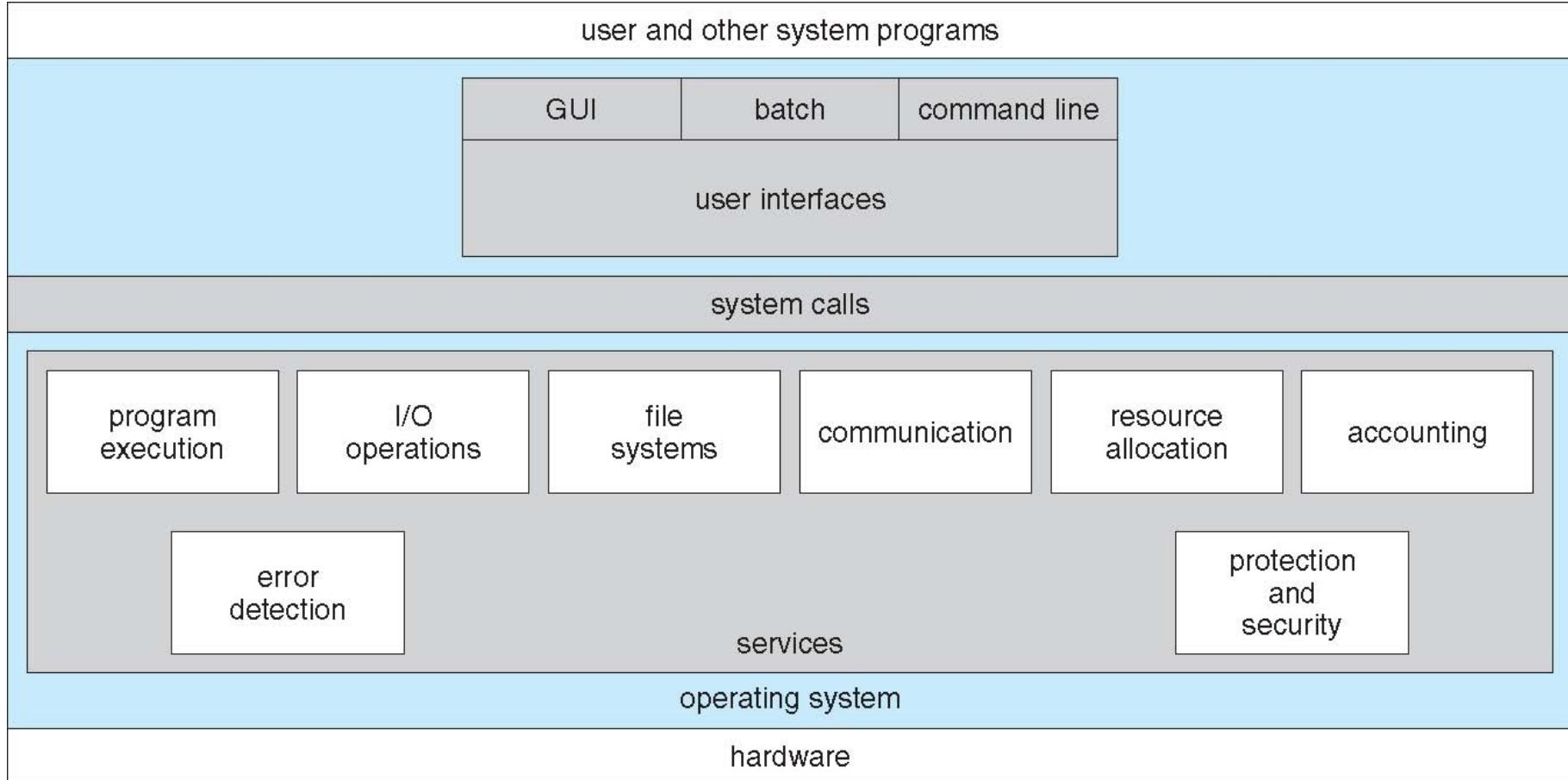
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Chapter 2. System Structures

A View of Operating System Services



Operation-System Services (1 / 3)

- ▶ User Interface (UI)
 - Command line Interface, batch interface, graphical user interface (GUI), etc.
 - Interface between the user and the operating system
 - Friendly UI's
 - Command-line-based interfaces or mused-based window-and-menu interface
 - For example, UNIX shell and command.com in MS-DOS
- ▶ Program Execution
 - Loading, running, terminating, etc.

Operation-System Services (2/3)

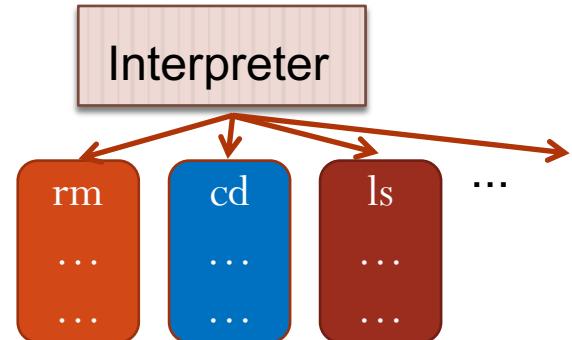
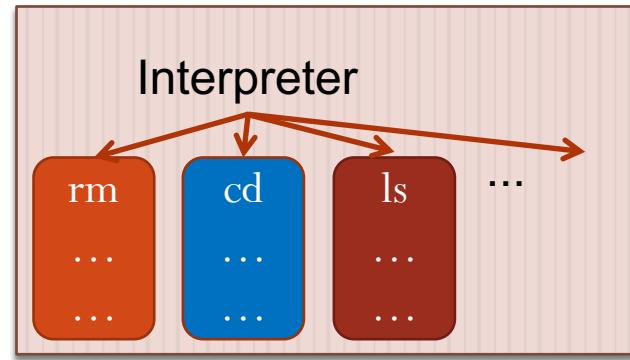
- ▶ I/O Operations
 - General/special operations for devices
 - Efficiency & protection
- ▶ File-System Manipulation
 - Read, write, create, delete, etc.
 - File and Directory Management
 - Permission Management
- ▶ Communications
 - Intra-processor or inter-processor communication
 - Shared memory or message passing

Operation-System Services (3/3)

- ▶ Error Detection
 - Possible errors from CPU, memory, devices, user programs
→ Ensure correct & consistent computing
- ▶ Resource Allocation
 - Multiple users might use some shared resources
 - Resource management has to be efficiency
- ▶ Accounting
 - Statistics or accounting
- ▶ Protection and Security
 - Ensure that all access to system resources is controlled
 - Enforce that all requests are authenticated

User OS Interface— Command Interpreter

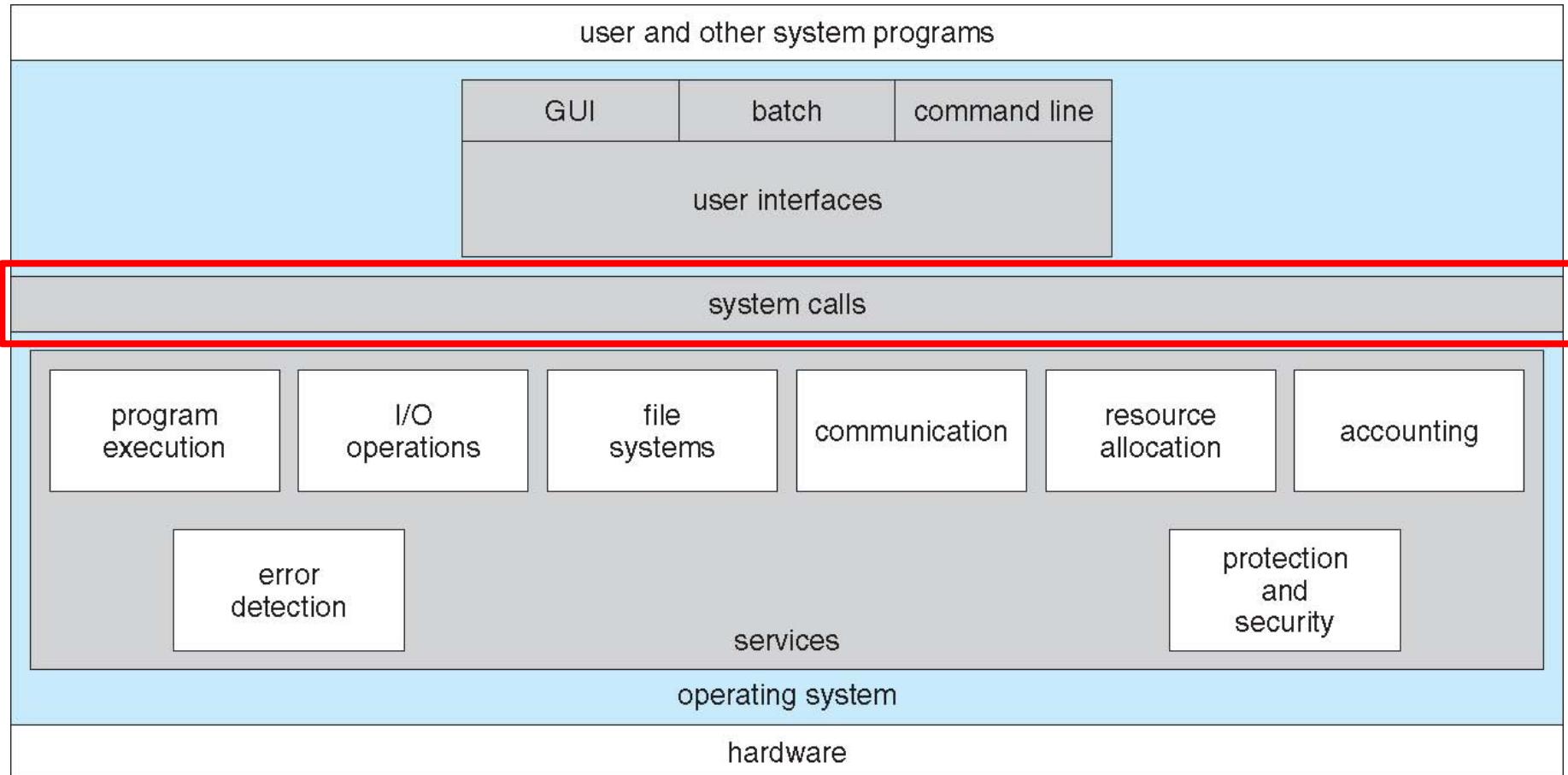
- ▶ Two Approaches to Implement a Command-Line Interpreter (CLI):
 - Contain codes to execute commands
 - Fast but the interpreter tends to be big
 - Painful in revision
 - Implement commands as system programs → Search programs which correspond to the commands (UNIX)
 - Using parameter passing
 - Being slow
 - Inconsistent interpretation of parameters



User OS Interface— GUI

- ▶ Components
 - Screen, icons, folders, pointer, etc.
- ▶ History
 - Xerox PARC research facility (1970's)
 - Mouse— 1968
 - Mac OS— 1980's
 - Windows 1.0~ 10
- ▶ Trends
 - Mixture of GUI and command-line interfaces
 - Multimedia, intelligence, etc.

System Calls in an OS



System Calls (1/2)

- ▶ System Calls
 - Interface between user processes and the OS
- ▶ Application Programming Interface (API)
 - Most details of OS interface hidden from programmer by API
 - Examples:
 - Win32 API for Windows
 - POSIX* API for POSIX-based systems including UNIX, Linux, and Mac OS X
 - Benefits (API vs System Calls)
 - Good portability, Ease of use, and Better functionality

*POSIX: Portable Operating System Interface

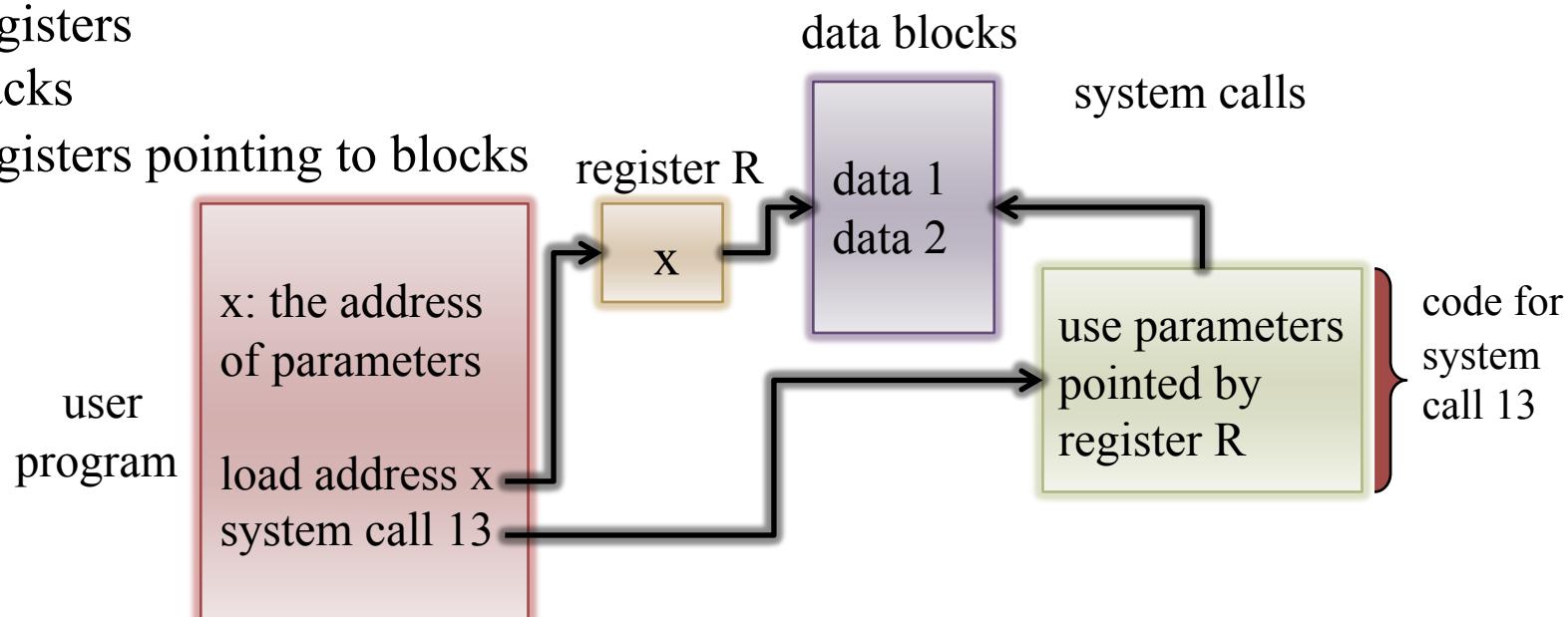


System Calls (2/2)

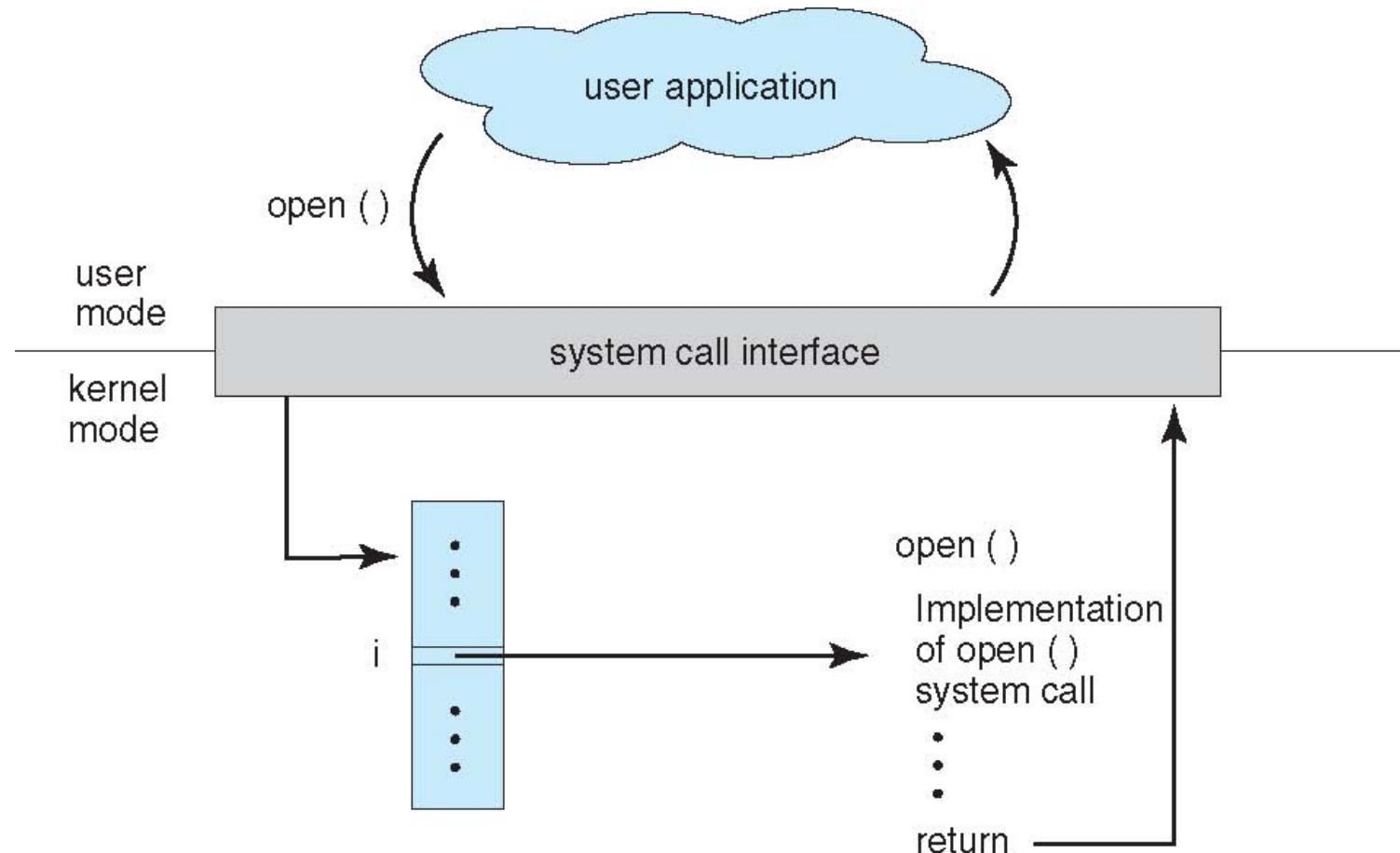
- ▶ Triggering a System Call
 - Use a special instruction supported by the hardware
 - For Intel x86, it is “int 0x80”
 - Provide the type and parameters of the system call

▶ Parameter Passing

- Registers
- Stacks
- Registers pointing to blocks

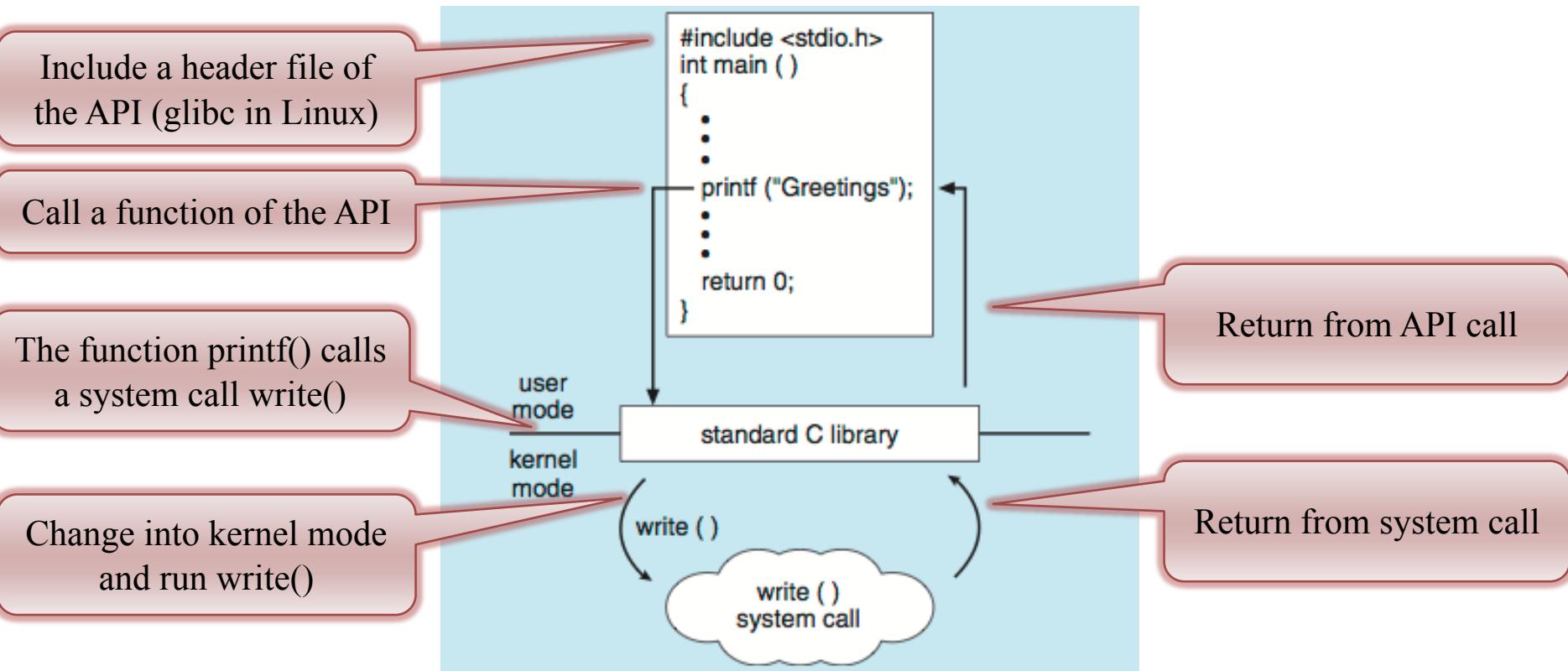


Relationship of System Call and OS



API, System Call and OS

- ▶ A C program can invoke printf() in the library (API)
- ▶ In the API implementation, printf() calls write() system call



Types of System Calls

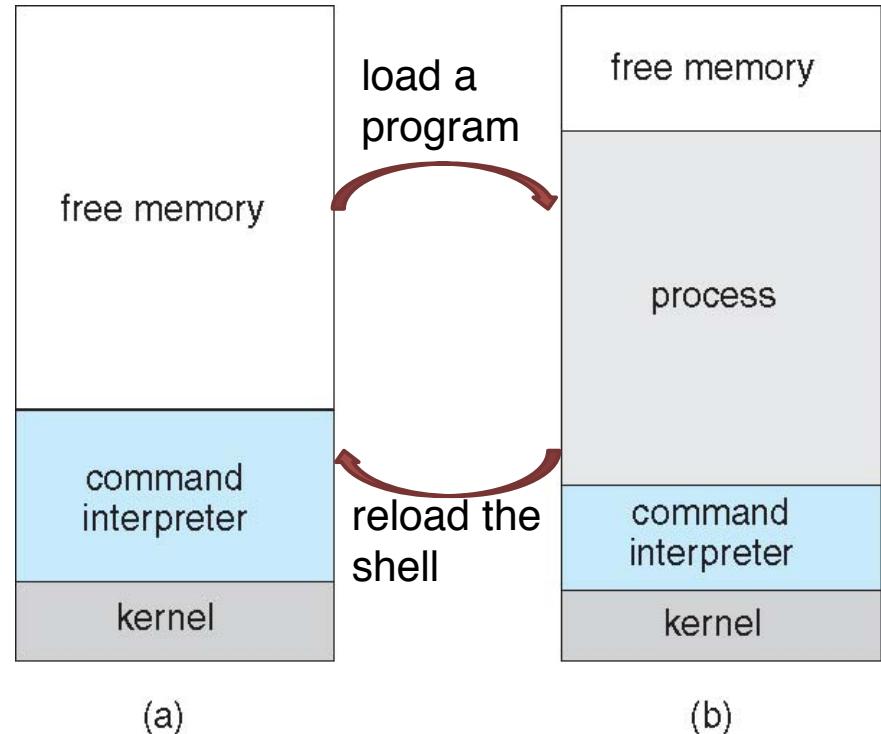
- ▶ Process Control
- ▶ File Management
- ▶ Device Management
- ▶ Information Maintenance
- ▶ Communications
- ▶ Protection

System Calls— Process Control (1 / 3)

- ▶ Load and execute
 - Have to return the control
- ▶ End (normal exit) or abort (abnormal)
 - Error level or no
 - Interactive, batch, GUI-supported systems
- ▶ Creation and/or termination of other processes
 - To support the techniques of multiprogramming and timesharing mentioned in Chapter 1
- ▶ Get process attributes, set process attributes
- ▶ Wait for time, wait event, signal event
- ▶ Allocate and free memory

System Calls— Process Control (2/3)

- ▶ Example: MS-DOS
 - Single-tasking
 - Shell is invoked when system is booted
 - Single memory space
 - Loads program into memory, overwriting all but the kernel
 - Program exit → shell reloaded

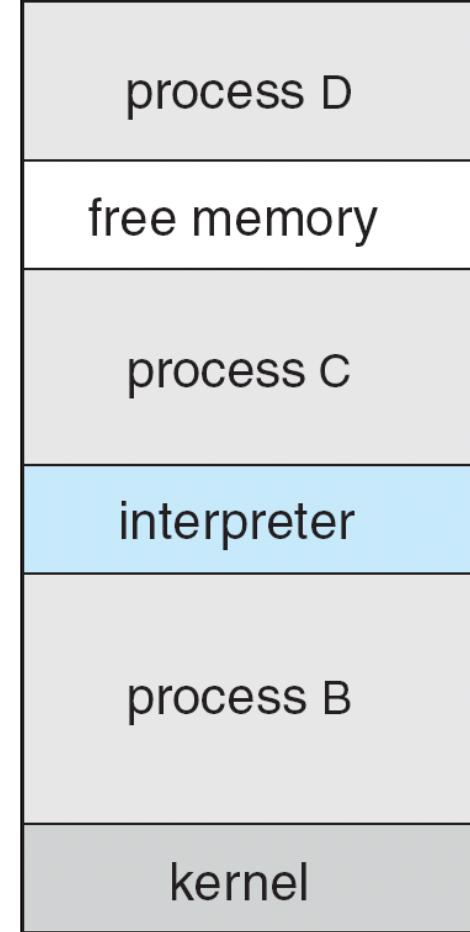


(a) At system startup (b) running a program

System Calls— Process Control (3/3)

▶ Example: FreeBSD

- Multitasking
- OS invokes user's choice of shell
- Shell executes fork() system call to create process
- OS loads program into process
- Shell waits for process to terminate or continues with user commands
- Process exits with return code
 - with code of 0 → no error
 - with code > 0 → error code



System Calls— File Management

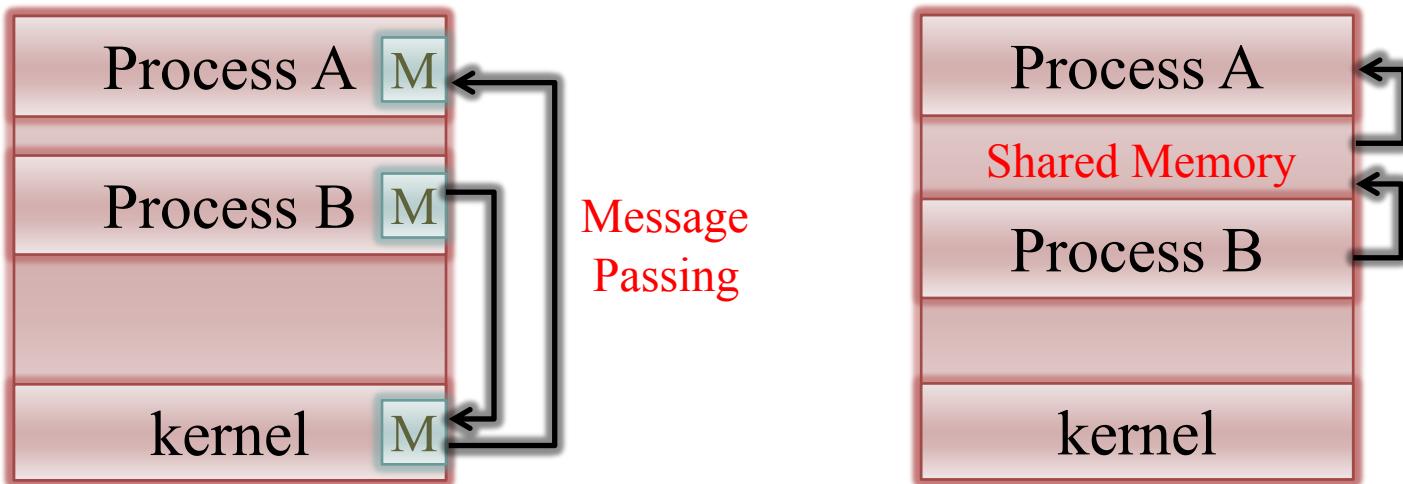
- ▶ Create and delete
- ▶ Open and close
- ▶ Read, write, and reposition (e.g., rewinding)
- ▶ Get or set attributes of files
- ▶ Operations for directories

System Calls— Device Management

- ▶ Request device, release device
- ▶ Read, write, reposition
- ▶ Get device attributes, set device attributes
- ▶ Logically attach or detach devices

System Calls— Communications

- ▶ Message Passing
 - Open, close, accept connections
 - No access conflict and easy implementation
- ▶ Shared Memory
 - Memory mapping and process synchronization
 - Short latency and high throughput



System Calls— Information Maintenance and Protection

- ▶ Information Maintenance
 - Get time or date, set time or date
 - Get system data, set system data
- ▶ Protection
 - Control access to resources
 - Get and set permissions
 - Allow and deny user access

System Programs

- ▶ Goal:
 - Provide a convenient environment for program development and execution
- ▶ Types
 - File Management, e.g., rm
 - Status information, e.g., date
 - File Modifications, e.g., editors
 - Program Loading and Executions, e.g., loader
 - Programming Language Supports, e.g., compilers
 - Communications, e.g., telnet



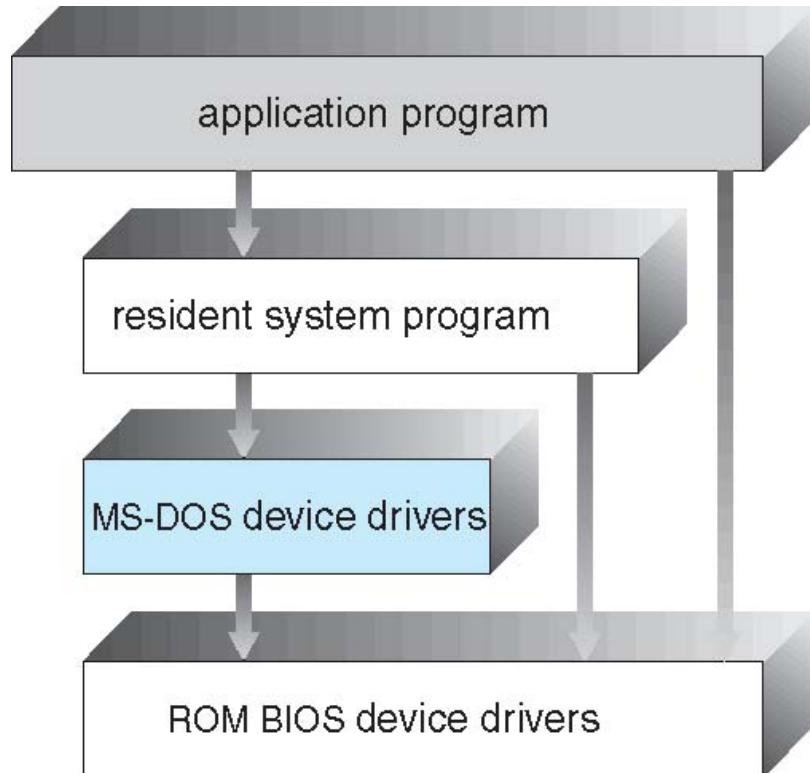
Policies and Approaches of OS Implementation

Operating System Design and Implementation

- ▶ Design Goals and Specifications
 - User goals: ease of use, short latency
 - System goals: reliable, high utilization
- ▶ Separation of Policy and Mechanism
 - Policy: What will be done
 - Mechanism : How to do things
- ▶ OS Implementation in High-Level Languages
 - Advantages:
 - Being easy to understand and debug
 - Being written fast, more compact, and portable
 - Disadvantages:
 - Less efficient
 - Larger size

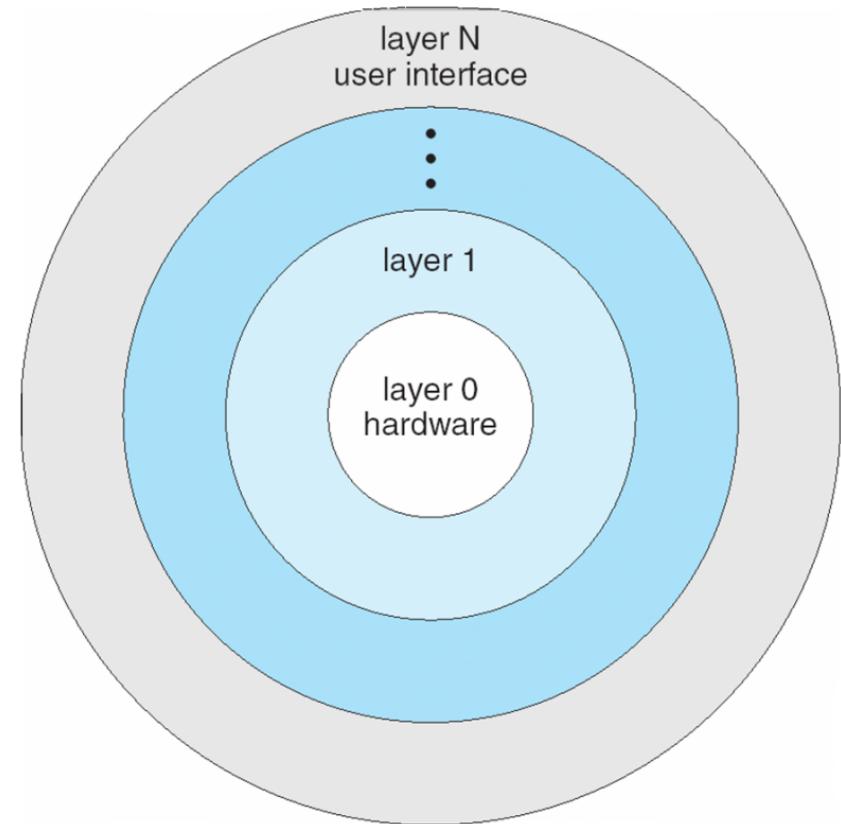
Operating System Structure— MS-DOS

- ▶ Not divided into modules
- ▶ Although MS-DOS has some structure, its interfaces and levels of functionality are not well separated



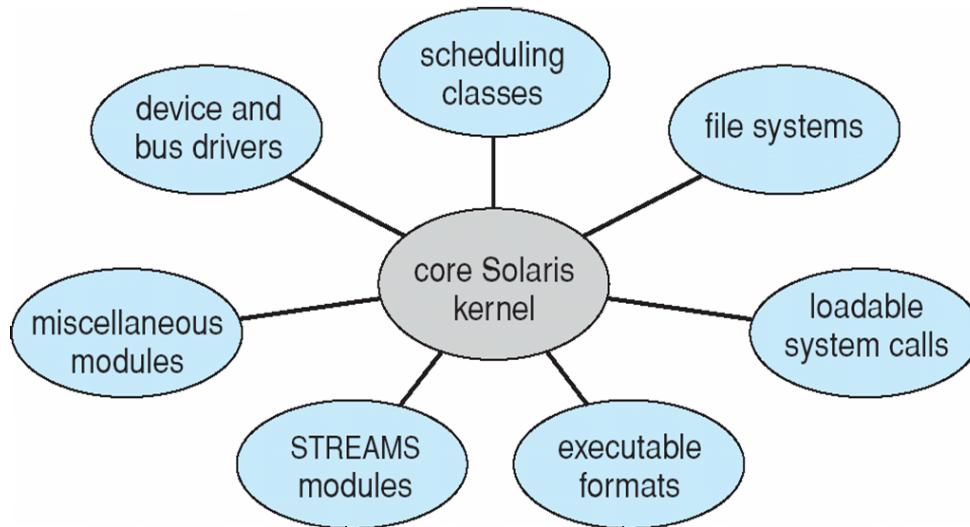
Operating System Structure— Layered Approach

- ▶ Advantage: Modularity
 - Debugging & Verification
- ▶ Difficulty: Appropriate layer definitions, less efficiency due to overheads
- ▶ A Layer Definition Example:
 - L5 User programs
 - L4 I/O buffering
 - L3 Operator-console device driver
 - L2 Memory management
 - L1 CPU scheduling
 - L0 Hardware



OS Structure— Modules

- ▶ Most modern operating systems implement loadable kernel modules
 - Uses object-oriented approach
 - Each core component is separate
- ▶ Solaris Modular Approach

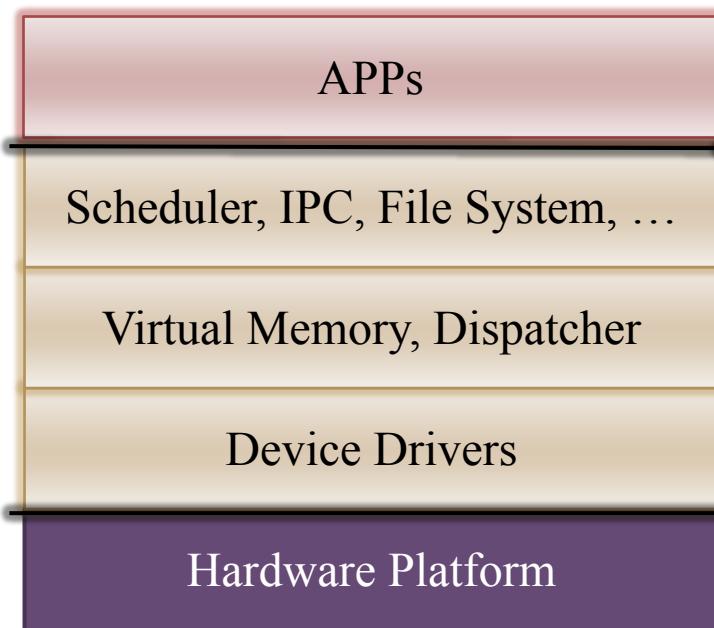


OS Structure— Microkernels

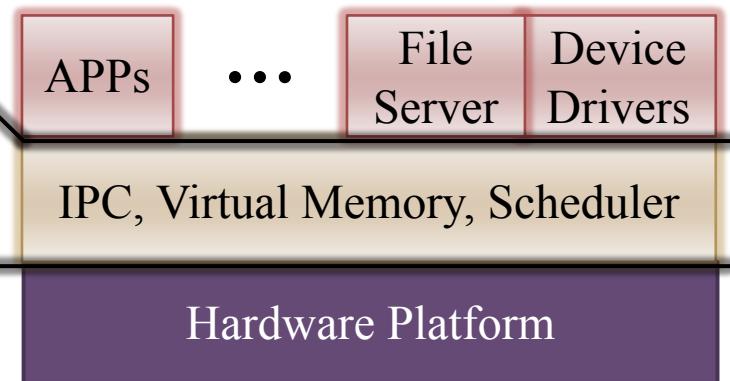
- ▶ The concept of microkernels was proposed in CMU in mid 1980s (Mach)
 - Moving all nonessential components from the kernel to the user or system programs
- ▶ Benefits
 - Ease of OS service extensions → portability, reliability, security
- ▶ Examples
 - Tru64 UNIX (Mach kernel), MacOS X (Darwin kernel), L4 Microkernel

Monolithic Kernel and Microkernel

Monolithic Kernel



Microkernel

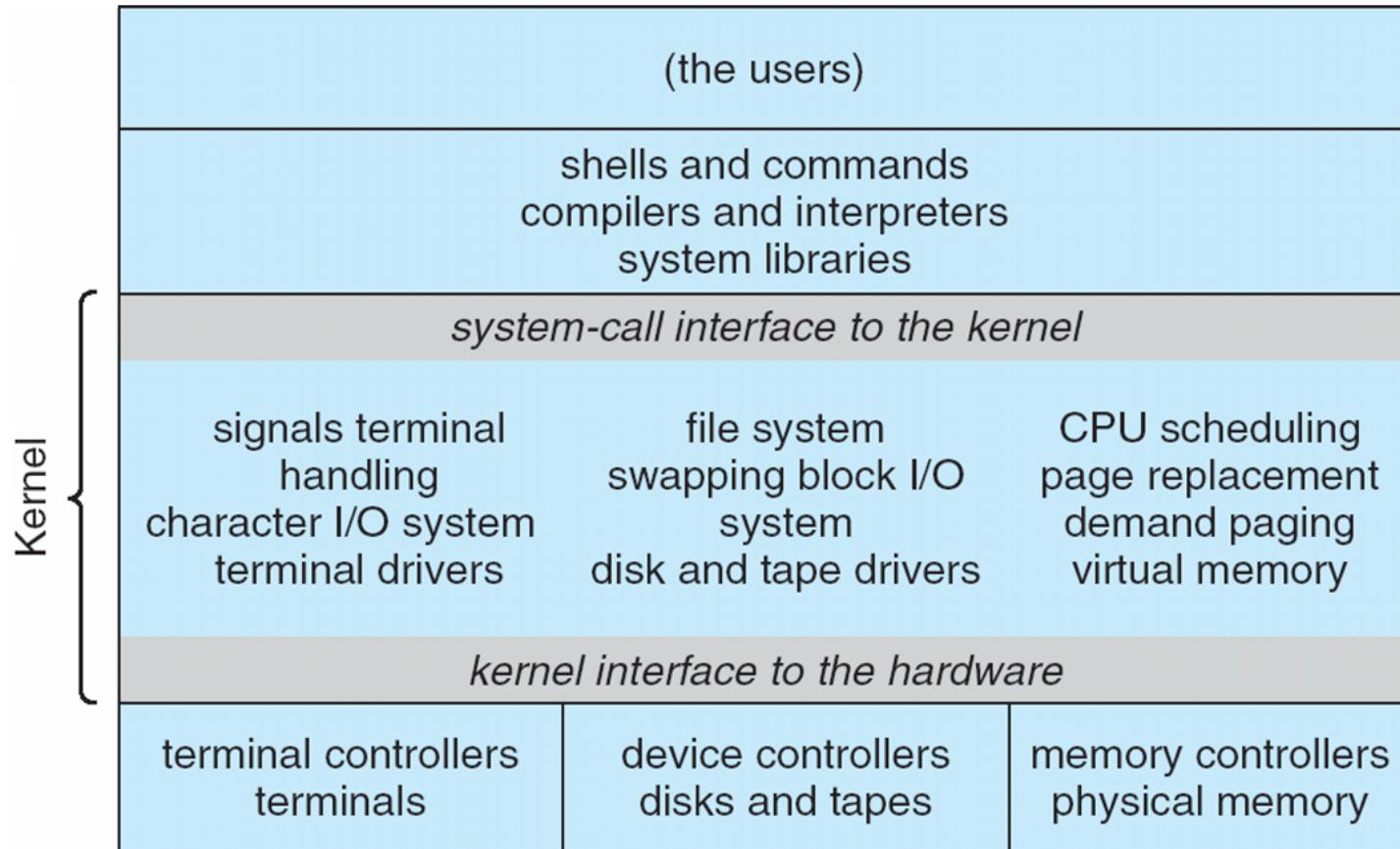


Hybrid Systems

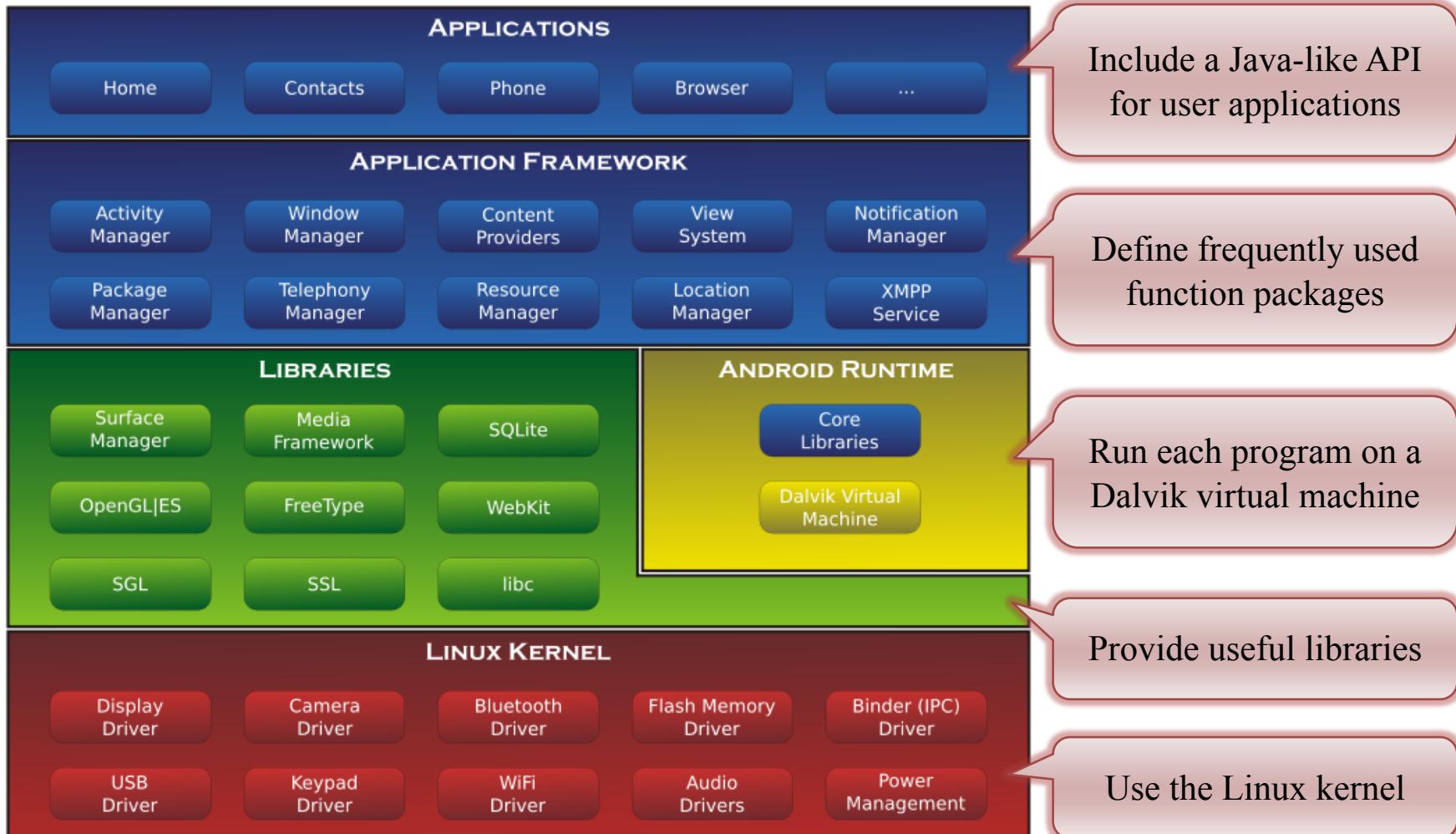
- ▶ Most modern operating systems actually use more than one model for their implementations
- ▶ Hybrid combines multiple approaches to address performance, security, usability needs
 - Linux and Solaris kernels in kernel address space, so monolithic, plus modular for dynamic loading of functionality
 - Windows mostly monolithic, plus microkernel for different subsystem personalities
 - Apple Mac OS X is based on a microkernel and also hybrid, layered, Aqua UI plus Cocoa programming environment

Traditional UNIX System Structure

- ▶ Beyond simple but not fully layered



OS Structure—Android



Source: [http://en.wikipedia.org/wiki/Android_\(operating_system\)](http://en.wikipedia.org/wiki/Android_(operating_system))

OS Structure— iOS

- ▶ Apple mobile OS for iPhone, iPad
 - Structured on Mac OS X, added functionality
 - Also runs on different CPU architecture (ARM vs. Intel)
 - Media services layer for graphics, audio, video
 - Cocoa Touch Objective-C and Swift APIs for developing apps



Figure 2.17 Architecture of Apple's iOS.

Operating System Debugging

- ▶ Debugging
 - An activity in finding and fixing errors or bugs, including performance problem, that exist in hardware or software
- ▶ Terminologies
 - Profiling— A procedure to understand the statistical trends
 - Performance tuning— A procedure that seeks to improve performance by removing bottlenecks
 - Crash— A kernel failure
 - Core dump— A capture of the memory of a process or OS

Operating System Generation

- ▶ Operating systems are designed to run on any of a class of machines; the system must be configured for each specific computer site
- ▶ SYSGEN program obtains information concerning the specific configuration of the hardware system
 - Used to build system-specific compiled kernel
 - Can generate more efficient code than one general kernel

Ease of modification

No recompilation &
completely table-driven

Good performance and smaller size

Linking of modules for
selected OS

Recompilation of a
modified source code

System Boot

- ▶ When power is initialized on a system, execution starts at a fixed memory location
 - Firmware ROM is used to hold initial boot code
- ▶ Operating systems must be made available to hardware so hardware can start it
 - Small piece of code—bootstrap loader, stored in ROM or EEPROM locates the kernel, loads it into memory, and starts it
 - Sometimes two-step process where boot block at fixed location loaded by ROM code, which loads bootstrap loader from disk
- ▶ Common bootstrap loader, GRUB, allows selection of kernel from multiple disks, versions, kernel options