ĐẠI HỌC ĐÀ NẴNG
TRƯỜNG ĐẠI HỌC CÔNG NGHỆ THÔNG TIN VÀ TRUYỀN THÔNG VIỆT - HÀN
Vietnam - Korea University of Information and Communication Technology

Chapter 1 - INTRODUCTION

- Introduction
- Computer hardware review
- Operating system concepts

Introduction

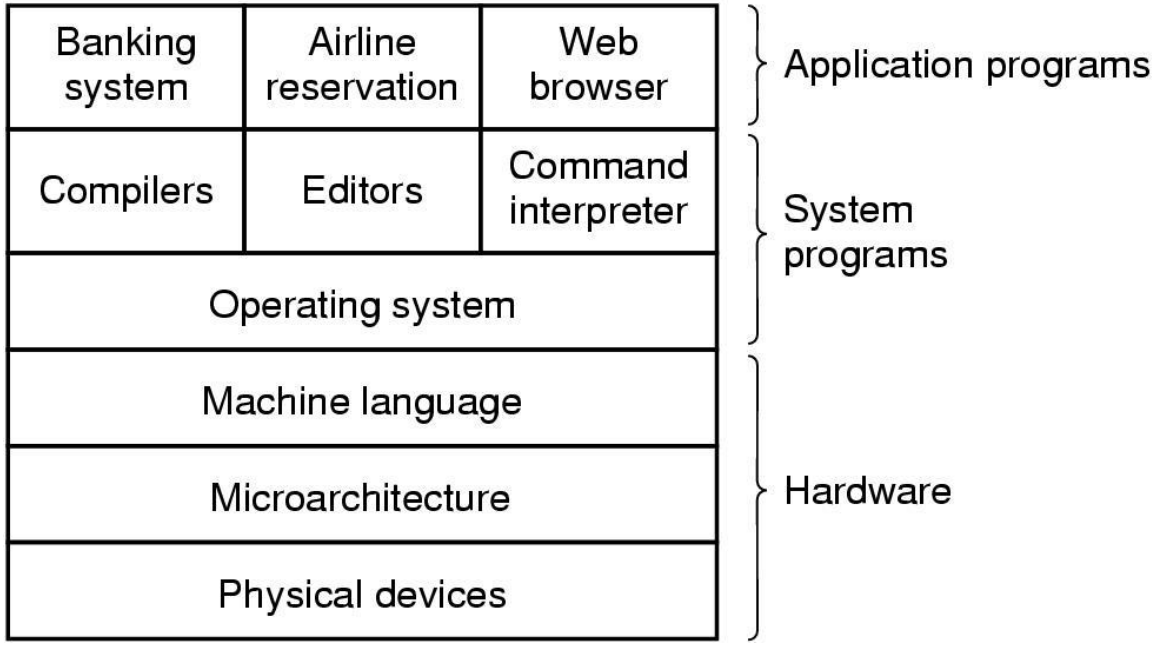
- What is an operating system
- History of operating systems
- The operating system zoo

What is an operating system?

- Anyone?
- Give a few names of an OS?
  - Desktops?
  - Smart phones?

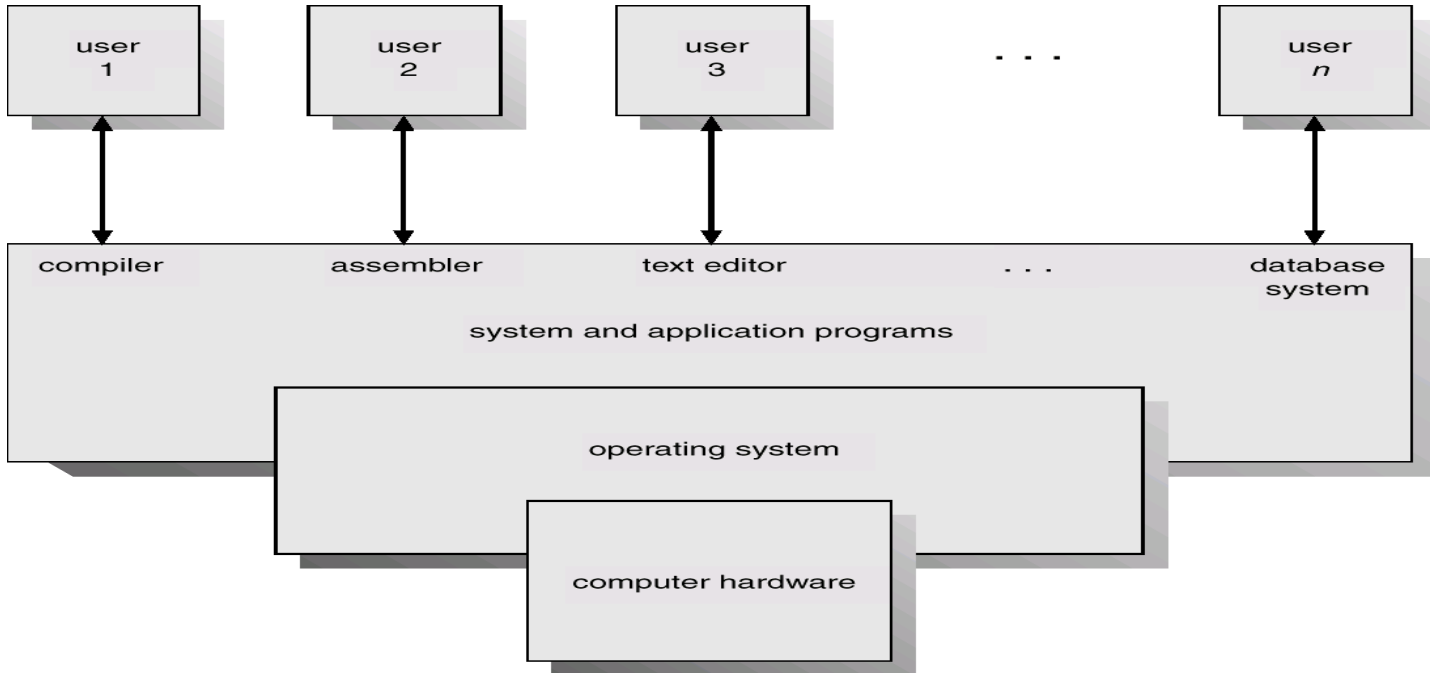
Computer system

- A computer system consists of
  - hardware
  - system programs
  - application programs



What is an Operating System

- A program that acts as an intermediary between a user of a computer and the computer hardware.
- The OS is “all the code that you didn’t have to write” to implement your application.



What is an Operating System

- OS is an extended machine
  - Hides the messy details which must be performed
  - Presents user with a virtual machine, easier to use

- OS is a resource manager
  - Each program gets time with the resource
  - Each program gets space on the resource

History of Operating Systems

History of Operating Systems

- First generation 1945 - 1955
  - vacuum tubes, plug boards
- Second generation 1955 - 1965
  - transistors, batch systems
- Third generation 1965 – 1980
  - ICs and multiprogramming
- Fourth generation 1980 – present
  - personal computers

History of Operating Systems
First generation 1945 - 1955

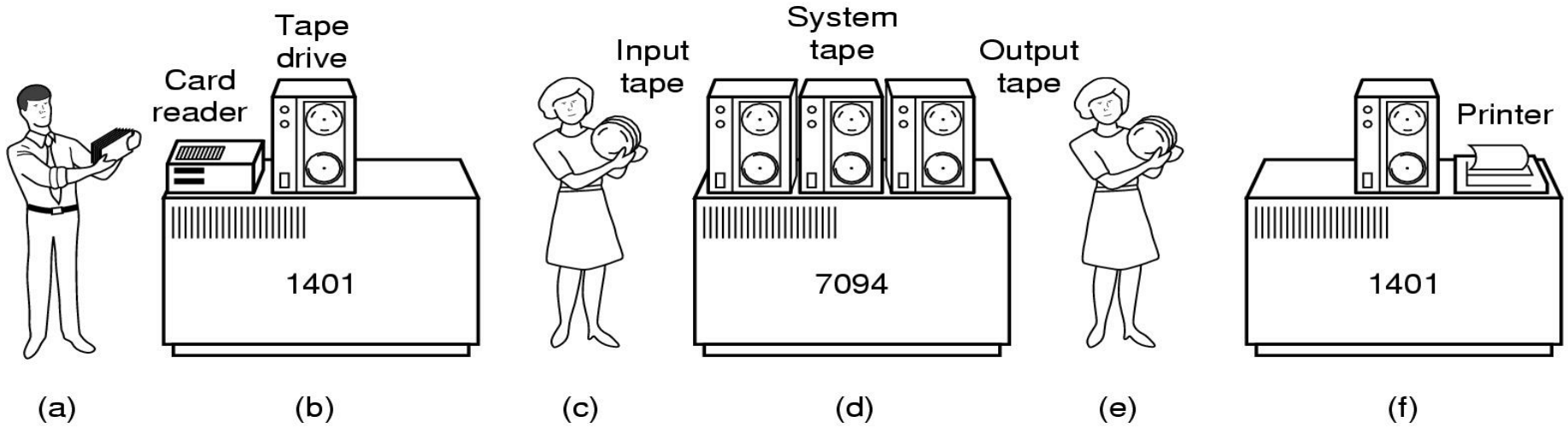
- Computers: ENIAC, UNIVAC, etc.
- Operating System: No OS,
- Machine Language, plugboards
- Single group: designed, built, programmed, operated and maintained each machine

History of Operating Systems
Second Generation 1955 – 1965 (1)

- Computers: IBM 1401, IBM 7094, etc.
- Operating System : FMS (Fortran Monitor System), IBSYS for Computer 7094.
- Batch Systems
  - Function of Early Batch System
  - Structure of a typical FMS job
- Separation between designers, builders, programmers, operators and maintenance personnel

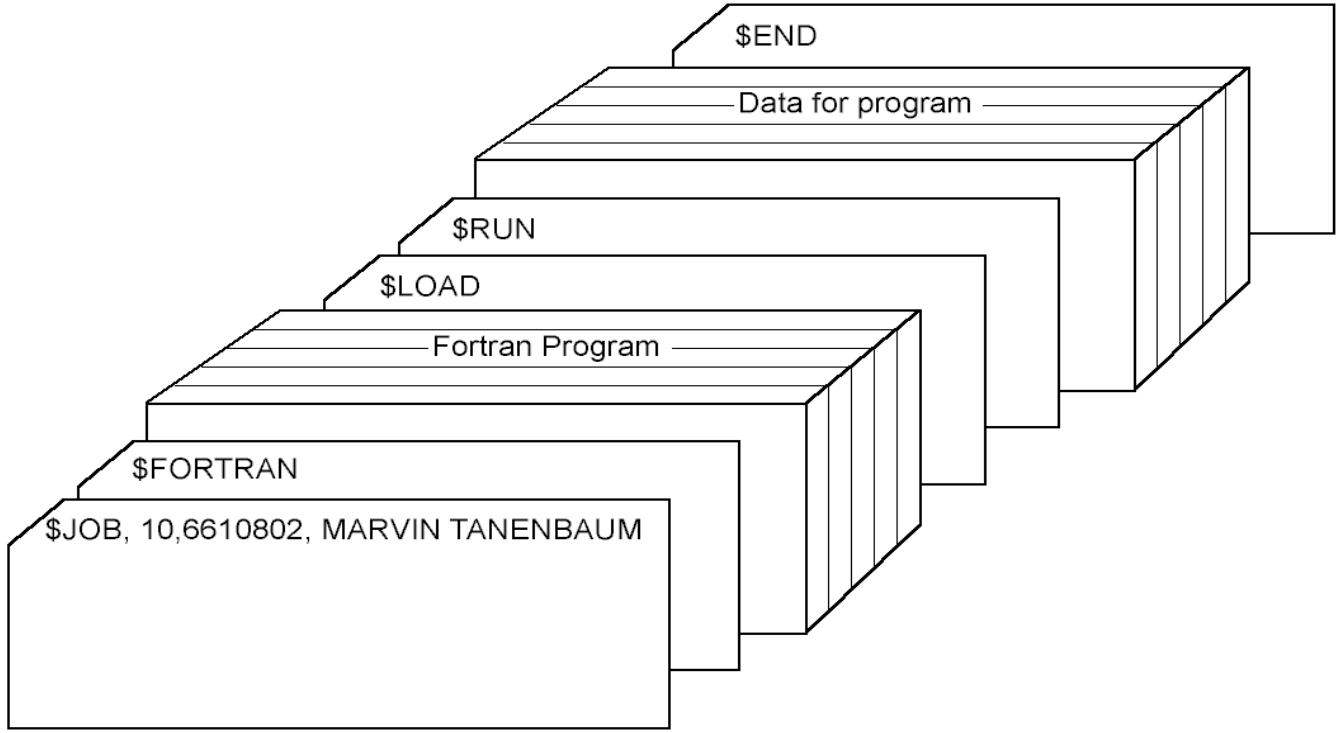
History of Operating Systems
Second Generation 1955 – 1965 (2)

- Early batch system
  - bring cards to 1401
  - read cards to tape
  - put tape on 7094 which does computing
  - put tape on 1401 which prints output



History of Operating Systems
Second Generation 1955 – 1965 (3)

- Structure of a typical FMS job – 2nd generation

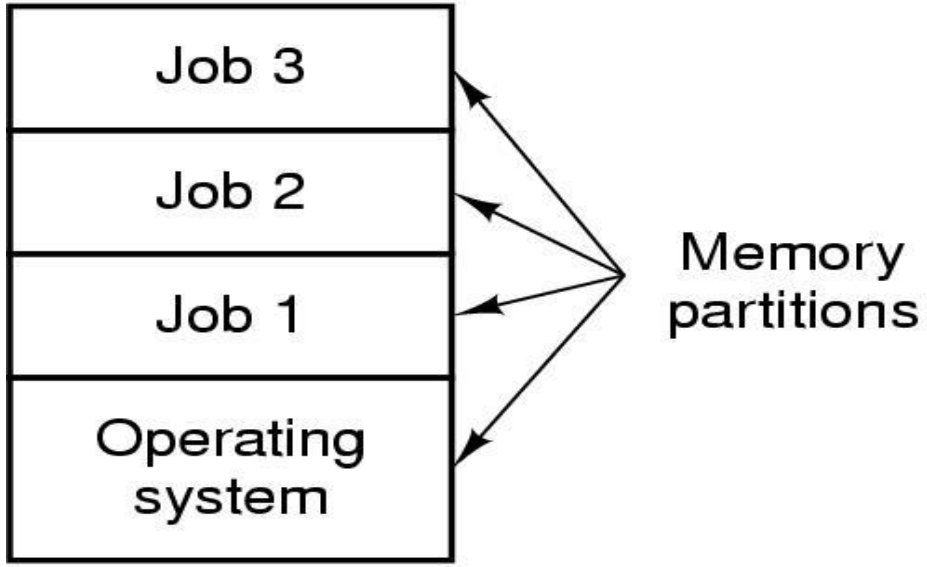


History of Operating Systems
Third generation 1965 – 1980 (1)

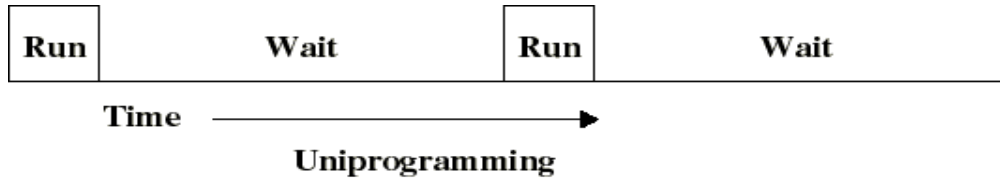
- Computers: System/360, IBM370, IBM4300…
- Operating System:
  - OS/360: to work on all models
  - Multiprogamming
  - Time Sharing:
    - ✓ CTSS (Compatible Time Sharing System),
    - ✓ MULTICS (MULTiplexed Information and Computing Service),
    - ✓ Unix

History of Operating Systems
Third generation 1965 – 1980 (2)

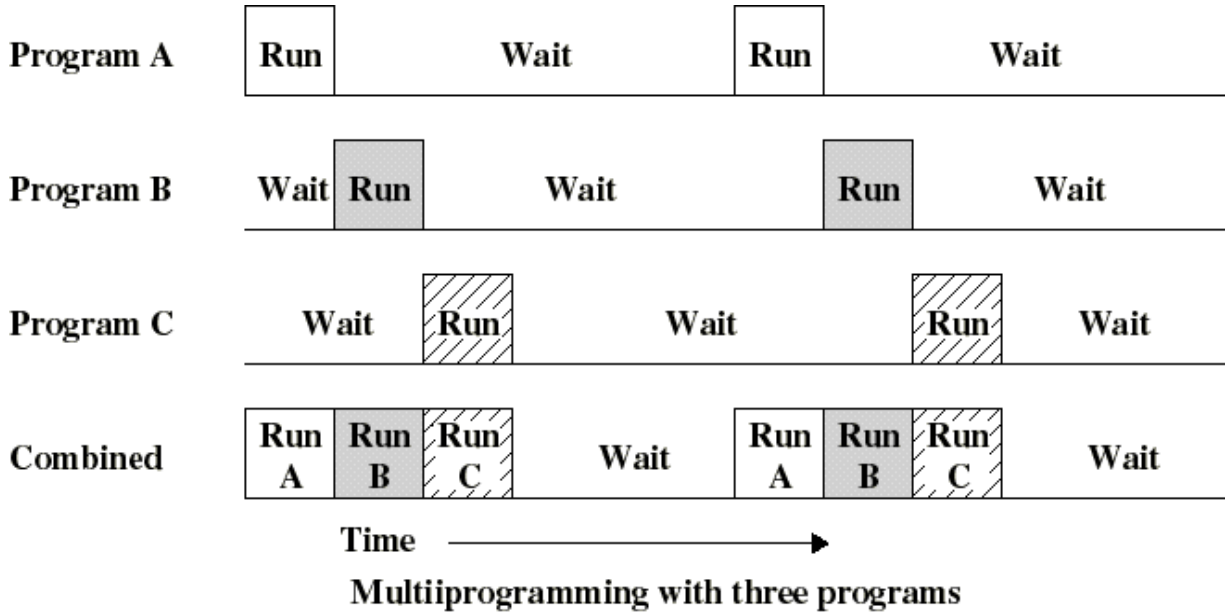
- Multiprogramming system
  - Three jobs in memory – 3rd generation



History of Operating Systems
Third generation 1965 – 1980 (3)



Uniprogramming



Multiiprogramming with three programs

History of Operating Systems
Fourth generation 1980 – present

- Computers: IBM PC 80x86, Macintosh, etc.
- Operating System:
  - 1977: CP/M (Control Program for Microcomputer)
  - 1980: DOS (Disk Operating System)
  - GUI with Macintosh
  - 1985-1995: Window 3.x
  - 1995: Window 95
  - 1996: Window NT 4.0
  - 1999: Window 2000
  - Window 2003
  - Unix

The Operating System Zoo

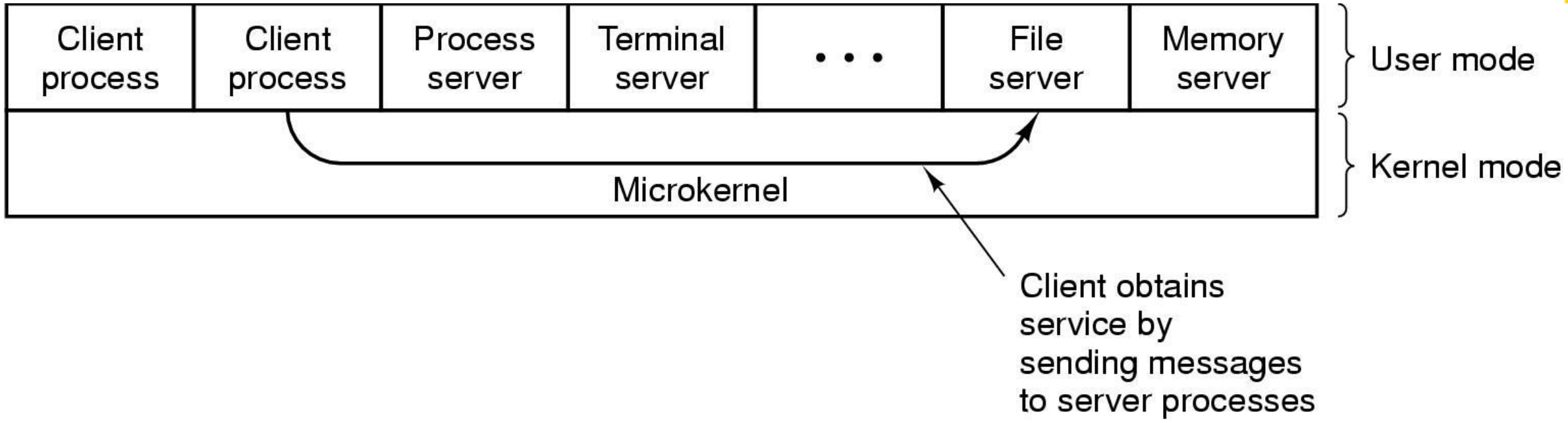
The Operating System Zoo

- Mainframe operating systems
- Server operating systems
- Multiprocessor operating systems
- Personal computer operating systems
- Real-time operating systems
- Embedded operating systems
- Smart card operating systems

The Operating System Zoo
Mainframe operating systems

- Batch
- Multiprogrammed
- Time-sharing, multitasking
- Application: High-End Web Server, Servers for Business-To Business transactions
- Example: OS/390

The Operating System Zoo
Server operating systems



The Operating System Zoo Multiprocessor operating systems

- Multiple CPU
- Share computer bus, clock
- Advantage:
  - ✓ High system throughput
  - ✓ High availability
  - ✓ Multiprocessor system and Multicomputer system

The Operating System Zoo
Personal computer operating systems

- Many I/O devices
- Interface to single user
- Many OS (MS Windows, Mac OS, Solaris, Linux, etc.).

The Operating System Zoo
Real-time operating systems

- Time is a key parameter
- Two types of real-time system
  - ✓ Hard real-time system for industrial process control system, etc.
  - ✓ Soft real-time system for multimedia system

The Operating System Zoo
Embedded operating systems

- Personal digital assistant (PDA): Palm, Pocket-PC, Cellular phones), control devices
- Restriction of memory size, speed of CPU, screen size, powers
- Operating System: PalmOS, Windows CE (Consumer Electronic)

The Operating System Zoo
Smart card operating systems

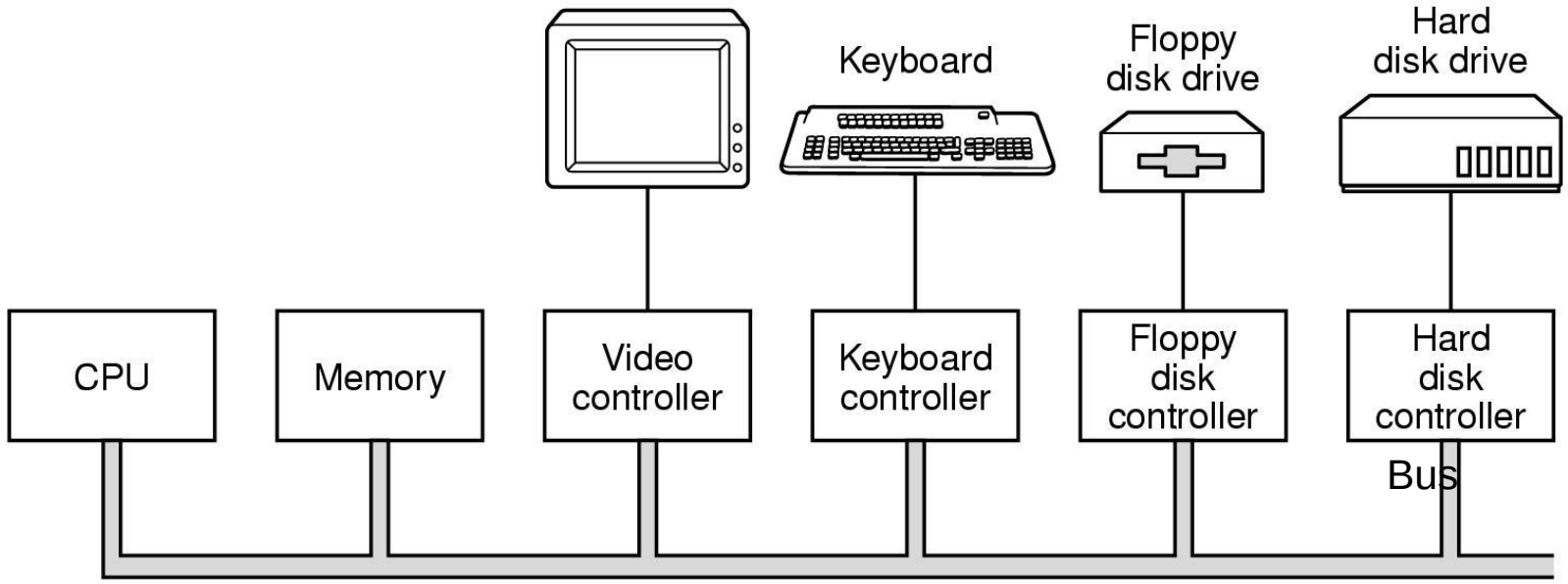
- CPU chips on Card
- Server processing power and memory constraint
- Specific Application:
  - Single function: electronic payments
  - Multiple function: proprietary systems
  - Java oriented: holds interpreter JVM

Computer Hardware Review

- CPU
- Memory
- I/O Devices
- Buses

Computer Hardware Review

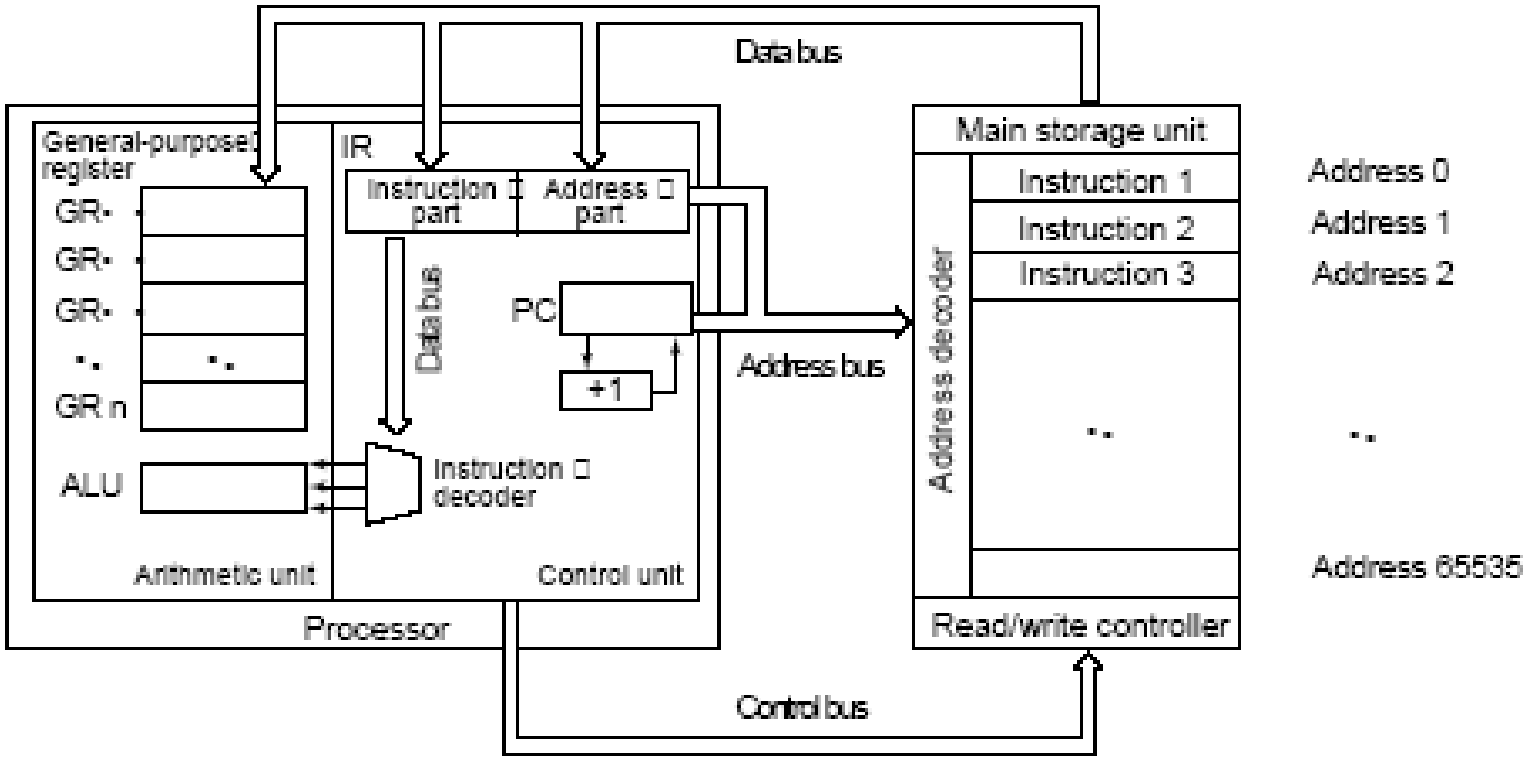
- Components of a simple personal computer



Computer Hardware Review
The CPU (1)

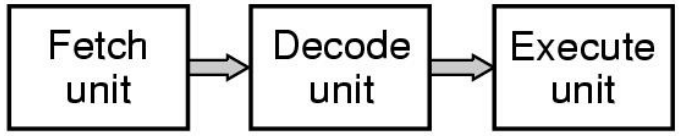
- PC Program Counter
- SP Stack Pointer
- PSW Program Status Word
- General Registers
- Instruction Cycle
- Pipeline
- Superscalar
- System Call

Computer Hardware Review
The CPU (2)

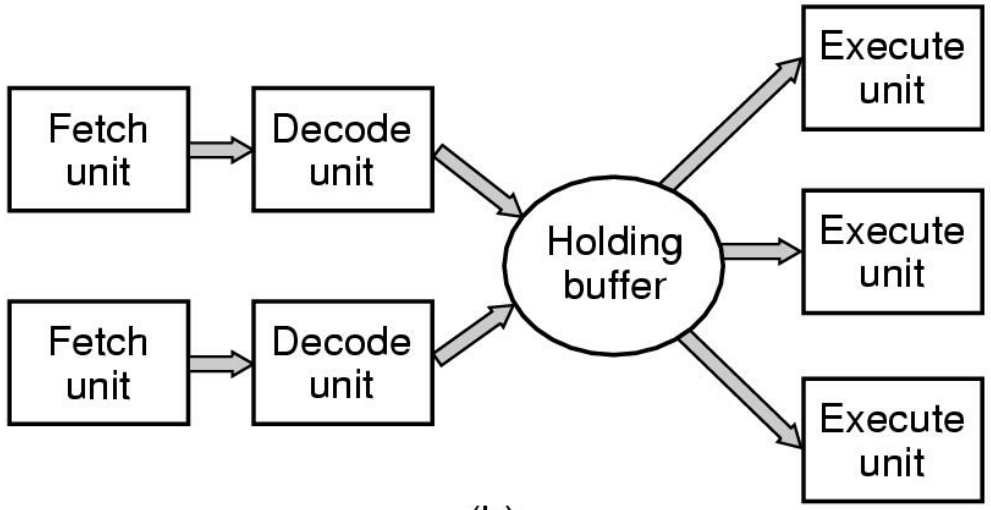


Computer Hardware Review
The CPU (3)

- (a) A three-stage pipeline
- (b) A superscalar CPU



(a)



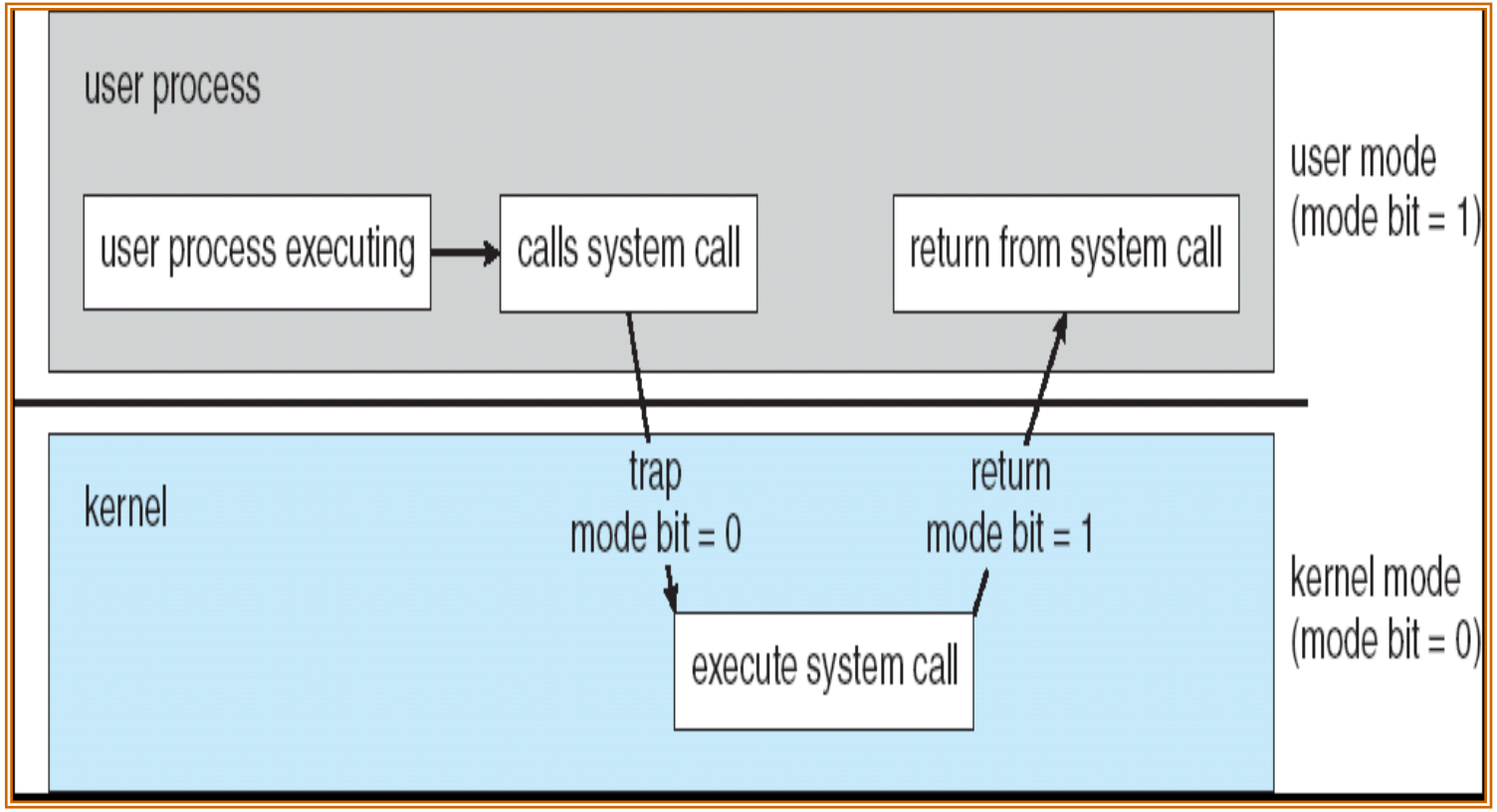
(b)

Computer Hardware Review
The CPU (4)

- Dual-mode operation allows OS to protect itself and other system components
  - User mode and kernel mode
  - Mode bit provided by hardware
    - ✓ Provides ability to distinguish when system is running user code or kernel code
    - ✓ Some instructions designated as privileged, only executable in kernel mode
    - ✓ System call changes mode to kernel, return from call resets it to user

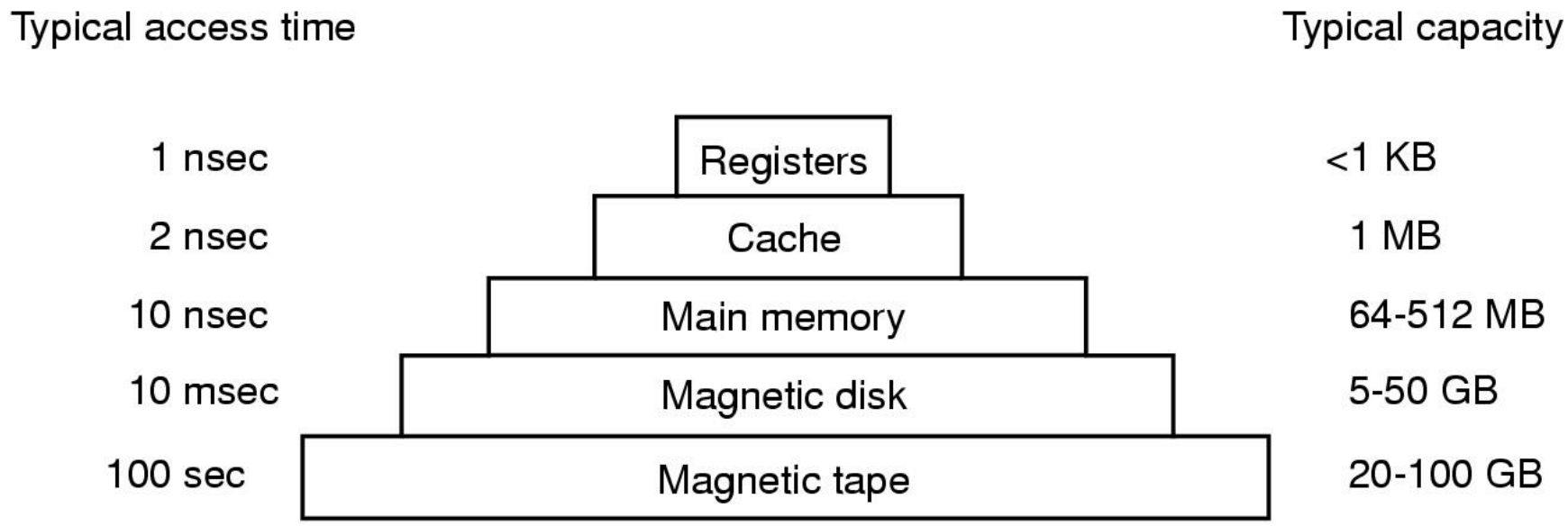
Computer Hardware Review
The CPU (5)

- Transition from User to Kernel Mode



Computer Hardware Review
Memory (1)

- Typical memory hierarchy
  - The numbers shown are rough approximations



Computer Hardware Review
Memory (2)

- Storage systems organized in hierarchy.
  - Speed
  - Cost
  - Size
  - Volatility

Computer Hardware Review
Memory (3)

- Registers:
  - Small number, Fast
  - Capacity:
    - ✓ 32*32 bit on 32-bit CPU
    - ✓ 64*64 bit on 64-bit CPU

Computer Hardware Review
Memory (4)

- Caching – copying information into faster storage system.
- Main memory can be viewed as a last cache for secondary storage.

Computer Hardware Review
Memory (5)

➢ **Caching**:

- Important principle, performed at many levels in a computer (in hardware, operating system, software)
- Information in use copied from slower to faster storage temporarily
- Faster storage (cache) checked first to determine if information is there
  - ✓ If it is, information used directly from the cache (fast)
  - ✓ If not, data copied to cache and used there
- Cache smaller than storage being cached
  - ✓ Cache management important design problem
  - ✓ Cache size and replacement policy

Computer Hardware Review
Memory (6)

➢ Main Memory

- RAM (Random Access Memory)
- Problem:
  - ✓ How protect the program from one another and the kernel from them all
  - ✓ How to handle relocation
- Solution: CPU equipped with two special registers
- Base Register and Limit Register
- MMU (Memory Management Unit) convert Virtual Address to Physical Address
- Context Switch; switching from one to another

Computer Hardware Review
Memory (7)

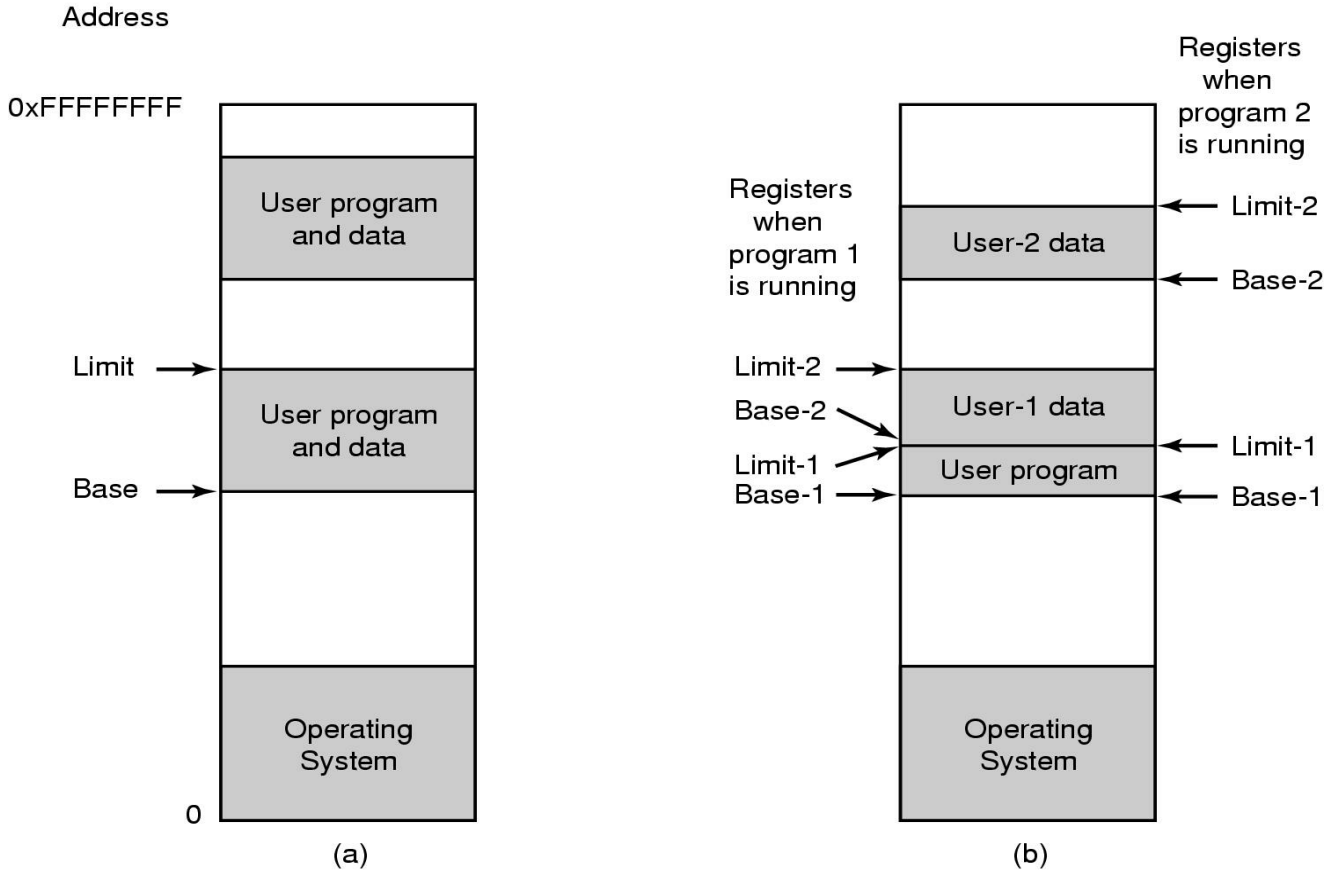
➢ Relocation and Protection

- Cannot be sure where program will be loaded in memory
  - ✓ Address locations of variables, code routines cannot be absolute
  - ✓ Must keep a program out of other processes' partitions

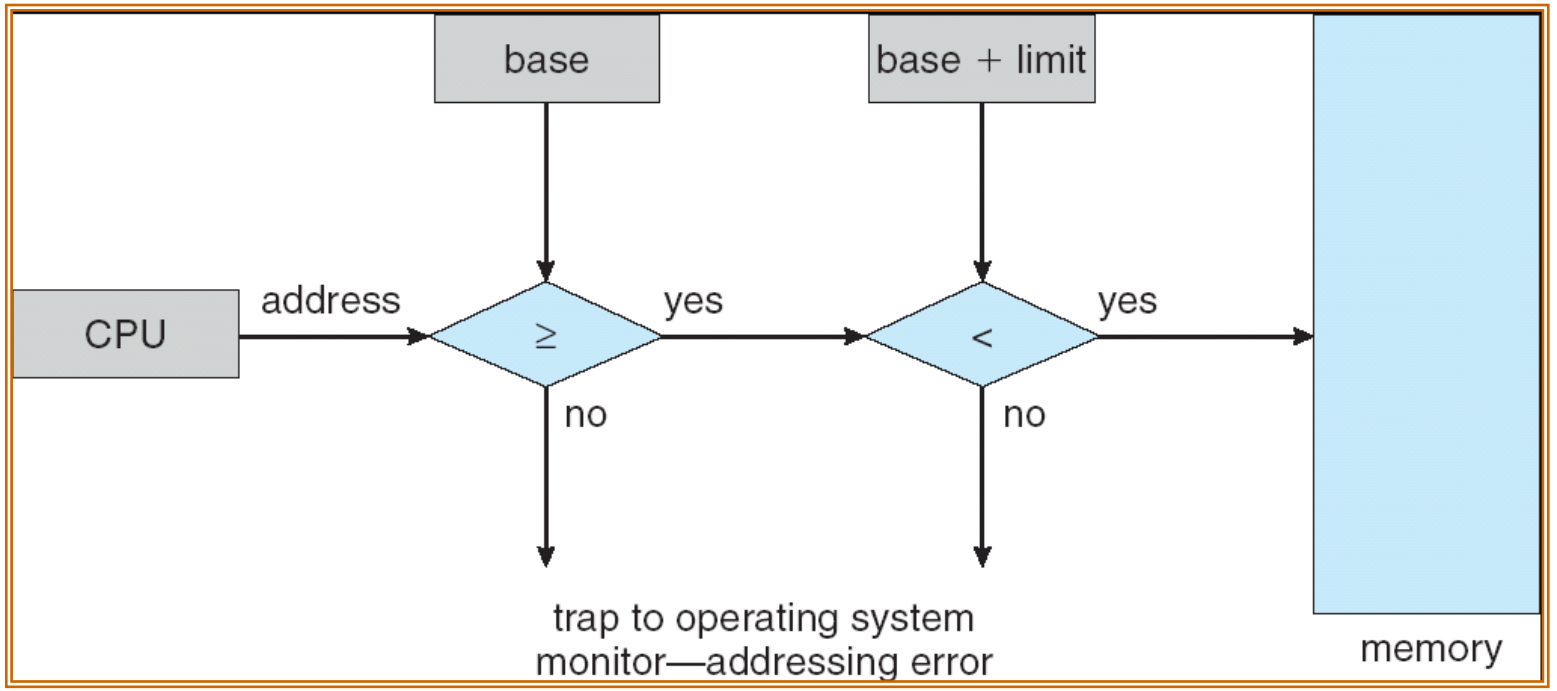
- Use base and limit values
  - ✓ Address locations added to base value to map to physical address
  - ✓ Address locations larger than limit value is an error

Computer Hardware Review
Memory (8)

One base-limit pair and two base-limit pairs



Computer Hardware Review
Memory (9)

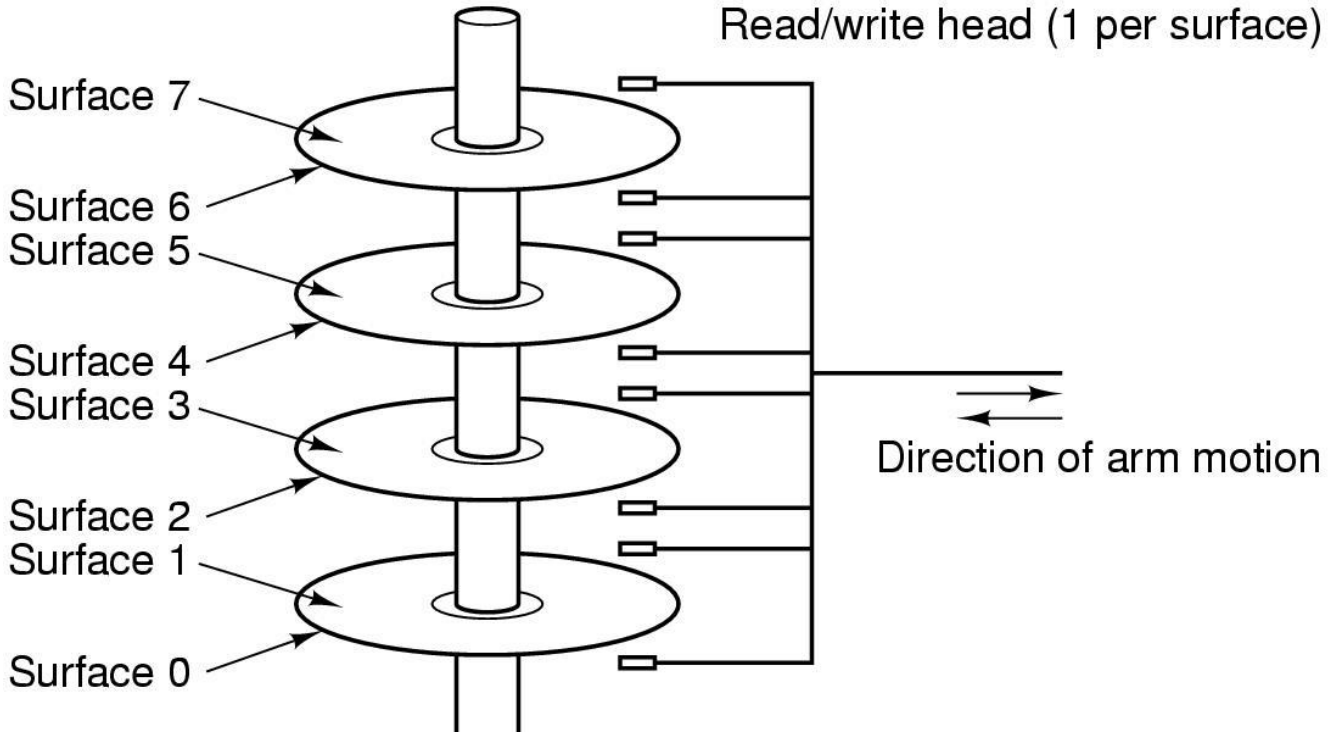


Computer Hardware Review
Memory (10)

- Other memory in computer
  - ROM (Read Only Memory)
  - EEPROM (Electrically Erasable ROM):
    - ✓ BIOS Basic Input Output System
  - CMOS:
    - ✓ Real time clock
    - ✓ Configuration Information

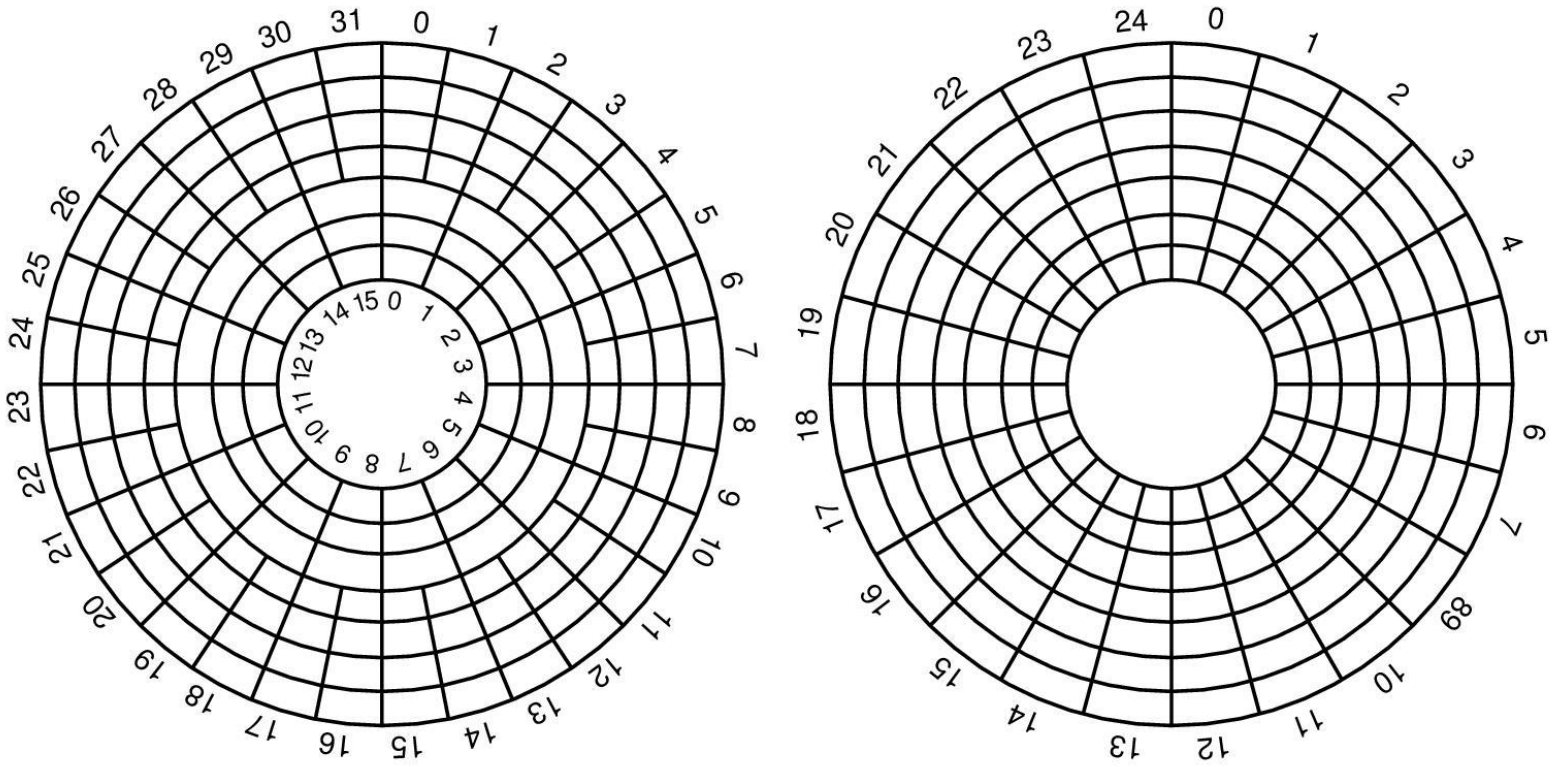
Computer Hardware Review
Memory (11)

Structure of a disk drive



Computer Hardware Review
Memory (12)

Disk: Cylinder, Track, sector



Computer Hardware Review

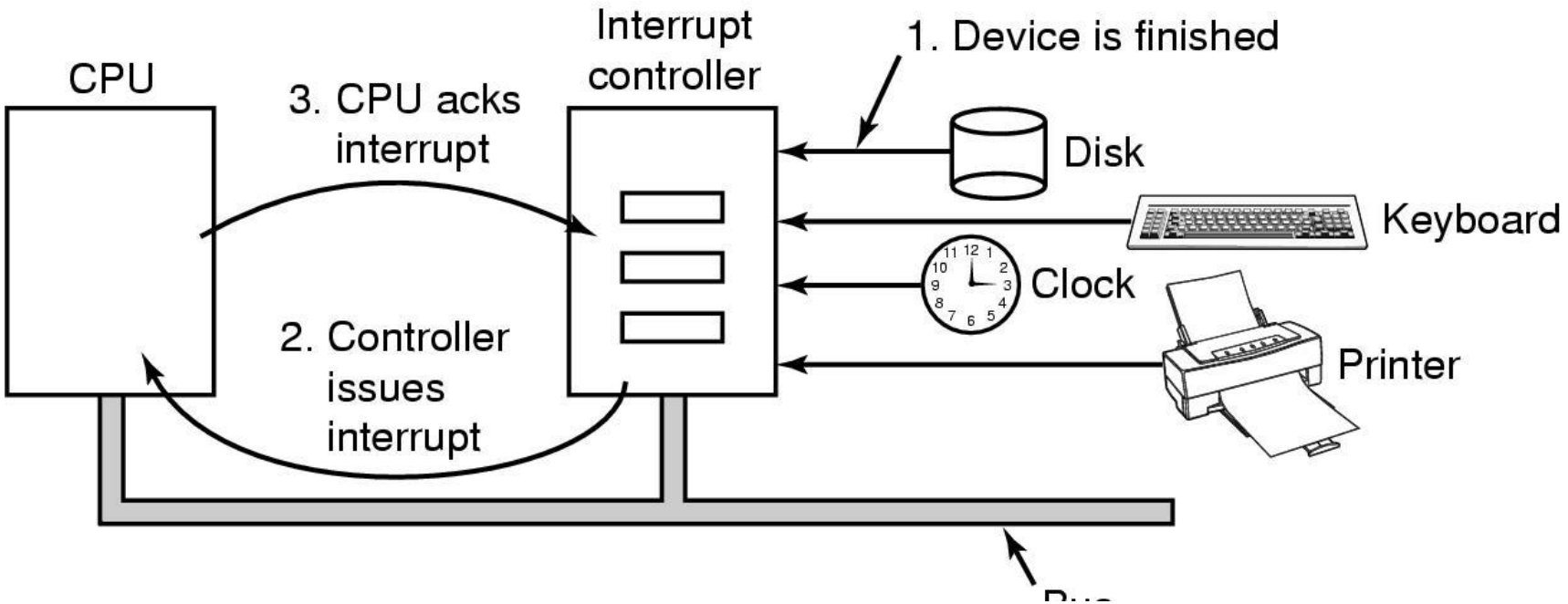
I/O Devices (1)

- Computer-System Operation
  - I/O devices and the CPU can execute concurrently.
  - Each device controller is in charge of a particular device type.
  - Each device controller has a local buffer.
  - CPU moves data from/to main memory to/from local buffers
  - I/O is from the device to local buffer of controller.
  - Device controller informs CPU that it has finished its operation by causing an *interrupt*.

Computer Hardware Review

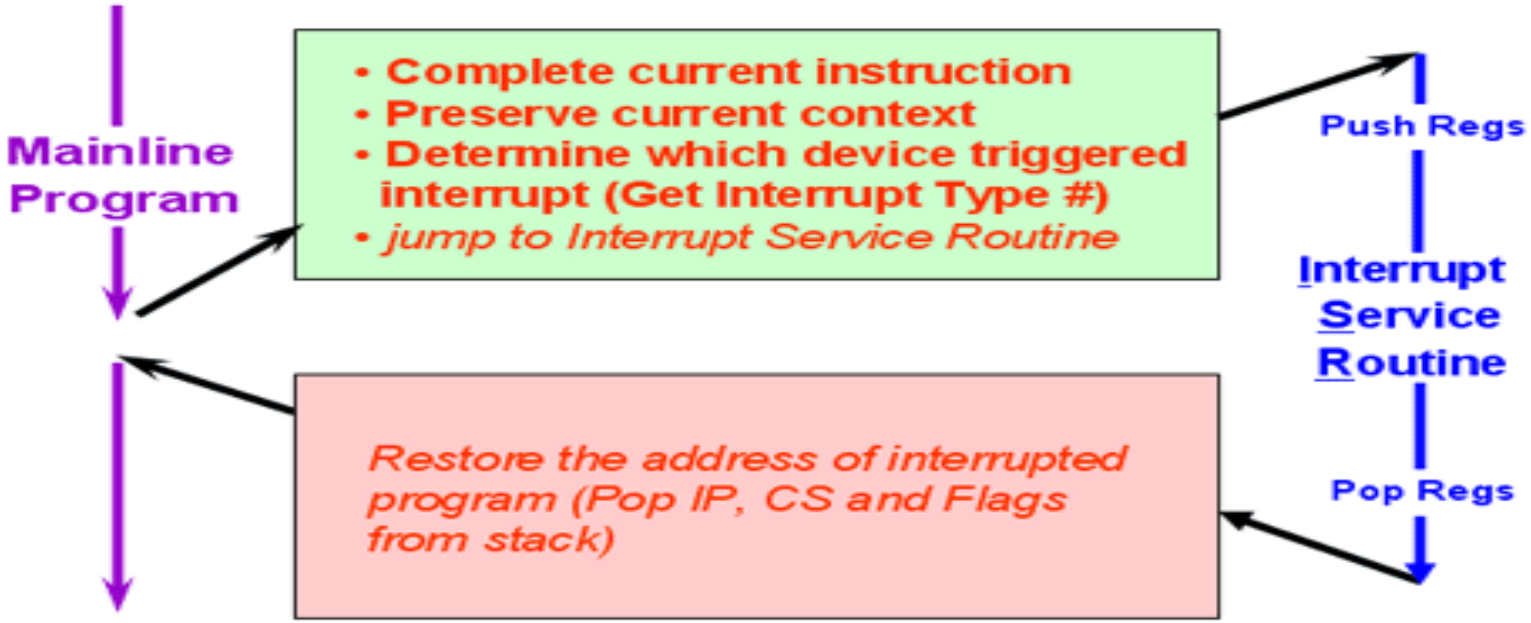
I/O Devices (2)

- How interrupts happens. Connections between devices and interrupt controller actually use interrupt lines on the bus rather than dedicated wires



Computer Hardware Review
I/O Devices (3)

- Example of Interrupt processing for PC



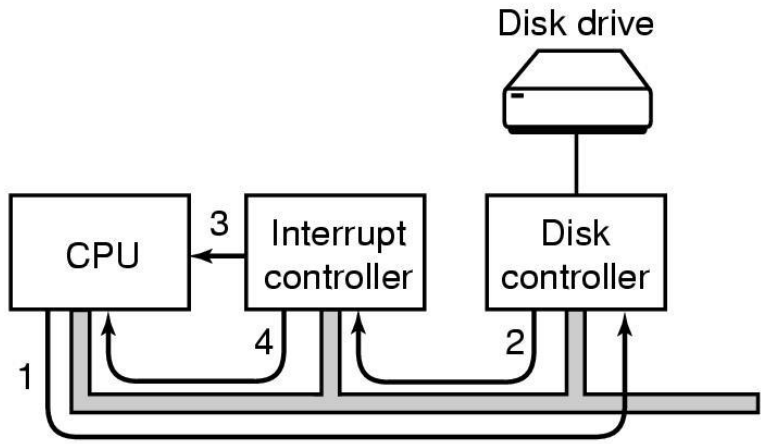
Computer Hardware Review
I/O Devices (3)

Common Functions of Interrupts

- Interrupt transfers control to the interrupt service routine generally, through the interrupt vector table, which contains the addresses of all the service routines.
- Interrupt architecture must save the address of the interrupted instruction.
- Incoming interrupts are disabled while another interrupt is being processed to prevent a lost interrupt.
- A trap is a software-generated interrupt caused either by an error or a user request.
- An operating system is interrupt driven.

Computer Hardware Review
I/O Devices (4)

- (a) Steps in starting an I/O device and getting interrupt
- (b) How the CPU is interrupted



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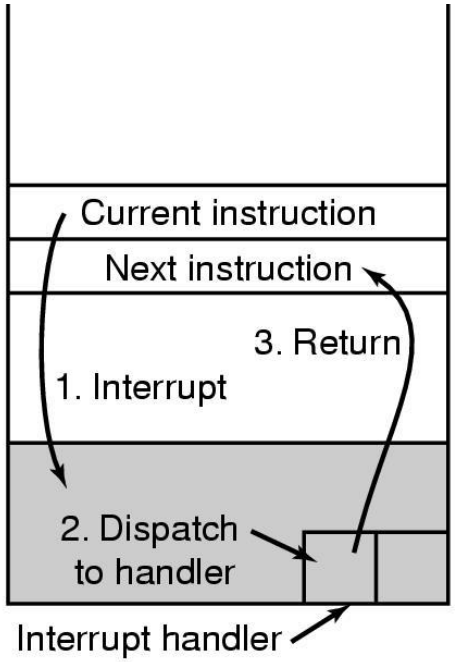

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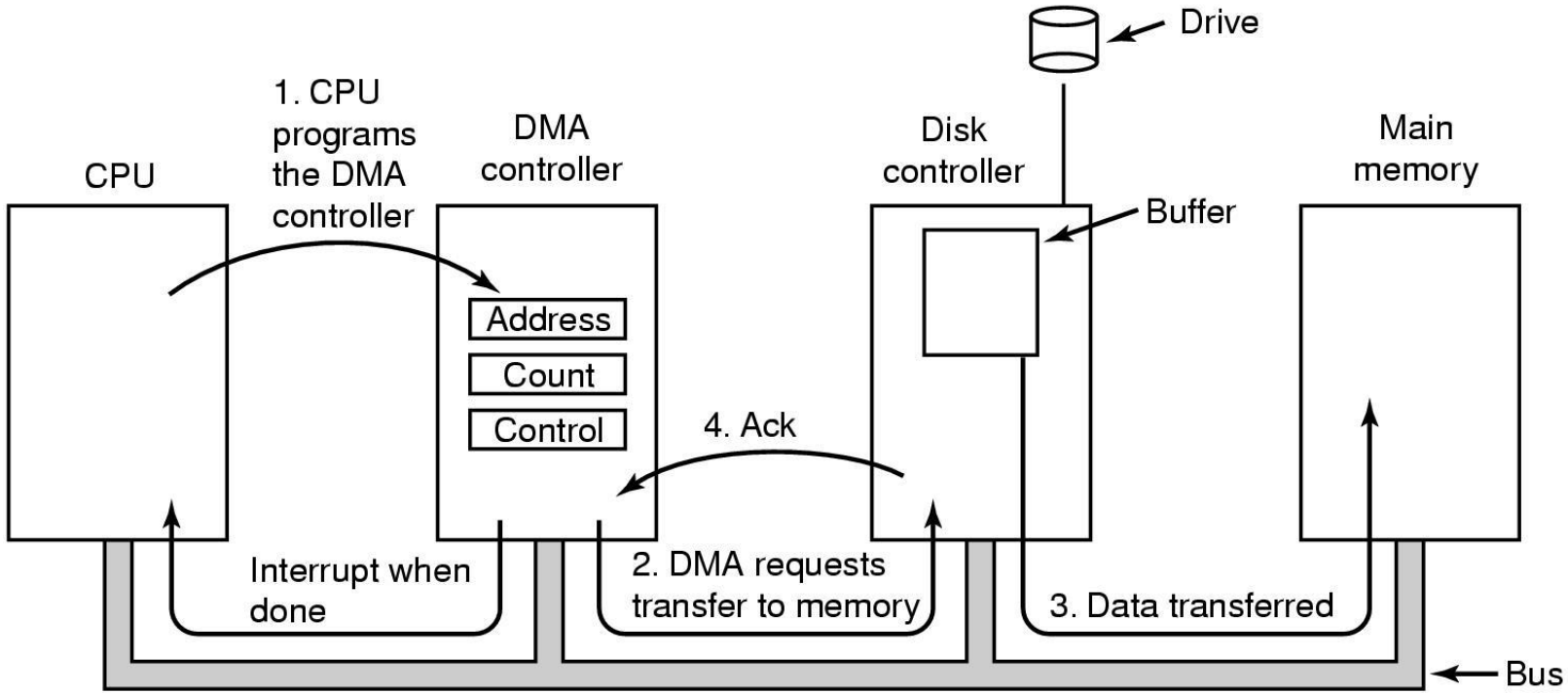
Computer Hardware Review
I/O Devices (6)

- Operation of a DMA transfer
- DMA (Direct Memory Access)

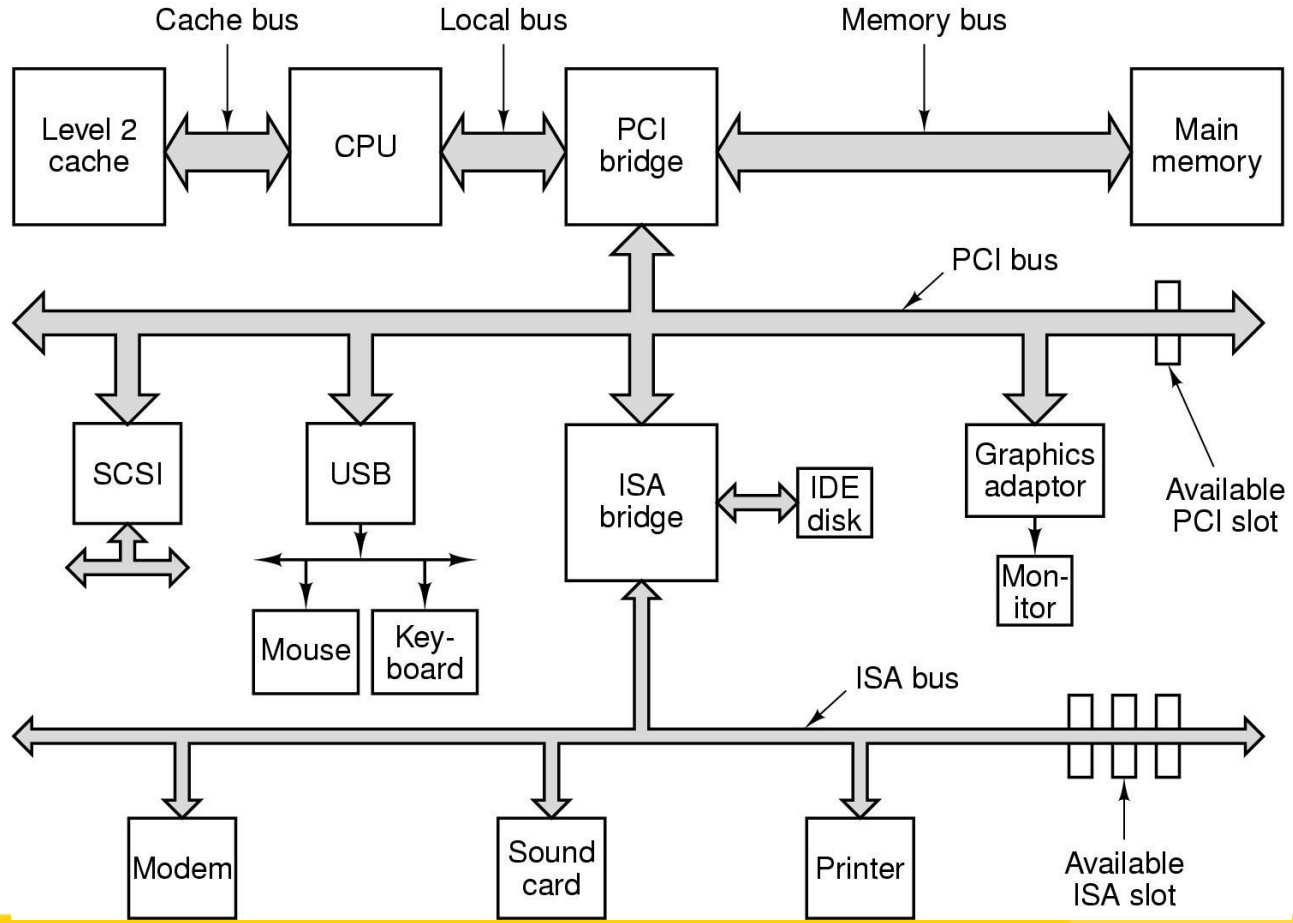


Computer Hardware Review
I/O Devices (7)

- DMA
  - Used for high-speed I/O devices able to transmit information at close to memory speeds.
  - Device controller transfers blocks of data from buffer storage directly to main memory without CPU intervention.
  - Only one interrupt is generated per block, rather than the one interrupt per byte.

Computer Hardware Review

- Structure of a large Pentium system



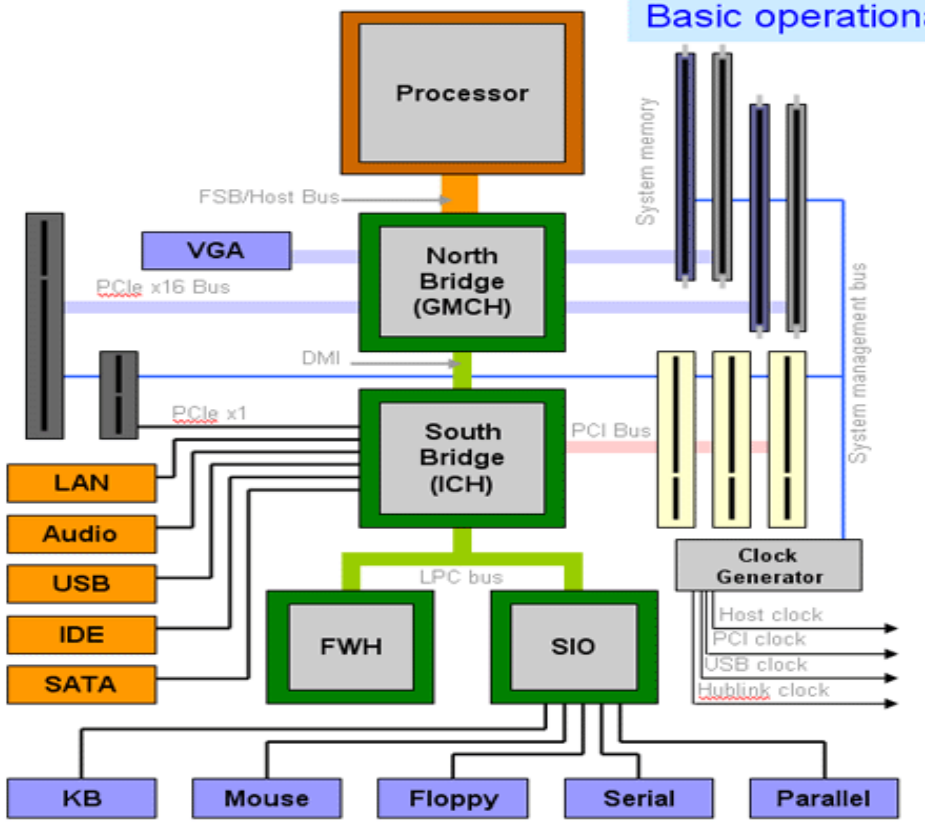
Computer Hardware Review
BUS

- Cache BUS
- Local BUS
- System BUS
- ISA Industry Standard Architecture
- PCI Peripheral Component Interconnect
- USB Universal Serial BUS
- SCSI Small Computer System Interface
- IDE Integrated Drive Electronic

Computer Hardware Review
Personal Computer (PC)

Chipset: North Bridge, South Bridge, & Firmware Hub

Basic operational design is called its architecture



- North Bridge
  - HOST-PCI Bridge
  - DRAM Controller
  - AGP Interface
- South Bridge (ICH)
  - PCI-PCI Bridge
  - 8254 Timer; 8259 Intr. Ctlr; 8237 DMAC; RTC
  - EIDE Interface
  - USB Ctlr
- Super I/O
  - Kybd/Mouse Ctlr
  - Floppy Ctlr
  - Serial & IR port
  - Parallel ports

Operating System Concepts

- OS Components
- System calls
- Operating system structure

OS Components

- Process Management
- Main Memory Management
- File management
- I/O Management
- Secondary Storage Management
- Protection and Security

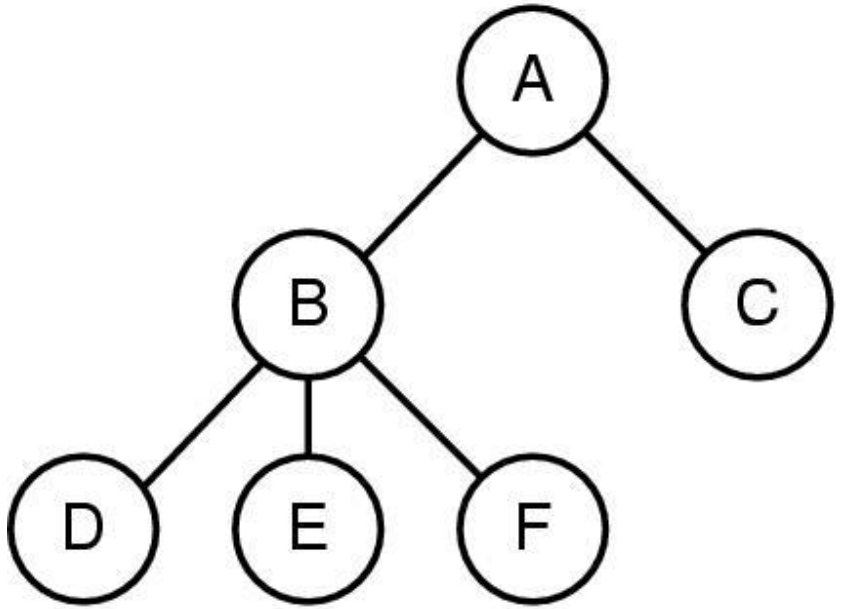
Operating System Concepts
OS Components (1)

Process Management

- Process is a Program in execution
- A process needs certain resources, including CPU time, memory, files, and I/O devices, to accomplish its task.
- Tasks of process management of OS:
  - ✓ Process creation and deletion.
  - ✓ process suspension and resume
  - ✓ Provision of mechanisms for:
    - Process synchronization
    - Interprocess communication
    - Prevent or avoid deadlock

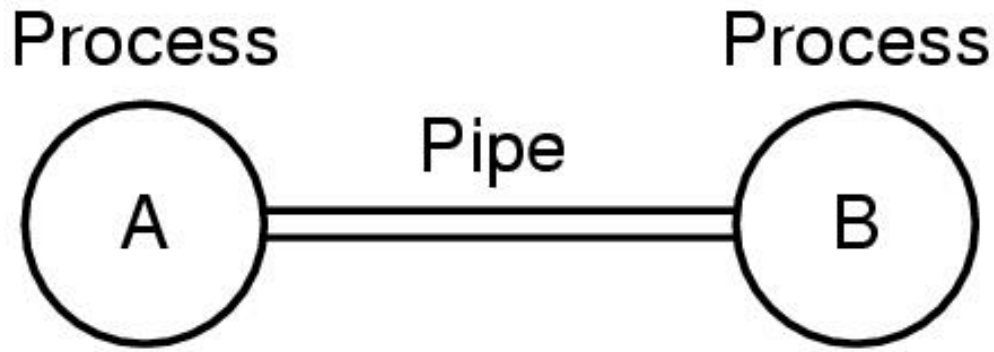
Operating System Concepts
OS Components (2)

- A process tree
  - A created two child processes, B and C
  - B created three child processes, D, E, and F



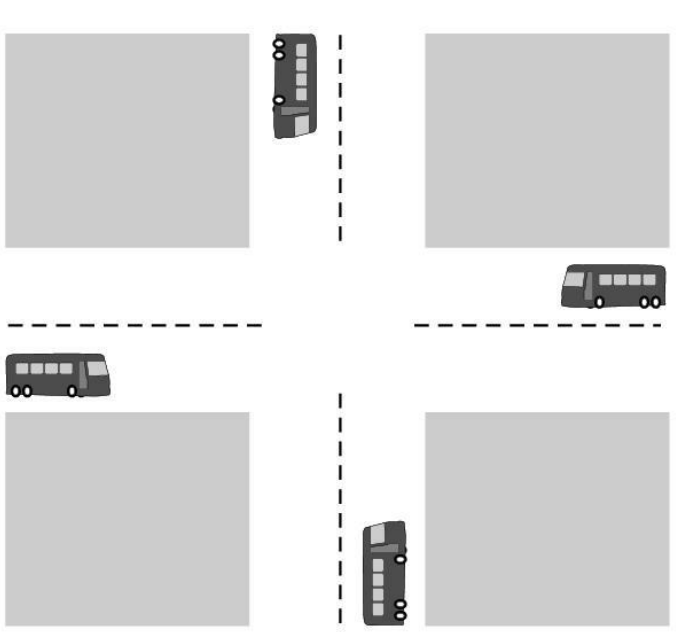
Operating System Concepts
OS Components (3)

- Two processes connected by a pipe



Operating System Concepts
OS Components (4)

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



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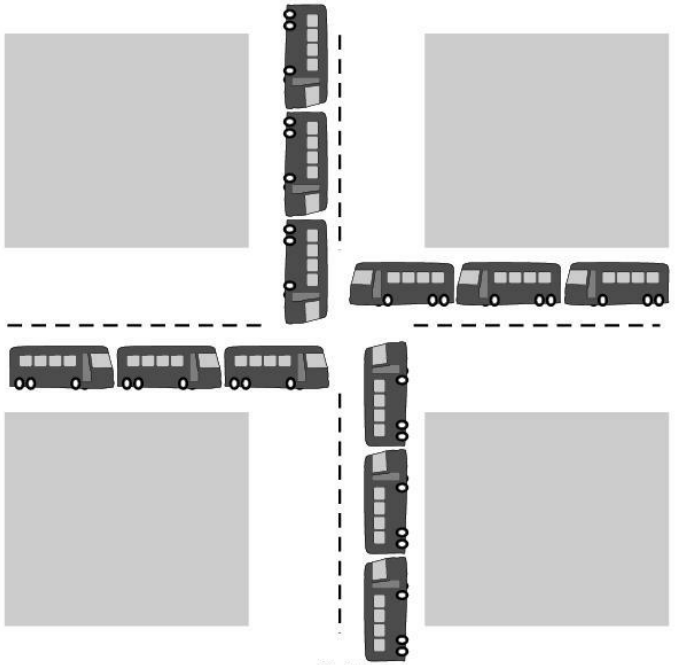


(b)

Operating System Concepts
OS Components (5)

The Deadlock Problem

- A set of blocked processes each holding a resource and waiting to acquire a resource held by another process in the set.
- Example
  - ✓ System has 2 disk drives.
  - ✓ P1 and P2 each hold one disk drive and each needs another one.

Operating System Concepts
OS Components (6)

➢ Main Memory Management:

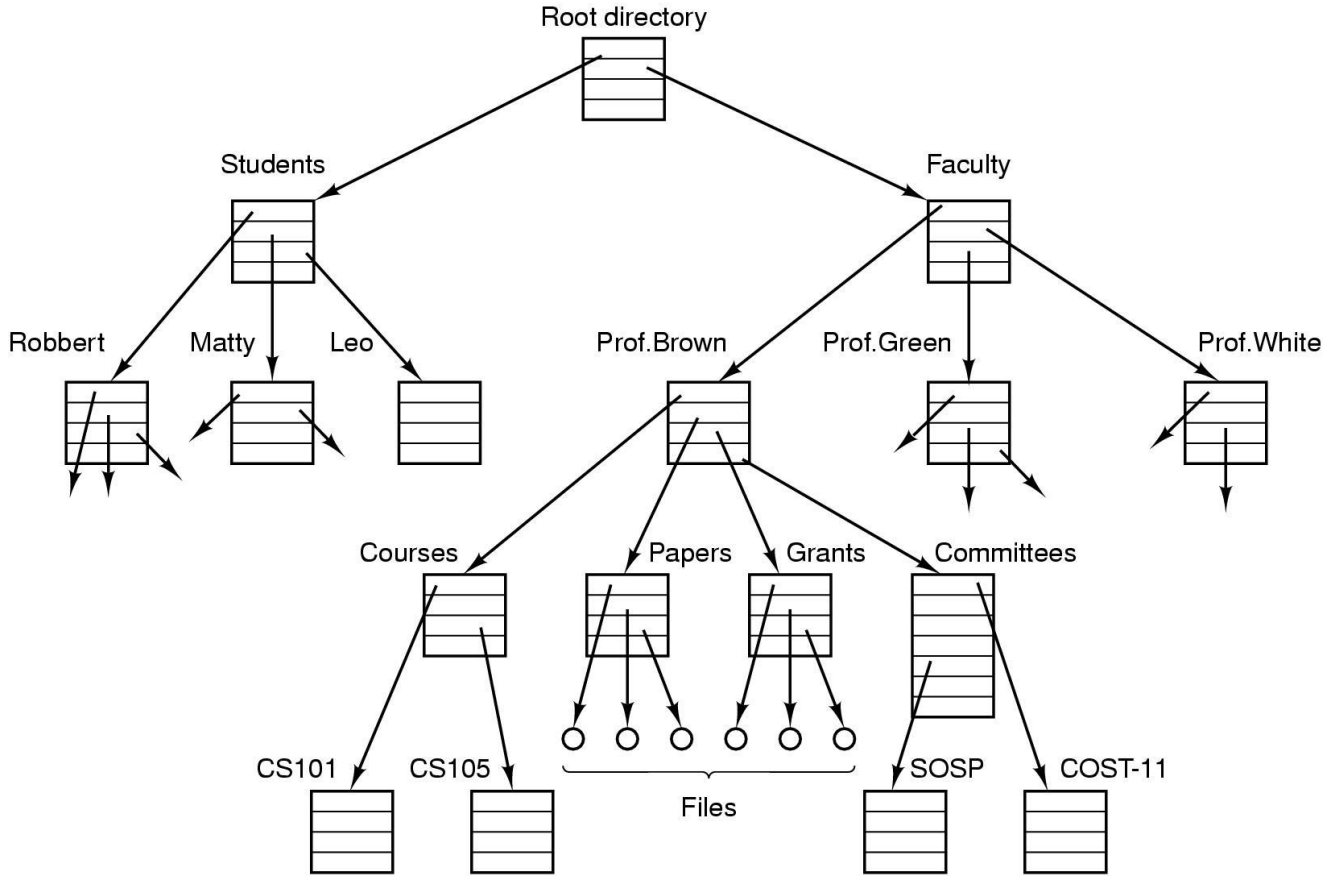
- Motivations:
  - ✓ Increase system performance
  - ✓ Maximize memory utilization
- Task of main memory of management:
  - ✓ Keep track of which parts of memory are currently being used and by whom.
  - ✓ Decide which processes to load when memory space becomes available.
  - ✓ Allocate and deallocate memory space as needed

Operating System Concepts
OS Components (7)

- File management
  - File system
    - ✓ File
    - ✓ Directory
  - Task of file management of OS:
    - ✓ Create and delete File/Dicrectory
    - ✓ Manipulate: rename, copy, move, new,…
    - ✓ Mapping files onto secondary storage.
    - ✓ File backup on stable (nonvolatile) storage media

Operating System Concepts
OS Components (8)

- File system for a university department



Operating System Concepts
OS Components (9)

➢I/O Management

- Hide the specialty of H/W devices
- Task of I/O Management of OS:
  - ✓Manage main memory for the devices using caching, buffering, and spooling
  - ✓Maintain and provide a general device-driver interfaces
  - ✓Drivers for specific hardware devices.

Operating System Concepts
OS Components (10)

➢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.
- Common secondary storage devices: Magnetic disk and Optical disk
- Task of Secondary Storage Management of OS:
  - ✓Free space management
  - ✓Storage allocation
  - ✓Disk scheduling

Operating System Concepts
OS Components (11)

Protection and Security

- Protection – any mechanism for controlling access of processes or users to resources defined by the OS
- Security – defense of the system against internal and external attacks
  - ✓ Huge range, including denial-of-service, worms, viruses, identity theft, theft of service

Operating System Concepts
OS Components (12)

Protection and Security

- Systems generally first distinguish among users, to determine who can do what
  - ✓ User identities (user IDs, security IDs) include name and associated number, one per user
  - ✓ User ID then associated with all files, processes of that user to determine access control
  - ✓ Group identifier (group ID) allows set of users to be defined and controls managed, then also associated with each process, file
  - ✓ Privilege escalation allows user to change to effective ID with more rights

Operating System Concepts
Operating System Services

- One set of operating-system services provides functions that are helpful to the user:
  - User interface - Almost all operating systems have a user interface (UI)
    - ✓ Varies between Command-Line (CLI), Graphics User Interface (GUI)
  - Program execution - The system must be able to load a program into memory and to run that program, end execution, either normally or abnormally (indicating error)
  - Control access to I/O device.
  - File-system manipulation

Operating System Concepts
Operating System Services

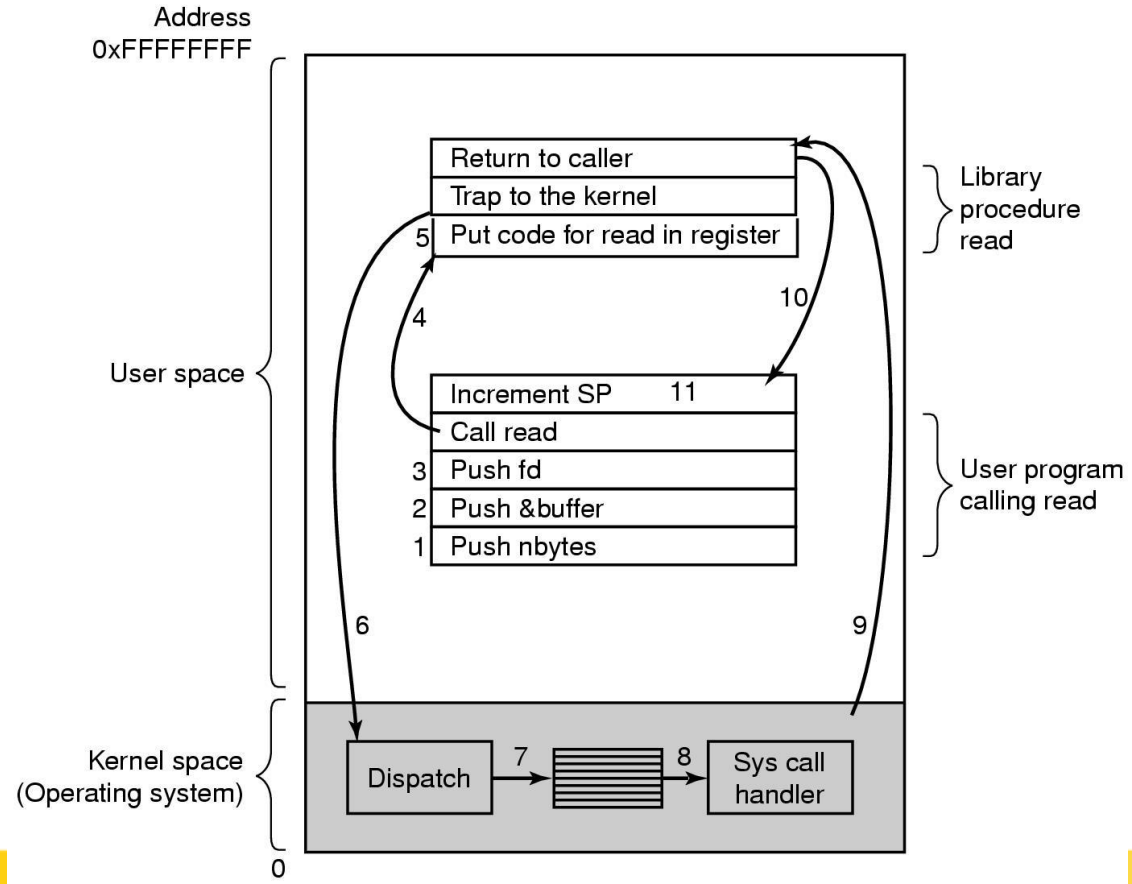
- Communications – Processes may exchange information, on the same computer or between computers over a network
- Error detection – OS needs to be constantly aware of possible errors

System Calls

- Making System Calls
- Major POSIX System Calls
- Examples of System Calls

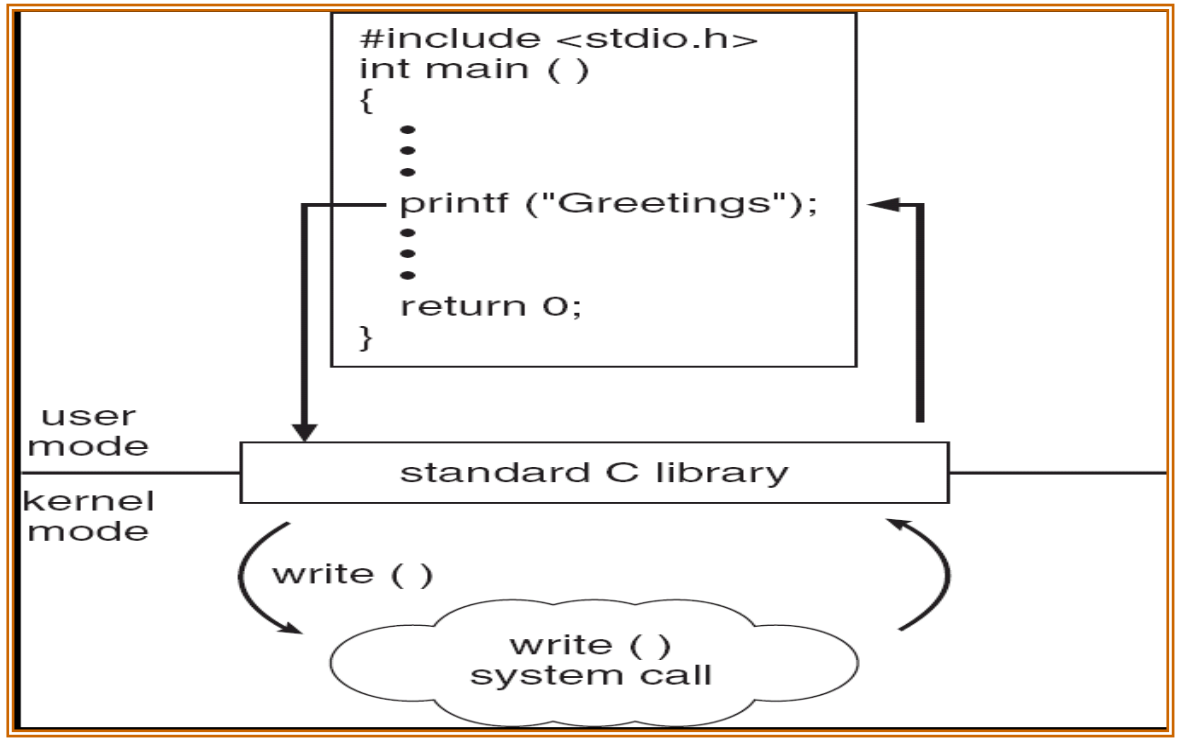
System Calls
Making System Calls (1)

- There are 11 steps in making the system call
- Example: read (fd, buffer, nbytes)



System Calls
Making System Calls (2)

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



System Calls
POSIX System Calls (1)

- Some System Calls For Process Management
- POSIX (Portable Operating System Interface)

Process management

Call	Description
pid = fork( )	Create a child process identical to the parent
pid = waitpid(pid, &statloc, options)	Wait for a child to terminate
s = execve(name, argv, environp)	Replace a process' core image
exit(status)	Terminate process execution and return status

System Calls
POSIX System Calls (2)

- Some System Calls For File Management

Directory and file system management

Call	Description
s = mkdir(name, mode)	Create a new directory
s = rmdir(name)	Remove an empty directory
s = link(name1, name2)	Create a new entry, name2, pointing to name1
s = unlink(name)	Remove a directory entry
s = mount(special, name, flag)	Mount a file system
s = umount(special)	Unmount a file system

System Calls
POSIX System Calls (3)

- Some System Calls For Directory Management

Directory and file system management

Call	Description
s = mkdir(name, mode)	Create a new directory
s = rmdir(name)	Remove an empty directory
s = link(name1, name2)	Create a new entry, name2, pointing to name1
s = unlink(name)	Remove a directory entry
s = mount(special, name, flag)	Mount a file system
s = umount(special)	Unmount a file system

System Calls
POSIX System Calls (4)

- Some System Calls For Miscellaneous Tasks

Miscellaneous

Call	Description
s = chdir(dirname)	Change the working directory
s = chmod(name, mode)	Change a file's protection bits
s = kill(pid, signal)	Send a signal to a process
seconds = time(&seconds)	Get the elapsed time since Jan. 1, 1970

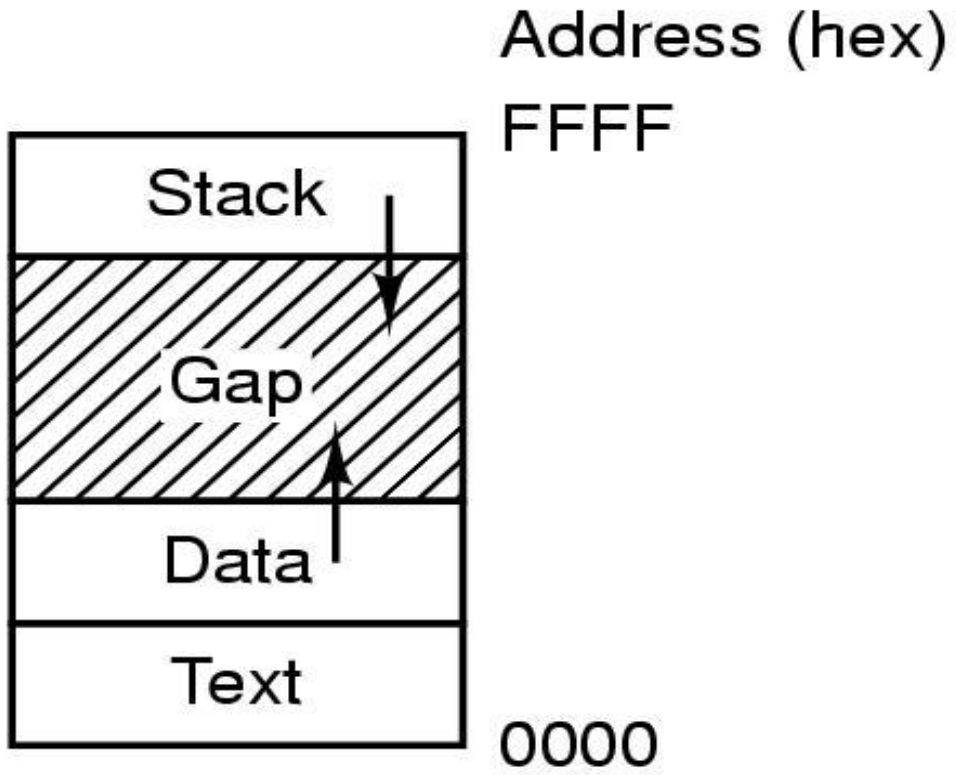
System Calls Examples (1)

- A stripped down shell:

```
while (TRUE) {                                  /* repeat forever */
    type_prompt( );                             /* display prompt */
    read_command (command, parameters)          /* input from terminal */
if (fork() != 0) {                              /* fork off child process */
    /* Parent code */
    waitpid( -1, &status, 0);                   /* wait for child to exit */
} else {
    /* Child code */
    execve (command, parameters, 0);            /* execute command */
 }
}
```

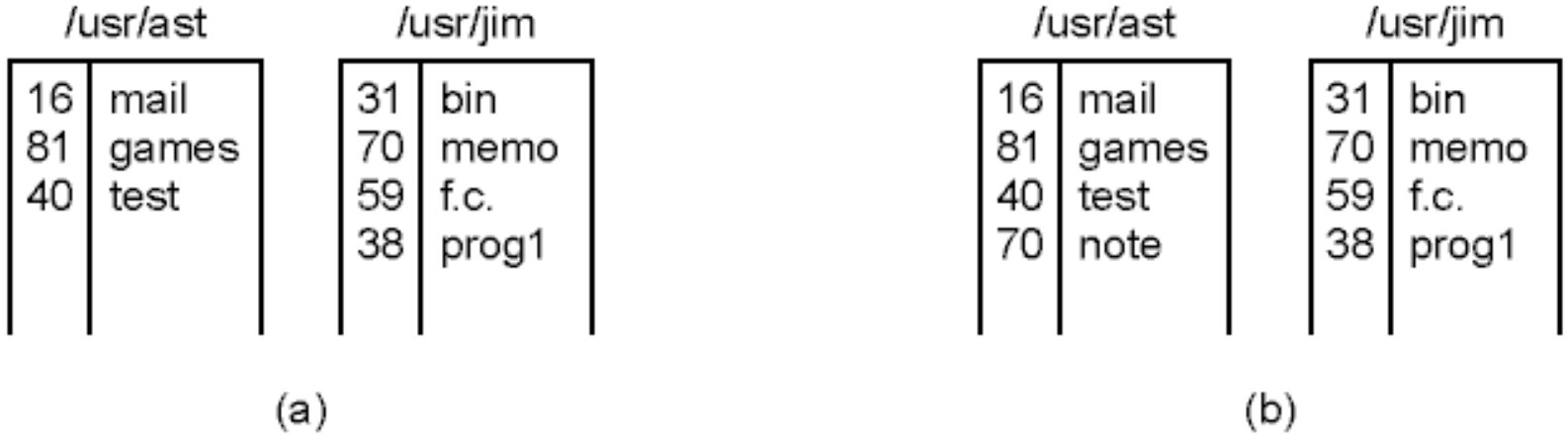
System Calls
Examples (2)

- Processes have three segments: text, data, stack



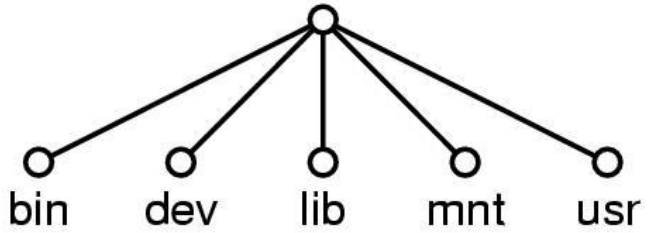
System Calls Examples (3)

- (a) Two directories before linking /usr/jim/memo to ast's directory
- (b) The same directories after linking

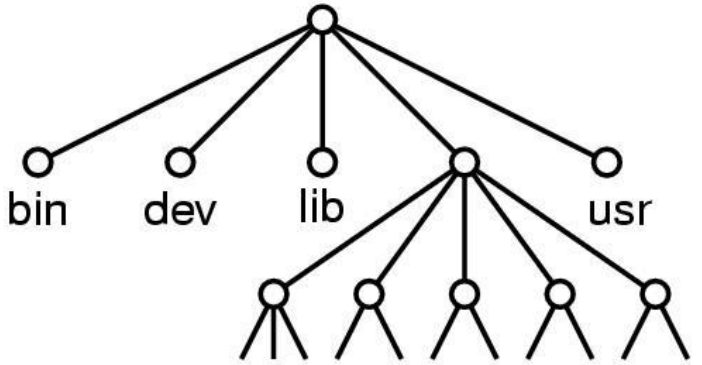


System Calls Examples (4)

- (a) File system before the mount
- (b) File system after the mount



(a)



(b)

System Calls

- Some Win32 API calls

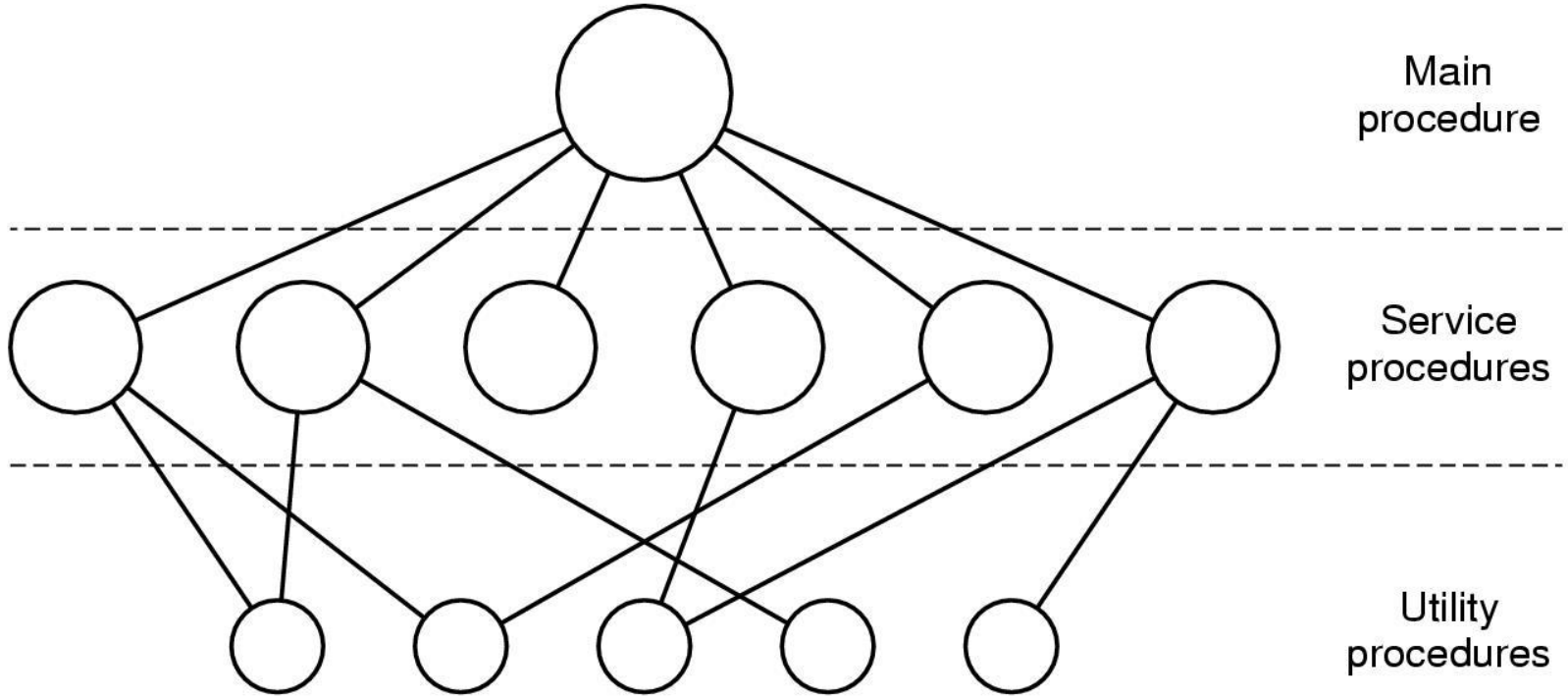
UNIX	Win32	Description
fork	CreateProcess	Create a new process
waitpid	WaitForSingleObject	Can wait for a process to exit
execve	(none)	CreateProcess = fork + execve
exit	ExitProcess	Terminate execution
open	CreateFile	Create a file or open an existing file
close	CloseHandle	Close a file
read	ReadFile	Read data from a file
write	WriteFile	Write data to a file
lseek	SetFilePointer	Move the file pointer
stat	GetFileAttributesEx	Get various file attributes
mkdir	CreateDirectory	Create a new directory
rmdir	RemoveDirectory	Remove an empty directory
link	(none)	Win32 does not support links
unlink	DeleteFile	Destroy an existing file
mount	(none)	Win32 does not support mount
umount	(none)	Win32 does not support mount
chdir	SetCurrentDirectory	Change the current working directory
chmod	(none)	Win32 does not support security (although NT does)
kill	(none)	Win32 does not support signals
time	GetLocalTime	Get the current time

Operating System Structure

- Monolithic system
- Layered System
- Virtual Machine
- Client-server model
- Microkernel

Operating System Structure
Monolithic system (1)

- Simple structuring model for a monolithic system



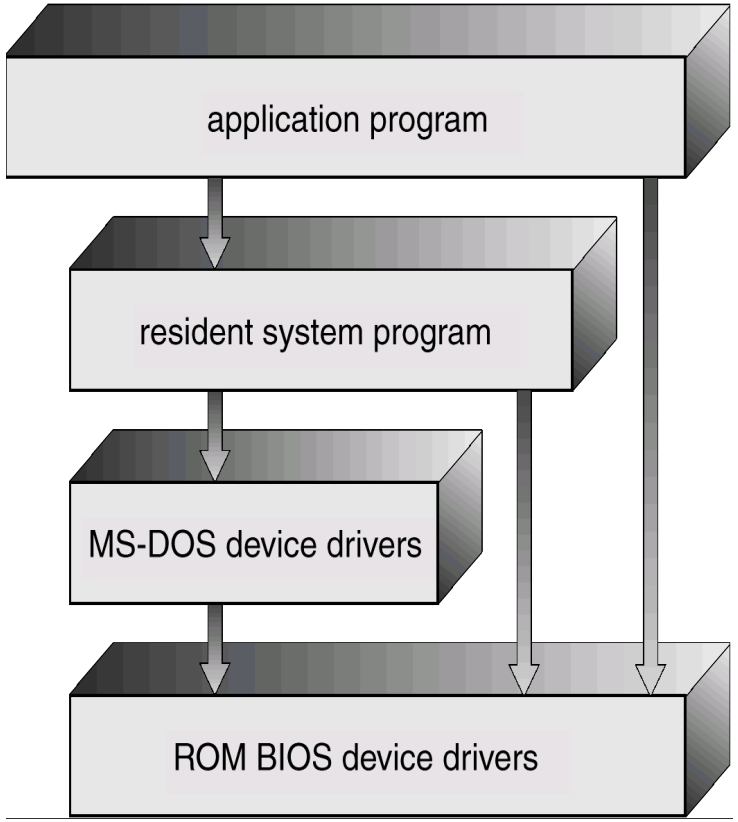
Operating System Structure
Monolithic system (2)

- Structure of Operating System:
  - A main program that invokes the requested service procedure.
  - A set of service procedures that carry out the system calls.
  - A set of utility procedures that help the service procedures.

Operating System Structure

Monolithic system (3) : Example

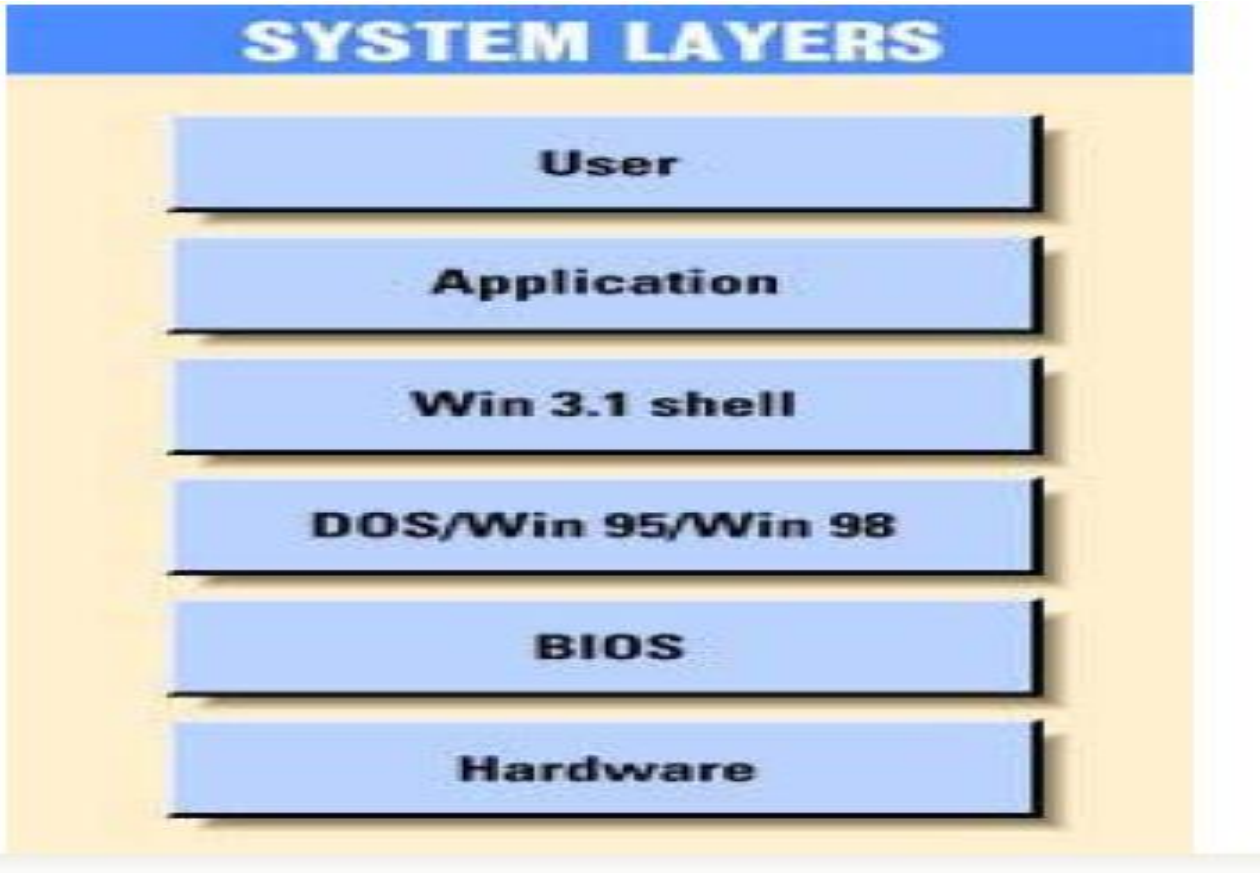
- Monolithic
  - MS-DOS – written to provide the most functionality in the least space:
    - ✓ Not divided into modules;
    - ✓ Although MS-DOS has some structure, its interfaces and levels of functionality are not well separated



Operating System Structure
Layered System (1)

- Many Layers
- Each layer has well defined functions
- Upper layer can only calls functions of closely lower layer
- Advantages:
  - Easier to extend
  - Easier to debug from lower to upper layer

Operating System Structure
Layered System (2): Example

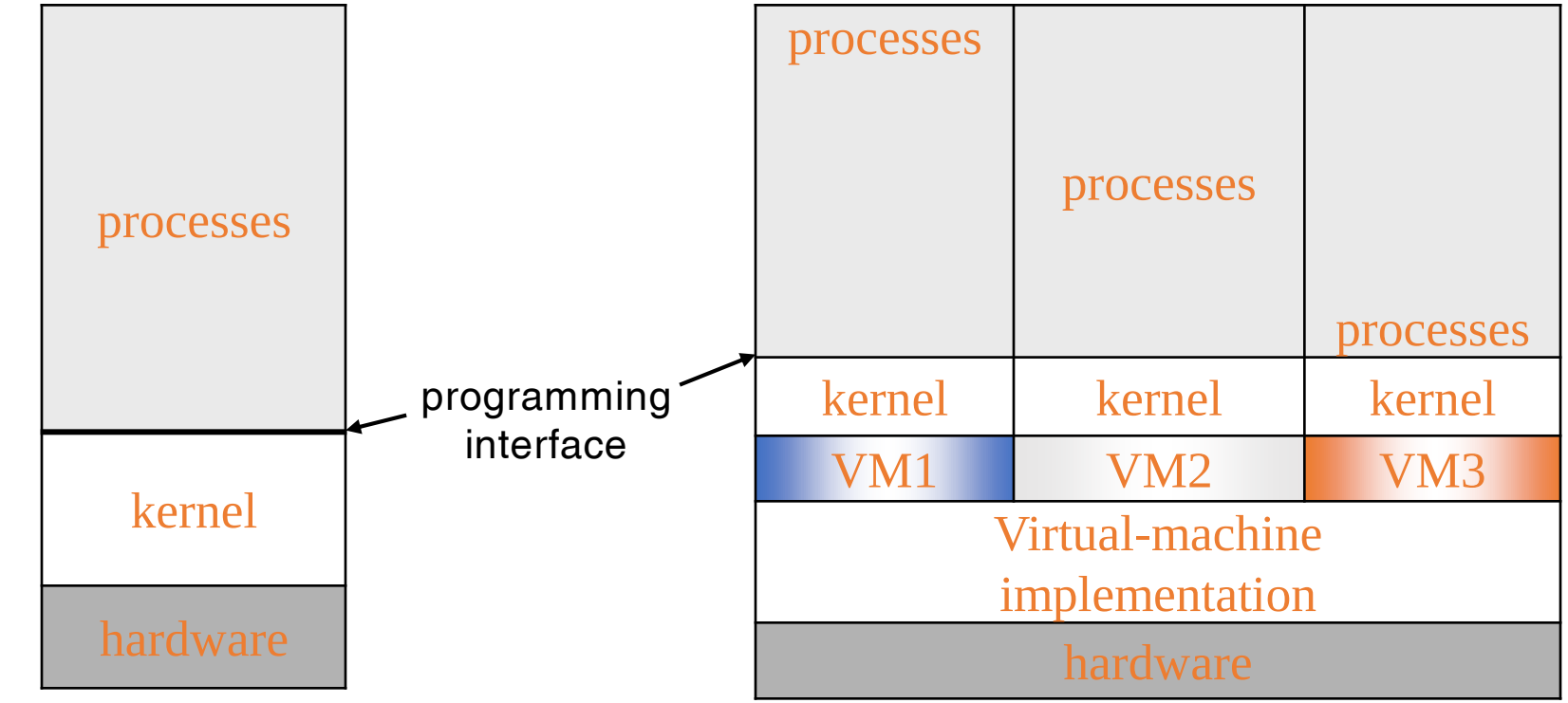


Operating System Structure
Layered System (3): Example

- Structure of the THE operating system

Layer	Function
5	The operator
4	User programs
3	Input/output management
2	Operator-process communication
1	Memory and drum management
0	Processor allocation and multiprogramming

Operating System Structure
Virtual Machine (1)



Non-virtual machine system model

Virtual machine system model

Operating System Structure
Virtual Machine (2)

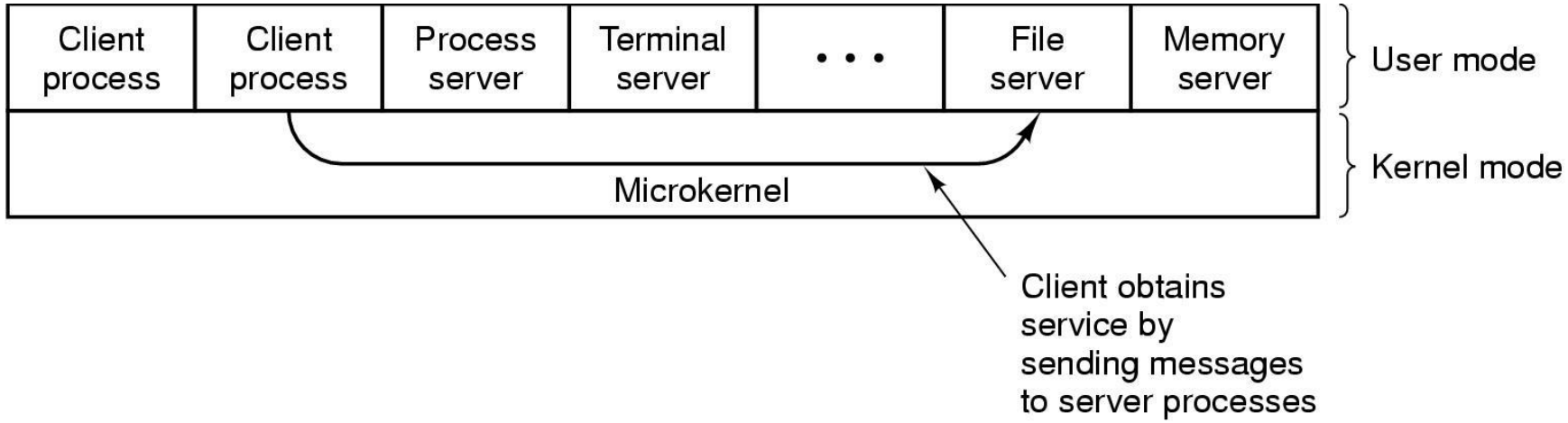
- A *virtual machine* takes the layered approach to its logical conclusion. It treats hardware and the operating system kernel as though they were all hardware
- A virtual machine provides an interface *identical* to the underlying bare hardware
- The operating system creates the illusion of multiple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

Operating System Structure
Virtual Machine (3)

- 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

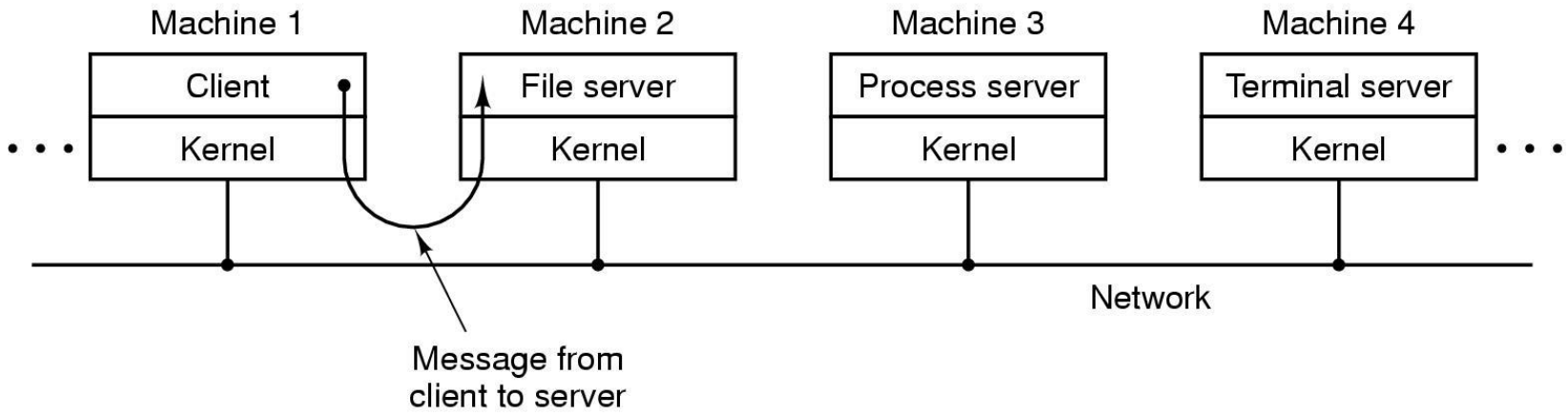
Operating System Structure
Client-server model (1)

- The client-server model



Operating System Structure
Client-server model (2)

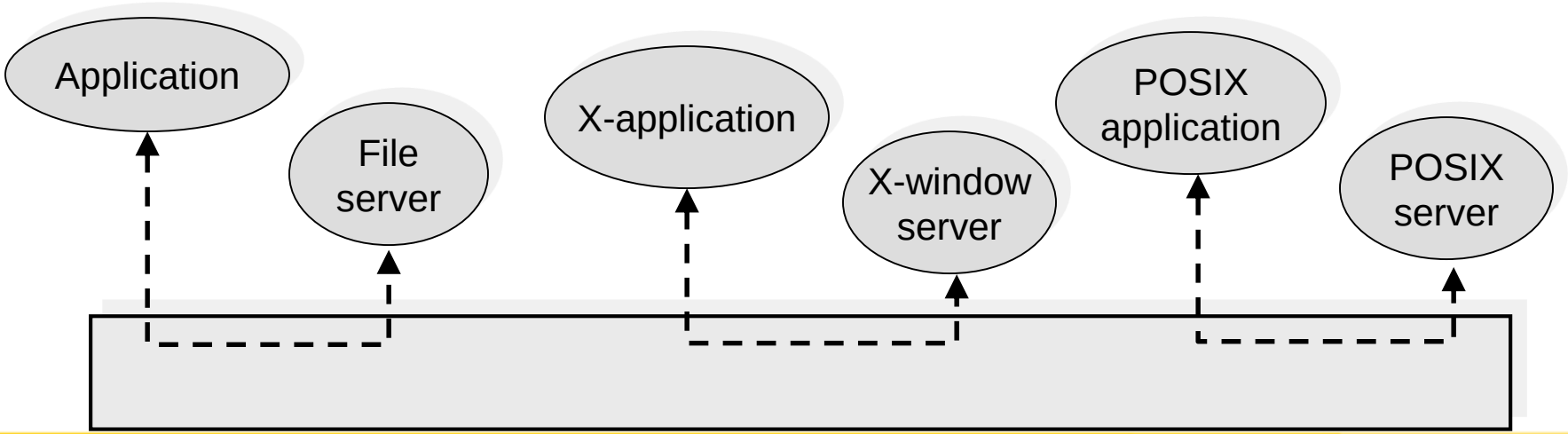
- The client-server model in a distributed system



Operating System Structure
Microkernel: Example

➢Microkernel

- OS design: The operating system is divided into microkernel (CMU Mach OS - 1980)
  - ✓ Moves as much from the kernel into “user” space
  - ✓ kernel → microkernel
  - ✓ Communication takes place between user modules using message passing.



Metric Units

- The metric prefixes

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

SUMMARY

- Introduction
- Computer hardware review
- Operating system concepts