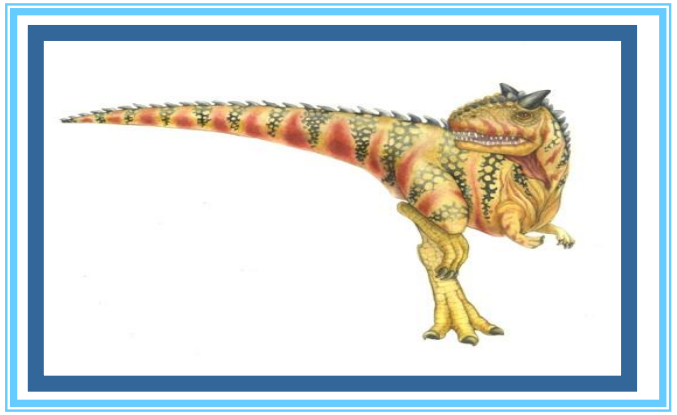
Chapter 1: Introduction



Chapter 1: Introduction

1.1 What Operating Systems Do

1.2 Computer-System Organization

1.3 Computer-System Architecture

1.4 Operating-System Operations

1.5 Resource Management

1.6 Security and Protection

1.7 Virtualization

1.8 Distributed Systems

1.9 Kernel Data Structures

1.10 Computing Environments

1.11 Free and Open-Source Operating

Chapter Objectives

- Describe the general organization of a computer system and the role of interrupts.
- Describe the components in a modern multiprocessor computer system.
- Illustrate the transition from user mode to kernel mode.
- Discuss how operating systems are used in various computing environments.
- Provide examples of free and open-source operating systems.

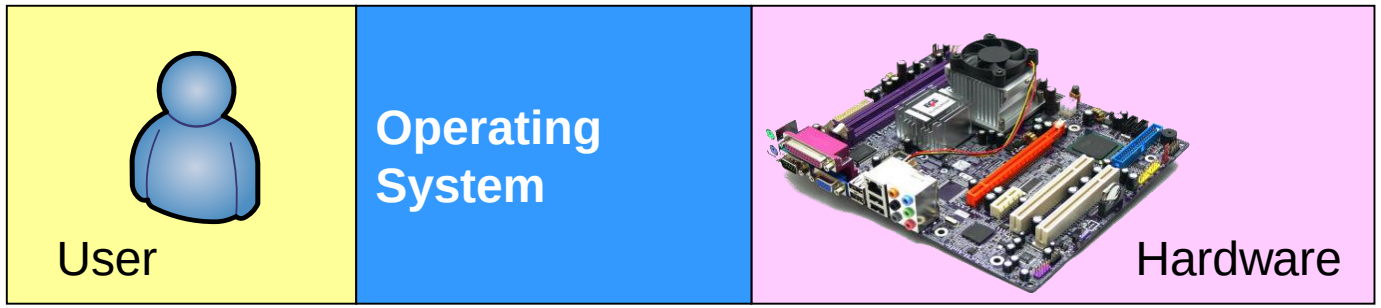
操作系统

- 操作系统的名称：
  - 监控（督）程序（系统）（Monitor)
  - 执行系统（程序）(Executive System(program))
  - 控制系统（程序）(Control System program))
  - 管理程序(Supervisor, Supervisory System)
  - 内核(Kernel)
  - 操作系统(Operating System)

1.1 WHAT OPERATING SYSTEM DO

What Operating System Do?

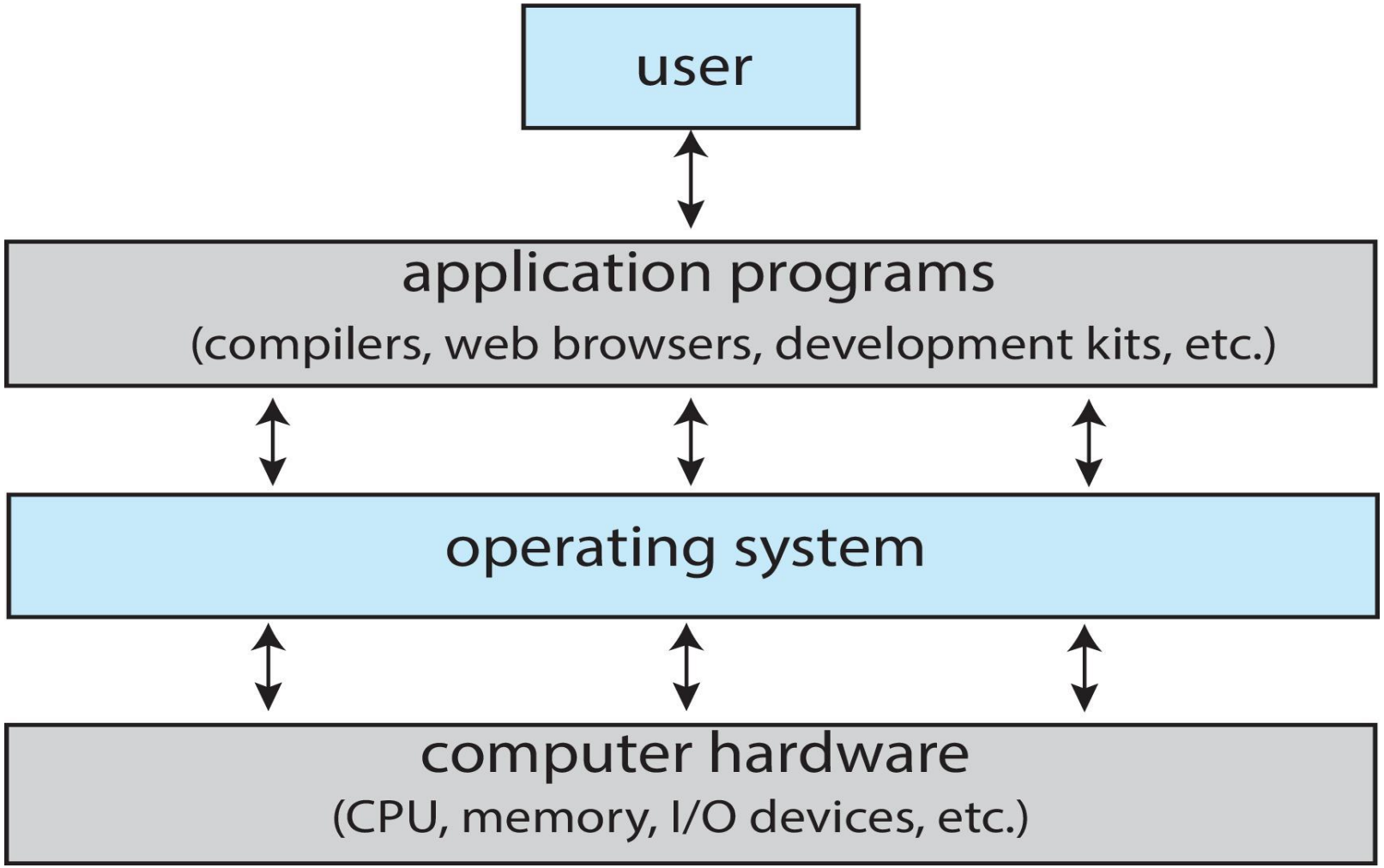
- A program that acts as an intermediary between a user of a computer and the computer hardware.
- Operating system goals:
  - Execute user programs and make solving user problems easier.
  - Make the computer system convenient to use.
  - Use the computer hardware in an efficient manner.



Computer System Structure

- Computer system can be divided into four components
  - Hardware – provides basic computing resources
    - CPU, memory, I/O devices
  - Operating system
    - Controls and coordinates use of hardware among various applications and users
  - Application programs – define the ways in which the system resources are used to solve the computing problems of the users
    - Word processors, compilers, web browsers, database systems, video games
  - Users
    - People, machines, other computers

Four Components of a Computer System



What is Operating System ?

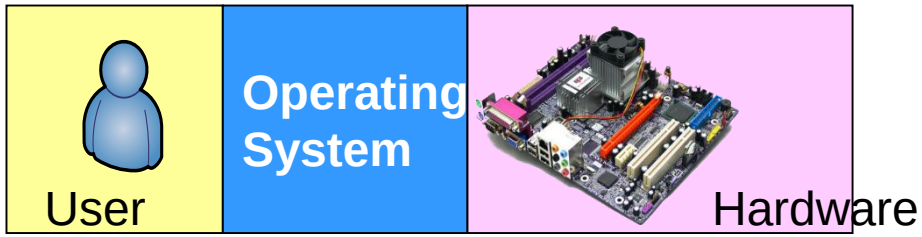
1、从计算机系统组成观点——操作系统是系统软件

- 计算机系统组成：
  - 软件：
    - 应用软件
    - 系统软件（操作系统等）
  - **硬件：**
    - 输入 / 输出（I / O）设备
    - 存储器(内存)
    - 中央处理器(CPU)

What is Operating System ?

2. User View :操作系统是用户与计算机硬件之间接口

- Computer计算机硬件
  - PC
  - mainframe, or minicomputer
  - mobile computers



- 操作系统提供的接口有：
  - 命令级接口
    - 键盘或鼠标等命令。
    - Mobile user interfaces such as **touch screens, voice recognition**
  - 程序级接口，它提供一组系统调用System calls，即操作系统服务，供用户程序和其它程序调用。

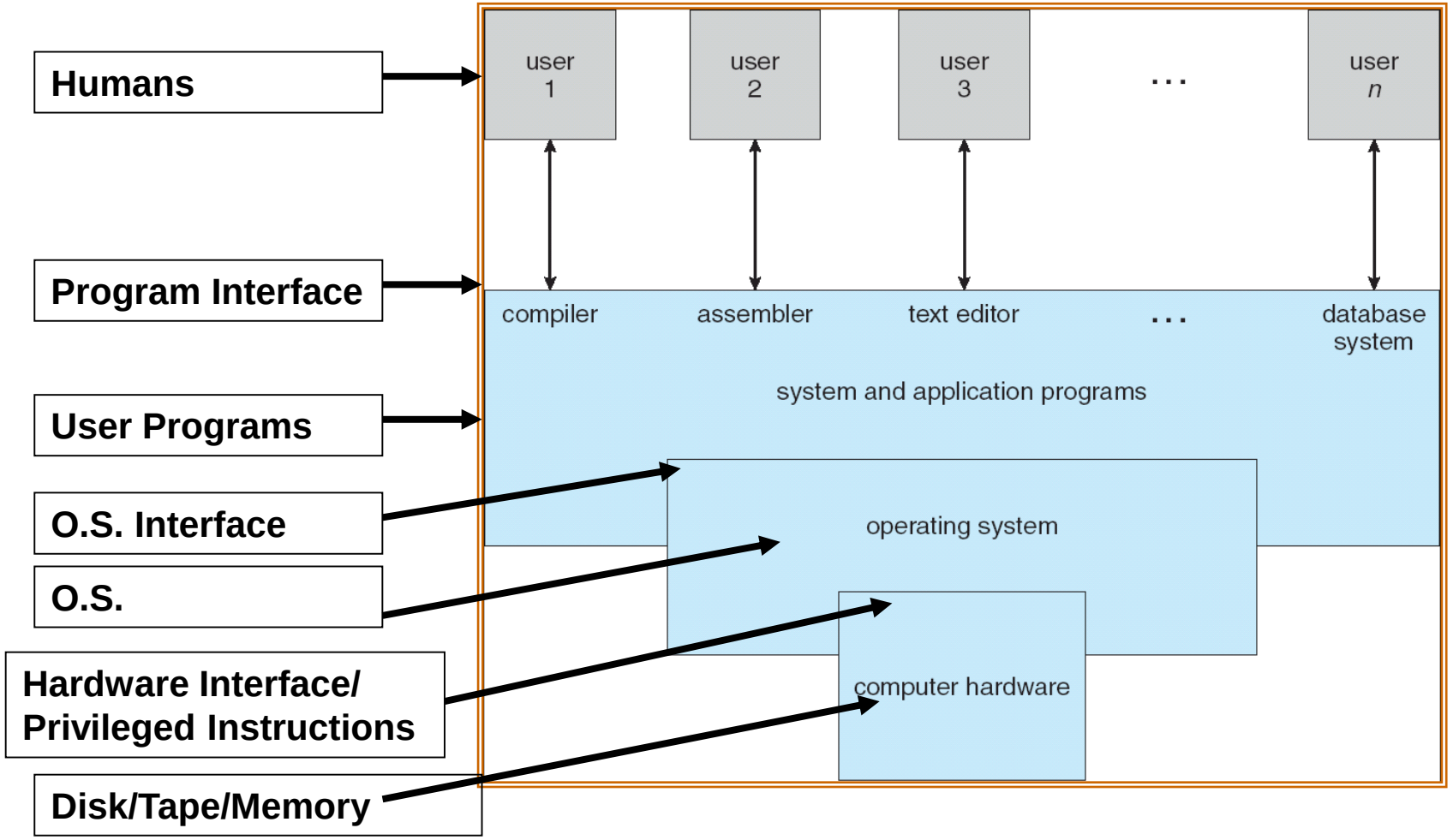
What is Operating System ?

3. System View:操作系统是计算机系统资源的管理者

- OS is a resource allocator
  - Manages all resources
  - Decides between conflicting requests for efficient and fair resource use
- OS is a control program
  - Controls execution of programs to prevent errors and improper use of the computer

What is Operating System ?

- 4. 从软件分层、扩充机器的观点：操作系统是扩充裸机的第一层系统软件



Operating System Definition

5. No universally accepted definition

- "it includes Everything a vendor ships when you order an operating system" is good approximation
  - But varies wildly
- Everything else is either a system program (系统程序，ships with the operating system) or an application program，and mobile computing also include middleware

操作系统课程介绍的内容

- "The one program running at all times on the computer" is the **kernel**（内核）.

Operating System Definition (Cont.)

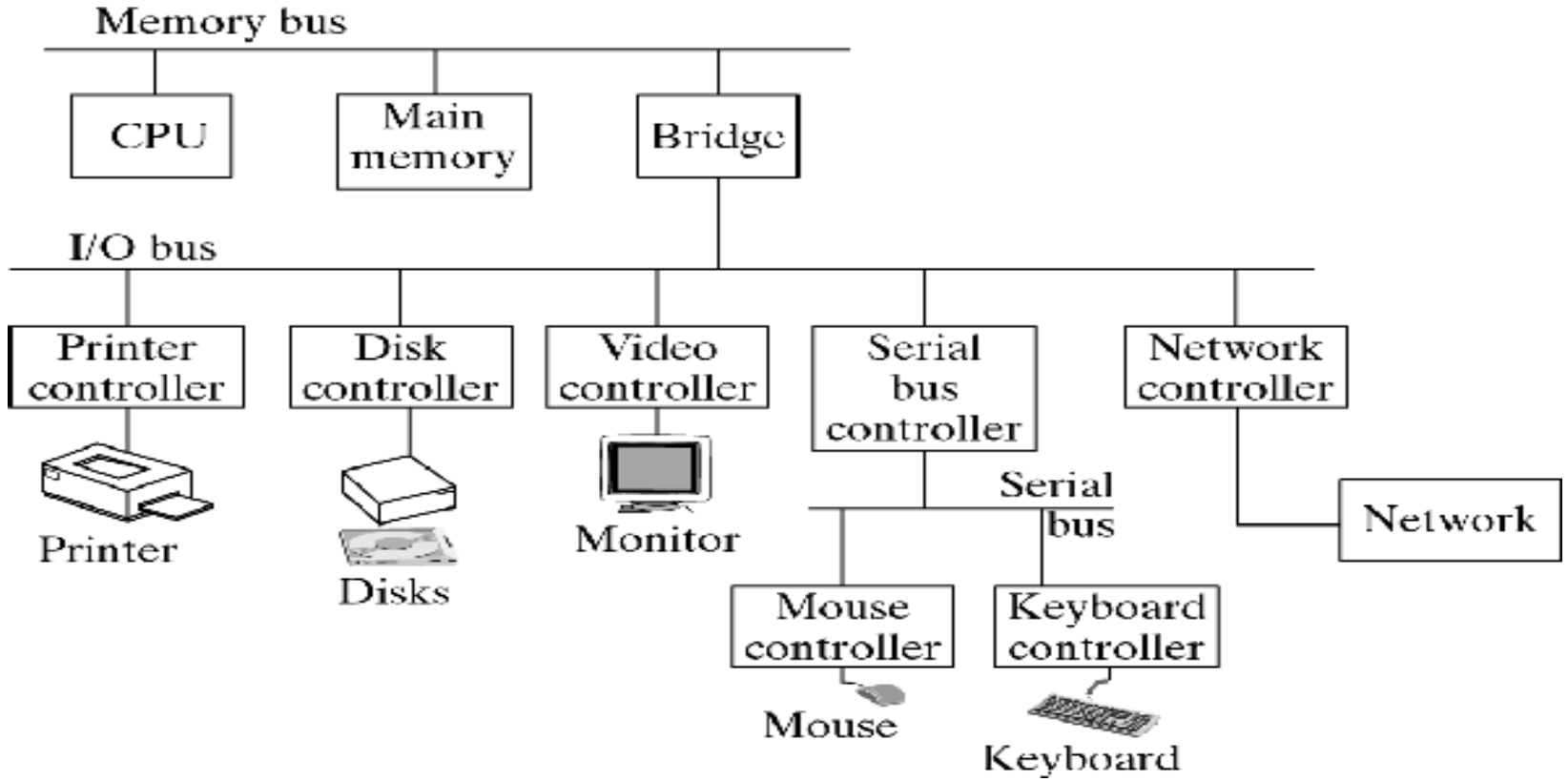
- 操作系统是一组有效控制和管理计算机各种硬件和软件资源，合理的组织计算机的工作流程 ，以及方便用户的程序的集合。 ——*很多中文书的描述*
- *体现：*
  - 有效（efficient）：系统效率高，资源利用率高

    （如：CPU使用率，内存、外部设备是否忙）
  - 合理：公平，如果不公平则会产生“死锁”或“饥饿”
  - 方便（convenience）：用户界面，编程接口

1.2 COMPUTER-SYSTEM ORGANIZATION

Computer System Organization

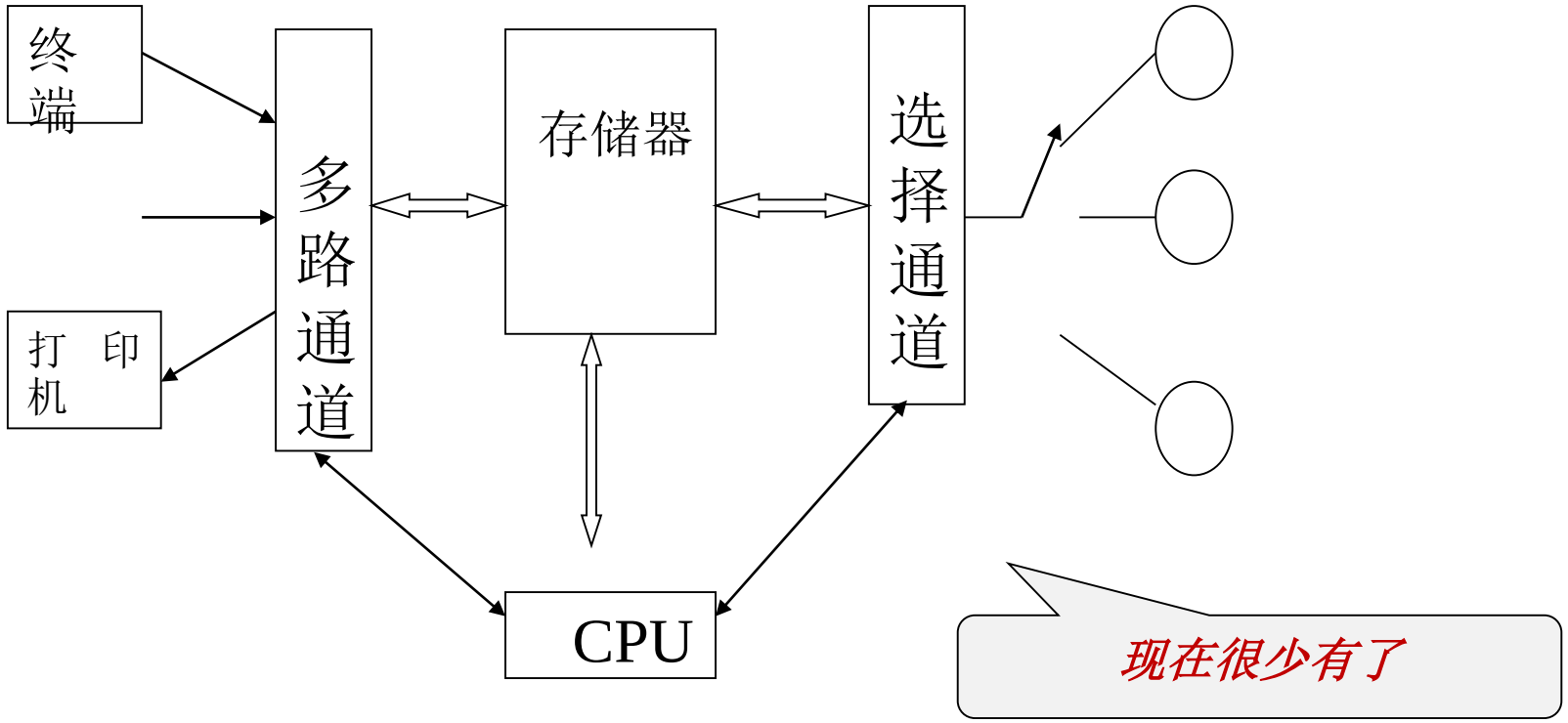
- 总线结构， 微型计算机是以总线为纽带来构成计算机系统，中央处理机（CPU）、存储器、 I／O设备（包括外存磁盘、磁带）都挂接在总线。



A modern computer system，总线型

Computer System Organization

- 主机型：这类计算机以存储器为中心，CPU和各种通道都与存储器相连。



A computer system，主机型

1.2.1 Computer-System Operation

- I/O devices and the CPU can execute concurrently（并行运行）
- Each device controller is in charge of a particular device type
- Each device controller has a local buffer
- Each device controller type has an operating system **device driver** to manage it
- 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 Startup

- bootstrap program is loaded at power-up or reboot
  - Typically stored in ROM or EEPROM, generally known as firmware
  - Initializates all aspects of system
  - Loads operating system kernel and starts execution

Common Functions of Interrupts

- 中断(Interrupt)：指系统发生某个异步/同步事件后,处理机暂停正在执行的程序,转去执行处理该事件程序的过程。
- Interrupt transfers control to the interrupt service routine generally, through the *interrupt vector*（中断向量）, which contains the addresses of all the service routines.
- Interrupt architecture must save the address of the interrupted instruction.

Common Functions of Interrupts

- Incoming interrupts are *disabled* while another interrupt is being processed to prevent a *lost interrupt*.
- A *trap*（陷入） is a software-generated interrupt caused either by an error or a user request.
- An operating system is *interrupt* driven.

中断

- 广义中断
  - 中断(外中断)
    - I/O中断
    - 时钟中断
  - 异常(内中断)
    - 系统调用（陷入）
    - 缺页异常
    - 断点指令
    - 其他程序性异常
      (如算术溢出等)

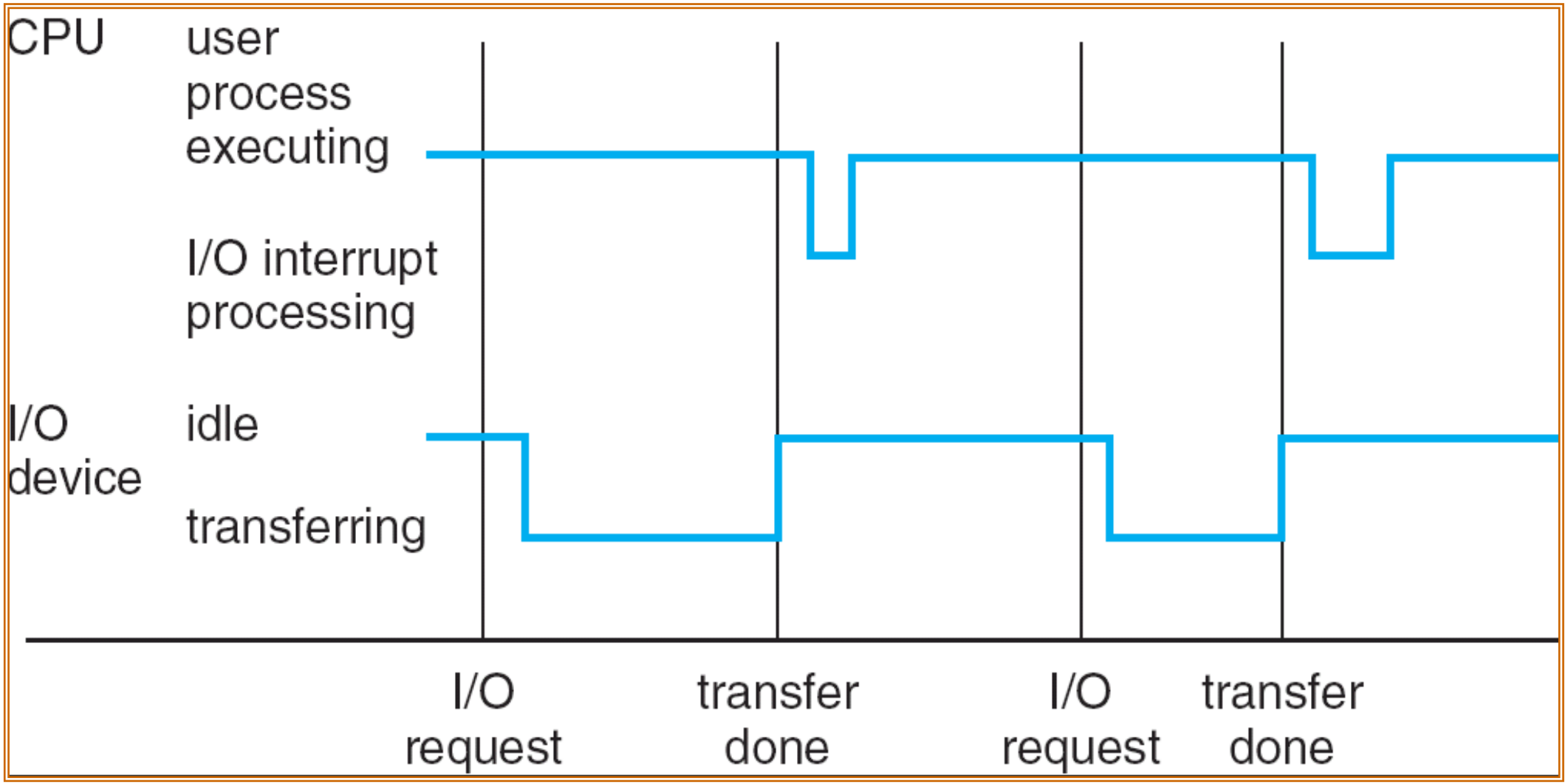
中断

- 外部中断(interrupt)，异步中断：
  - 外部设备所发出的I/O请求
  - 分为可屏蔽的和不可屏蔽的两类，由一些硬件设备产生，可以在指令执行的任意时刻产生。
- 异常(exception)，内部中断，同步中断：
  - 由CPU（正在执行的进程）产生，一条指令终止执行后CPU才会发出中断。
  - 常见的异常有除零、溢出及页面异常(fault出错)等。另一种情况是使用int指令(trap陷入)，Linux使用该指令来实现系统调用。 fault与trap区别

Interrupt Handling（中断处理）

- The operating system preserves the state of the CPU by storing registers and the program counter.
- Determines which type of interrupt has occurred:
  - *Polling* 轮询
  - *vectored* interrupt system 矢量化中断系统
- Separate segments of code determine what action should be taken for each type of interrupt

Interrupt Time line



1.2.2 Storage Structure

- Main memory（主存） – only large storage media that the CPU can access directly.
- Secondary storage（辅存） – extension of main memory that provides large nonvolatile storage capacity.
- **Hard Disk Drives (HDD，硬盘）** – rigid metal or glass platters covered with magnetic recording material
  - Disk surface is logically divided into *tracks*, which are subdivided into *sectors*.
  - The *disk controller* determines the logical interaction between the device and the computer.
- **Non-volatile memory (NVM，非易失存储器)** devices– faster than hard disks, nonvolatile
  - Various technologies
  - Becoming more popular as capacity and performance increases, price drops

Storage Hierarchy

- Storage systems organized in hierarchy.
  - Speed
  - Cost
  - Volatility
- *Caching*（高速缓存）– copying information into faster storage system; main memory can be viewed as a last *cache* for secondary storage.

Caching （高速缓存）

- 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

Storage-Device Hierarchy

寄存器

高速缓存

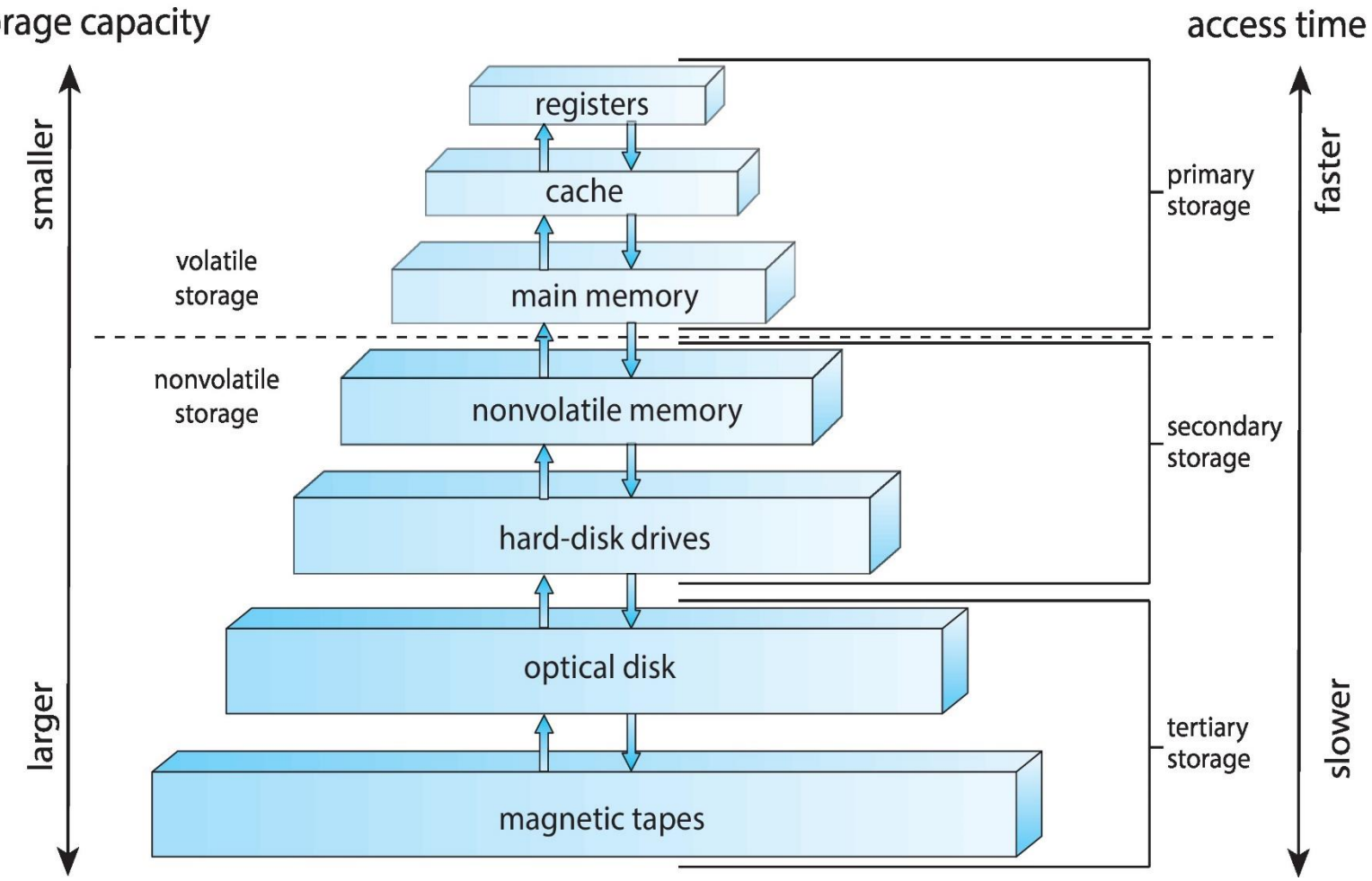
主存储器

闪存

磁盘

光盘

磁带



1.2.3 I/O Structure

- I/O方式
  - 程序I/O (Programmed I/O)
  - 中断 I/O (Interrupt I/O):同步I/O和异步I/O
  - DMA方式
  - 通道方式
- Synchronous I/O（同步I/O）:After I/O starts, control returns to user program only upon I/O completion.
  - Wait for I/O completion,tow ways:
    - wait instruction idles the CPU until the next interrupt
    - wait loop (loop: jmp loop).
  - At most one I/O request is outstanding at a time, no simultaneous I/O processing.

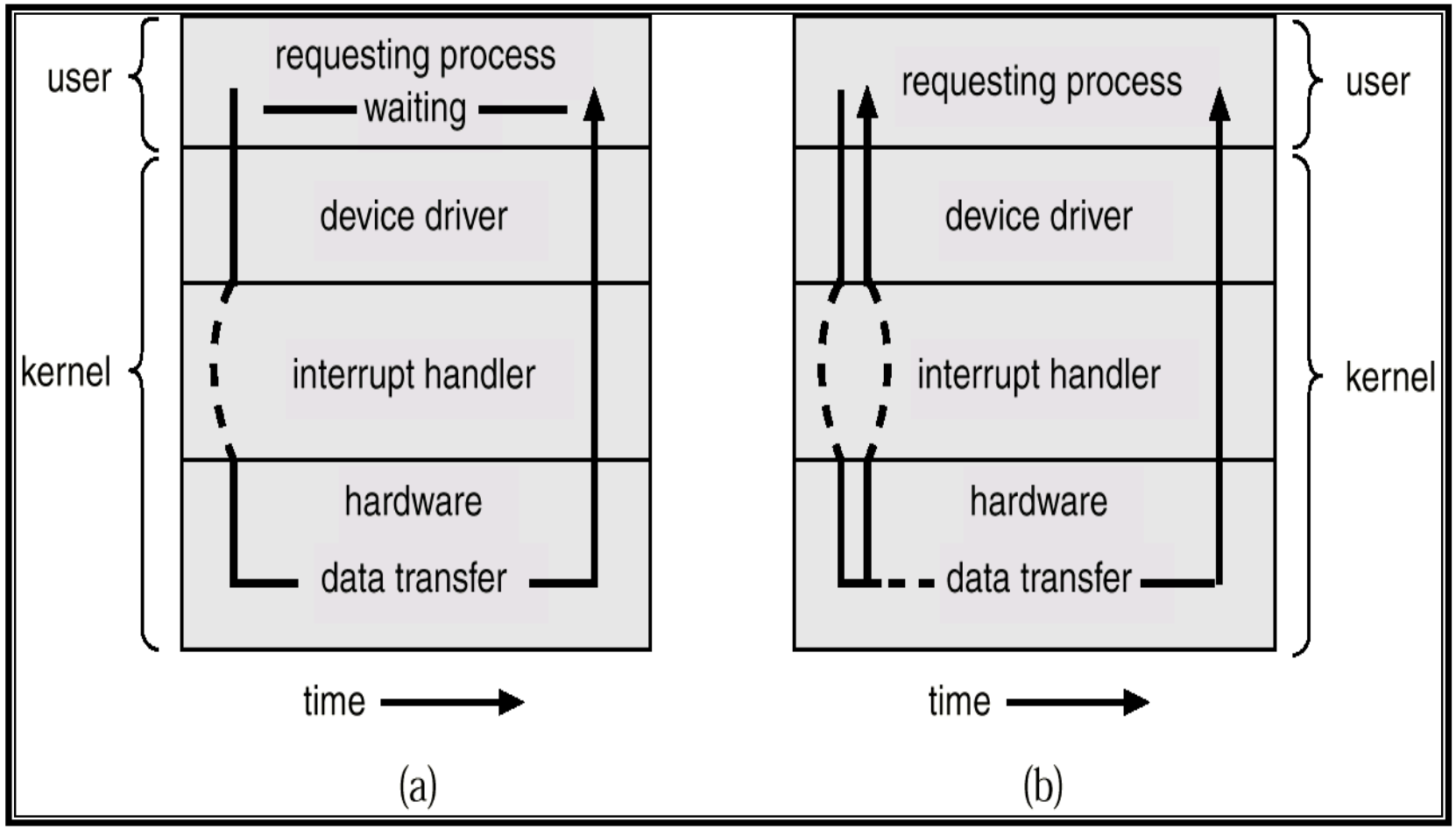
I/O Interrupts

- Asynchronous I/O（异步I/O） : After I/O starts, control returns to user program without waiting for I/O completion.
  - *System call*系统调用– request to the operating system to allow user to wait for I/O completion.
  - *Device-status table* contains entry for each I/O device indicating its type, address, and state.
  - Operating system indexes into I/O device table to determine device status and to modify table entry to include interrupt.

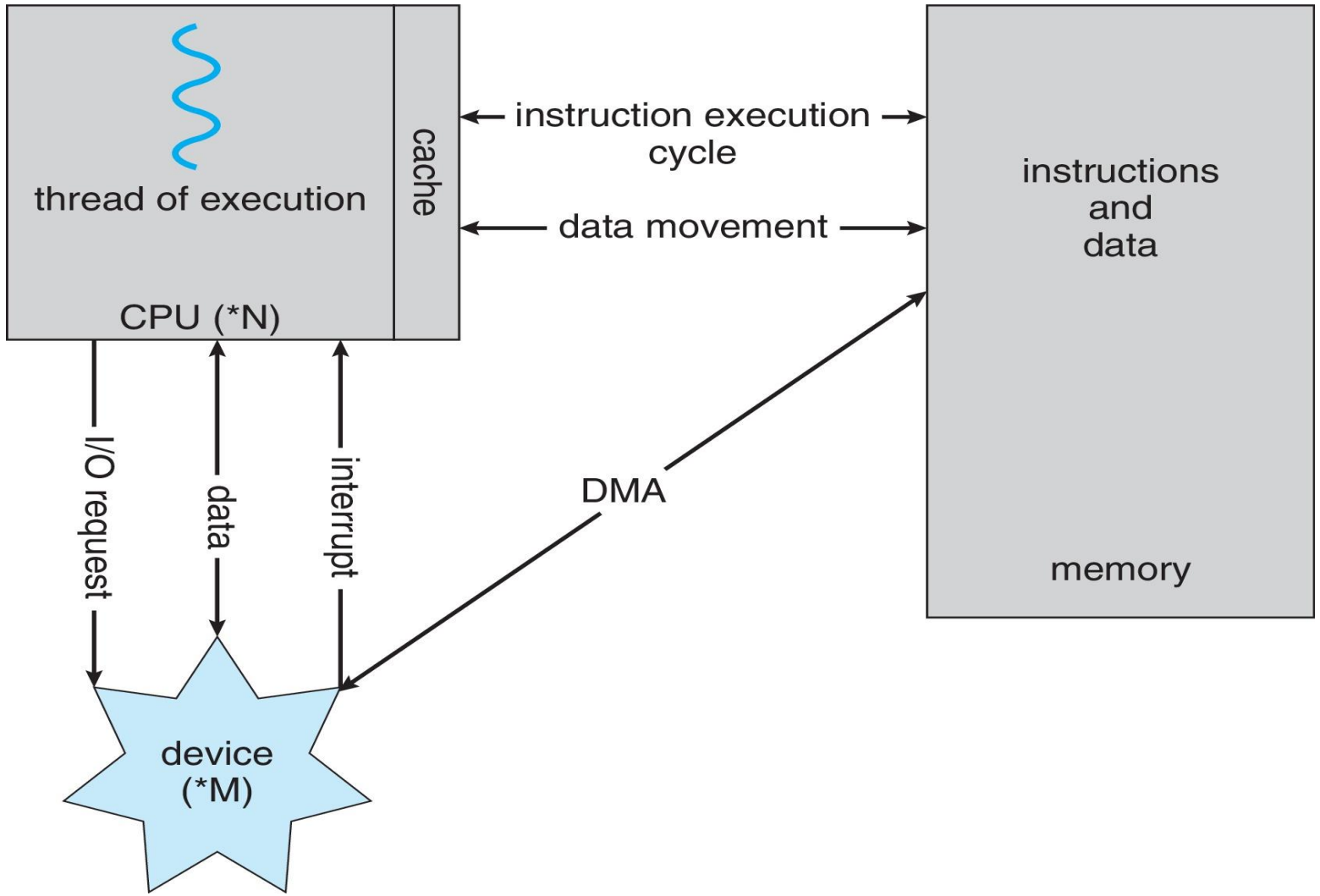
Two I/O Methods

Synchronous

Asynchronous

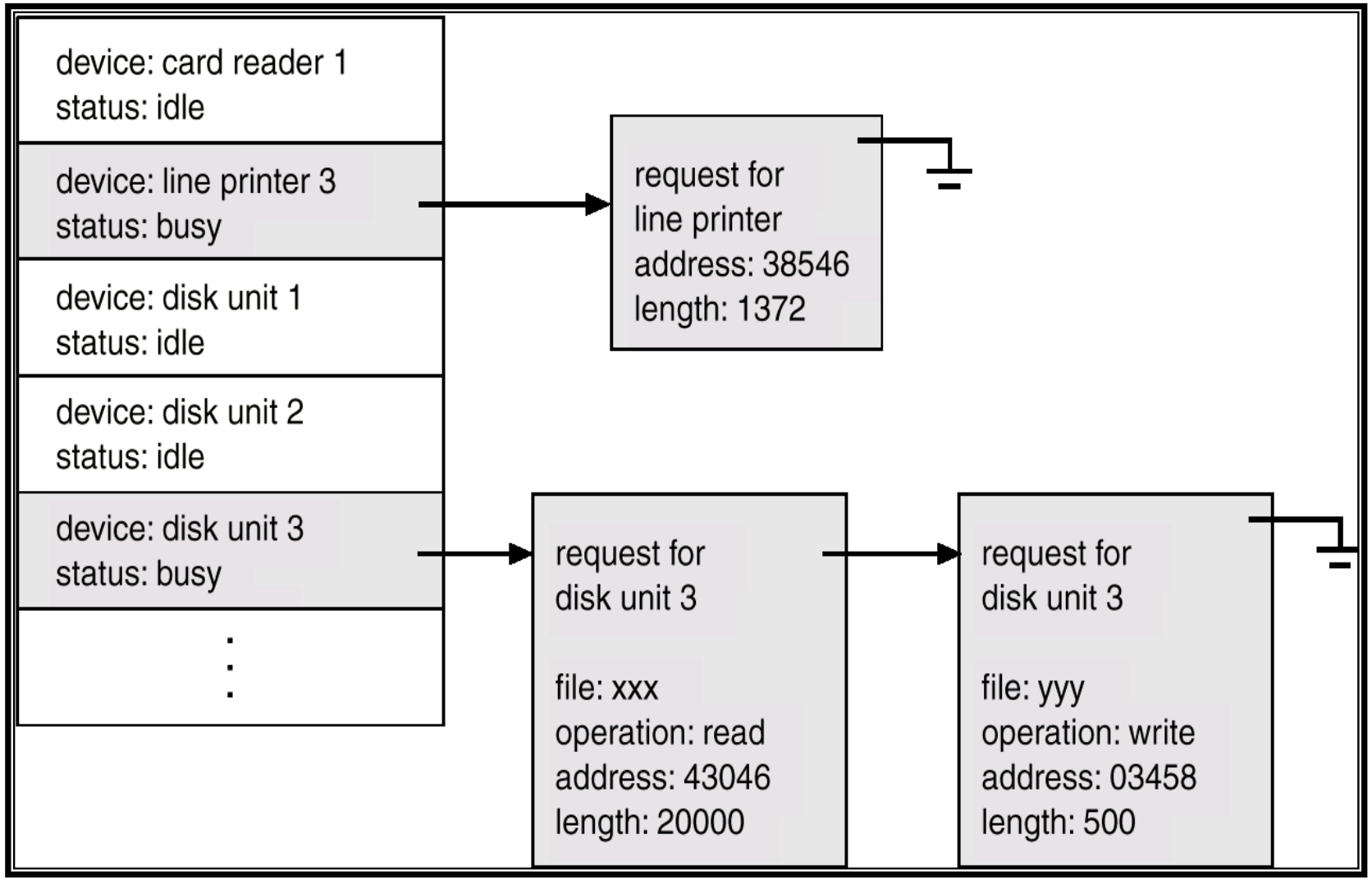


How a Modern Computer Works



A von Neumann architecture

Device-Status Table



Direct Memory Access Structure
直接内存访问(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 on interrupt is generated per block, rather than the one interrupt per byte.

1.3 COMPUTER-SYSTEM ARCHITECTURE

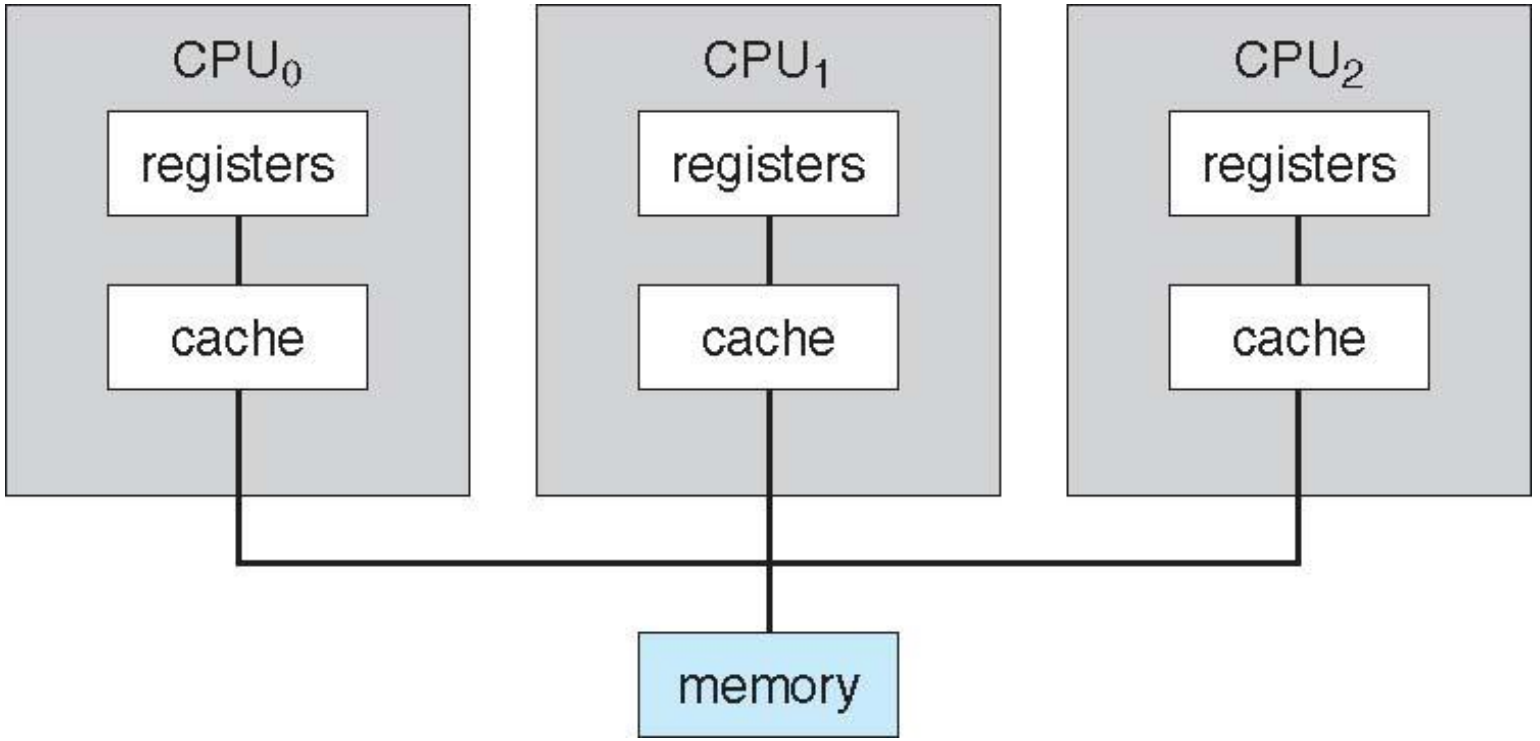
Single-Processor Systems（单处理器系统）

- Many years ago, most computer systems used a single processor containing one CPU with a single processing core.
- Most systems use a single general-purpose processor

Multiprocessor Systems（多处理器系统）

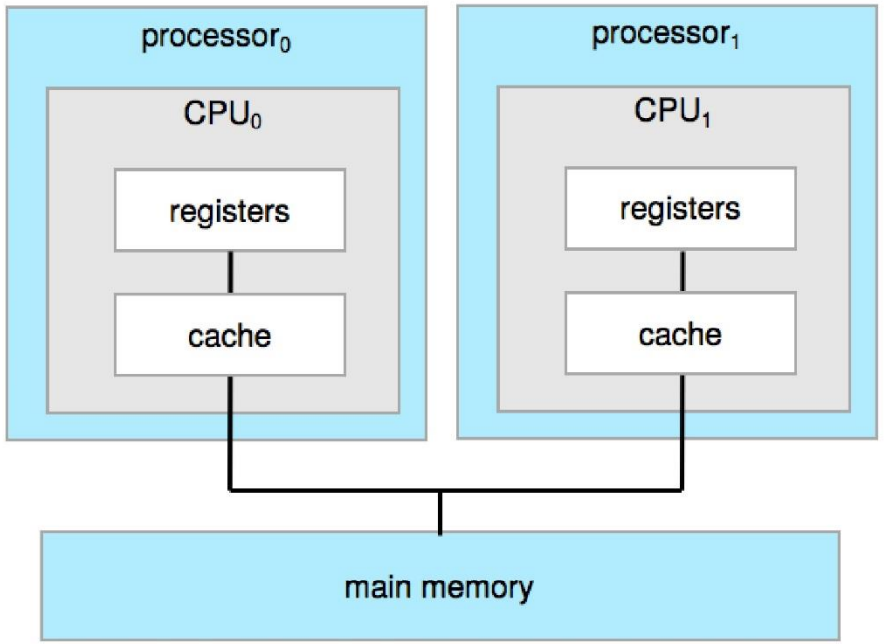
- Multiprocessors systems growing in use and importance
  - Also known as parallel systems, tightly-coupled systems
  - Advantages include:
    1. Increased throughput
    2. Economy of scale
    3. Increased reliability – graceful degradation or fault tolerance
  - Two types:
    1. Asymmetric Multiprocessing
    2. Symmetric Multiprocessing

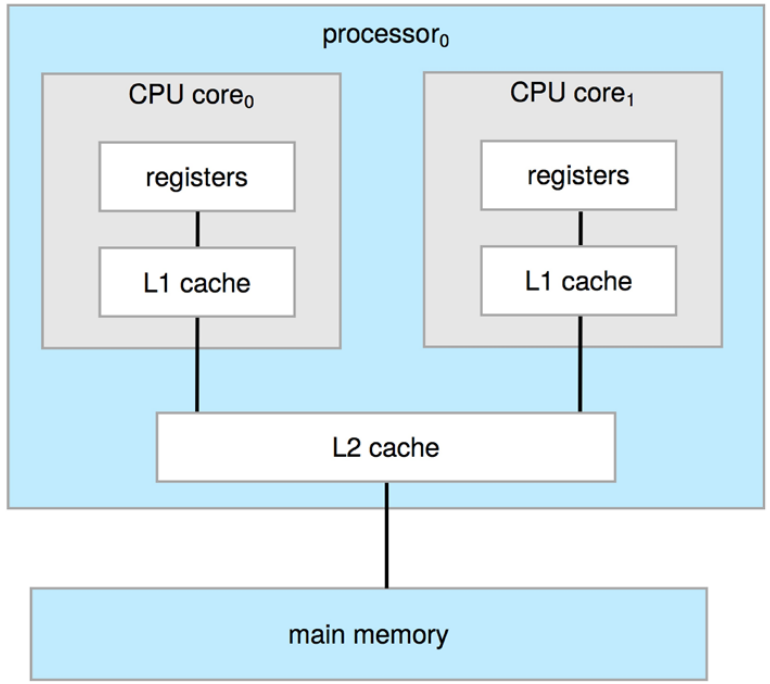
Symmetric Multiprocessing Architecture



A Dual-Core Design

- Multi-chip（多个芯片） and **multicore（多核）**
- Systems containing all chips
  - Chassis containing multiple separate systems





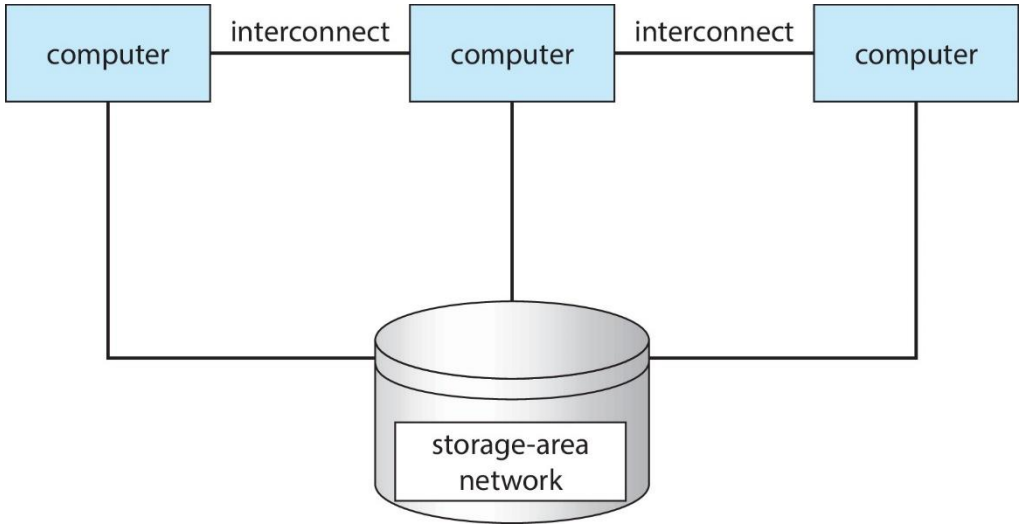
DEFINITIONS OF COMPUTER SYSTEM COMPONENTS

- **CPU**—The hardware that executes instructions.
- **Processor**—A physical chip that contains one or more CPUs.
- **Core**—The basic computation unit of the CPU.
- **Multicore**—Including multiple computing cores on the same CPU.
- **Multiprocessor**—Including multiple processors.

Although virtually all systems are now multicore, we use the general term ***CPU*** when referring to a single computational unit of a computer system and ***core*** as well as ***multicore*** when specifically referring to one or more cores on a CPU.

Clustered Systems集群系统

- 集群系统(Cluster)：是由一组互联的主机（节点）构成统一的计算机资源，通过相应软件协调工作的计算机机群，给人以一台机器的感觉。
- Usually sharing storage via a storage-area network (SAN)
- Provides a high-availability service which survives failures
  - Asymmetric clustering（非对称集群） has one machine in hot-standby mode
  - Symmetric clustering （对称集群） has multiple nodes running applications, monitoring each other



Clustered Systems

- Some clusters are for high-performance computing (HPC，高性能计算)
  - Applications must be written to use parallelization
- Some have distributed lock manager (DLM，分布式锁管理器) to avoid conflicting operations
- Other forms of cluster:parall cluster,cluster over a WAN。
- Cluster technology is changing rapidly.
  - Some cluster products support thousands of systems in a cluster, as well as clustered nodes that are separated by miles.
  - Storage-Area Network ,SAN存储区域网.

1.4 OPERATING-SYSTEM OPERATIONS (操作系统的执行)

Operating-System Operations

- Interrupt driven by hardware
- Software error or request creates exception（异常） or trap（陷入）
  - Division by zero, request for operating system service
- Other process problems include infinite loop, processes modifying each other or the operating system

Privileged instructions

- *Privileged instructions* can be issued only in monitor mode.

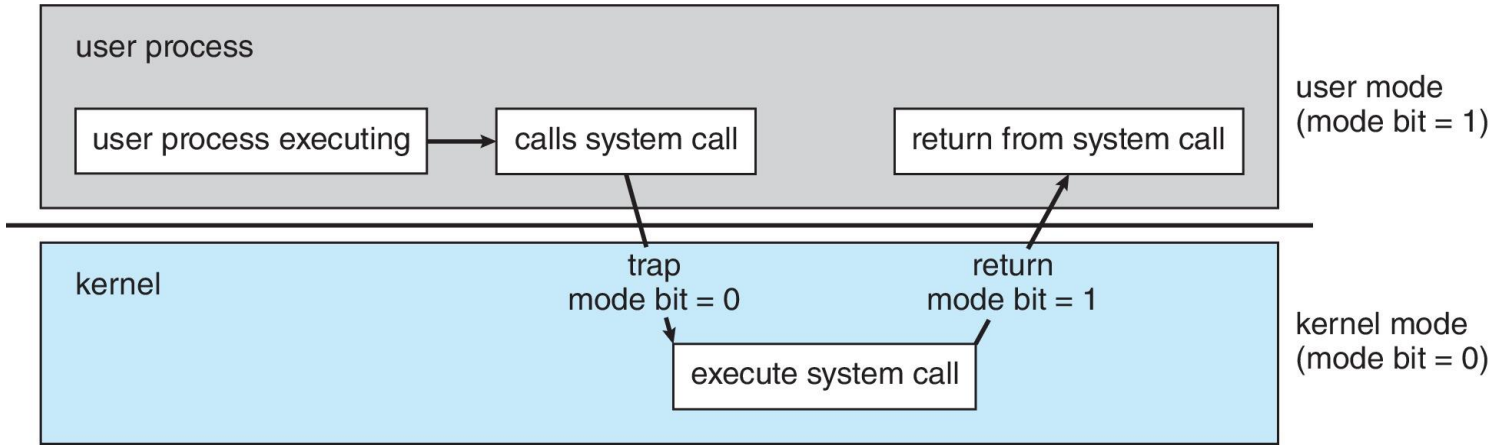
- 特权指令：不允许用户程序中直接使用的指令。例如：I/O指令、设置时钟、置控制寄存器等指令都是特权指令。
- 非特权指令：用户程序中所使用的指令。

Operating-System Operations

- Dual-mode operation allows OS to protect itself and other system components
  - User mode（用户模式，用户态） and kernel mode (also *monitor mode* or *system mode* or *supervisor mode* or *privileged mode*) （内核模式，内核态）
    - 用户态：执行用户程序时
    - 内核态（管态、核心态、系统态、特权模式）：执行操作系统程序时

重要概念

  - i386支持Ring0-Ring3



内核态与用户态

- 内核态与用户态之间的区别
  - 内核态
    - 能够访问所有系统资源，可以执行特权指令，可以直接操作和管理硬件设备。
    - 操作系统内核程序运行在内核态下
    - 使用内核栈
  - 用户态
    - 只能访问属于它的存储空间和普通寄存器，只能执行普通指令。
    - 用户程序以及操作系统核外服务程序运行在用户态下
    - 使用用户栈

Operating-System Operations

- Timer（定时器） to prevent infinite loop / process hogging resources
  - Set interrupt after specific period
  - Operating system decrements counter
  - When counter zero generate an interrupt
  - Set up before scheduling process to regain control or terminate program that exceeds allotted time

1.5 RESOURCE MANAGEMENT
(资源管理)

操作系统功能部件

- 进程管理 Process Management
- 主存管理 Main Memory Management
- 文件系统管理 File-System Management
- 大容量储存管理 Mass-Storage Management
- 高速缓存管理 Cache Management
- I/O系统管理 I/O System Management

Process Management

- A process is a program in execution. It is a unit of work within the system. Program is a ***passive entity***, process is an ***active entity***.
- Process needs resources to accomplish its task
  - CPU, memory, I/O, files
  - Initialization data
- Process termination requires reclaim of any reusable resources
- Single-threaded process has one **program counter** specifying location of next instruction to execute
  - Process executes instructions sequentially, one at a time, until completion
- Multi-threaded process has one program counter per thread
- Typically system has many processes, some user, some operating system running concurrently on one or more CPUs
  - Concurrency by multiplexing the CPUs among the processes / threads

Process Management Activities

- The operating system is responsible for the following activities in connection with process management:
  - Creating and deleting both user and system processes
  - Suspending and resuming processes
  - Providing mechanisms for process synchronization
  - Providing mechanisms for process communication
  - Providing mechanisms for deadlock handling

Memory Management

- To execute a program all (or part) of the instructions must be in memory
- All (or part) of the data that is needed by the program must be in memory
- Memory management determines what is in memory and when
  - Optimizing CPU utilization and computer response to users
- Memory management activities
  - Keeping track of which parts of memory are currently being used and by whom
  - Deciding which processes (or parts thereof) and data to move into and out of memory
  - Allocating and deallocating memory space as needed

File-system Management

- OS provides uniform, logical view of information storage
  - Abstracts physical properties to logical storage unit - **file**
  - Each medium is controlled by device (i.e., disk drive, tape drive)
    - Varying properties include access speed, capacity, data-transfer rate, access method (sequential or random)
- File-System management
  - Files usually organized into directories
  - Access control on most systems to determine who can access what
  - OS activities include
    - Creating and deleting files and directories
    - Primitives to manipulate files and directories
    - Mapping files onto secondary storage
    - Backup files onto stable (non-volatile) storage media

Mass-Storage Management

- Usually disks used to store data that does not fit in main memory or data that must be kept for a “long” period of time
- Proper management is of central importance
- Entire speed of computer operation hinges on disk subsystem and its algorithms
- OS activities
  - Mounting and unmounting
  - Free-space management
  - Storage allocation
  - Disk scheduling
  - Partitioning
  - Protection
- Some storage need not be fast
  - Tertiary storage includes optical storage, magnetic tape
  - Still must be managed – by OS or applications

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

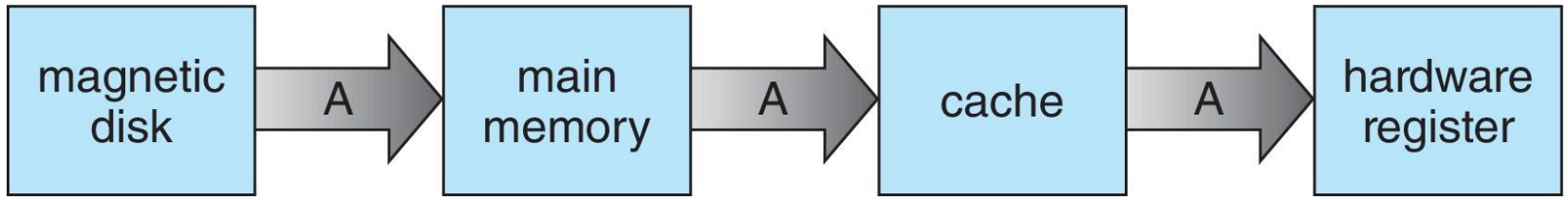
Characteristics of Various Types of Storage

Level	1	2	3	4	5
Name	registers	cache	main memory	solid-state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25-0.5	0.5-25	80-250	25,000-50,000	5,000,000
Bandwidth (MB/sec)	20,000-100,000	5,000-10,000	1,000-5,000	500	20-150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape

Movement between levels of storage hierarchy can be explicit or implicit

Migration of data “A” from Disk to Register

- Multitasking environments must be careful to use most recent value, no matter where it is stored in the storage hierarchy



- Multiprocessor environment must provide **cache coherency** in hardware such that all CPUs have the most recent value in their cache
- Distributed environment situation even more complex
  - Several copies of a datum can exist
  - Various solutions covered in Chapter 19

I/O Subsystem

- One purpose of OS is to hide peculiarities of hardware devices from the user
- I/O subsystem responsible for
  - Memory management of I/O including buffering (storing data temporarily while it is being transferred), caching (storing parts of data in faster storage for performance), spooling (the overlapping of output of one job with input of other jobs)
  - General device-driver interface
  - Drivers for specific hardware devices

1.6 SECURITY AND PROTECTION (安全和保护)

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
- 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

1.7 VIRTUALIZATION (虚拟化)

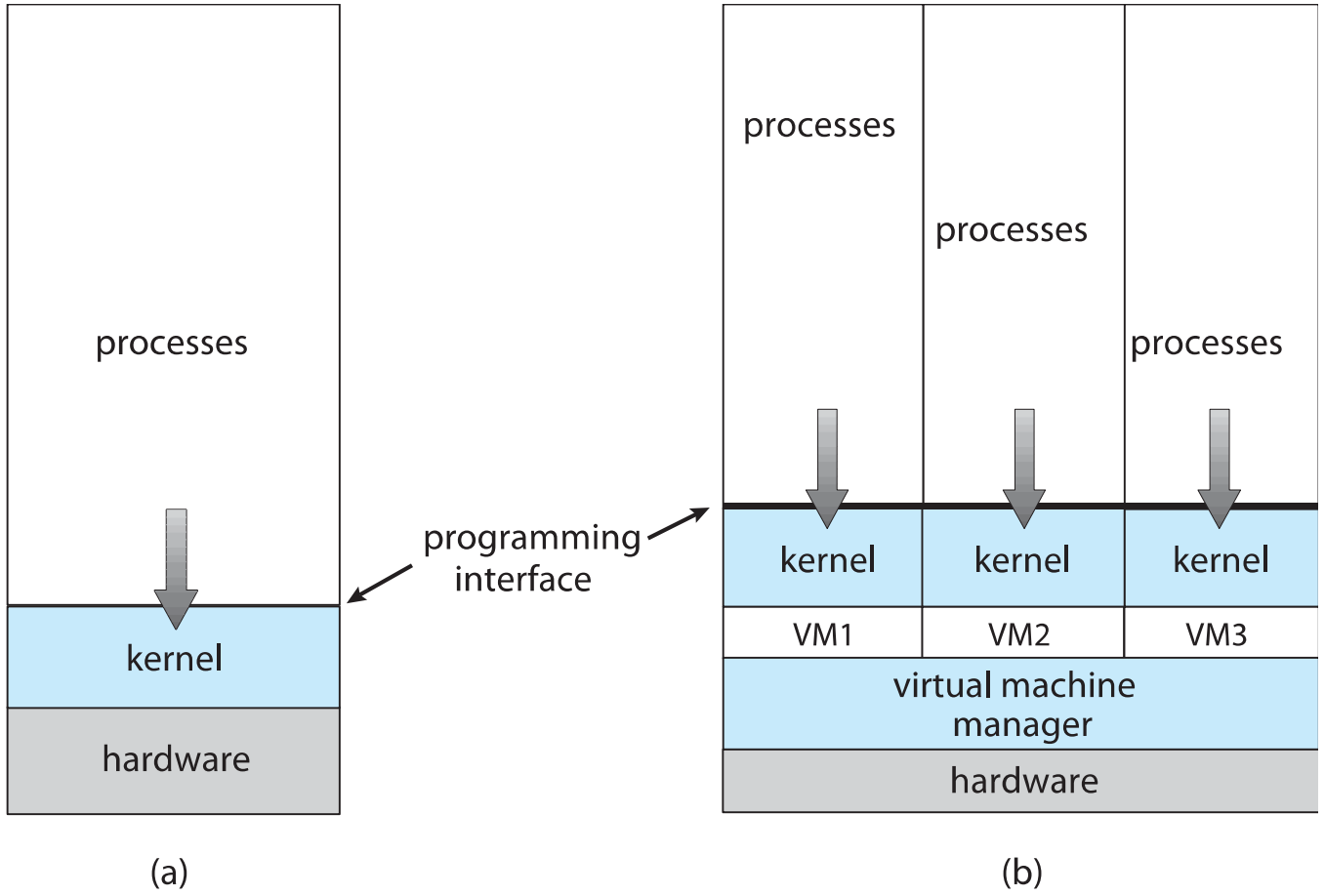
Virtualization

- Allows operating systems to run applications within other OSes
  - Vast and growing industry
- **Emulation** used when source CPU type different from target type (i.e. PowerPC to Intel x86)
  - Generally slowest method
  - When computer language not compiled to native code – **Interpretation**
- **Virtualization** – OS natively compiled for CPU, running **guest** OSes also natively compiled
  - Consider VMware running WinXP guests, each running applications, all on native WinXP **host** OS
  - **VMM** (virtual machine Manager) provides virtualization services

Virtualization (cont.)

- Use cases involve laptops and desktops running multiple OSes for exploration or compatibility
  - Apple laptop running Mac OS X host, Windows as a guest
  - Developing apps for multiple OSes without having multiple systems
  - QA testing applications without having multiple systems
  - Executing and managing compute environments within data centers
- VMM can run natively, in which case they are also the host
  - There is no general purpose host then (VMware ESX and Citrix XenServer)

Computing Environments - Virtualization



1.8 DISTRIBUTED SYSTEMS
(分布式系统)

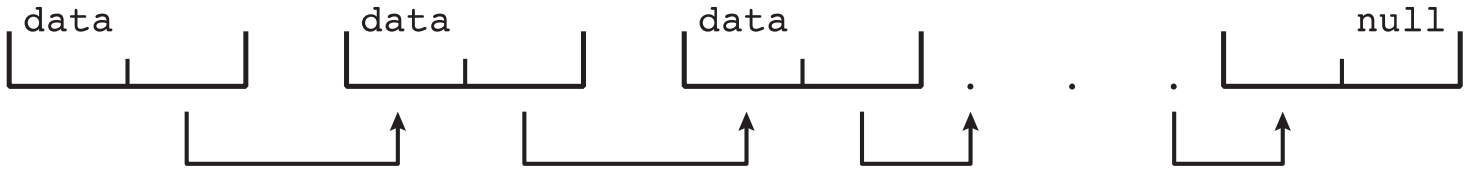
Distributed Systems

- Distributed computiing
  - Collection of separate, possibly heterogeneous, systems networked together
    - **Network** is a communications path, **TCP/IP** most common
      - **Local Area Network** (**LAN**)
      - **Wide Area Network** (**WAN**)
      - **Metropolitan Area Network** (**MAN**)
      - **Personal Area Network** (**PAN**)
  - **Network Operating System** provides features between systems across network
    - Communication scheme allows systems to exchange messages
    - Illusion of a single system

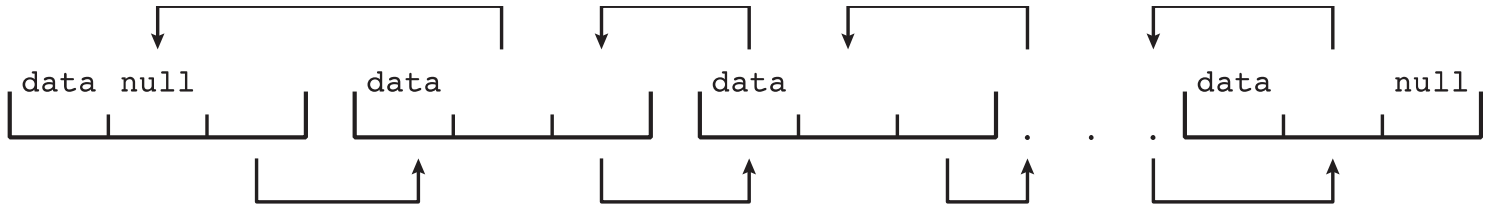
1.9 KERNEL DATA STRUCTURES (内核数据结构)

Kernel Data Structures

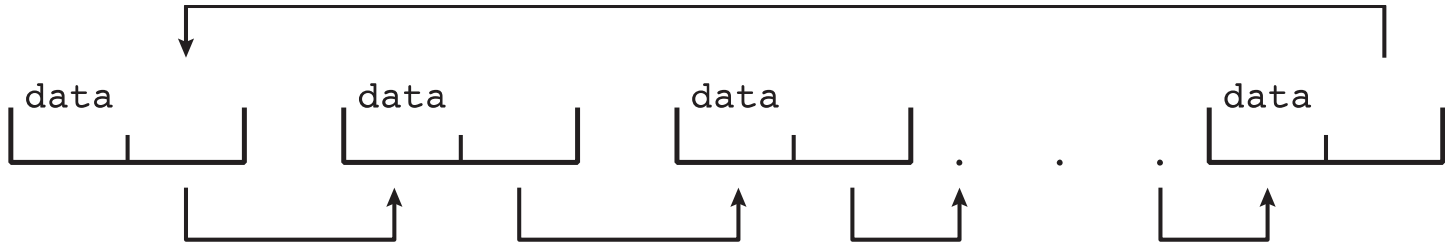
- Many similar to standard programming data structures
- ***Singly linked list***



- ***Doubly linked list***

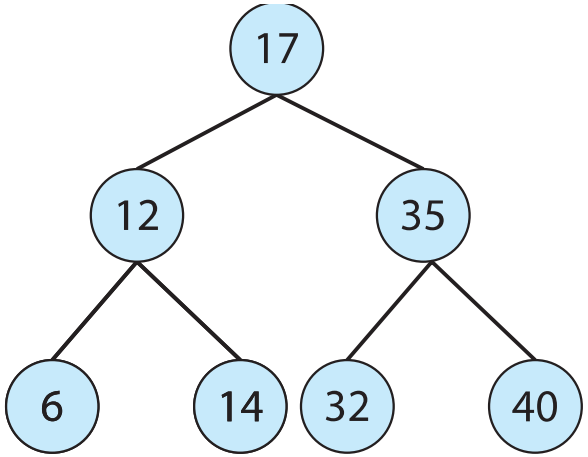


- ***Circular linked list***



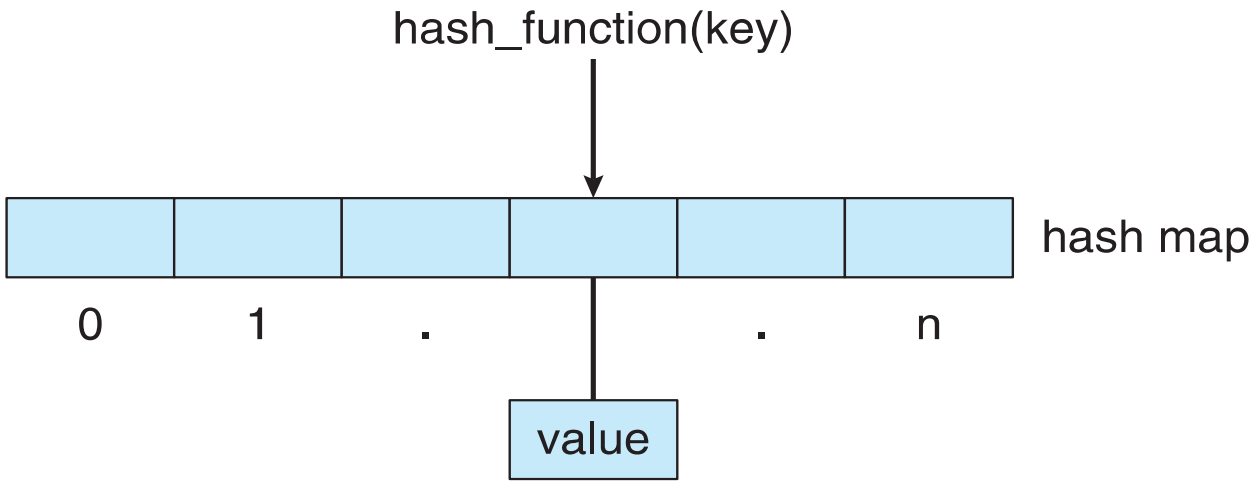
Kernel Data Structures

- **Binary search tree**
  left <= right
  - Search performance is *O(n)*
  - **Balanced binary search tree** is *O(lg n)*



Kernel Data Structures

- **Hash function** can create a **hash map**



- **Bitmap** – string of *n* binary digits representing the status of *n* items
- Linux data structures defined in ***include*** files `<linux/list.h>`, `<linux/kfifo.h>`, `<linux/rbtree.h>`

1.10 COMPUTING ENVIRONMENTS(计算环境)

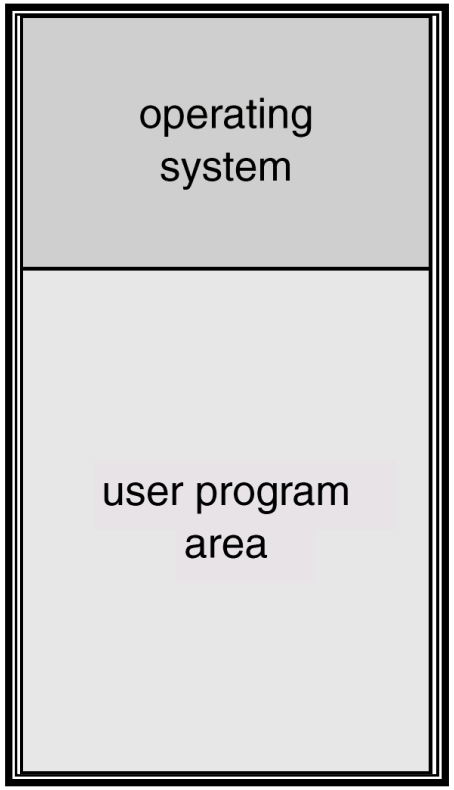
- Traditional（传统计算）
- Mobile （移动计算）
- Client-Server（客户机-服务器计算）
- Peer-to-Peer（点对点计算）
- Virtualization（虚拟化计算）
- Cloud Computing（云计算）
- Real-Time Embedded Systems(实时嵌入式系统)
- 国内操作系统现状

一、Traditional

- Stand-alone general purpose machines
- But blurred as most systems interconnect with others (i.e. the Internet)
- Portals provide web access to internal systems
- Network computers (thin clients) are like Web terminals
- Mobile computers interconnect via wireless networks
- Networking becoming ubiquitous – even home systems use firewalls to protect home computers from Internet attacks

1. Mainframe Systems大型机系统

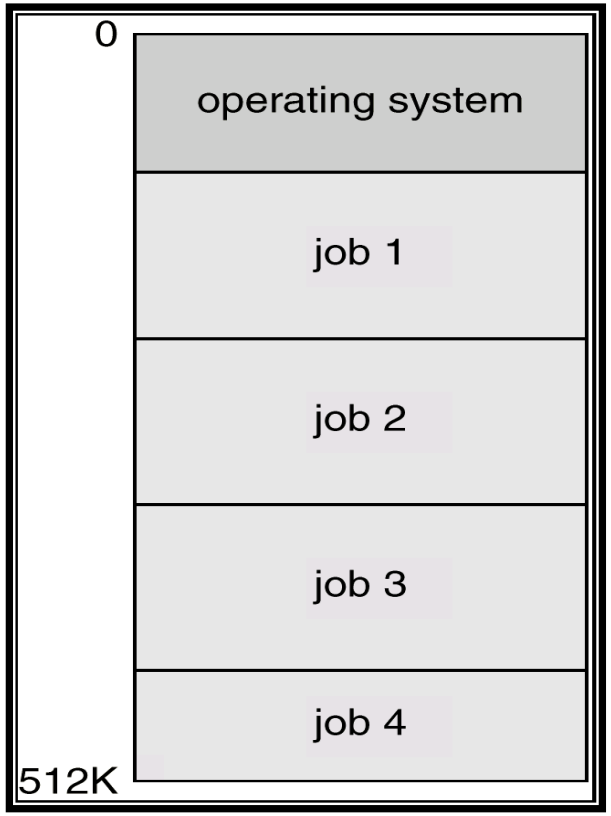
- 大型机（主机）的操作系统有：批处理系统、分时系统
- Batch System批处理系统
  - 单道批处理系统
  - 多道批处理系统



Multiprogrammed Systems

重要概念

- Multiprogramming（多道程序）
  - Several jobs are kept in main memory at the same time, and the CPU is multiplexed among them.



2. Time-Sharing Systems分时系统

- Timesharing (multitasking,多任务) is logical extension in which CPU switches jobs so frequently that users can interact with each job while it is running, creating interactive computing
- **所谓分时是指多个用户分时共享使用同一台计算机**，也就是说把计算机的系统资源（尤其是CPU时间）进行时间上分割，即将整个工作时间分成一个个的时间片，每个时间片分给一个用户使用，这样将CPU工作时间分别提供给多个用户使用，每个用户依次地轮流且使用一个时间片。
- 1961年11月MIT实现了第一个分时系统CTSS

响应时间

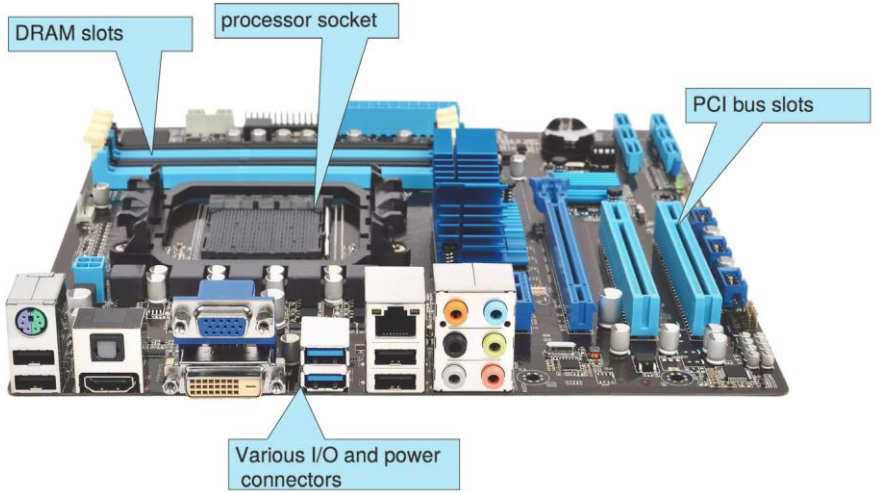
- 响应时间是分时系统的重要指标，它是用户发出终端命令到系统作出响应的时间间隔。系统的响应时间主要是根据用户所能接受的等待时间确定的。假设分时系统中进程数(用户数)为n，每个进程的运行时间片为q，则系统的响应时间为

  S＝n×q。

- UNIX、Linux、Windows

3. Desktop Systems

- *Personal computers*– computer system dedicated to a single user.
- I/O devices– keyboards, mice, display screens, small printers. I/O
- User convenience and responsiveness.
- Can adopt technology developed for larger operating system' often individuals have sole use of computer and do not need advanced CPU utilization of protection features.
- May run several different types of operating systems
- Windows, Mac OS X, UNIX, Linux



PC主要操作系统

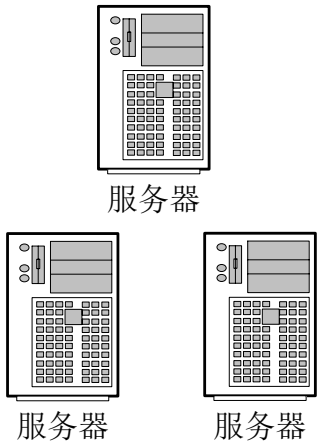
- Windows系列：DOS, Windows 3.x, Window 95/98/2000/XP/7/8/10, Windows NT/2000/2003/2008/2013/2017 server；
- UNIX大家庭：BSD, Open Solaris, AIX, HP_UX , SVR4；Mac OS X， Linux。

二、 Mobile

- Handheld smartphones, tablets, etc
- What is the functional difference between them and a “traditional” laptop?
- Extra feature – more OS features (GPS, gyroscope)
- Allows new types of apps like *augmented reality*
- Use IEEE 802.11 wireless, or cellular data networks for connectivity

- 智能手机、平板电脑操作系统
  - Android、iOS 、Windows phone

计算机应用领域



小型专用型

桌面通用型

高端服务型，高性能计算

嵌入式操作系统：
Android、iOS、
Windows、Linux.....

桌面操作系统：

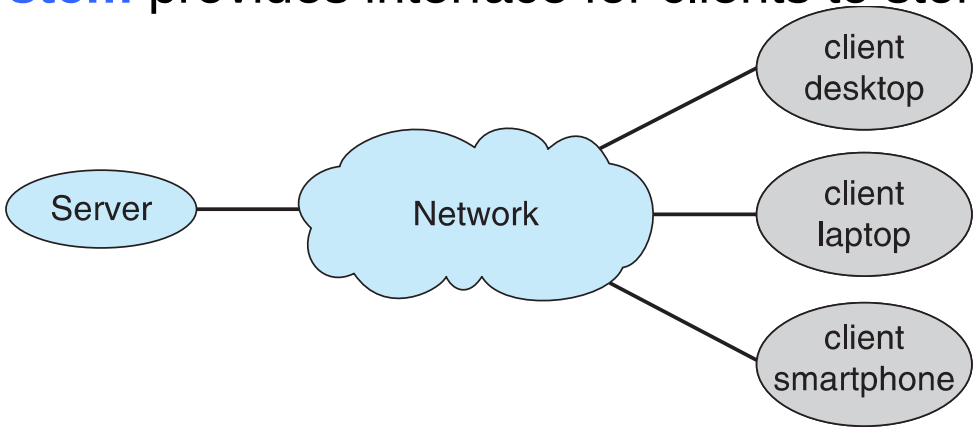
Windows、Mac OS X、
Linux…

服务器操作系统：

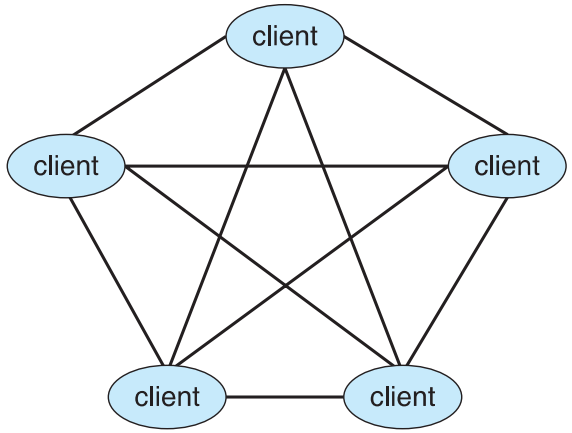
Unix、Linux、Windows、
Solaris、AIX…

三、Client-Server

- **Client-Server Computing**
  - Dumb terminals supplanted by smart PCs
  - Many systems now **servers**, responding to requests generated by **clients**
    - **Compute-server system** provides an interface to client to request services (i.e., database)
    - **File-server system** provides interface for clients to store and retrieve files



四、 Peer-to-Peer



- Another model of distributed system
- P2P does not distinguish clients and servers
  - Instead all nodes are considered peers
  - May each act as client, server or both
  - Node must join P2P network
    - Registers its service with central lookup service on network, or
    - Broadcast request for service and respond to requests for service via *discovery protocol*
  - Examples include Napster and Gnutella, Voice over IP (VoIP) such as Skype

- Blockchain technology 区块链技术

五、 Virtualization

- Allows operating systems to run applications within other OSes
  - Vast and growing industry
- Emulation used when source CPU type different from target type (i.e. PowerPC to Intel x86)
  - Generally slowest method
  - When computer language not compiled to native code – Interpretation
- Virtualization – OS natively compiled for CPU, running guest OSes also natively compiled
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  - VMM provides virtualization services

Virtualization

- Use cases involve laptops and desktops running multiple OSes for exploration or compatibility
  - Apple laptop running Mac OS X host, Windows as a guest
  - Developing apps for multiple OSes without having multiple systems
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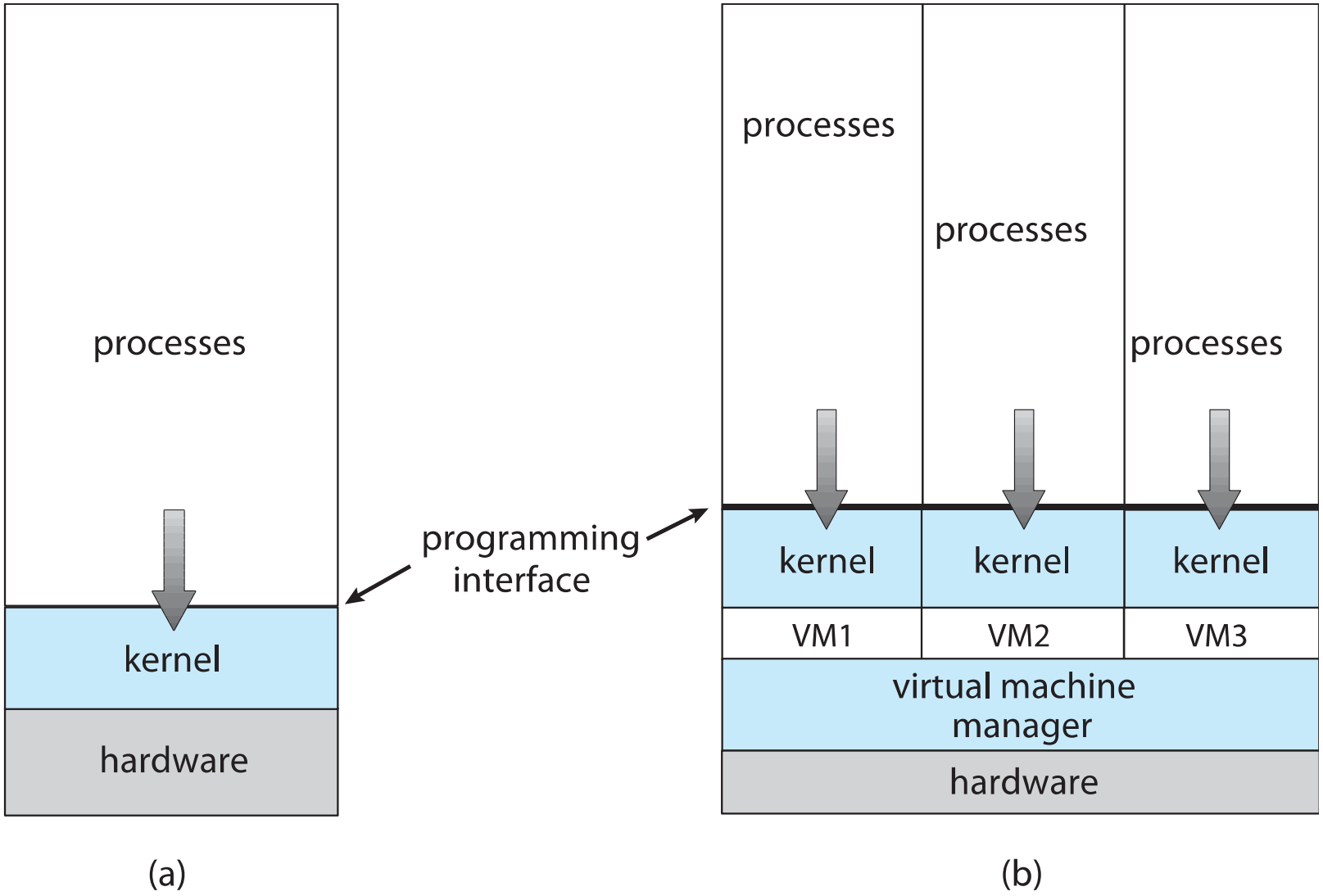
Virtualization



六、 Cloud Computing

- Delivers computing, storage, even apps as a service across a network
- Logical extension of virtualization as based on virtualization
  - Amazon EC2 has thousands of servers, millions of VMs, PBs of storage available across the Internet, pay based on usage

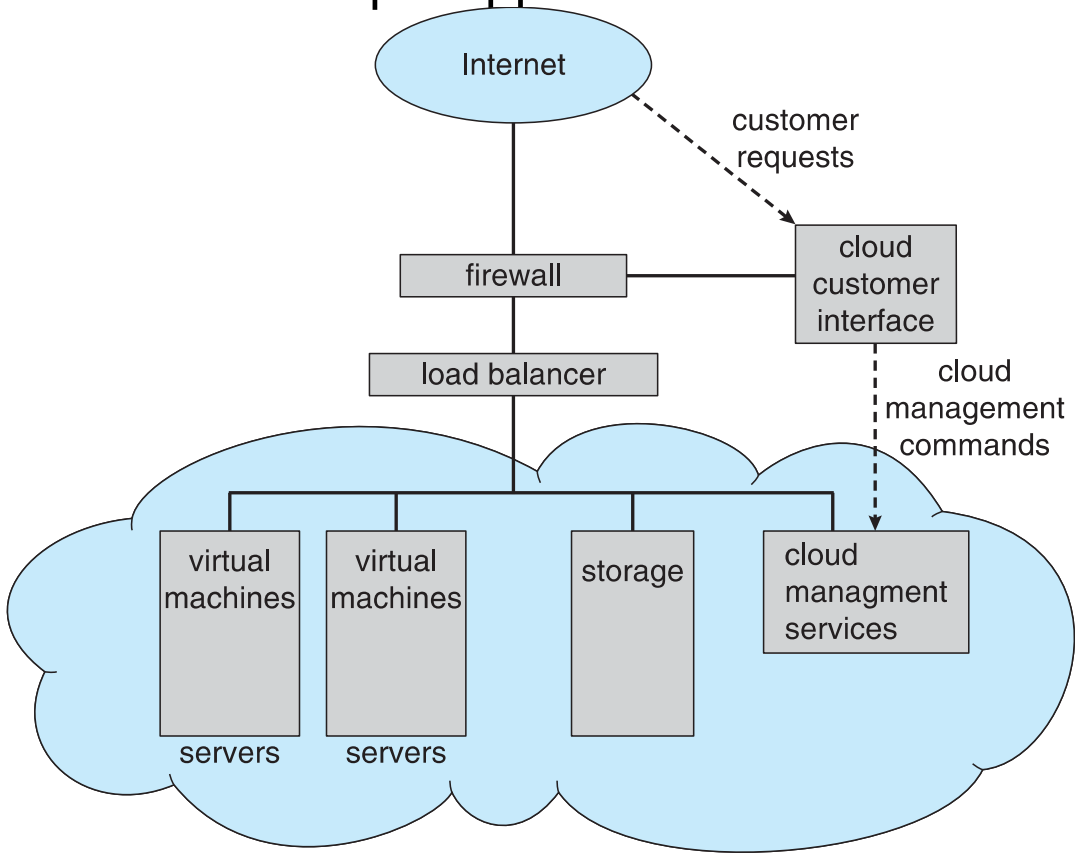
Cloud Computing

- Many types
  - Public cloud （公有云）– available via Internet to anyone willing to pay
  - Private cloud （私有云） – run by a company for the company's own use
  - Hybrid cloud （混合云）– includes both public and private cloud components

  - Software as a Service (SaaS，软件即服务) – one or more applications available via the Internet (i.e. word processor)
  - Platform as a Service (PaaS，平台即服务) – software stack ready for application use via the Internet (i.e a database server)
  - Infrastructure as a Service (IaaS，基础设施即服务) – servers or storage available over Internet (i.e. storage available for backup use)

Cloud Computing

- Cloud compute environments composed of traditional OSes, plus VMMs, plus cloud management tools
  - Internet connectivity requires security like firewalls
  - Load balancers spread traffic across multiple applications



七、 Real-Time Embedded Systems

- Real-time embedded systems most prevalent form of computers
  - Vary considerable, special purpose, limited purpose OS, real-time OS
  - Use expanding
- Many other special computing environments as well
  - Some have OSes, some perform tasks without an OS
- Real-time OS has well-defined fixed time constraints
  - Processing *must* be done within constraint
  - Correct operation only if constraints met

嵌入式系统

- 嵌入式系统是以应用为中心，以计算机技术为基础，采用可剪裁软硬件，适用于对功能、可靠性、成本、体积、功耗等有严格要求的专用计算机系统，用于实现对其他设备的控制、监视或管理等功能

- 嵌入式操作系统：运行在嵌入式系统环境中，对整个嵌入式系统以及它所操作、控制的各种部件装置等资源进行统一协调、调度和控制的系统软件

嵌入式操作系统

- 几种主流嵌入式操作系统
  - 嵌入式Linux：
    - μCLinux
    - RT-Linux
    - XLinux
    - 红旗嵌入式Linux
    - Montavista linux
    - 风河linux .....
  - VxWorks
  - QNX
  - Windows CE
  - uC/OS
  - Palm OS
  - L4

操作系统市场格局

- 当前三大体系：
  - Unix/Linux :服务器
  - Windows、Mac OS X： 桌面
  - Android、iOS、Windows phone：手机

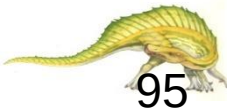
国内操作系统发展情况

- 我国信息系统对Windows的依赖度是全世界最高的
- “核高基”重大专项
  - 16项国家科技重大专项的第一项
  - 核心电子器件、高端通用芯片、基础软件（二件一芯）
  - 本质：OS、CPU

*麒麟操作系统

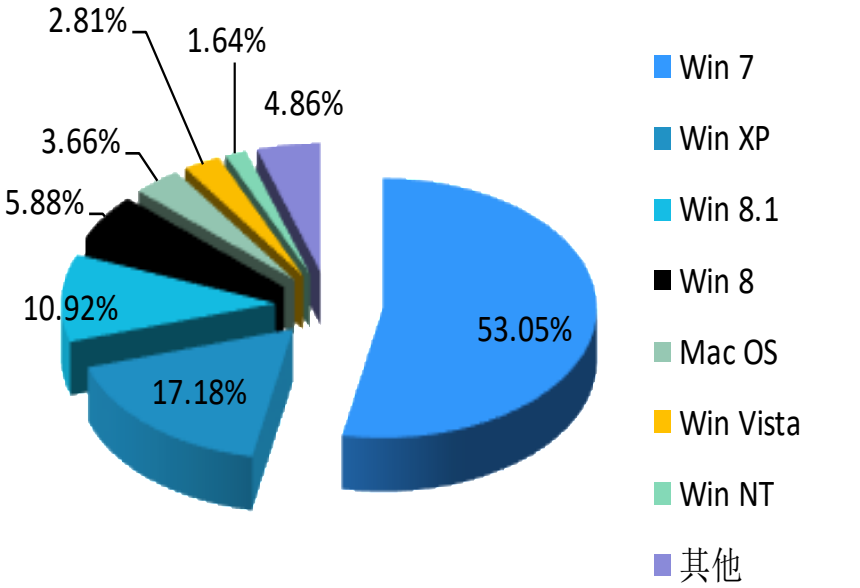
- COSIX失败
  - 1989－1997：17家单位、200多位科技人员、4000多万元
    - 没有配套的自主硬件平台
    - 没有配套的应用软件体系
    - 没有产业化政策向导
    - 没有形成支撑可持续发展的基本用户群
  - 处于同期研制的Windows和Linux大获成功

➢ 1990：windows 3.0, 1991:Linux kernel 0.11

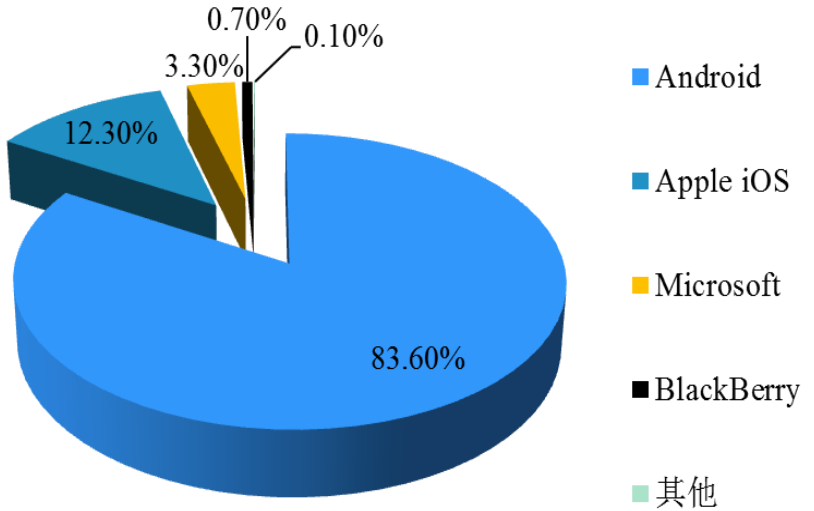


操作系统长期由国外厂商垄断

- 微软以及谷歌、苹果OS在国内具有绝对的垄断地位
  - 据工信部电信研究院的调研报告，国内自主操作系统装机普遍未超过市场份额的1%



图注：2014年10月全球桌面操作系统市场份额（来源：Net Applications）



图注：2014年第三季度全球移动操作系统市场份额（来源：Strategy Analytics）

作为核心基础软件的操作系统长期由国外厂商垄断

- 据2014年2月证券日报报道，有机构对我国130万套软硬件设备的统计数据显示，采用国外产品的比例为：操作系统97.25%、数据库95.06%、服务器86.72%、数据处理设备83.38%、网络设备62.28%
- 去IOE化（去掉IBM的小型机、Oracle数据库、EMC存储设备）已成为国内互联网产业界（如阿里、百度、腾讯等）的共识，并取得显著成效。而在操作系统领域，去“WINTEL联盟”还未取得显著成效，又引来了“双A联盟（Android+ARM）”
- 操作系统产品缺乏有效供给，成为国产自主替代的重要制约因素

- 2018年中兴通信事件有什么启发？

Windows为什么成功

- 80年代后期至90年代初期PC操作系统
  - Mac OS, IBM OS/2, Windows
  - 目前Windows市场份额逾80%
- 成功原因
  - 使用方便，易于操作
  - 固定硬件平台，确保基本用户群
  - 针对IBM PC开放硬件平台和Intel CPU特点进行针对性设计和优化
  - 在市场利益驱动下形成了软硬件一体的产业链
  - 硬件及外设厂商基于微软接口开发设备驱动
  - 应用软件厂商基于微软接口开发应用系统

Android为什么会成功？

1.11 FREE AND OPEN-SOURCE OPERATING SYSTEMS(自由和开源操作系统)

Open-Source Operating Systems

- Operating systems made available in source-code format rather than just binary closed-source
- Counter to the copy protection and Digital Rights Management (DRM) movement
- Started by Free Software Foundation (FSF), which has “copyleft” GNU Public License (GPL)
- Examples include GNU/Linux and BSD UNIX (including core of Mac OS X), and many more
- Can use VMM like VMware Player (Free on Windows), Virtualbox (open source and free on many platforms - http://www.virtualbox.com)
  - Use to run guest operating systems for exploration

在Linux概述中介绍

Summary

- An Operating System (from here on OS) is a software (a program) that performs two functions:
  - it extends the “use” of the computer hardware and
  - it manage the computer system resources

Summary

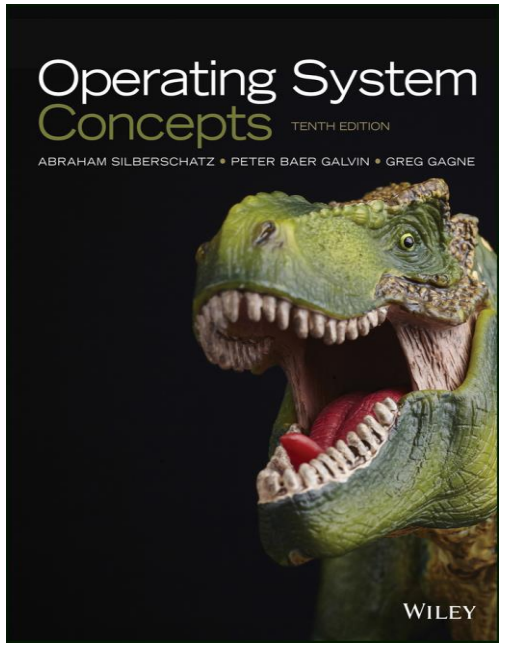
- batch system(批处理系统)、time-sharing system （分时系统）、real-time system （实时系统）
- interrupt（中断）、trap（陷入）
- kernel（内核）、microkernel（微内核）、monolithic kernel（单内核）
- multiprogramming（多道程序设计）
- privileged instruction（特权指令）
- kernel mode（内核模式）、user mode（用户模式）
- symmetric multiprocessing（SMP 对称多处理器）
- swapping（交换）
- system call（系统调用）
- Cloud Computing （云计算）

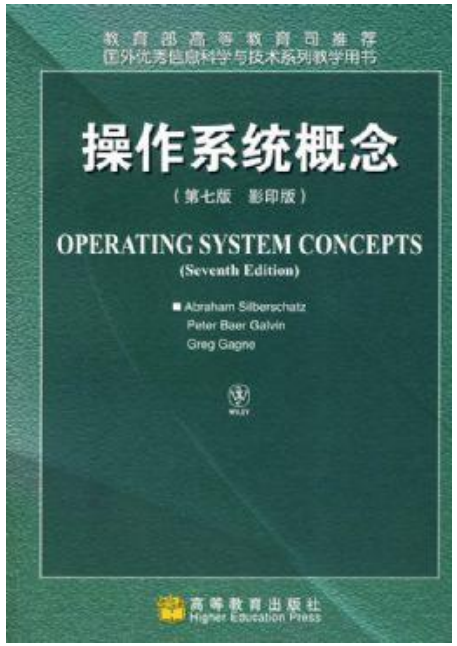
Homework

- 在“学在浙里”中，请按时完成

Reading Assignments

- Read for next week:
  - Chapters 2 of the text book:





End of Chapter 1