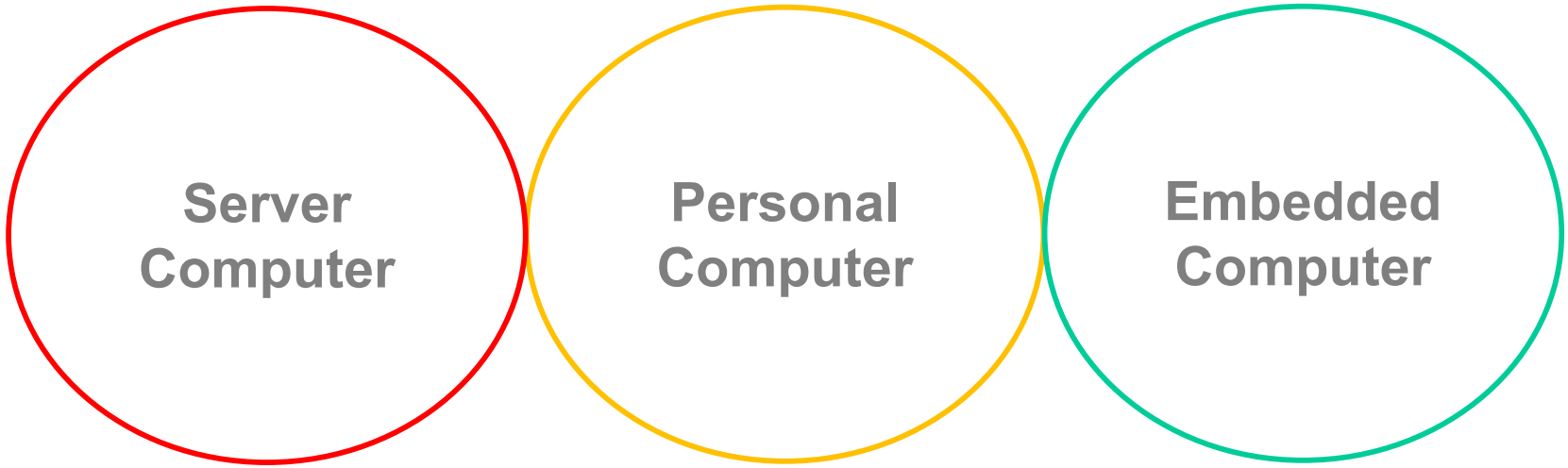
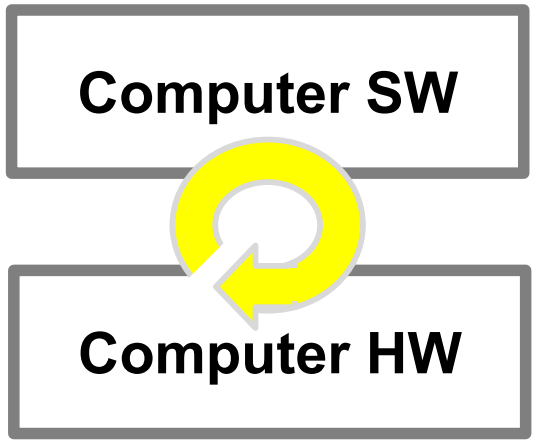
Chap. 1) Introduction

경희대학교 컴퓨터공학과

조 진 성

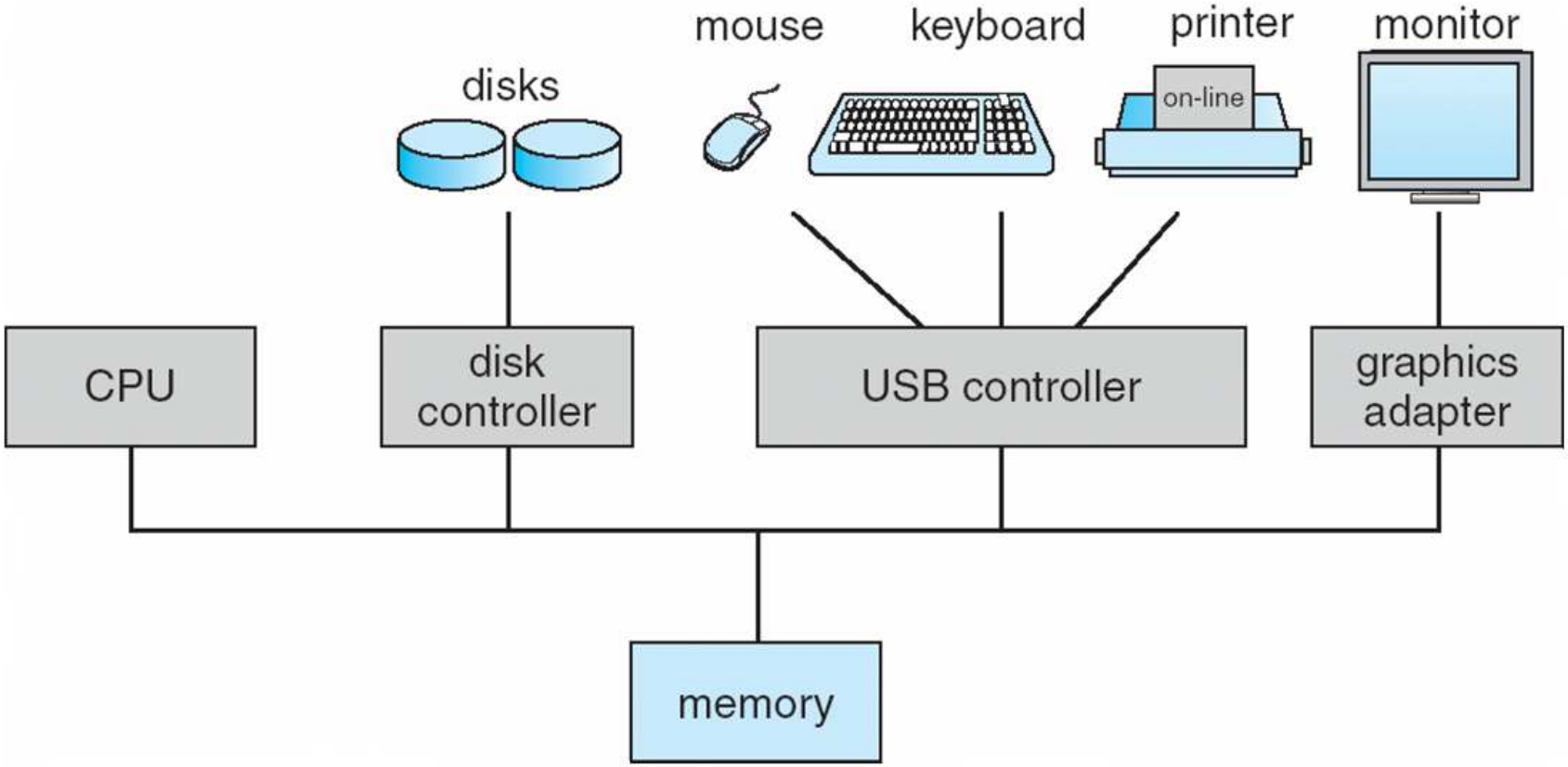
Computer ?


Server Computer
Personal Computer
Embedded Computer


Computer SW
Computer HW

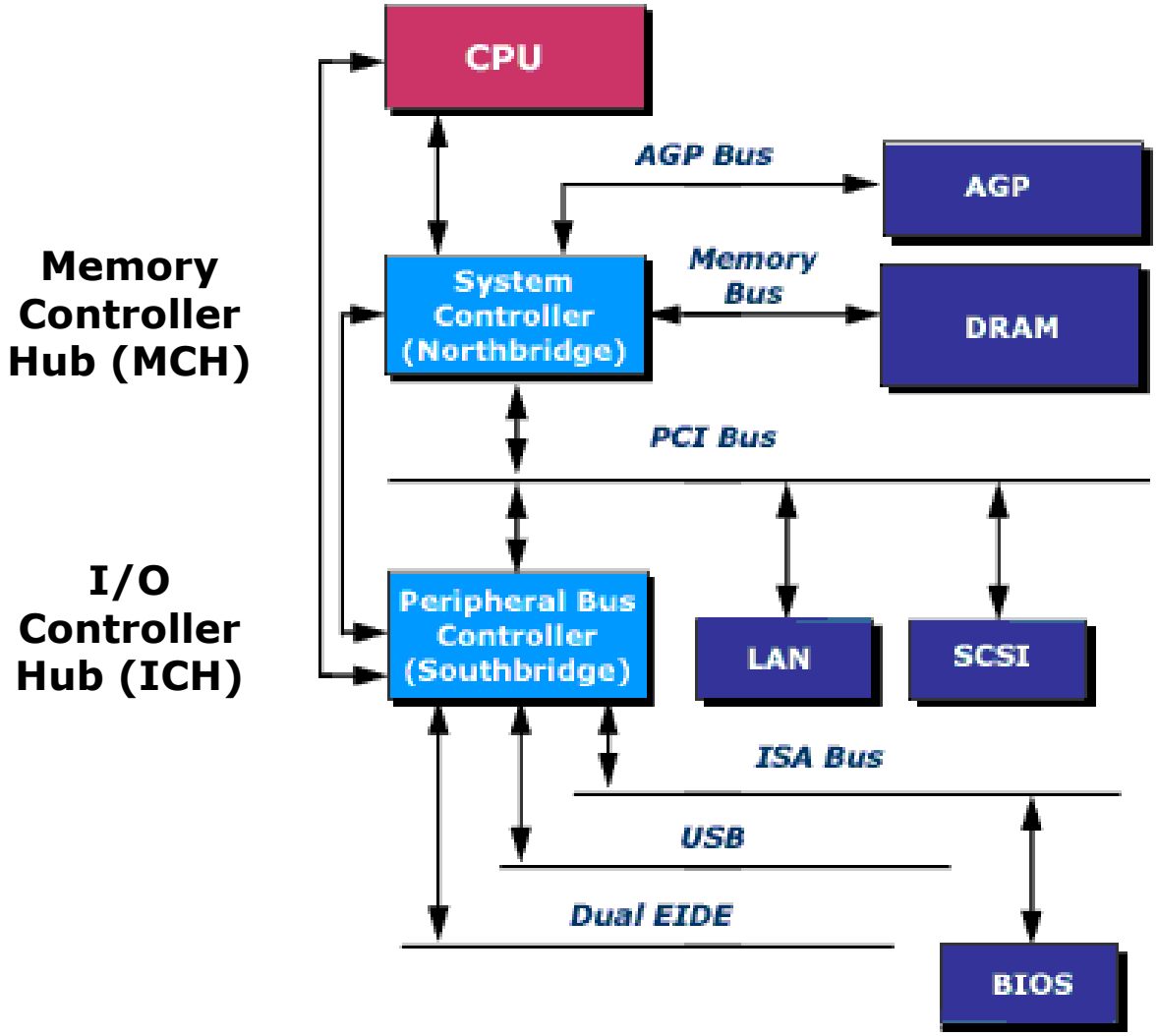
Computer ?

Computer system organization



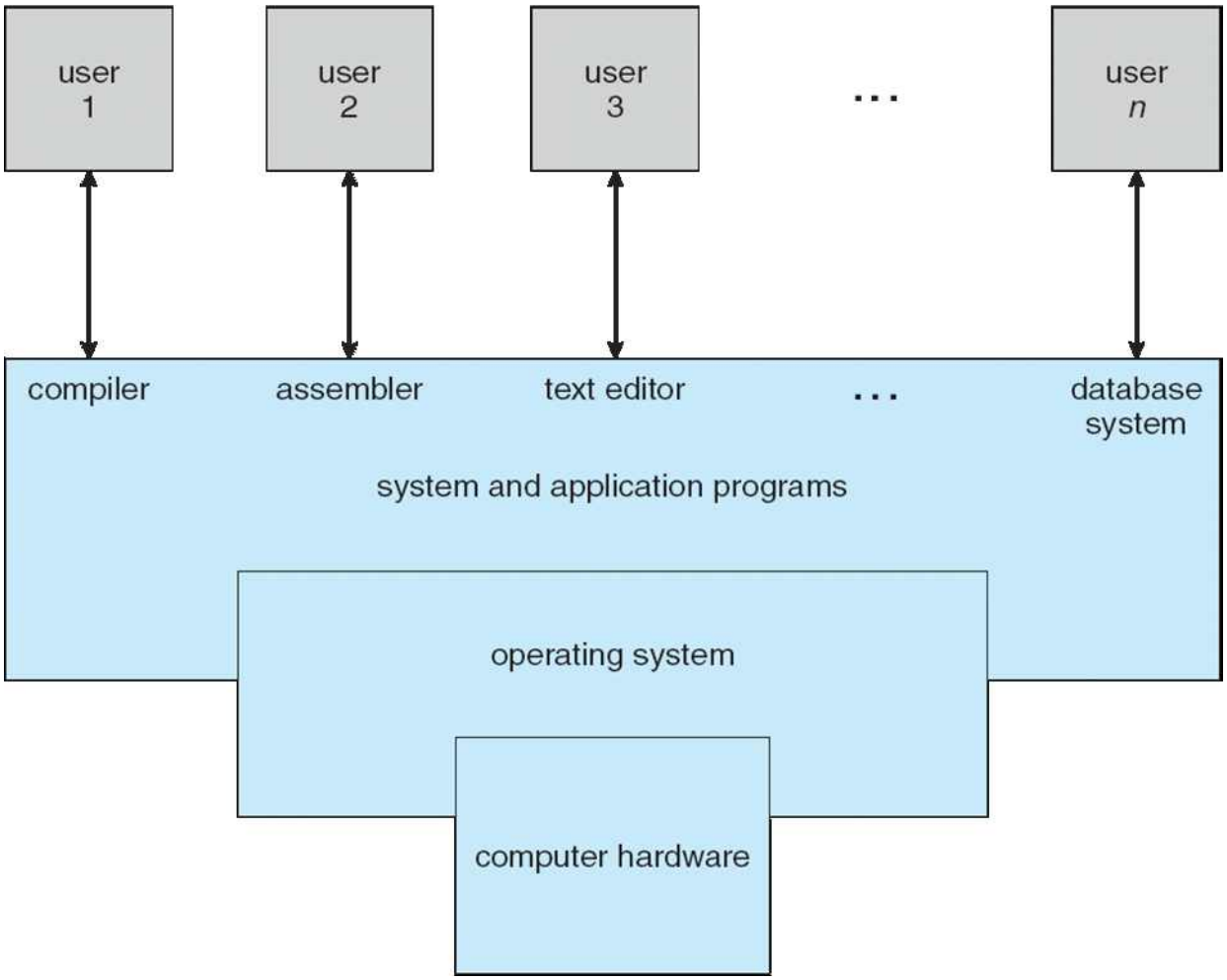
Computer ?

Modern PC architecture



Computer ?

Computer system components (Abstract view)



Operating Systems ?

OS is a resource manager

- ✓ Abstraction
- ✓ Sharing
  - Time multiplexing
  - Space multiplexing
- ✓ Protection
- ✓ Fairness
- ✓ Performance

Resources

- CPU
- Memory
- I/O devices
- …

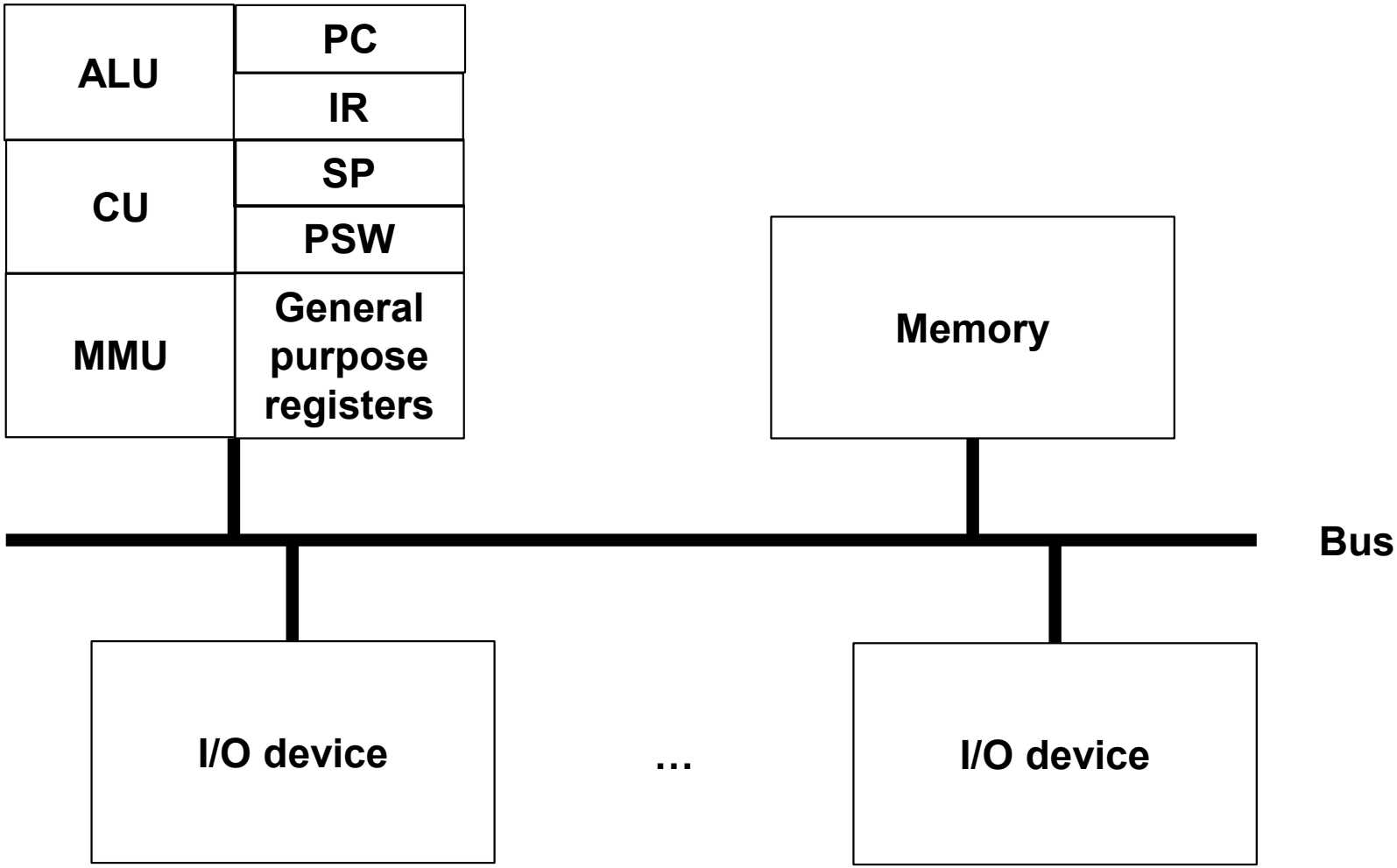
Definition in textbook

- ✓ Resource allocator
- ✓ Control program
- ✓ Kernel

SW which manages
'Computer HW' resources for
1) convenience
2) efficiency

Computer System Operation

Computer HW architecture (Abstract view)



Computer System Operation

CPU operation

- ✓ Von Neumann architecture

- ✓ Instructions
  - Arithmetic instructions: add, subtract, multiply, divide, …
  - Logical instructions: and, or, xor, not, shift, …
  - Control flow instructions: goto, if, call, return, …
  - Data instructions: load, store, move, input, output, …

Computer System Operation

Bootstrapping in Linux

- ✓ The CPU initializes itself and then execute an instruction at a fixed location (0xfffffff0).
- ✓ This instruction jumps into the BIOS/UEFI.
  - BIOS (Basic Input/Output System)
  - UEFI (Unified Extensible Firmware Interface)
- ✓ The BIOS/UEFI finds a boot device and fetches Boot Loader(LILO/GRUB).
  - MBR (Master Boot Record) in BIOS
  - ESP (Efi System Partition) in UEFI
- ✓ The BIOS/UEFI loads and transfers control to LILO/GRUB.
- ✓ LILO/GRUB loads the compressed kernel.
- ✓ The compressed kernel decompresses itself and transfers control to the uncompressed kernel.

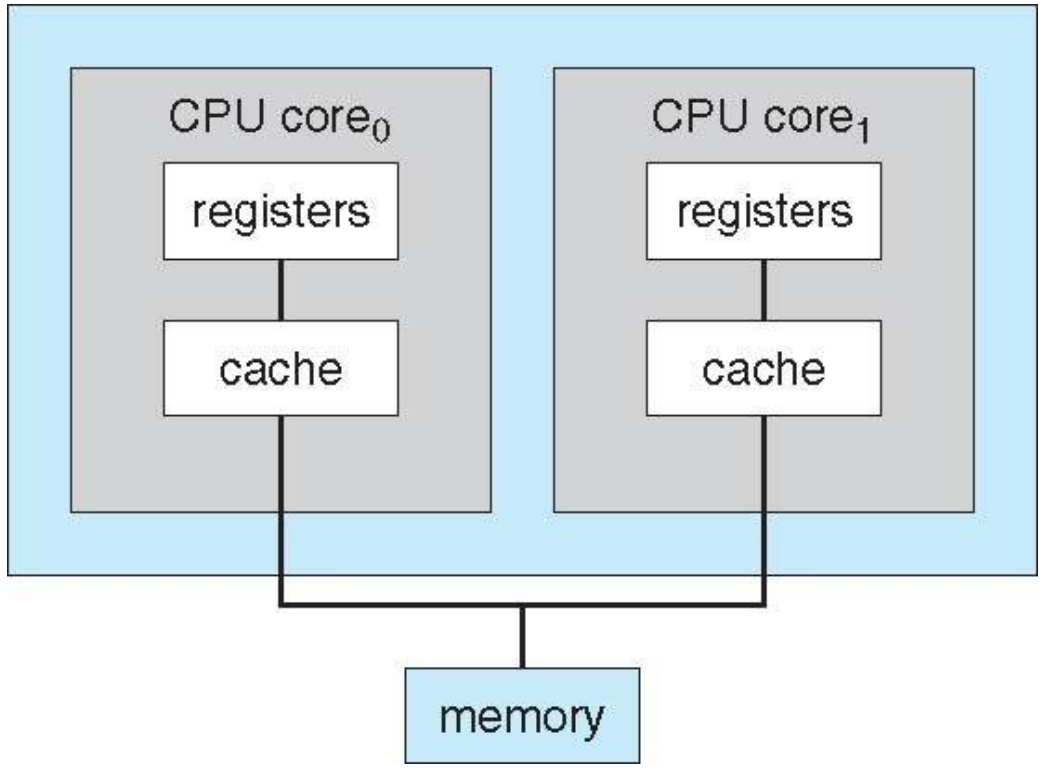
Computer System Operation

CPU

- ✓ Instruction Set Architecture (ISA)
  - CISC vs. RISC
  - Intel, SPARC, MIPS, PowerPC, ARM, Alpha, …
- ✓ Pipelining
  - Fetch, Decode, Execute, Write Back, etc.
- ✓ Instruction-Level Parallelism (ILP)
  - Superscalar vs. VLIW
  - Simultaneous multithreading
  - Multi-core

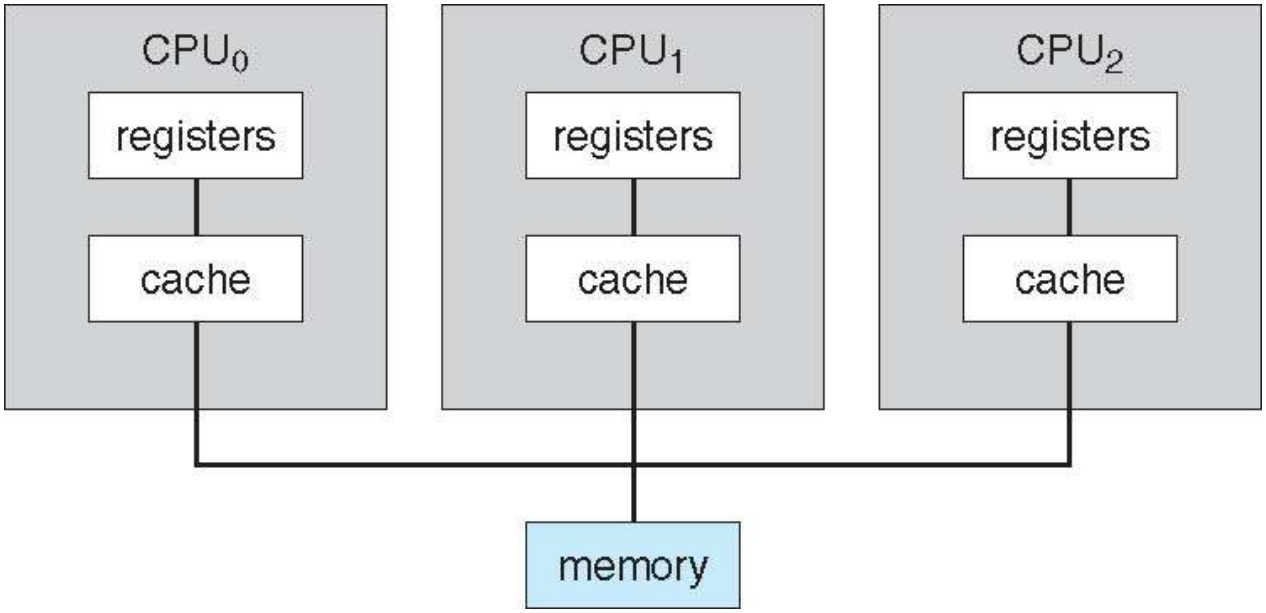
Computer System Operation

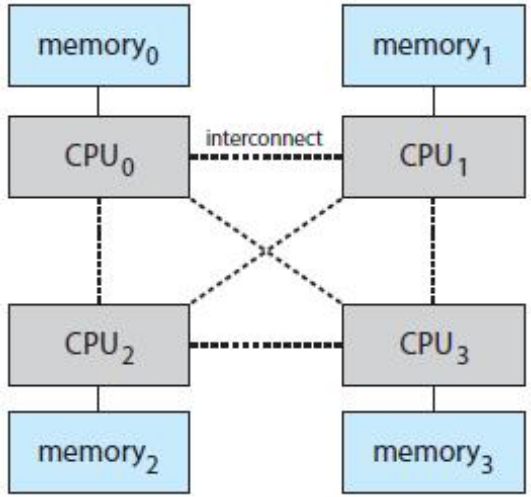
Multi-core architecture



Computer System Operation

Symmetric multiprocessing architecture



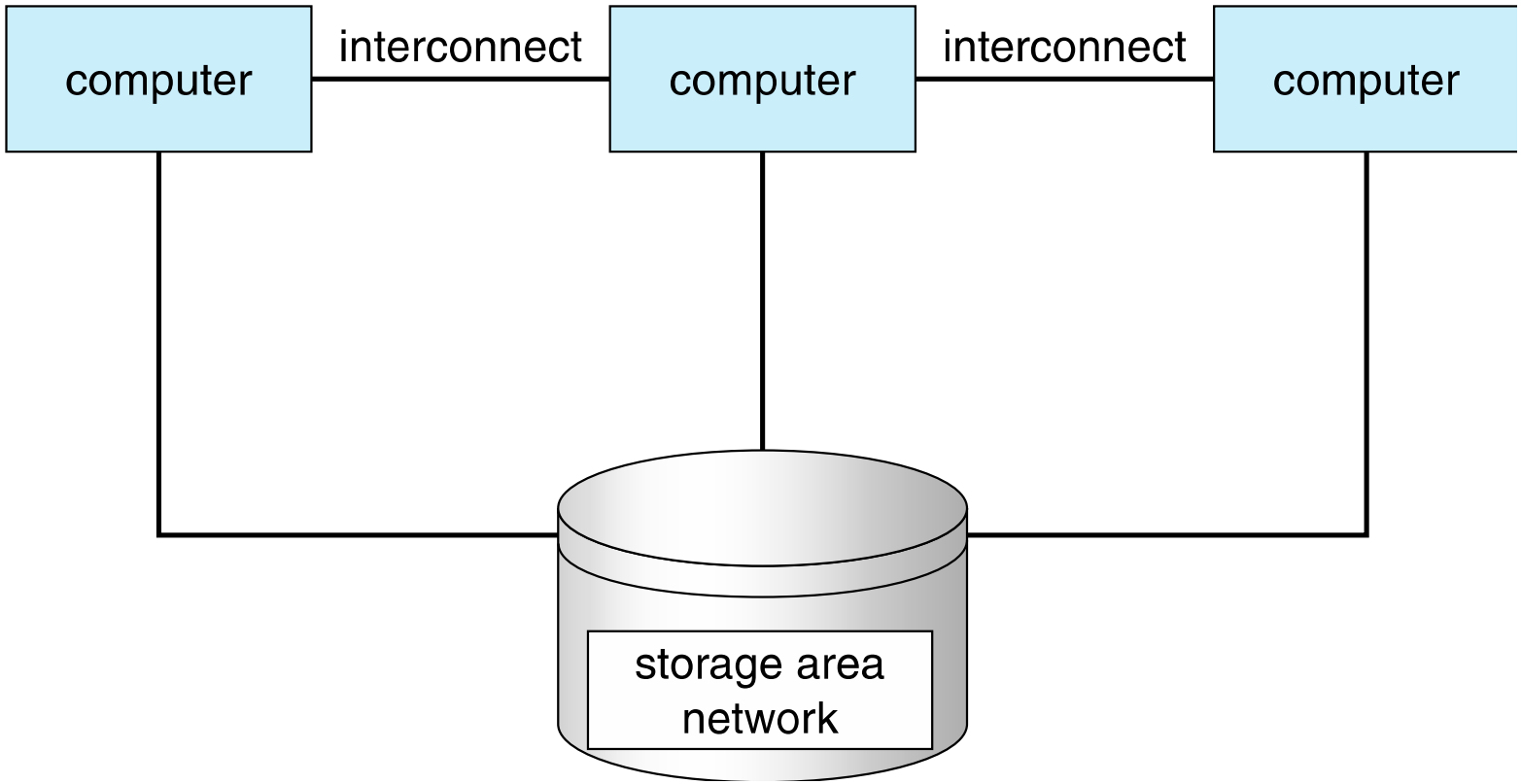


✓ Cf) NUMA (Non-Uniform Memory Access) multiprocessing architecture

Computer System Operation

Clustered system architecture

- ✓ Cf) Parallel vs. Distributed system



Computer System Operation

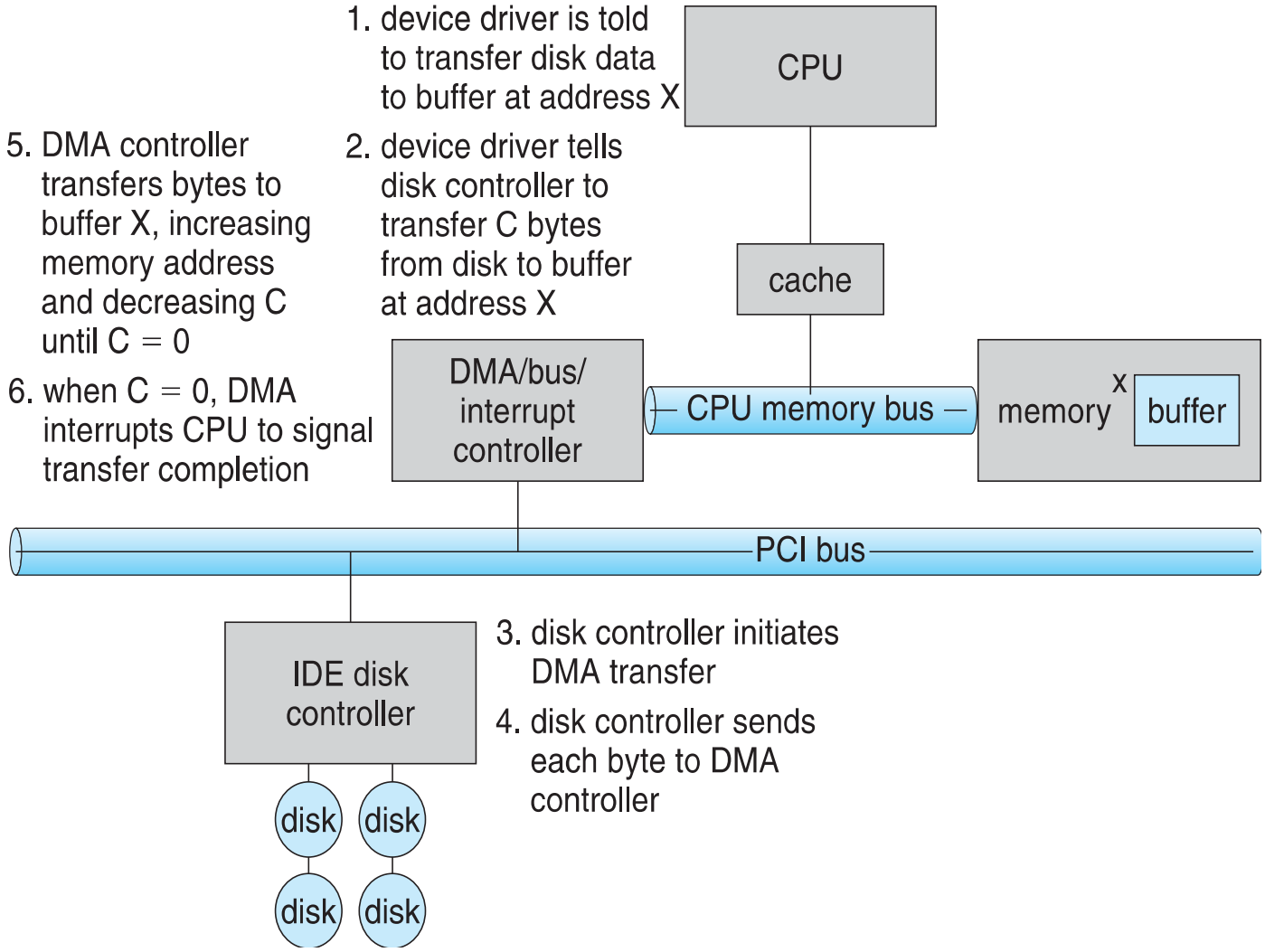
I/O operation

- ✓ I/O request via I/O instruction
  - Direct I/O vs. Memory-mapped I/O
  - Communicates with registers in I/O controller
  - Typically, IR (Instruction Register) & DR (Data Register)

- ✓ I/O method
  - Polling vs. Interrupt
  - Programmed I/O vs. DMA (Direct Memory Access)

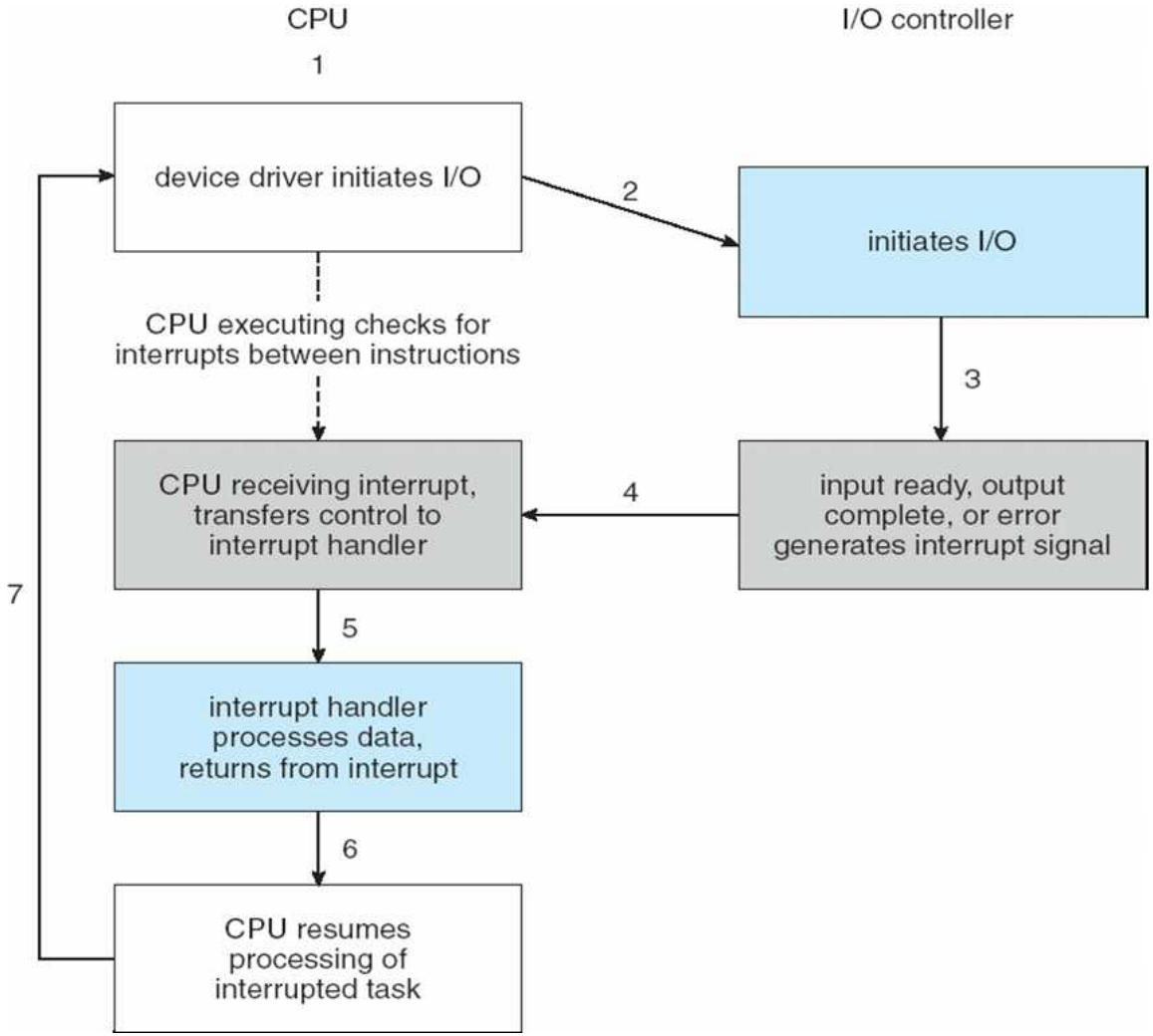
Computer System Operation

Six steps process to perform DMA transfer



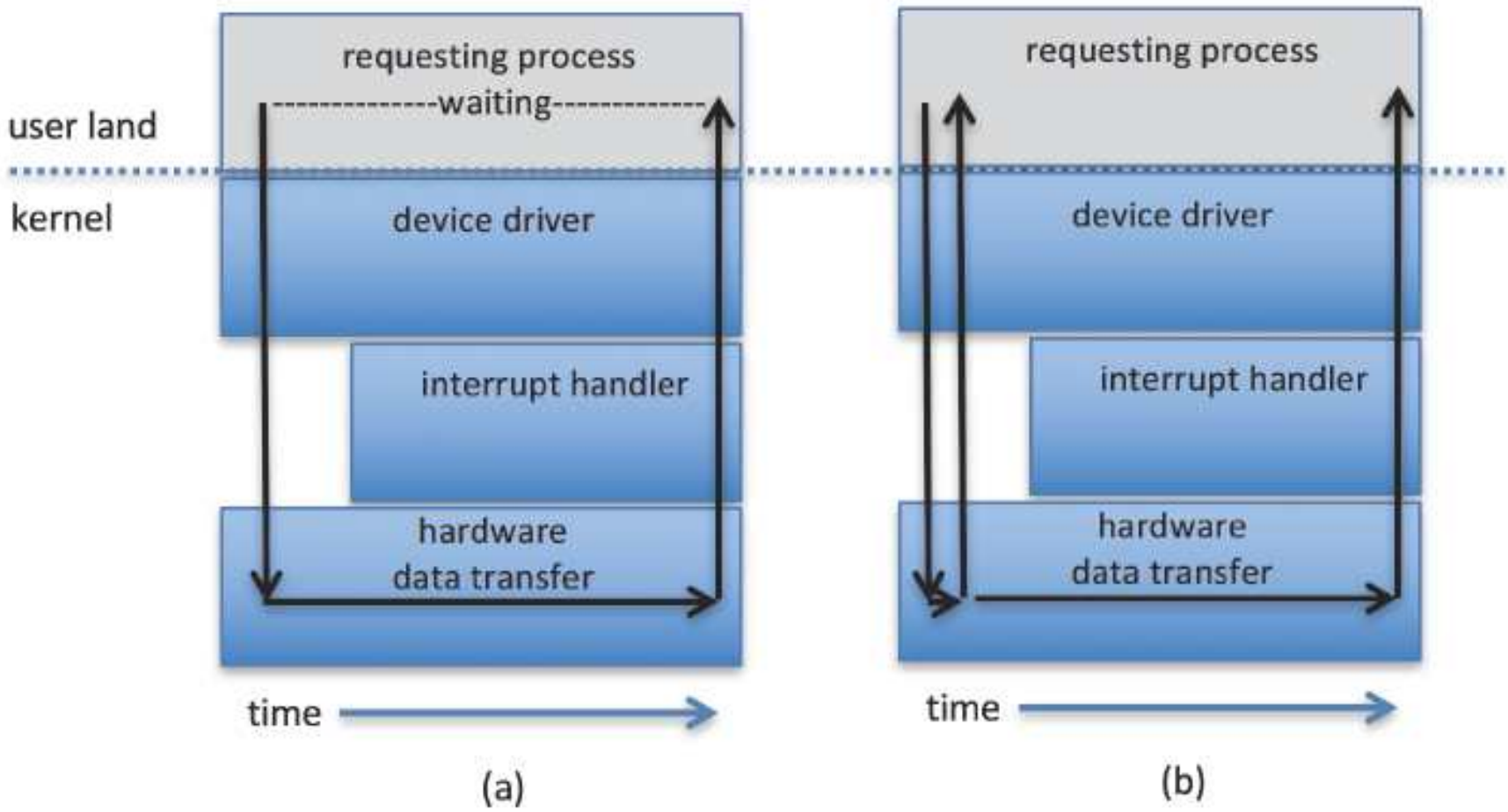
Computer System Operation

Interrupt-driven I/O cycle



Computer System Operation

I/O mode from the perspective of application processes



Computer System Operation

Interrupt

- ✓ Generated by hardware devices (asynchronous)
- ✓ E.g.) timer interrupt, keyboard interrupt, etc.

Trap

- ✓ Generated by application processes (synchronous)
- ✓ E.g.) system calls

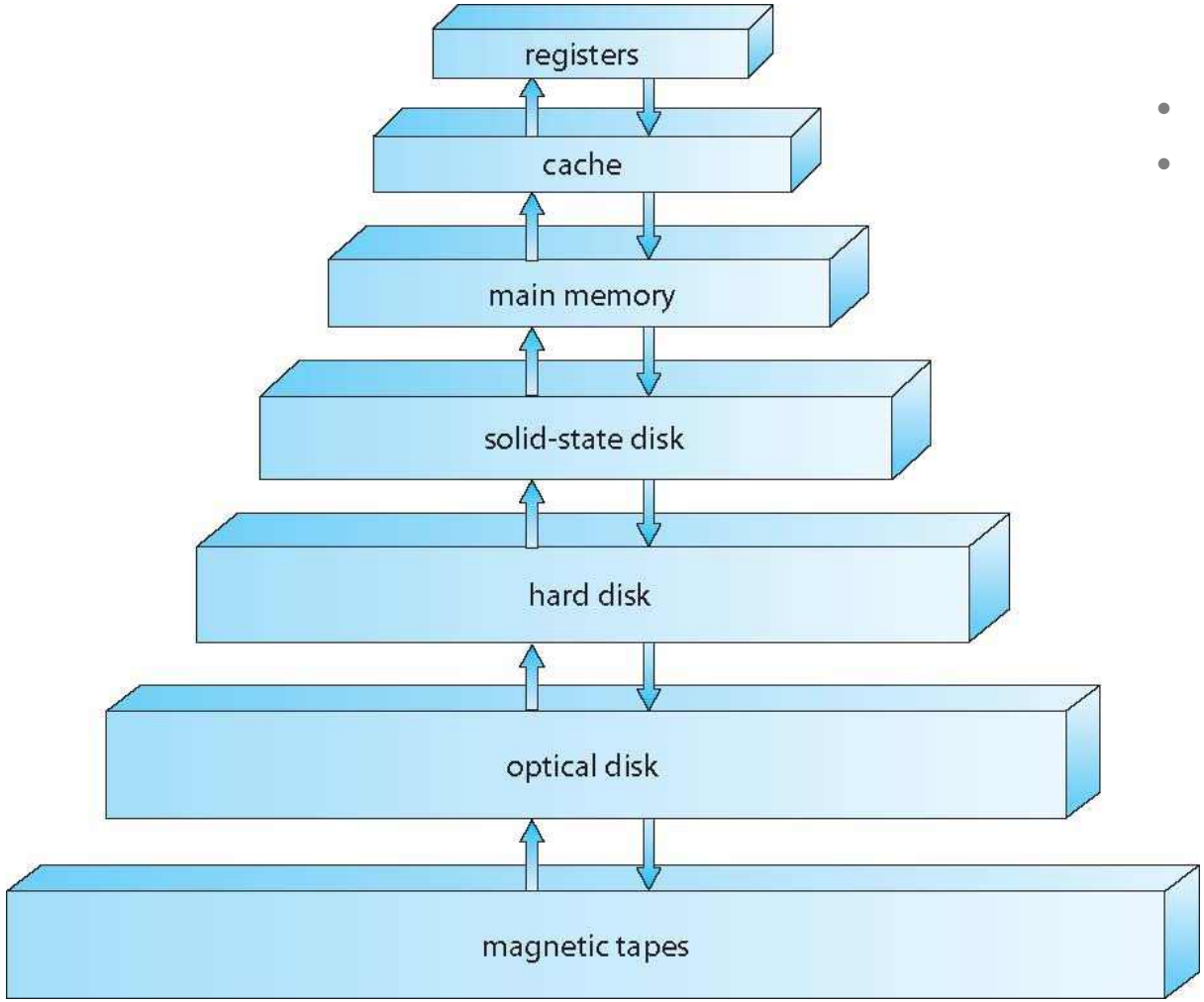
Fault (Exception)

- ✓ Generated by CPU instructions (synchronous)
- ✓ Divide-by-zero, page fault, protection fault, etc.

Hardware interrupt vs. Software interrupt

Computer System Operation

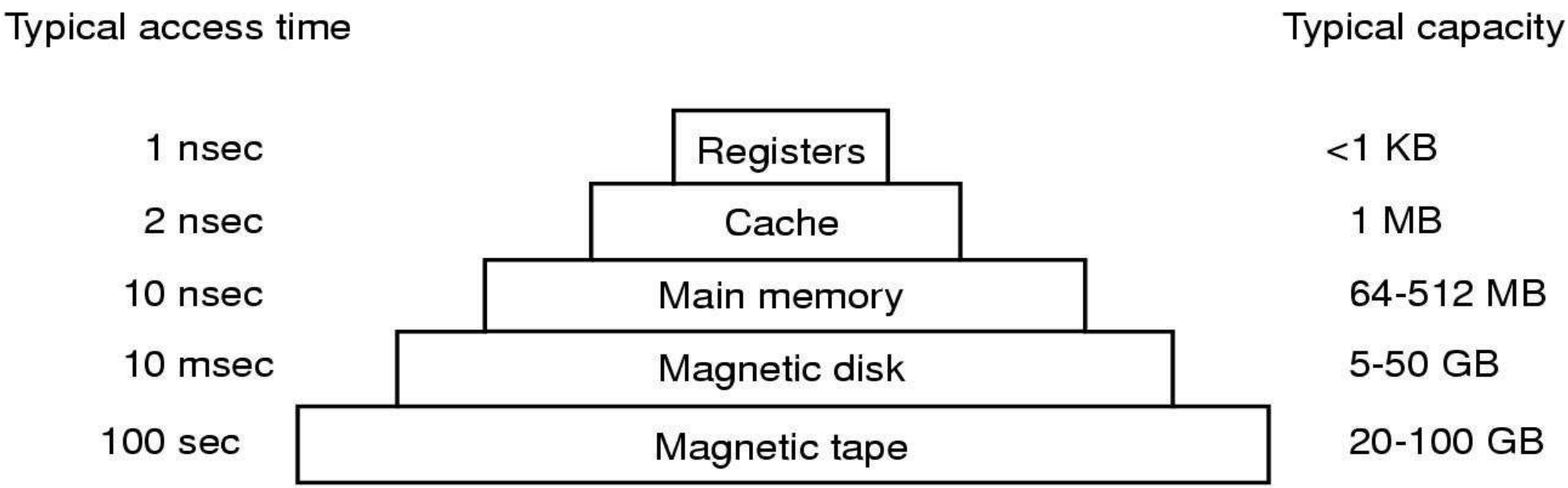
Storage (memory) hierarchy



- ROM vs. RAM
- SRAM vs. DRAM

Computer System Operation

Memory hierarchy



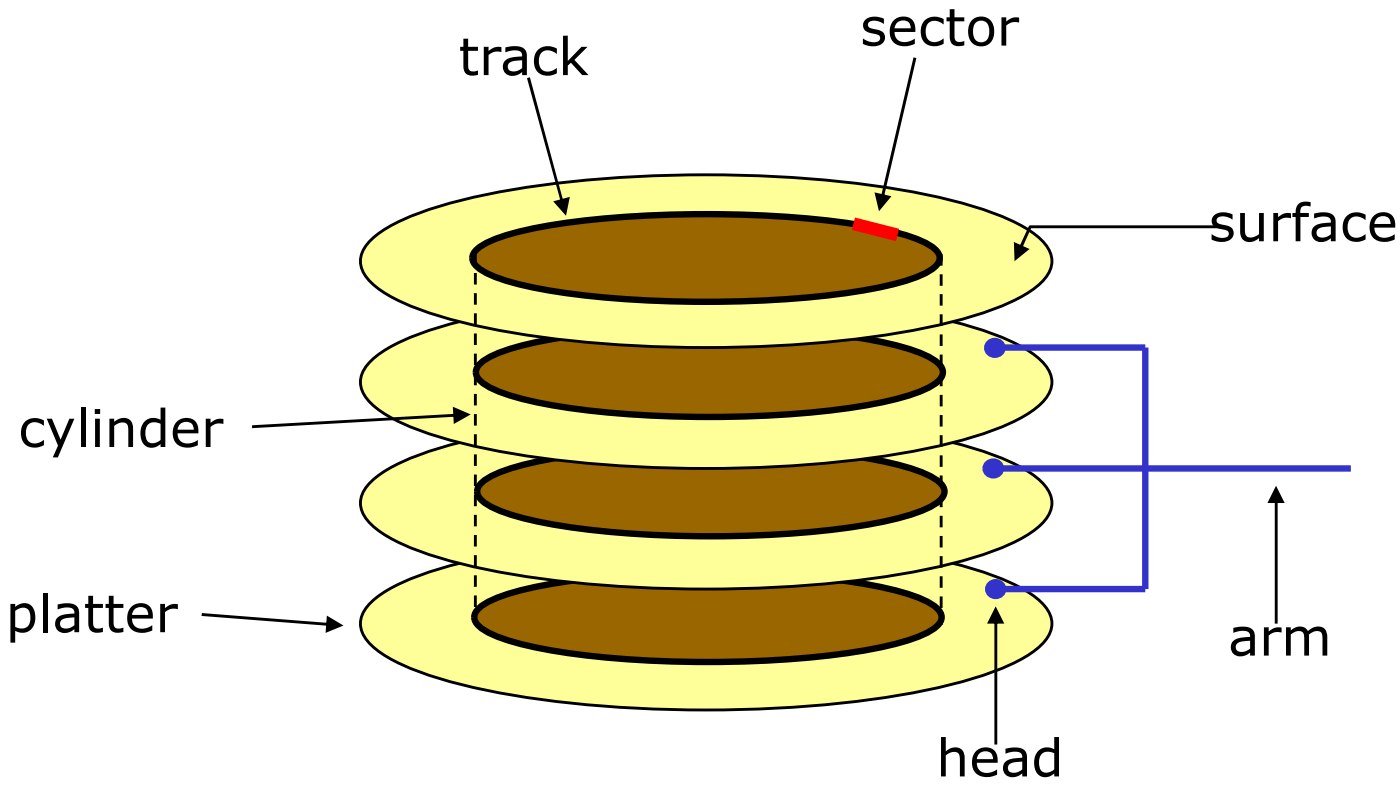
Caching

- ✓ Cache management policy
  - Write-through vs. Write-back
- ✓ Cache coherency

Computer System Operation

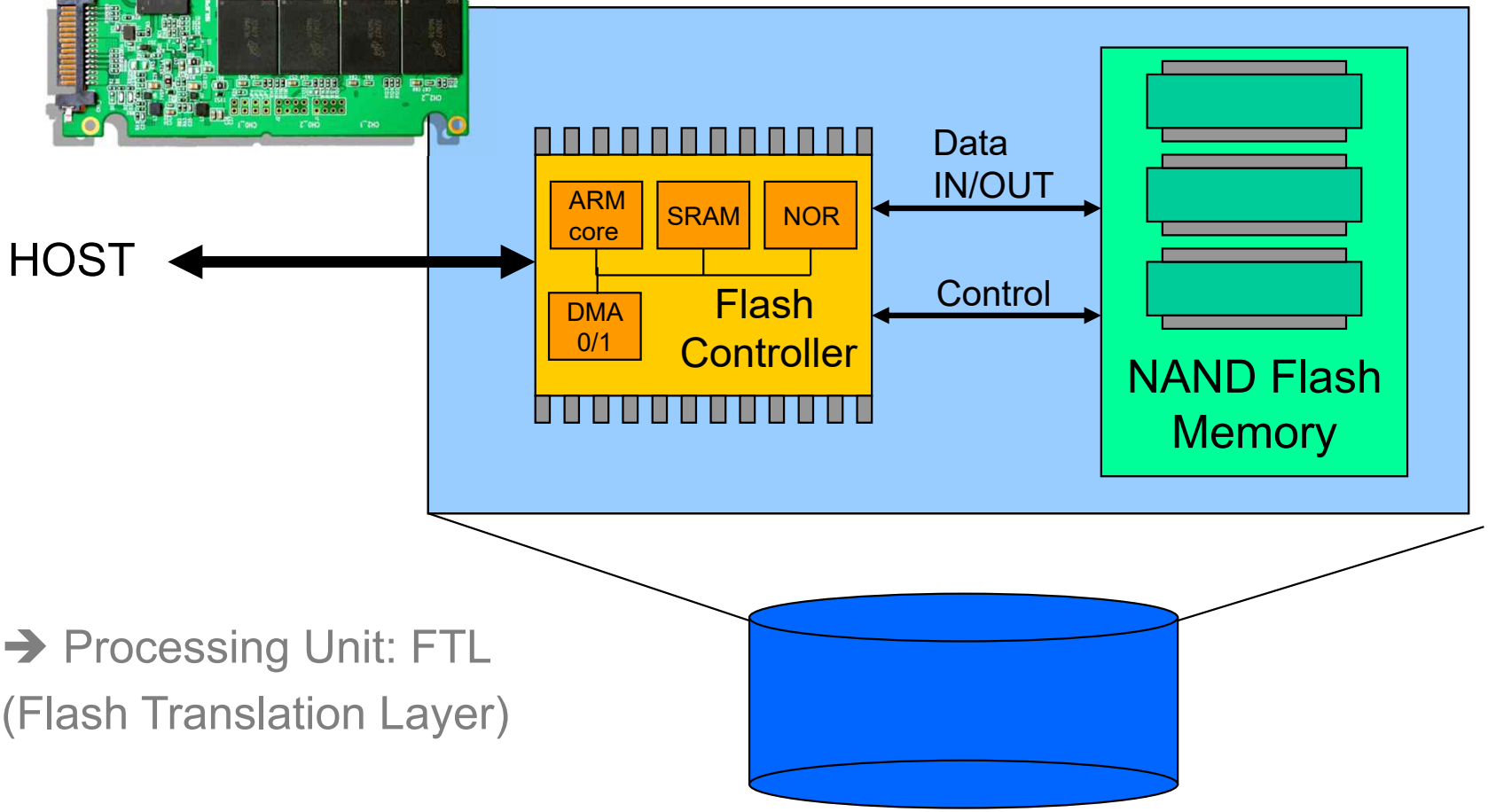
Physical hard disk structure (HDD)

- ✓ platters
- ✓ surfaces
- ✓ tracks
- ✓ sectors
- ✓ cylinders
- ✓ arm
- ✓ heads



Computer System Operation

Solid-State Drive (SSD)

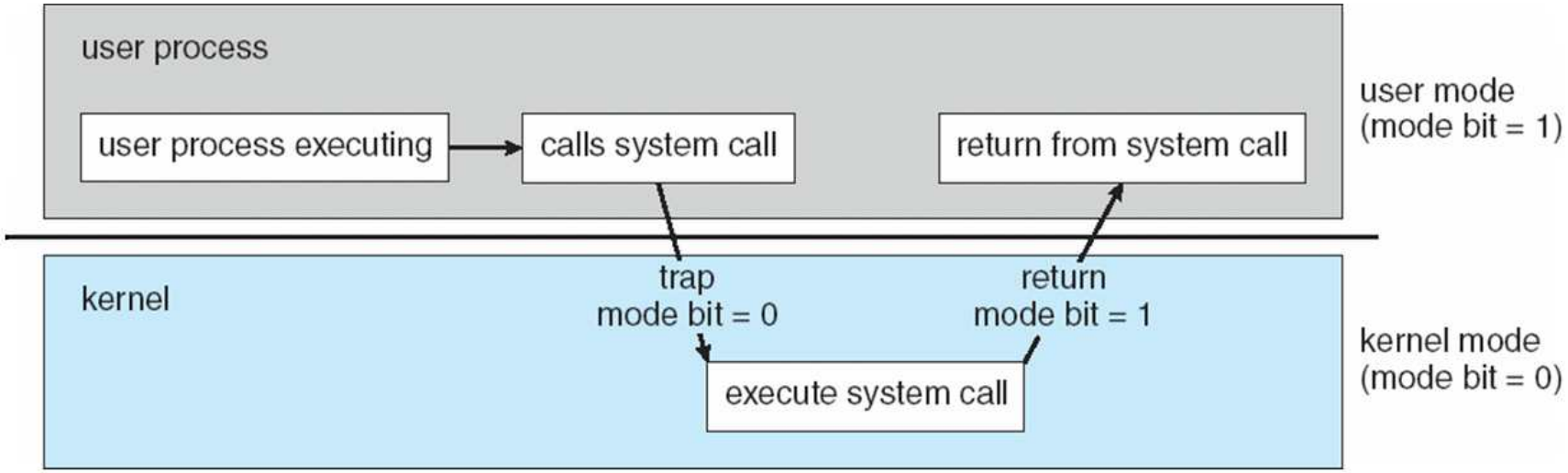


➔ Processing Unit: FTL
(Flash Translation Layer)

Computer System Operation

Hardware protection

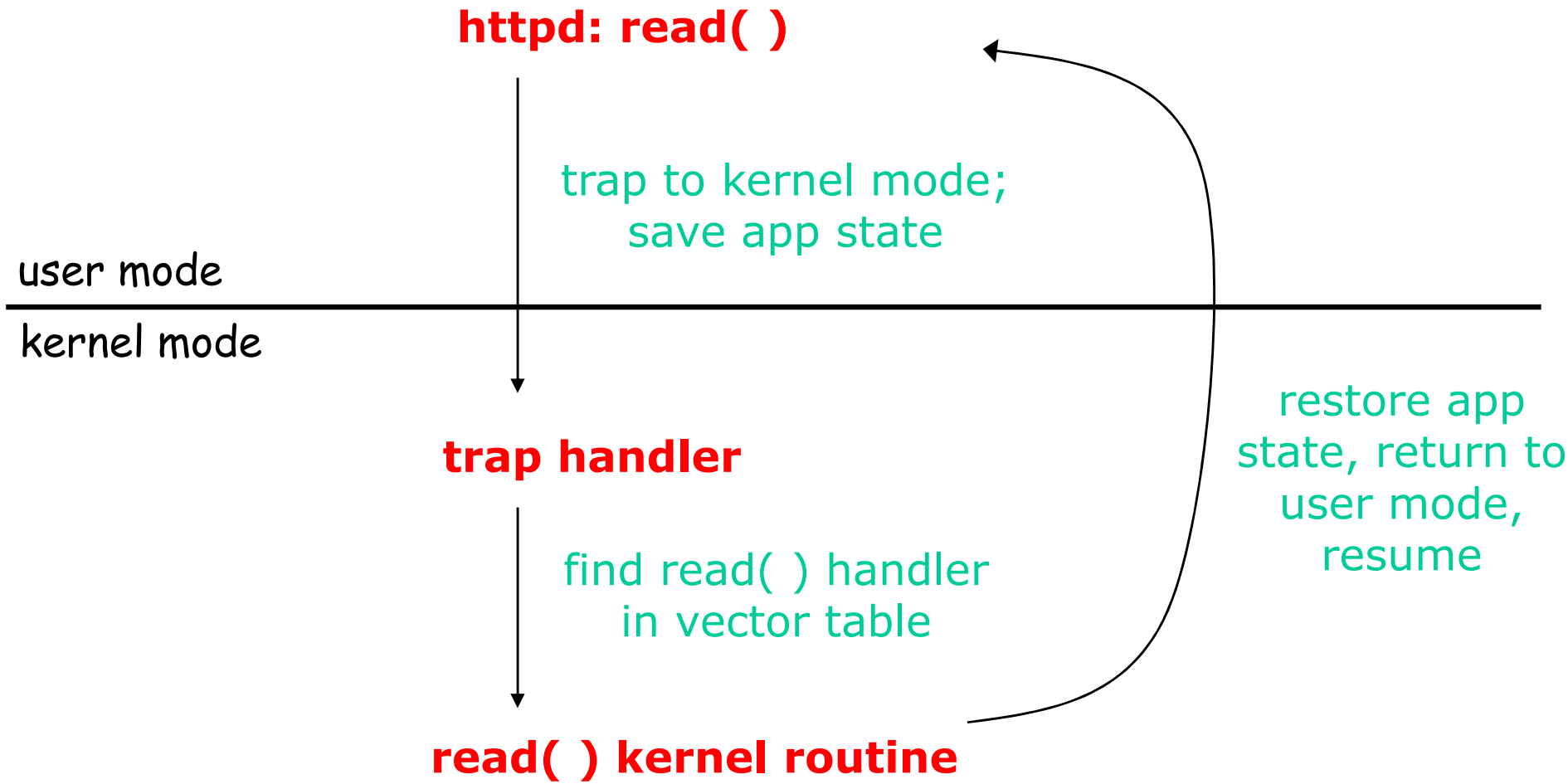
- ✓ CPU protection
  - Timer (periodic interrupt, 10ms in Linux)
- ✓ Memory protection
  - Protection fault (E.g. segmentation violation in Linux)
- ✓ I/O protection
  - Dual mode operation in CPU
  - Privileged instructions only in kernel mode



Computer System Operation

System call

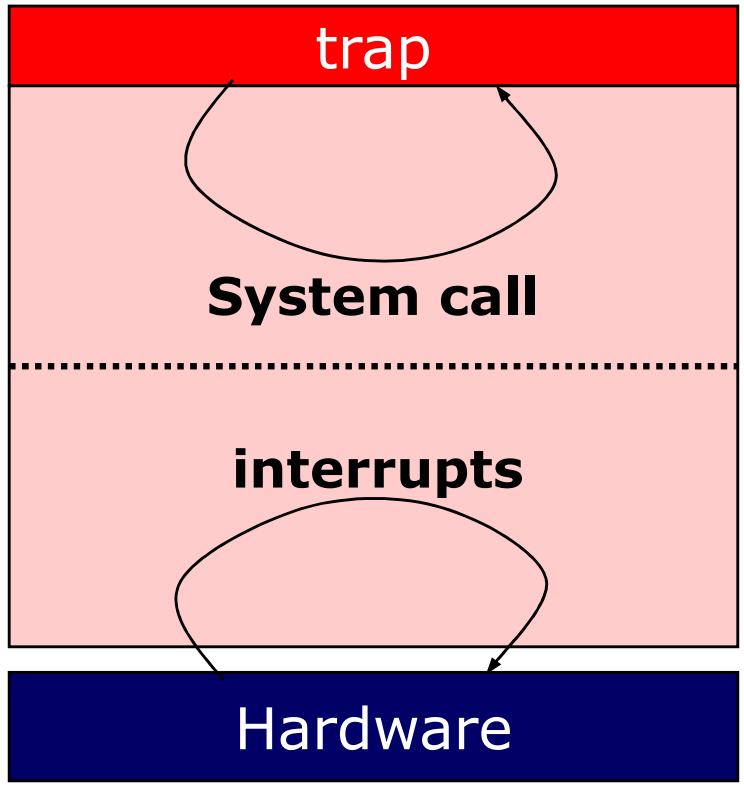
- ✓ Cf) Function call



Computer System Operation

OS takes control of the system

- ✓ Bootstrapping
- ✓ System calls
- ✓ Interrupts

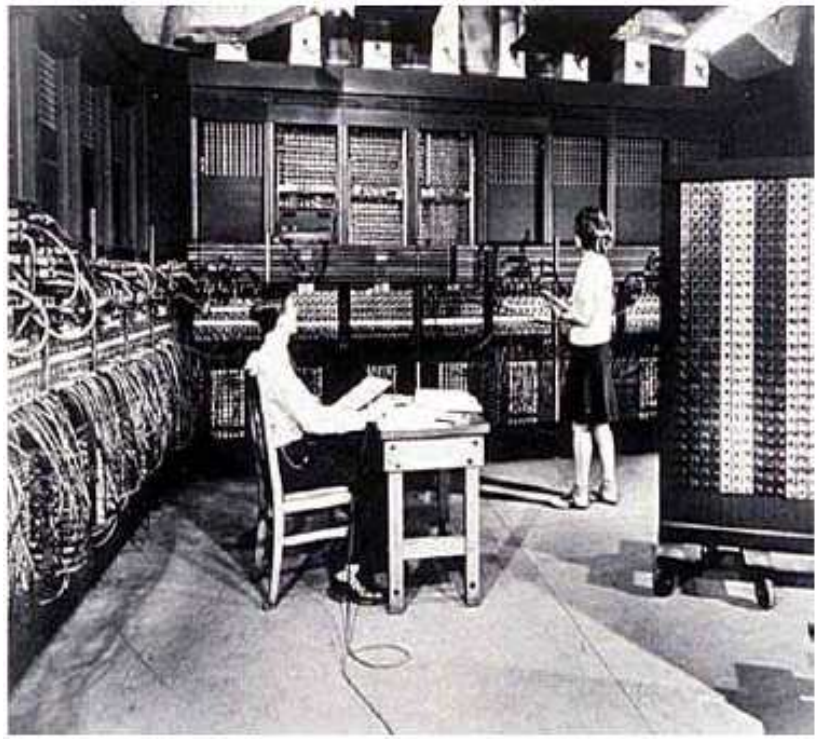


Computer History

1st Generation (1945-55)

- ✓ *Vacuum Tubes and Plugboards*

- ✓ No OS
- ✓ No Programming Languages
- ✓ No Assembly Languages



Eniac, 1940's

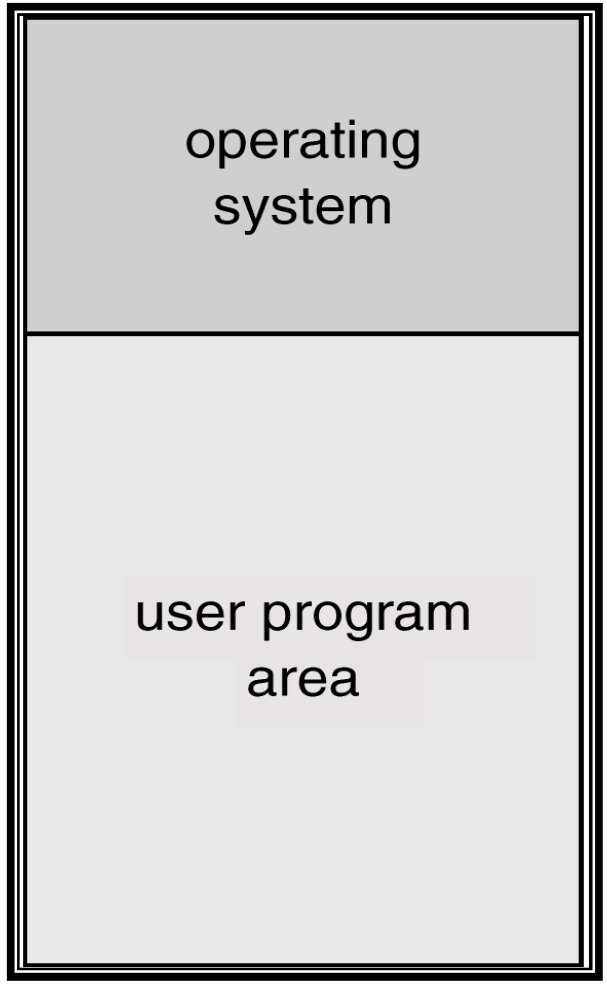
John Von Newman

Computer History

2nd Generation (1955-65)

- ✓ *Transistors and Mainframes*

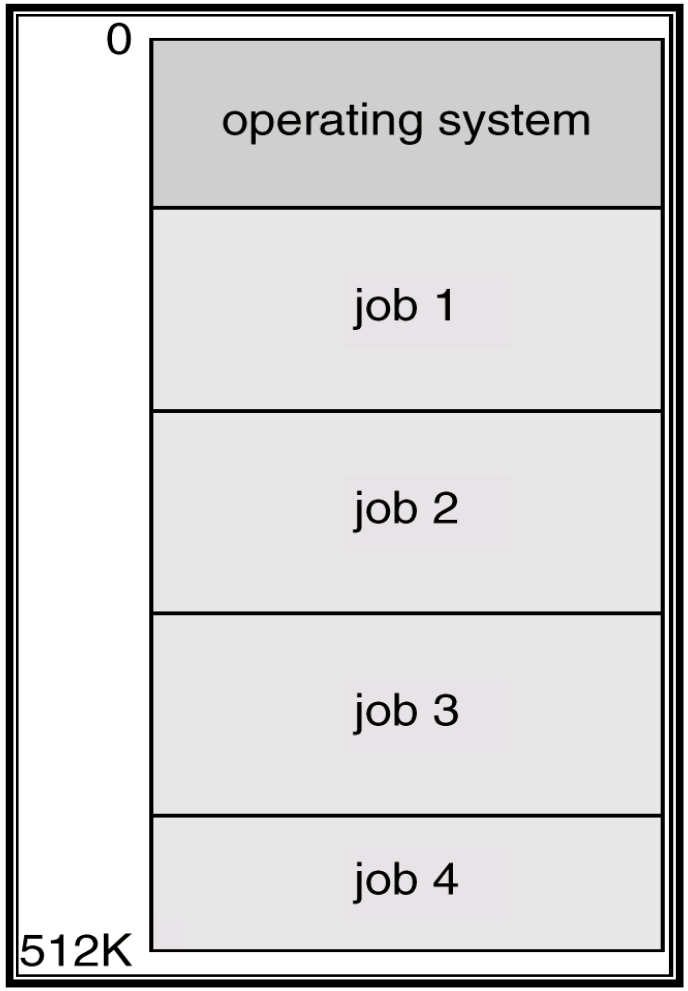
- ✓ Batch systems
  - OS is called “Resident Monitor”
  - CPU is underutilized due to the bottleneck in I/O



Computer History

3rd Generation (1965-80)

- ✓ *Integrated Circuits (ICs)*
- ✓ Architectural advances
  - The notion of “Computer Architecture”
  - IBM System/360 family
- ✓ Multiprogramming systems
  - Increased CPU utilization
- ✓ Time-sharing systems
  - Improved response time
  - Traditional OS features



Computer History

4th Generation (1980-)

- ✓ *LSIs & VLSIs*

- ✓ Architectural advances
  - Microprocessors: smaller and faster
  - Storages: larger and faster
  - CPU work is offloaded to I/O devices
  - Personal computers (Desktop system)

- ✓ Modern OS Features
  - GUI (Graphical User Interface)
  - Multimedia
  - Internet & Web
  - Networked / Distributed, etc.

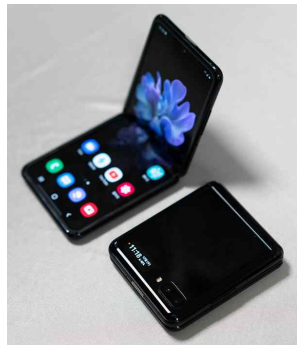
Computing Environments

Traditional computing

- ✓ Mainframe system
  - Batch system
  - Multiprogramming system
  - Time-sharing system
- ✓ Desktop system

Mobile computing

- ✓ Hand-held system
  - Limited memory
  - Slow processors
  - Small display screens



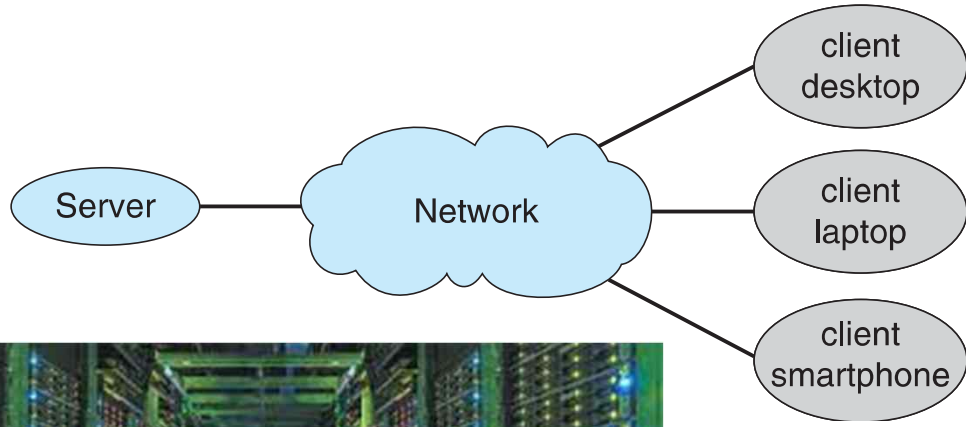
Real-time embedded computing

- ✓ Real-time systems
  - Hard real-time vs. Soft real-time
- ✓ Embedded systems

Computing Environments

Client-server computing

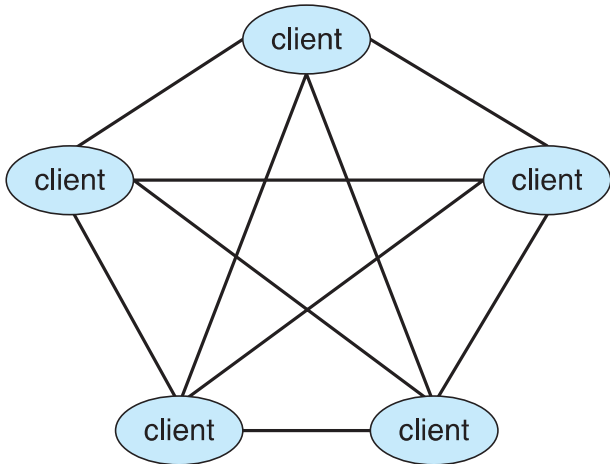
- ✓ Large-scale server in data center
- ✓ Clustered server
  - Parallel + Distributed + Storage



Computing Environments

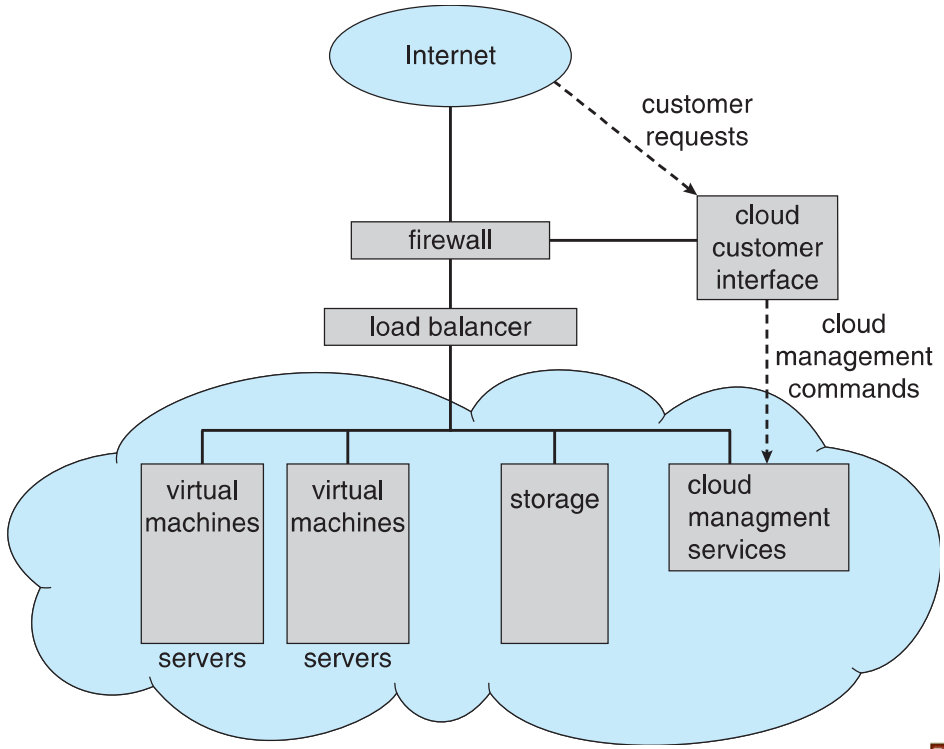
Peer-to-peer computing

- ✓ Discovery protocol
- ✓ Napster, Gnutella, VoIP, etc.



Cloud computing

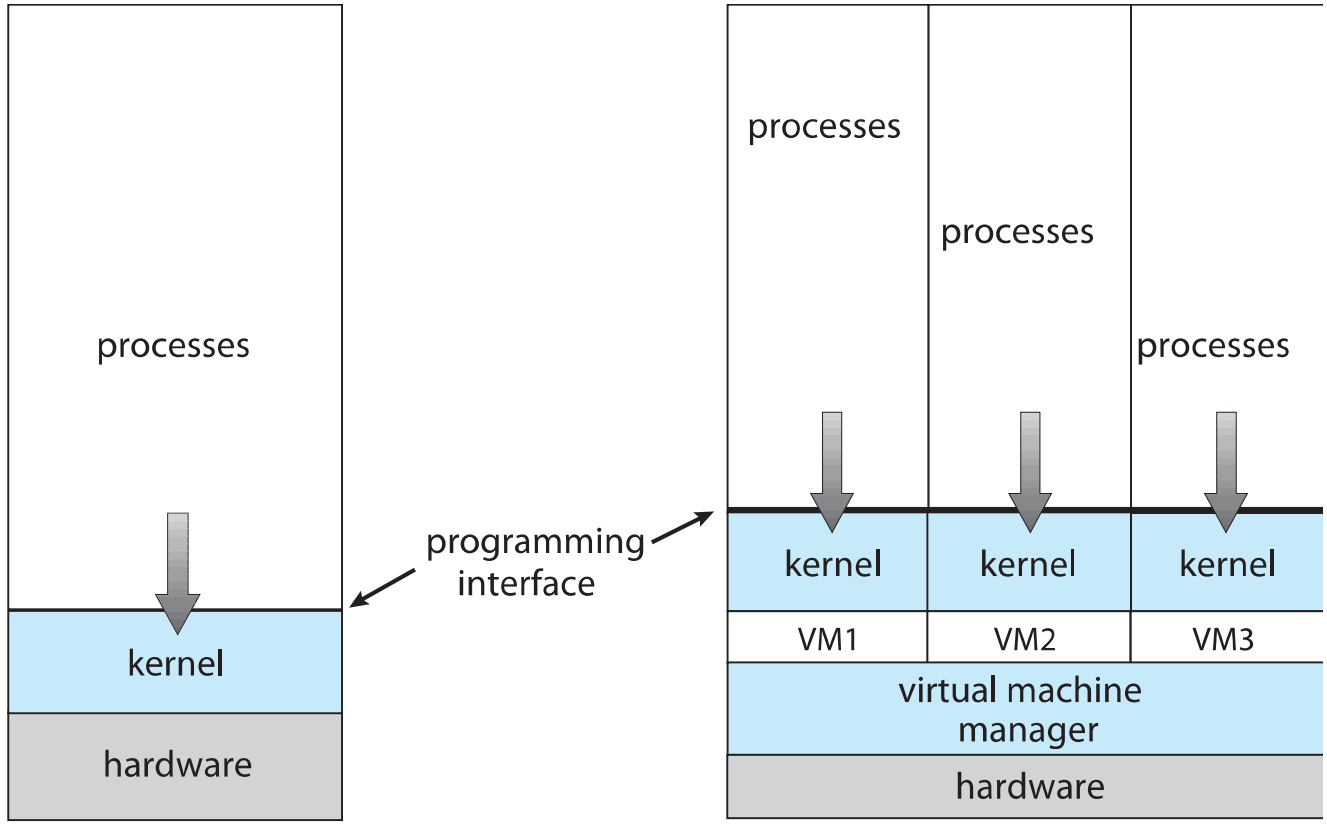
- ✓ Infrastructure as a Service (IaaS)
- ✓ Platform as a Service (PaaS)
- ✓ Software as a Service (SaaS)



Computing Environments

Virtualization

- ✓ VMM or Hypervisor

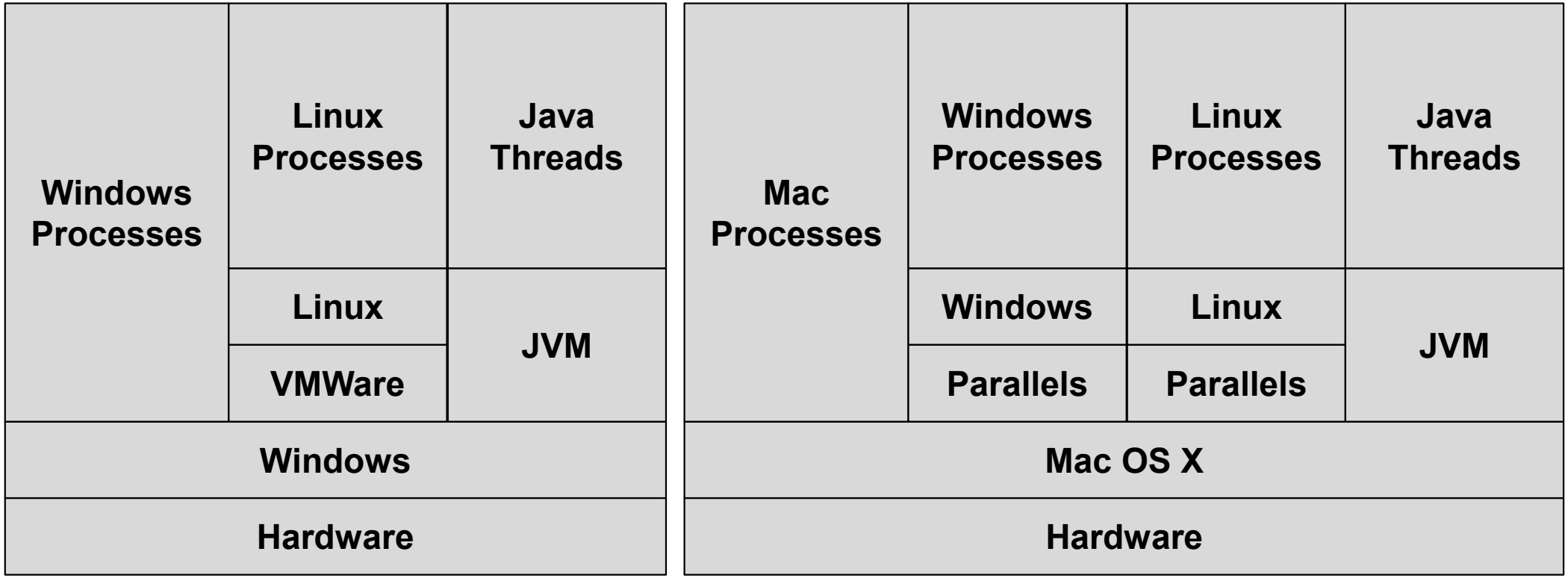


(a) Non-virtual Machine

(b) Virtual Machine

Computing Environments

Virtual machine examples



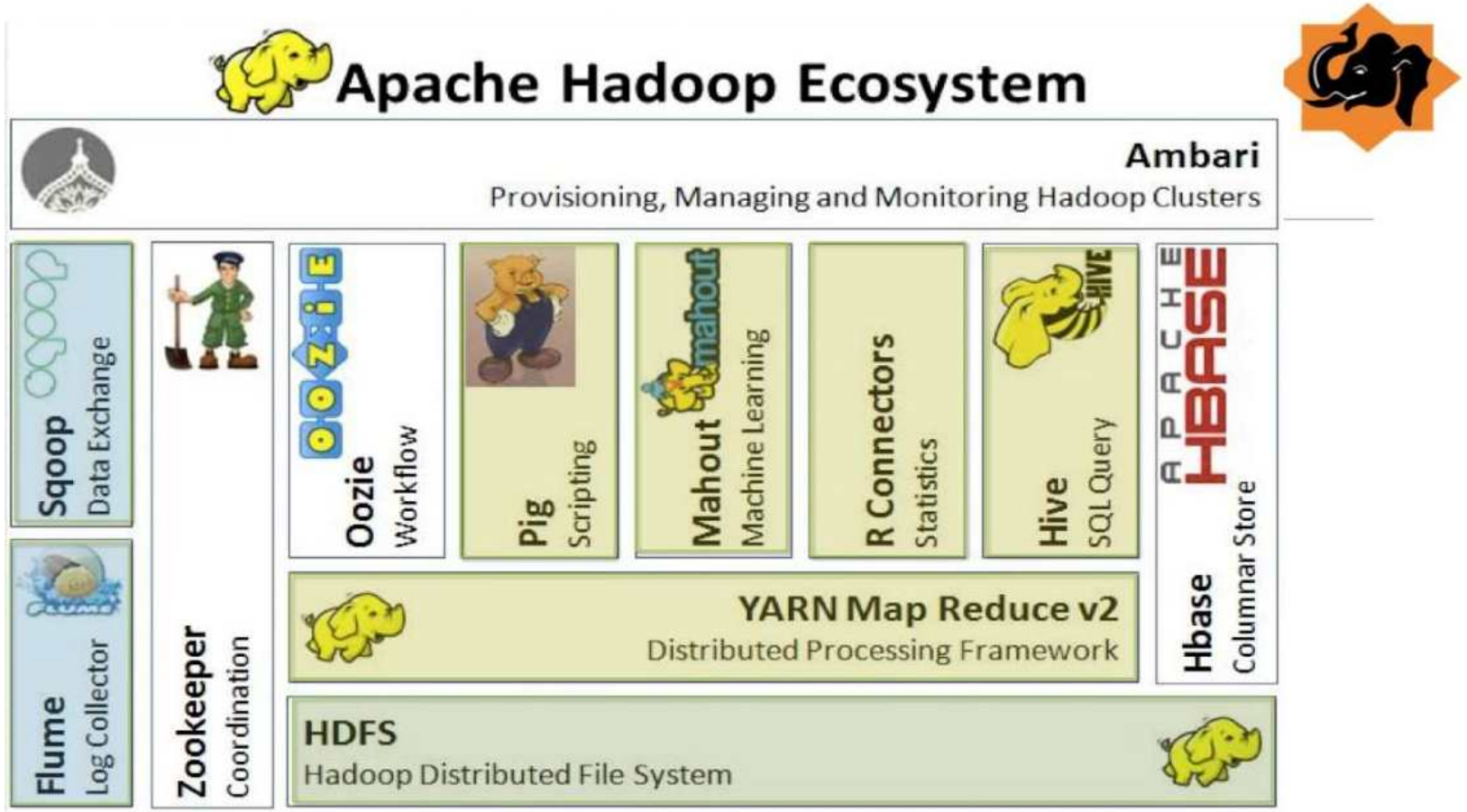
Java

- ✓ JVM executes “platform-neutral byte-codes”
- ✓ JIT (Just-In-Time) compilers increase performance

Computing Environments

Distributed computing

- ✓ Collection of separate, possibly heterogeneous, systems networked together
- ✓ Network operating systems provides illusion of a single system
- ✓ E.g.) Hadoop, Spark



OS History

A long time ago,
in a galaxy far, far away, …

IBM OS/360: Multiprogramming

MIT CTSS (Compatible Time-Sharing System)

MIT, Bell Labs, GE, MULTICS
(MULTiplexed Information and Computing Service)

And Unix was born in 1969

OS History: Unix (1969-85)

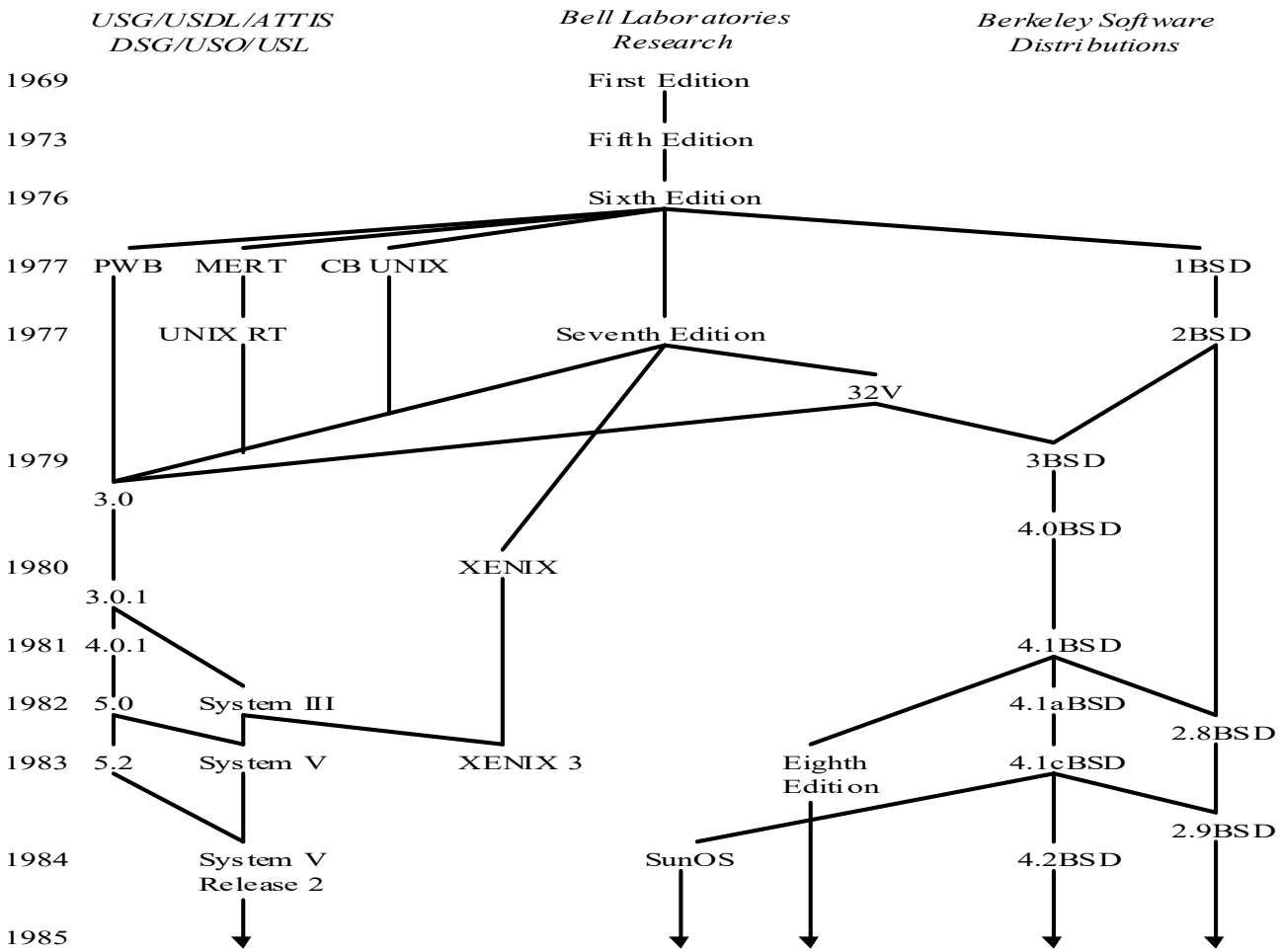


Figure 1.1 The UNIX system family tree, 1969-1985

OS History: Unix (1985-96)

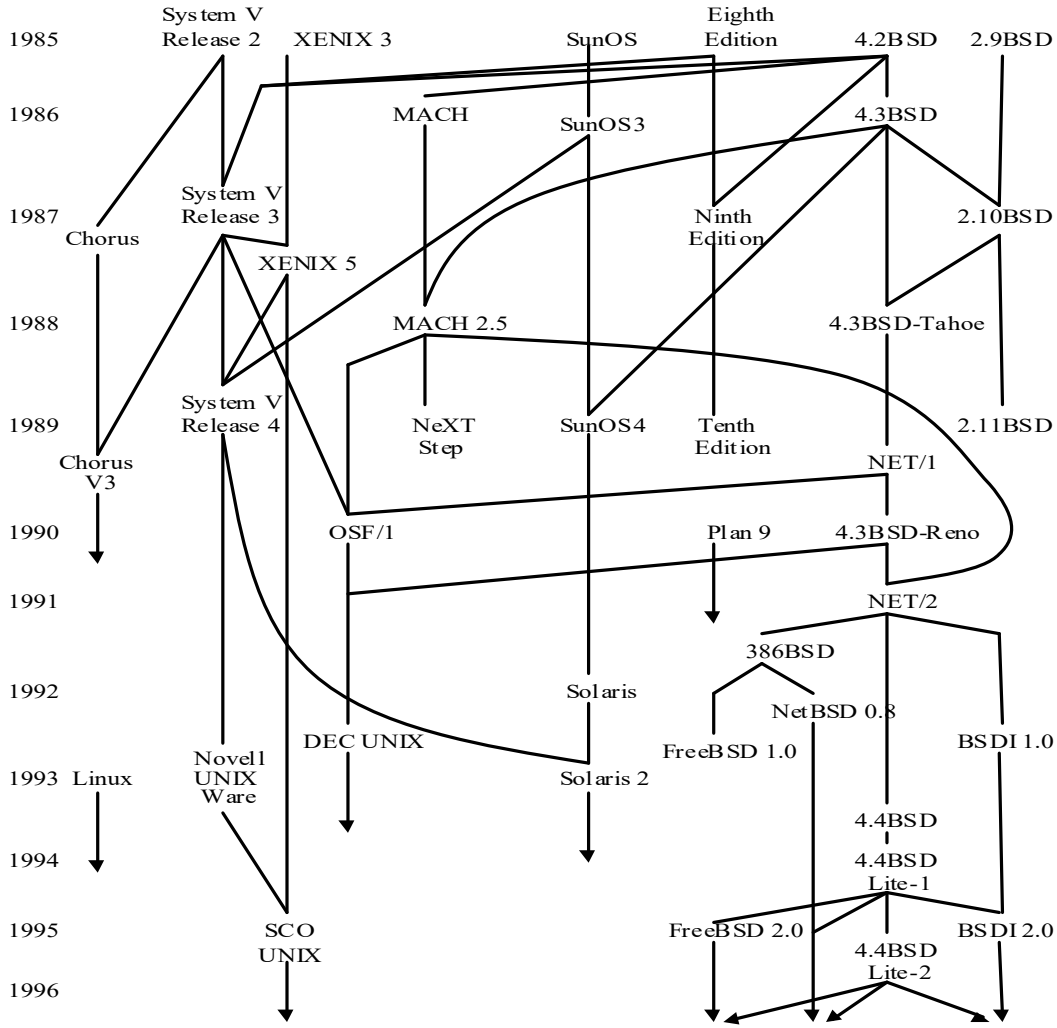


Figure 1.2 The UNIX system family tree, 1986-1996

OS History: Unix (1997-)

Sun Solaris

HP HP-UX

IBM AIX

Caldera (SCO) Unixware

Compaq (Digital) Tru64

SGI Irix

Linux, FreeBSD, NetBSD

Apple Mac OS X, etc.

Cf) POSIX

OS History: Windows & Linux

1981 82 84 86 88 90 91 92 93 94 95 96 97 98 99 00 01

MS-DOS Family

1.0 2.0 3.0 3.2 4.0 5.0 6.0 7.0

Windows Family

1.0 2.0 3.0 3.1 95 98 98 SE ME

Windows for WorkGroup Family

3.1 3.11

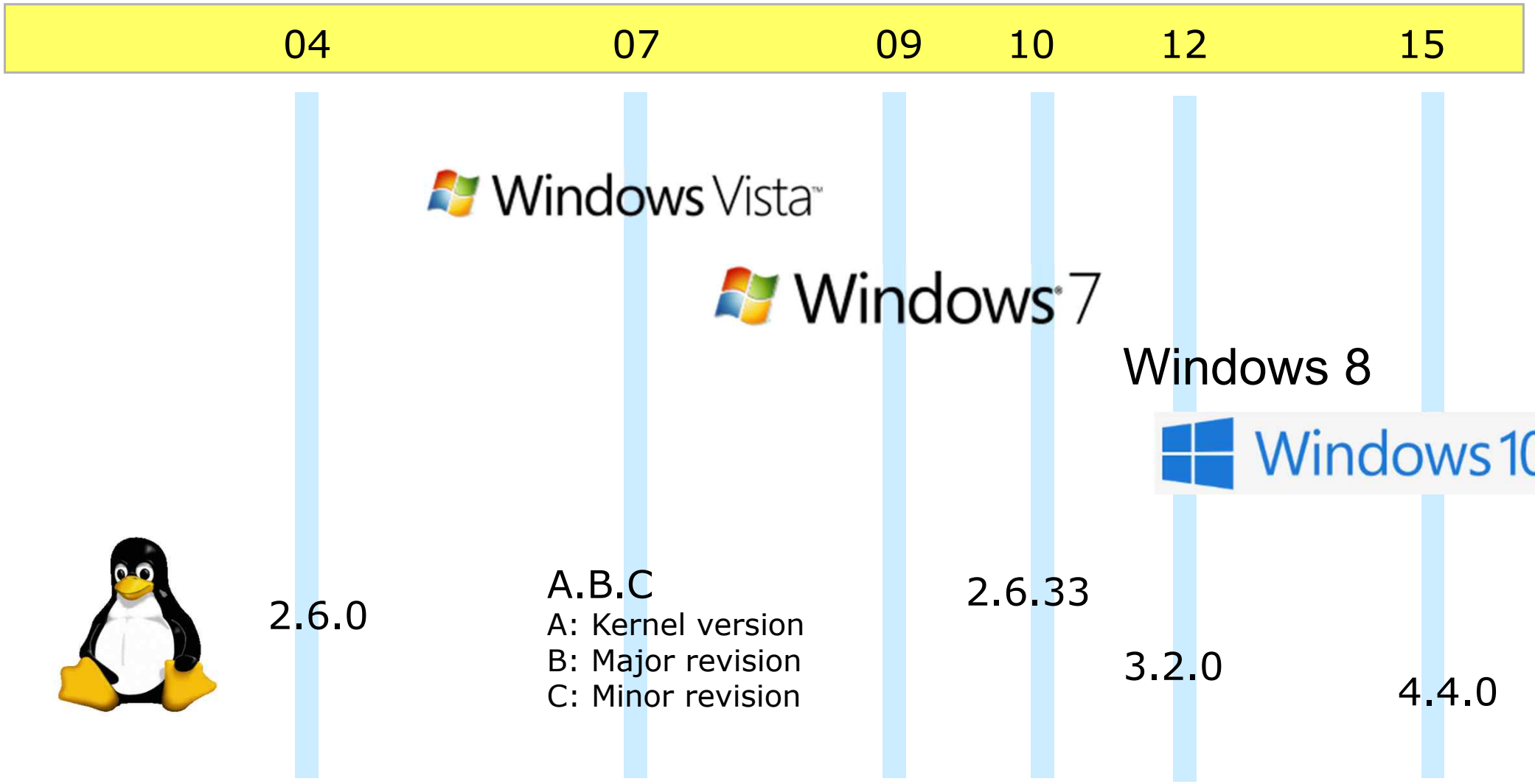
Windows NT Family

3.1 3.51 4.0 2K XP

Linux

0.01 0.99 1.0 1.2 2.0 2.1 2.2 2.4

OS History: Windows & Linux



OS History: Linux

1983

- ✓ Richard Stallman, GNU project and free software concept
- ✓ gcc, gdb, glibc, and other tools

1991

- ✓ Linus Tovalds, Linux kernel project
- ✓ Completely free operating system: Linux/GNU

1995

- ✓ Linux is more and more popular on server systems

2000

- ✓ Linux is more and more popular on embedded systems

2008

- ✓ Linux is more and more popular on mobile devices

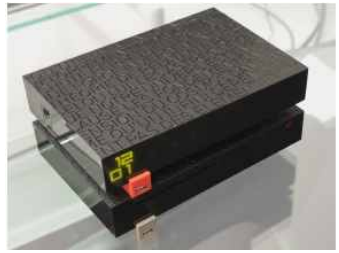
2010

- ✓ Linux is more and more popular on phones

OS History: Linux

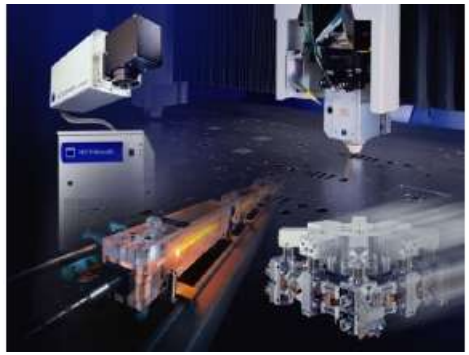
Television

Personal router



PoS (Point of Sales) terminal

Laser cutting machine



Viticulture machine

OS History: Taxonomy

Mainframe systems

- ✓ CTS, MULTICS, IBM MVS, VM

Desktop systems

- ✓ DOS, Windows, MacOS, Unix/Linux

Distributed systems

- ✓ Amoeba(Vrije Univ.), Locus(UCLA), Grapevine(Xerox), V(Stanford), Eden(U. of Washington), Chorus/Nucleus(Inria)

Embedded systems

- ✓ VxWorks, FreeRTOS, NuttX, Vertex, pSOS, OSE, Windows-CE, Embedded Linux
- ✓ Company-proprietary OS (Cisco, Qualcomm, Palm, Cellvic)

Real-time systems

- ✓ Real-Time Linux, Spring(U. of Massachusetts), HARTS(U. of Michigan), MARUTI(U. of Maryland)