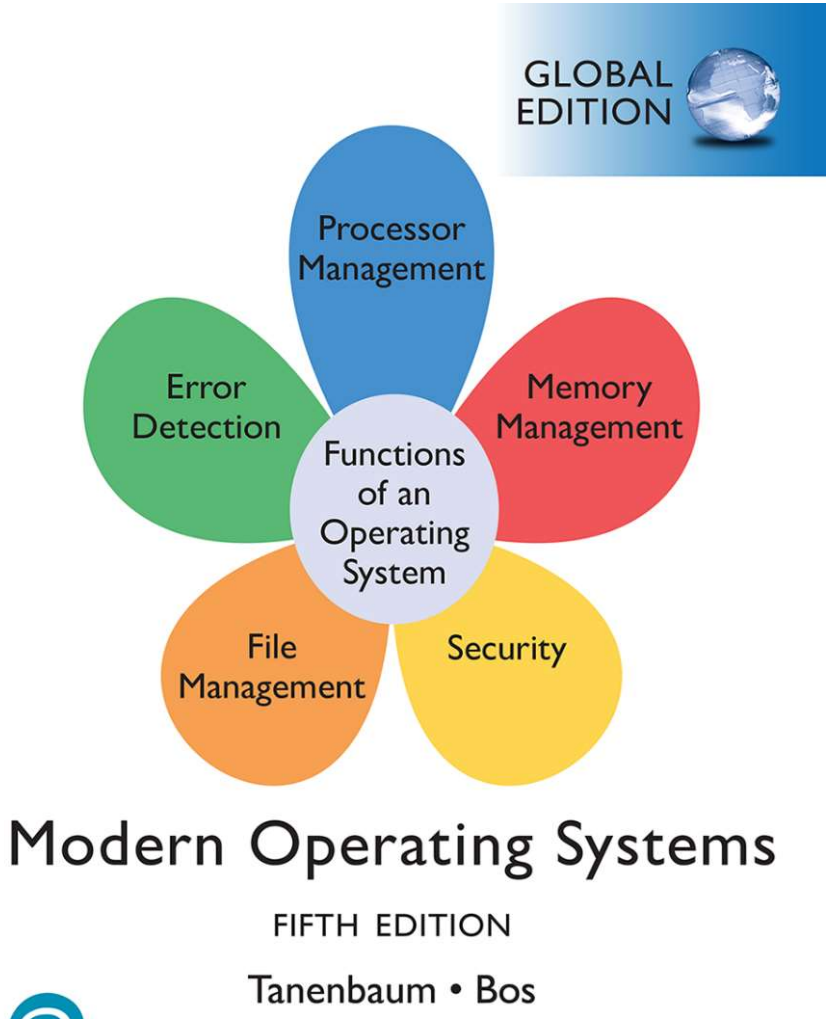
Modern Operating Systems

Fifth Edition, Global Edition



Lecture 1

Introduction - Definitions

What is an Operating System

The Operating System (OS) is a program that serves as an interface between a computer system's hardware and its users (applications). It performs:

- Controlled access to the system's resources (security)
- Sharing system resources (performance and fairness)
- Services for easy access to hardware
  - File systems
  - Network protocols
- A common hardware interface for programmers (POSIX)
  - hiding the messy details (abstraction, standardization)

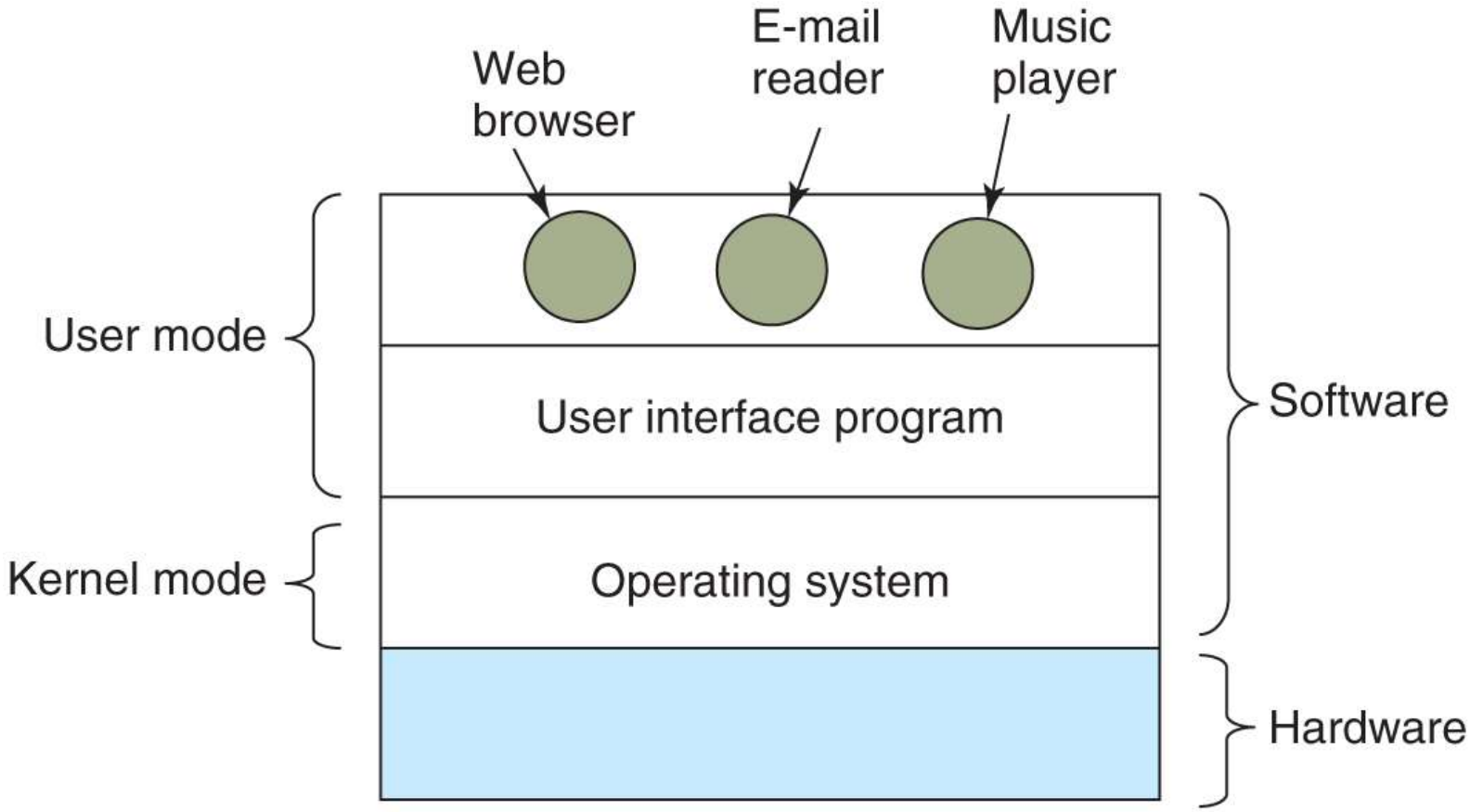
What is an Operating System

Top-down and bottom-up definitions

- Provides programs with easy and efficient access to system resources
- Provides a structured and controlled allocation of processors, memory, and other I/O devices among the various client programs that compete with each other to use them." (Tanenbaum, 2001)

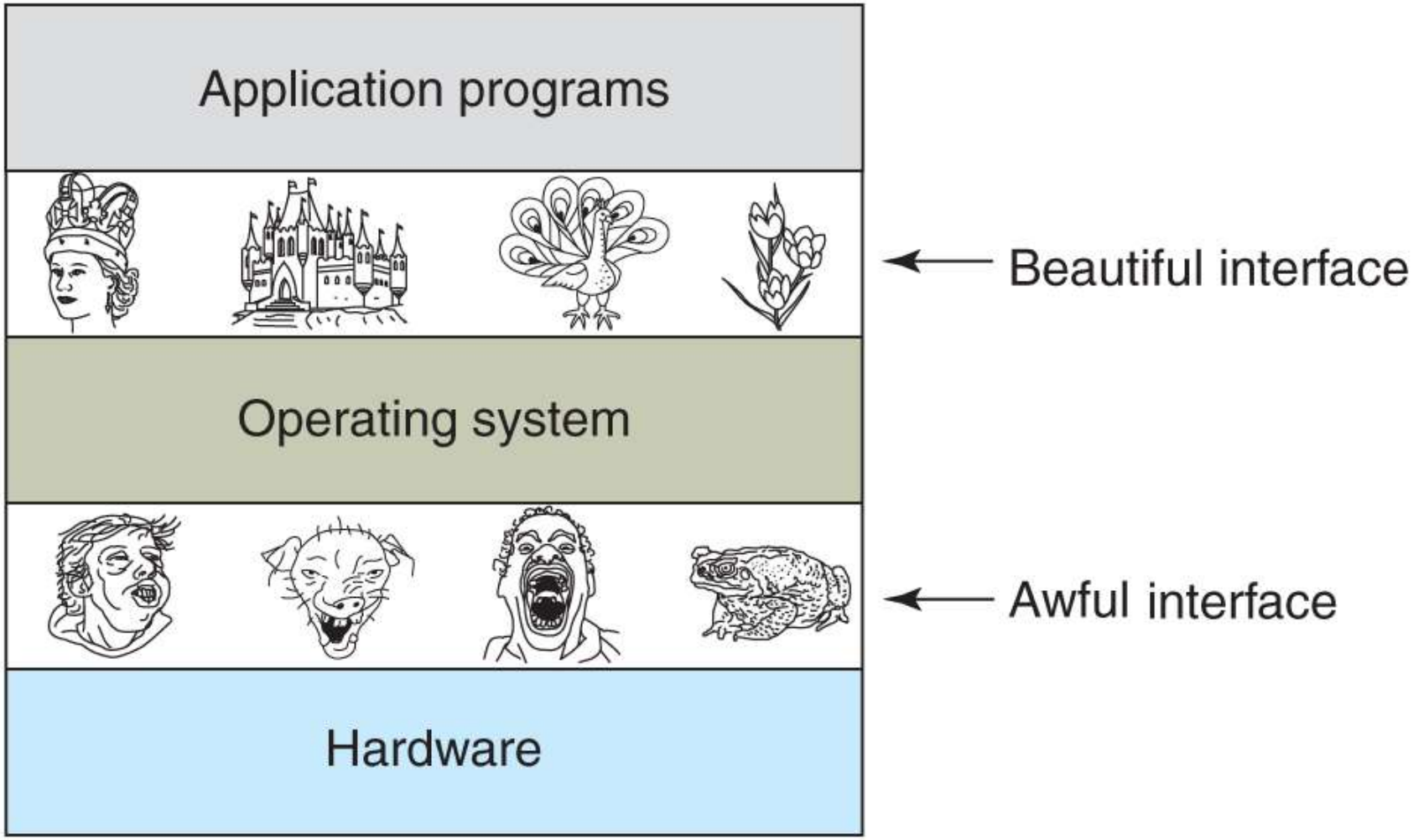
OS Layers: User vs Supervisor

Computers are equipped with an OS layer, whose job is to provide user programs with a better, simpler, cleaner, model of the computer and handle resource managing.



Operating Systems Layers: Why

Operating systems turn awful hardware into beautiful abstractions.

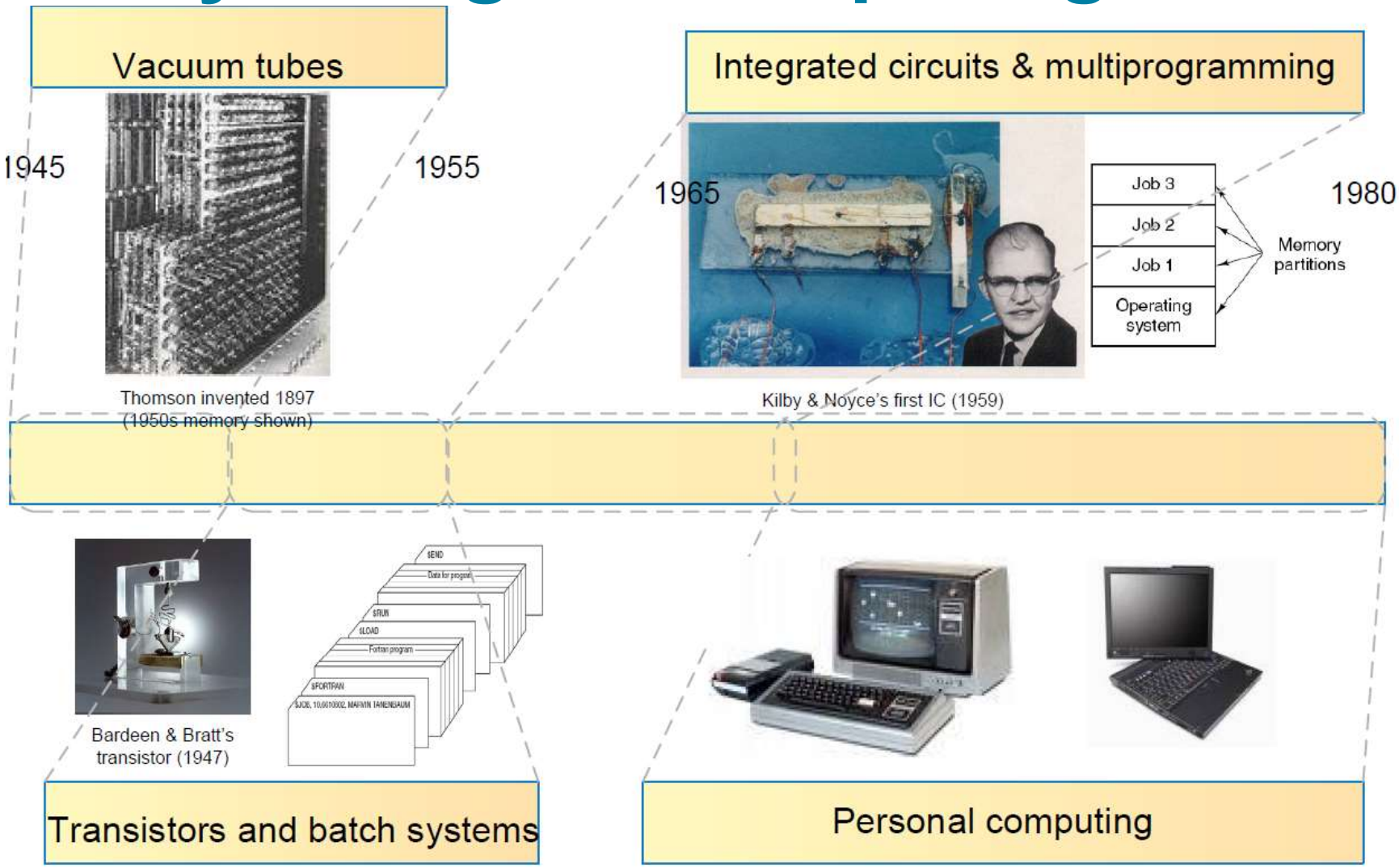


Operating System Layers

Structure of 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

History of Digital Computing

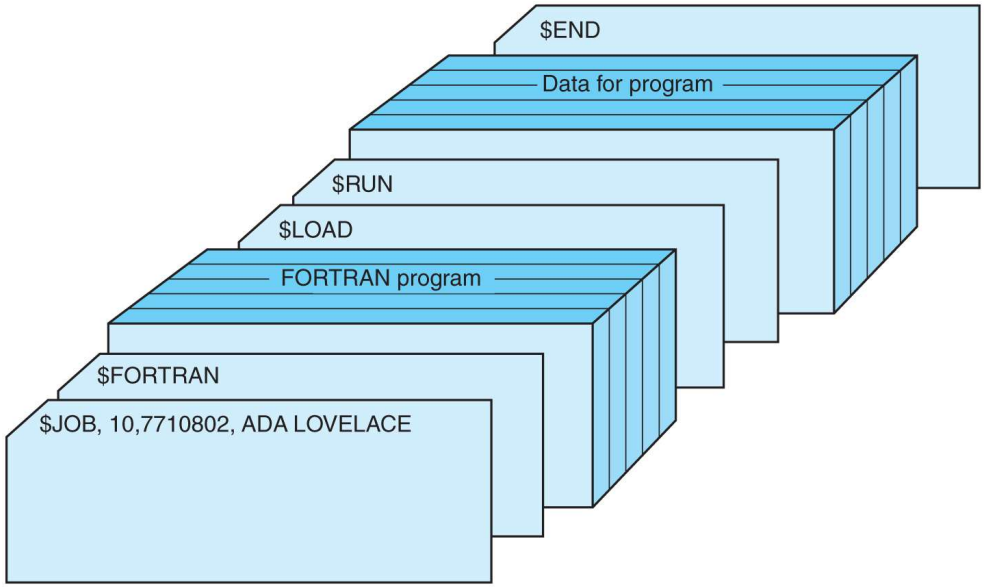


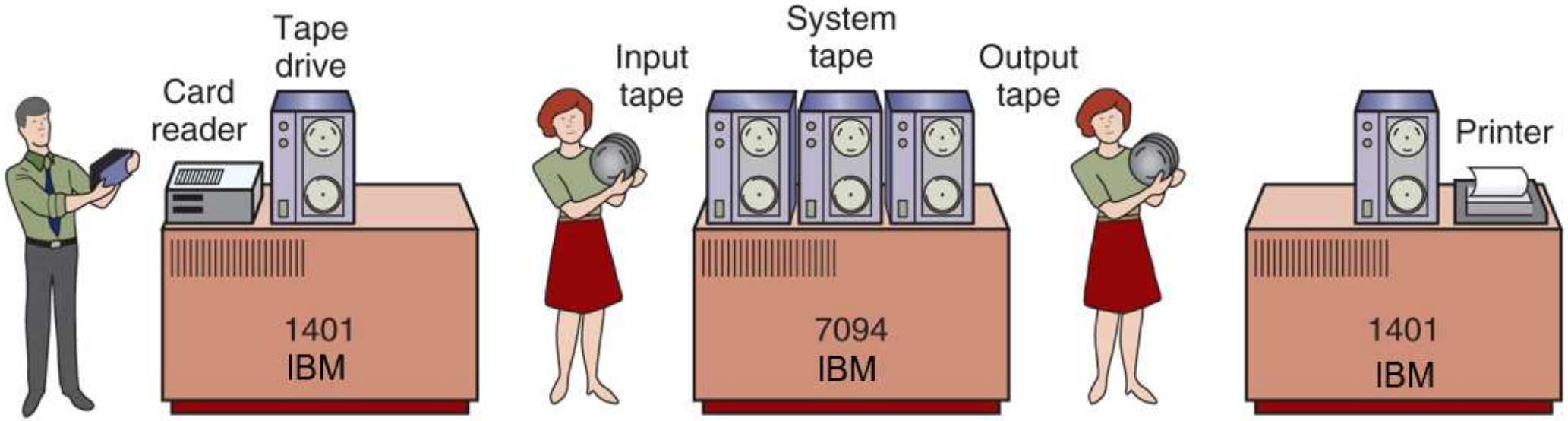
- 1955 1965 1980 2008s

Then, Mobile Computers, Edge Computing, Cloud, …

Fortran Monitoring System (FMS)

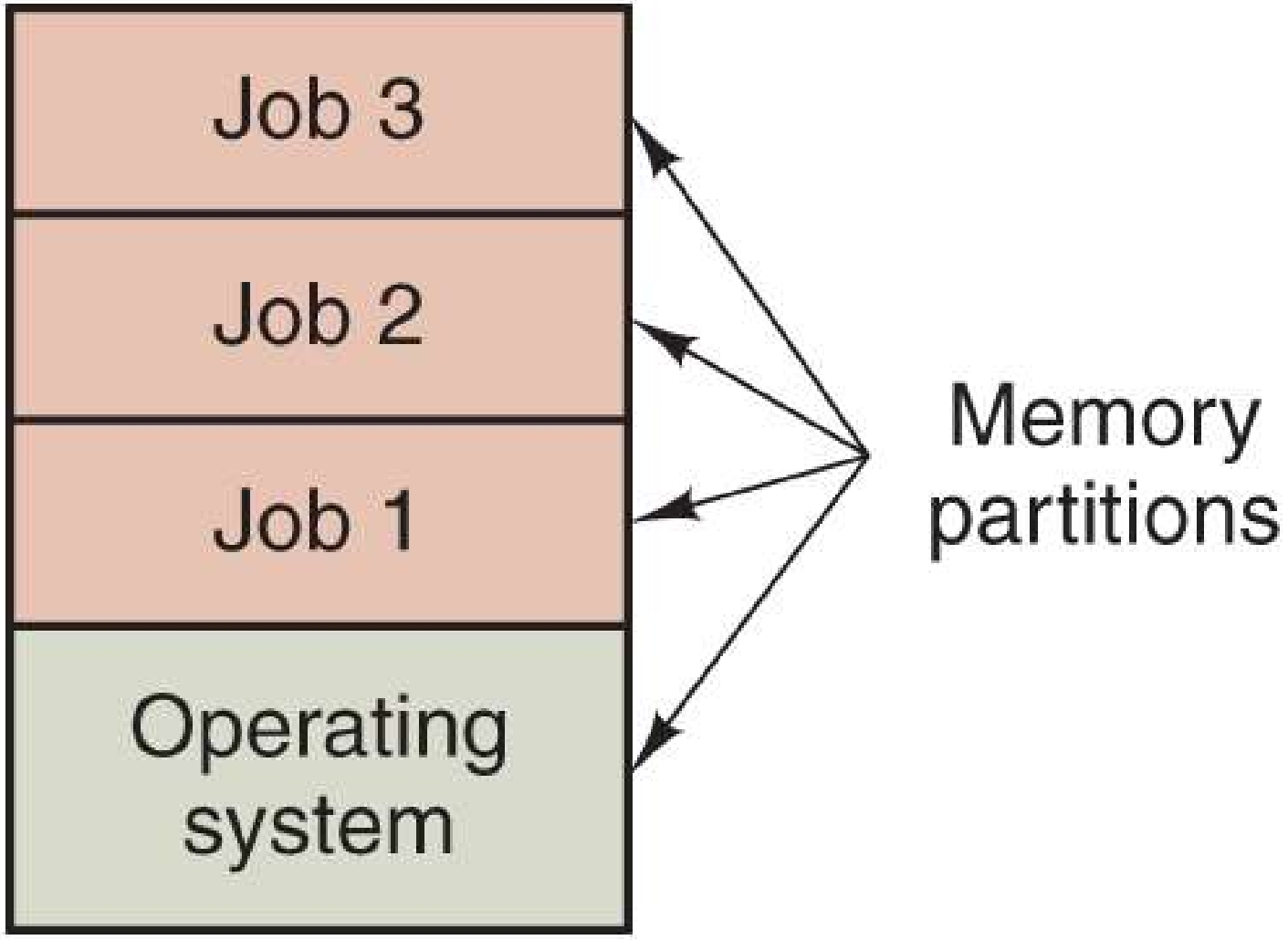
Structure of a typical FMS job.





Multiprogramming on Uniprocessors

A multiprogramming system executing three jobs “in parallel”

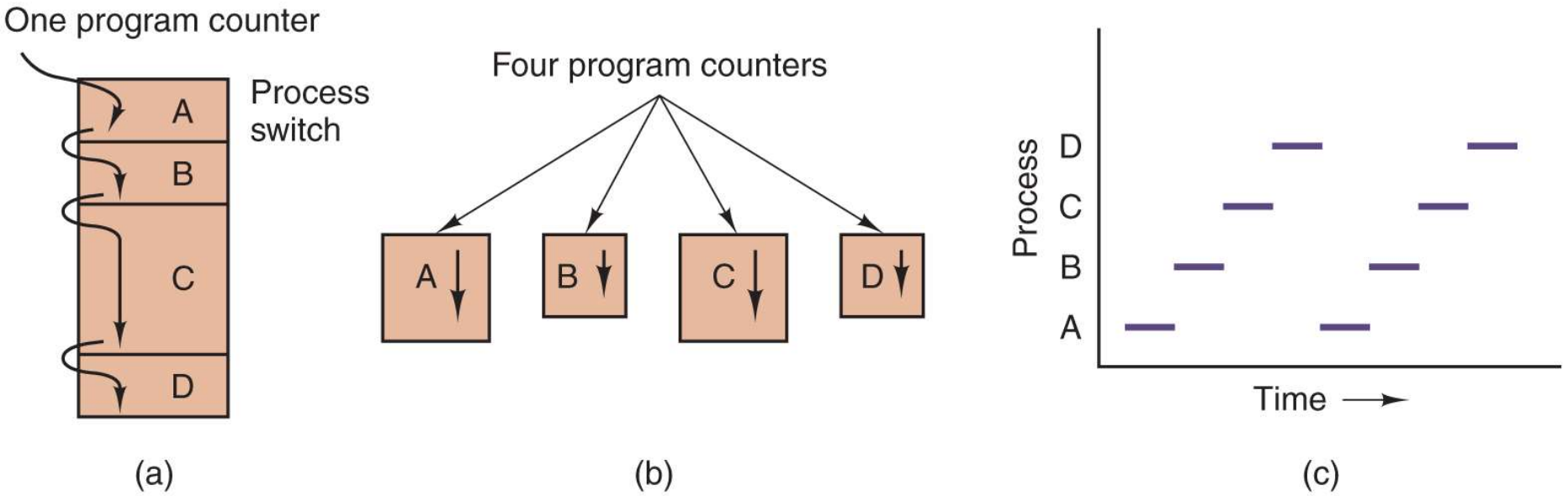


Multiprogramming

How do we transition from one process to another?

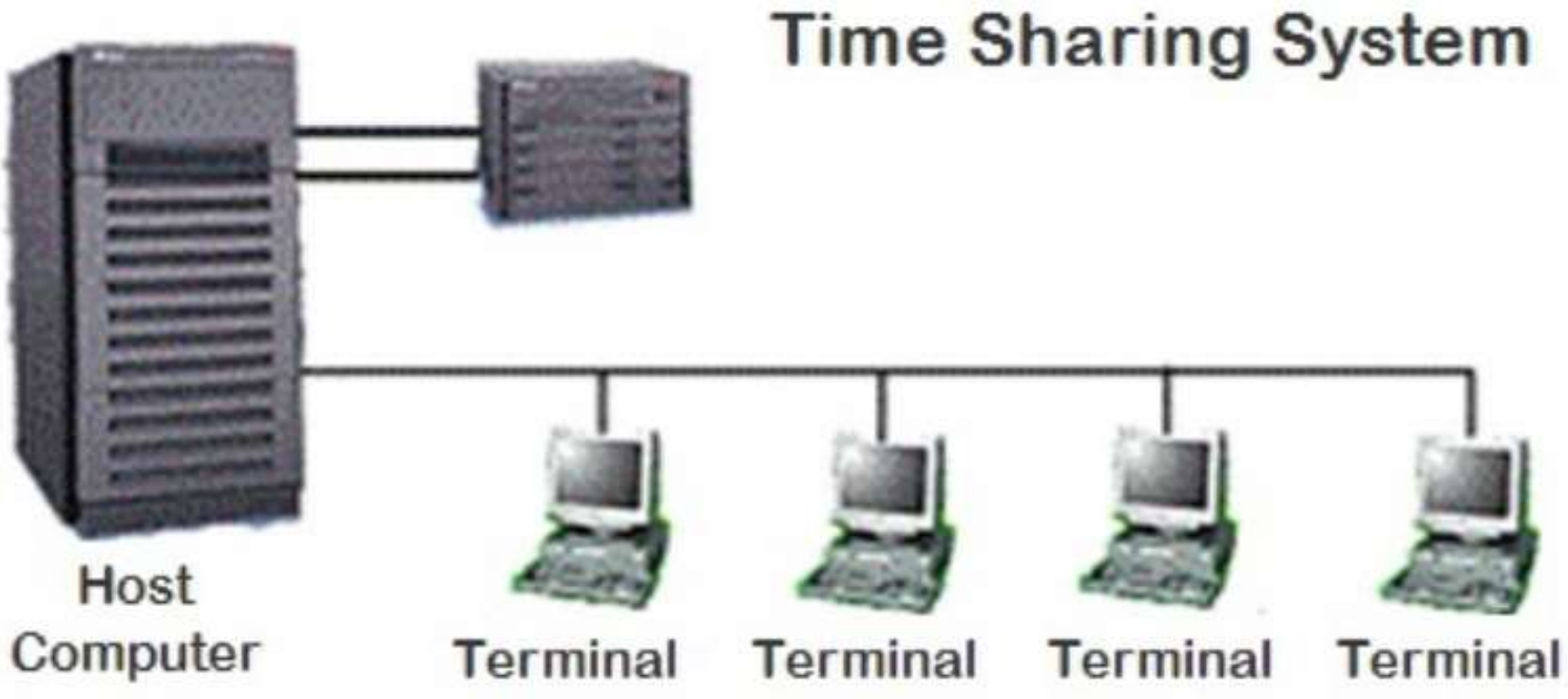
- preemptive multitasking: forced release of processor resource based on external conditions (e.g., wait)
- cooperative multitasking: processes explicitly “yield”

(a) Multiprogramming four programs
(b) Four independent, sequential processes
(c) Only one program is active at once.

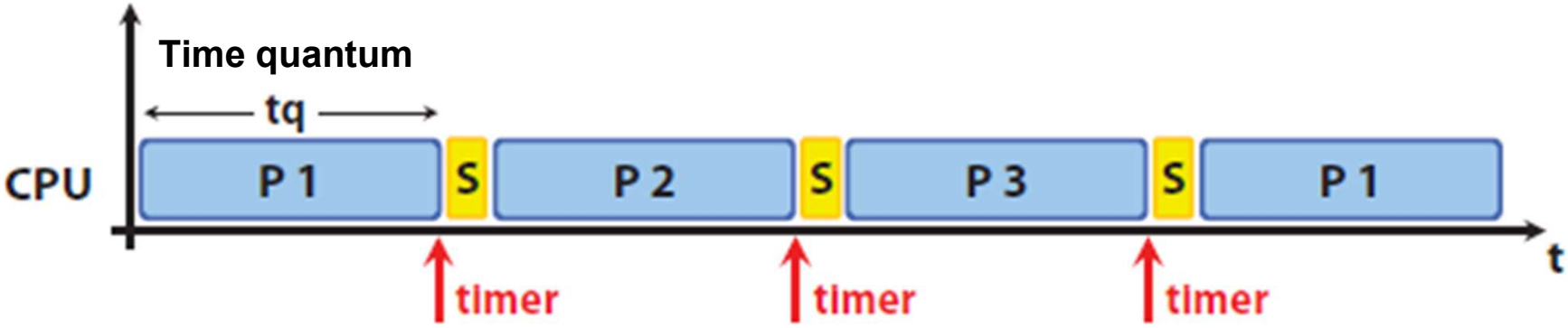


Multitasking (Time Sharing/Co-op Sched)

Time sharing allows users to connect in round robin fashion to share the mainframe resources (CPU, etc)



Context Switch



- The CPU switches from one process to another
- Save the state of the old process, e.g., PCB P1 & MMU data
- Flush & clear cache* and processor pipeline
- Restore the new process, e.g., PCB P2 & MMU data
- Return from interrupt to new process
- How long does it take? (Lost time for the CPU)
- How often does it occur?

*OS/CPU dependent

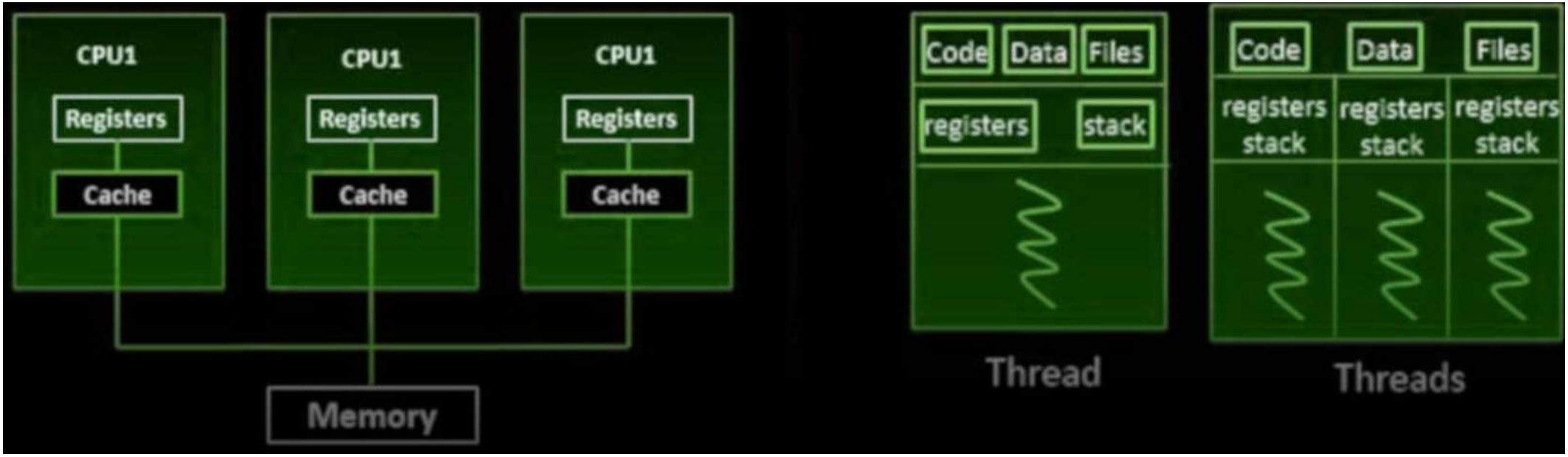
Scheduler: Dispatching

Responsible for context switches between processes

- Interrupt request occurs and dispatch service routine invoked
- Save memory management unit (MMU) data
- Save process state (e.g.registers)
- Flush and clear cache* and processor pipeline
- Load new MMU data
- Load new process state
- Return from interrupt into new process

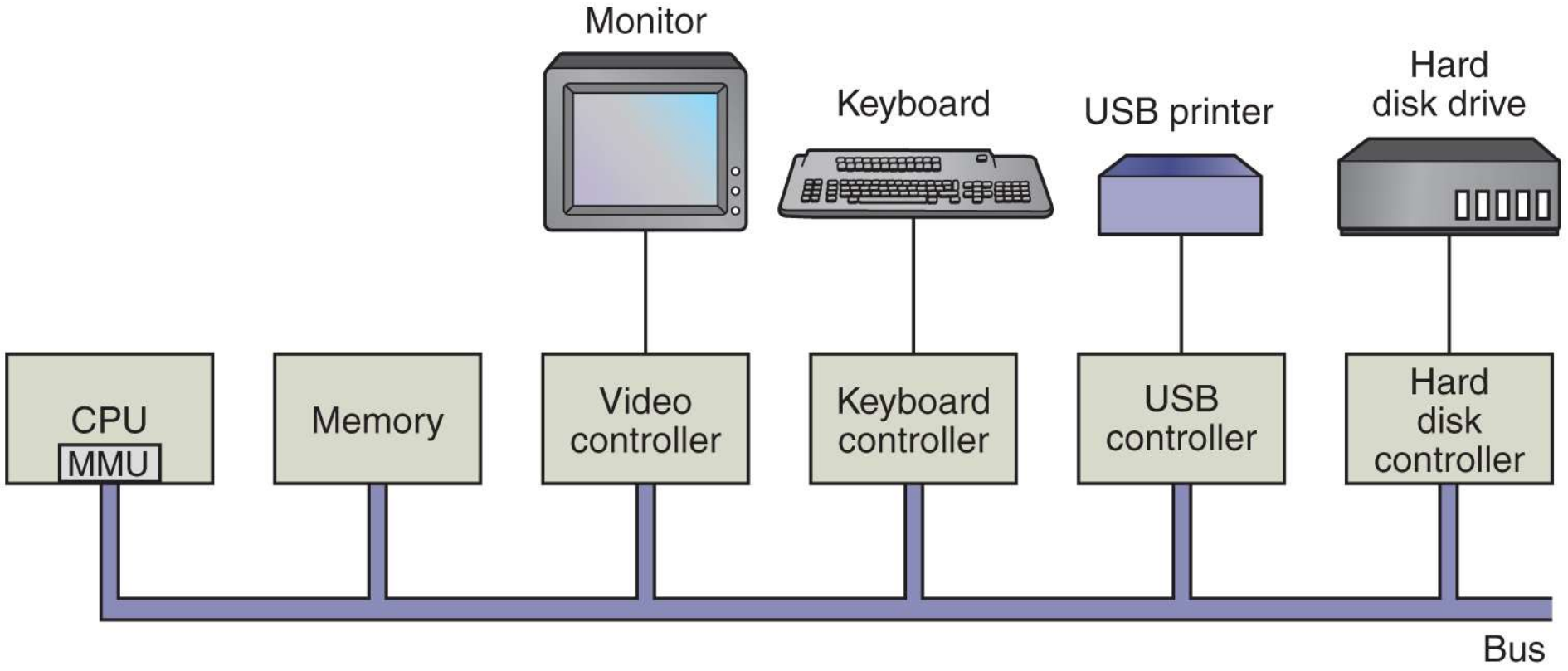
Multiprocessing vs Multithreading

Processes or threads run on multicores (SMP)



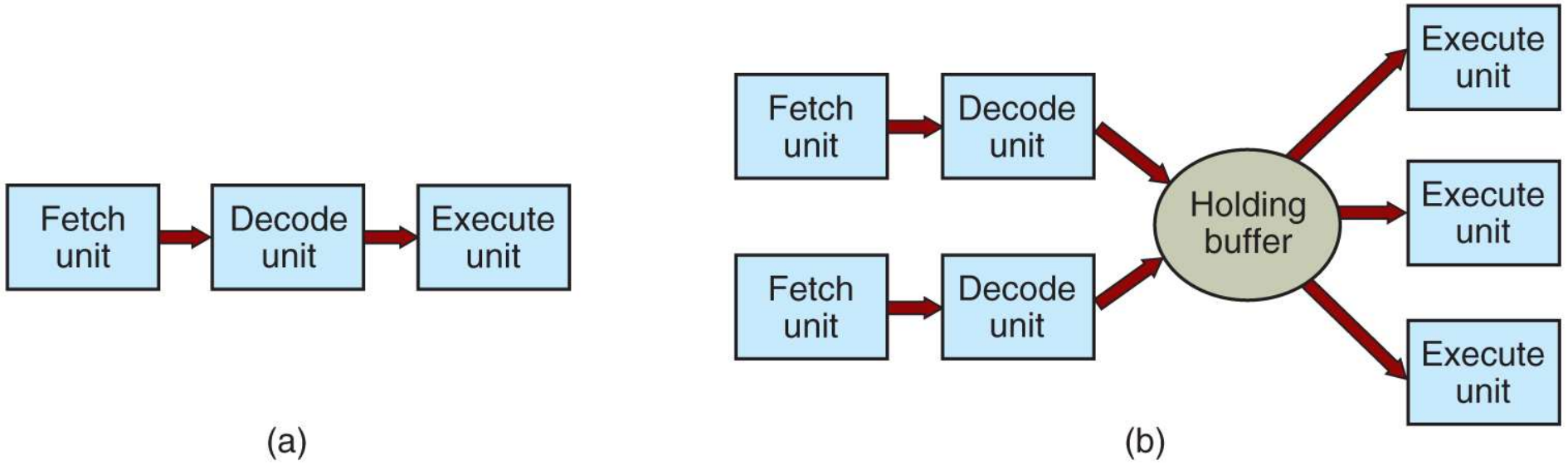
Modern PC - Hardware Components

Some of the components of a simple personal computer.



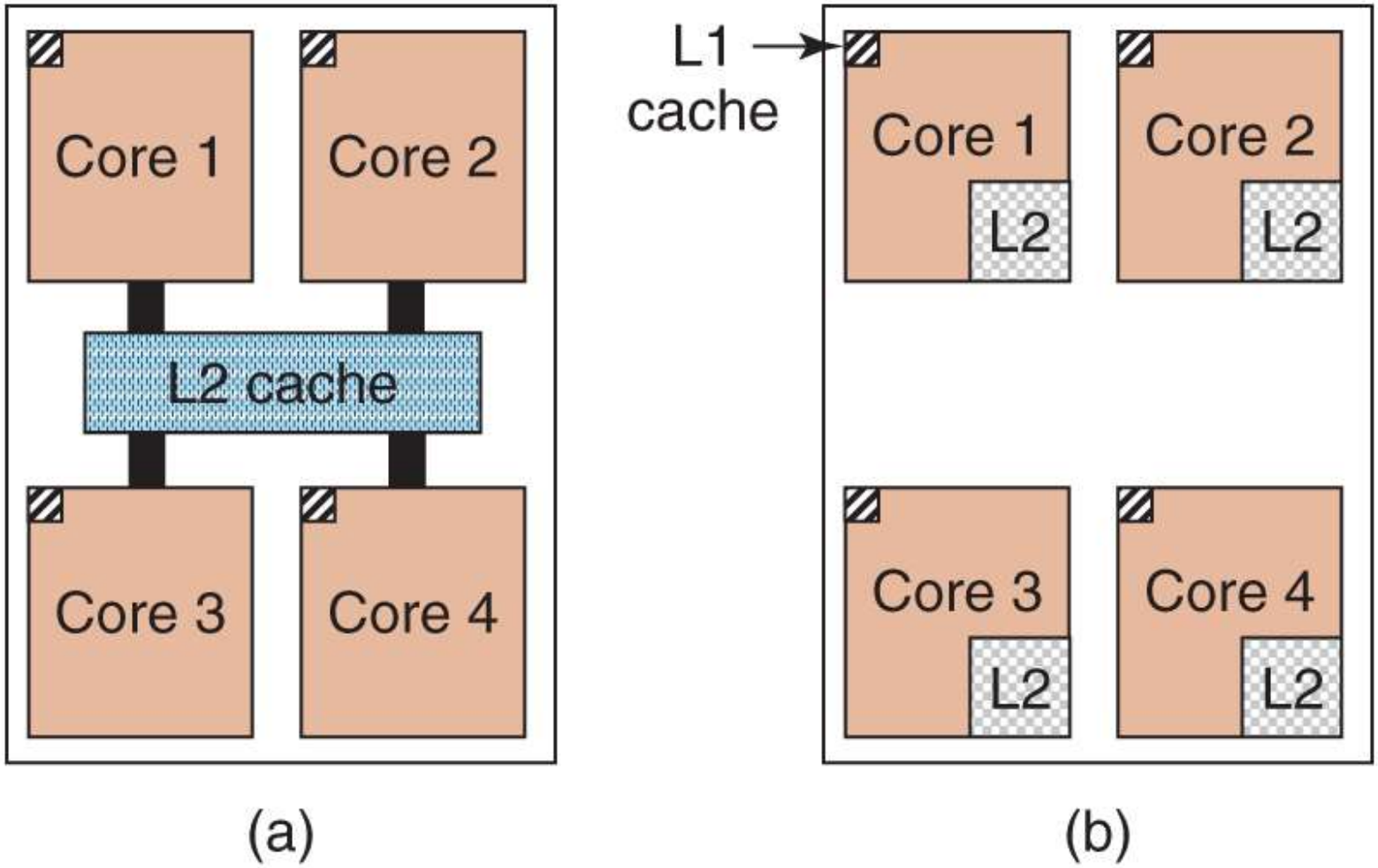
System Architecture - Exec Pipelines

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

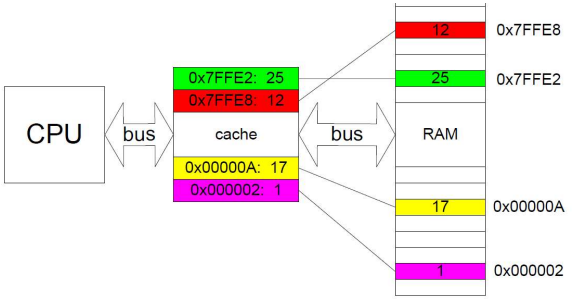


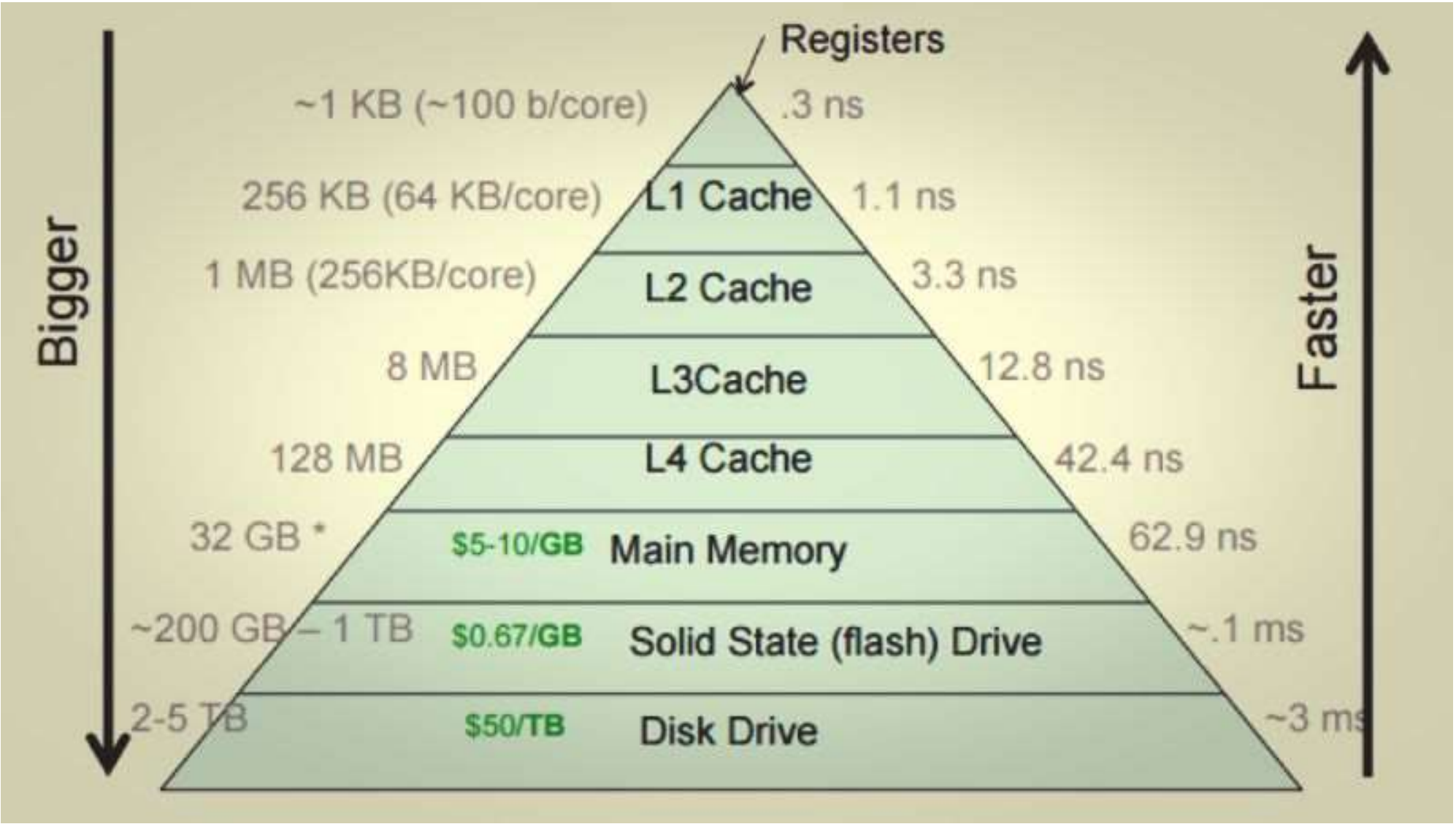
Multicore SoC (NoC)

(a) A quad-core chip with a shared L2 cache. (b) A quad-core chip with separate L2 caches.

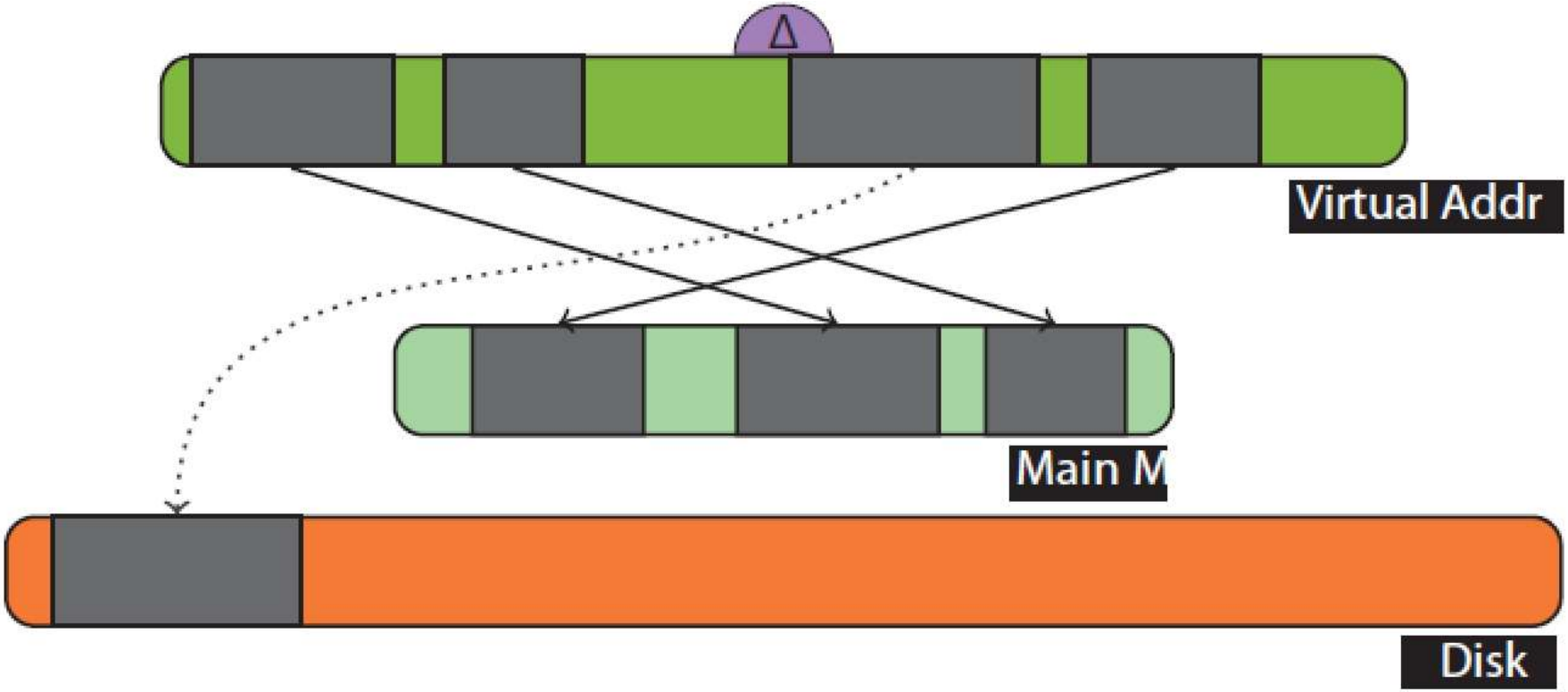


Memory Hierarchy





Memory Management



- Virtual to Physical Address Translation

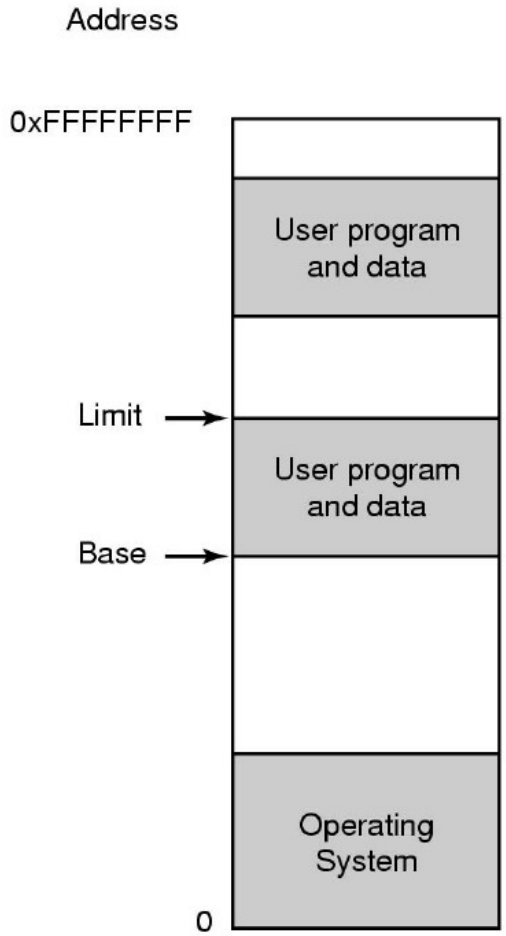
Memory Protection

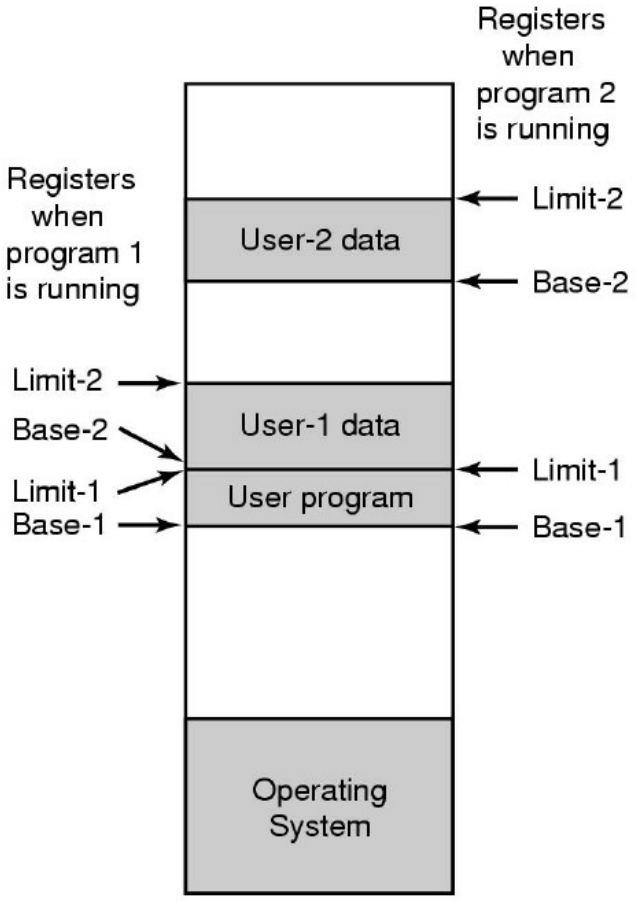
- Isolation (User- vs Kernel-space)
  - Trusted Execution Environments (Rich vs Secure world)
- Some instructions are privileged
- Interrupt service routines (ISR) runs in supervisor mode

Other concepts

- Authentication/Access Control (Hardware Protection, Shadow Stack)
- Protection/Sharing/Data Exec (Segmentation, Paging, VM/Containers)
- Base-Limit registers (Stack), Control-Flow Integrity
- Address Space Layout Randomization
- Encryption and Cryptography
- TPM, Secure Boot, Secure Firmware/Software over the Air Updates

Memory Protection (Base-Limit Pairs)





I/O Architecture

All Input/Output (I/O) is mediated by a controller (driver).

Two types of I/O

- Programmed: CPU polls device
- Interrupt driven: Device signals upon completion

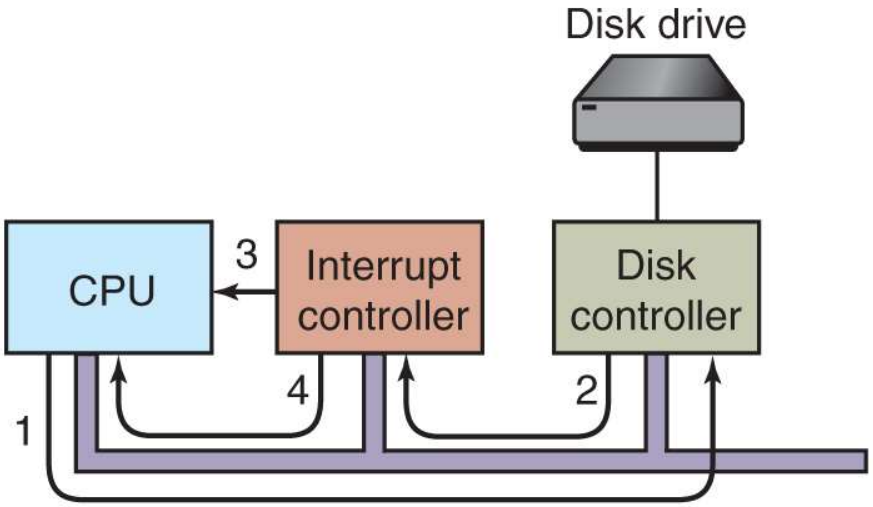
I/O can be

- Synchronous
- Asynchronous

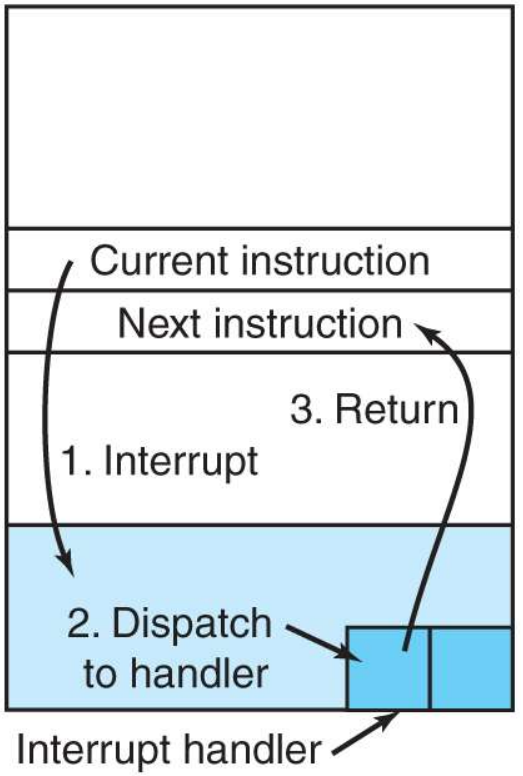
System Architecture: I/O Interrupts

(a) Operating an I/O device, which requested an interrupt

(b) (b) Interrupt processing involves requesting the interrupt, running the handler, and returning to the user program



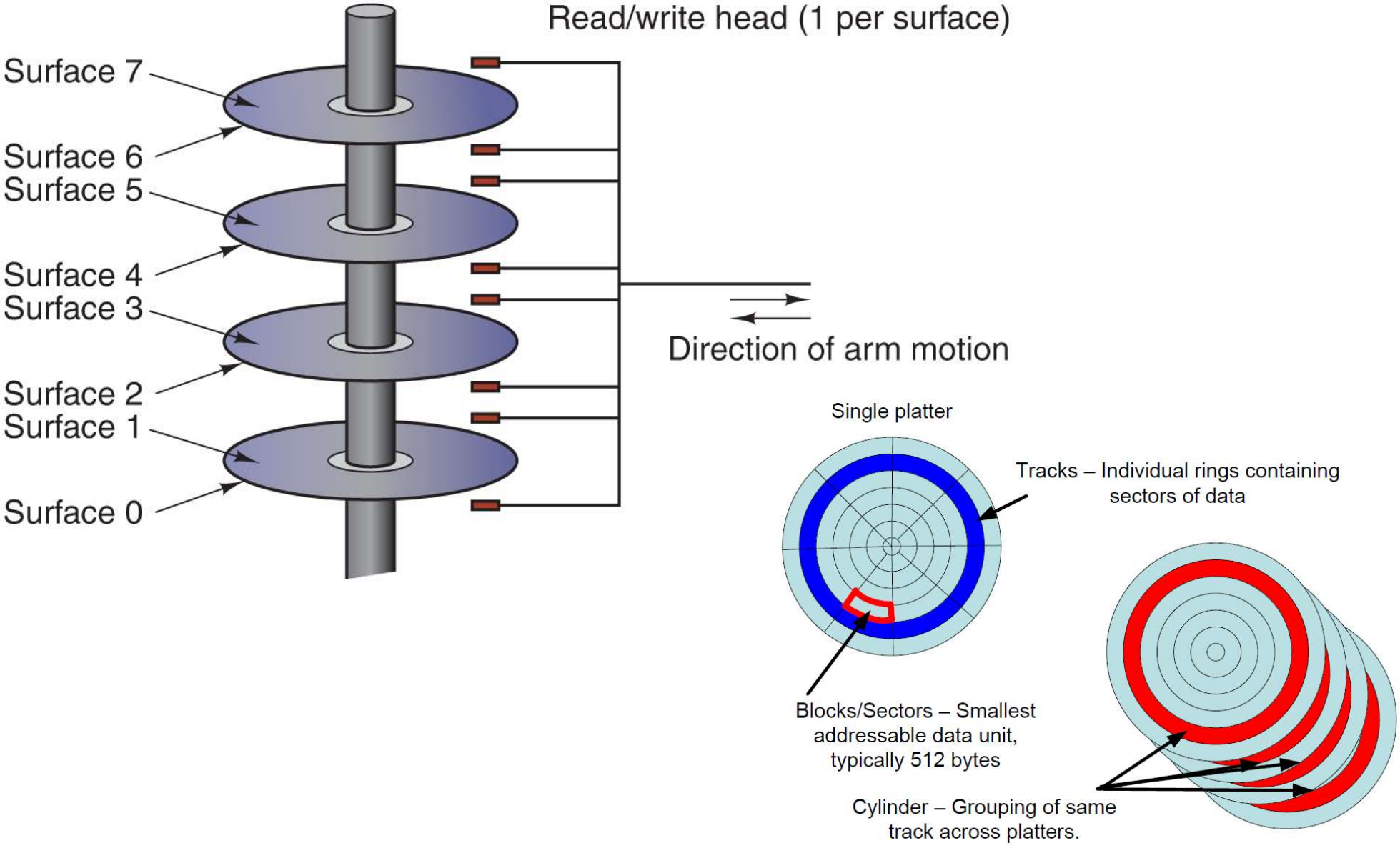
(a)



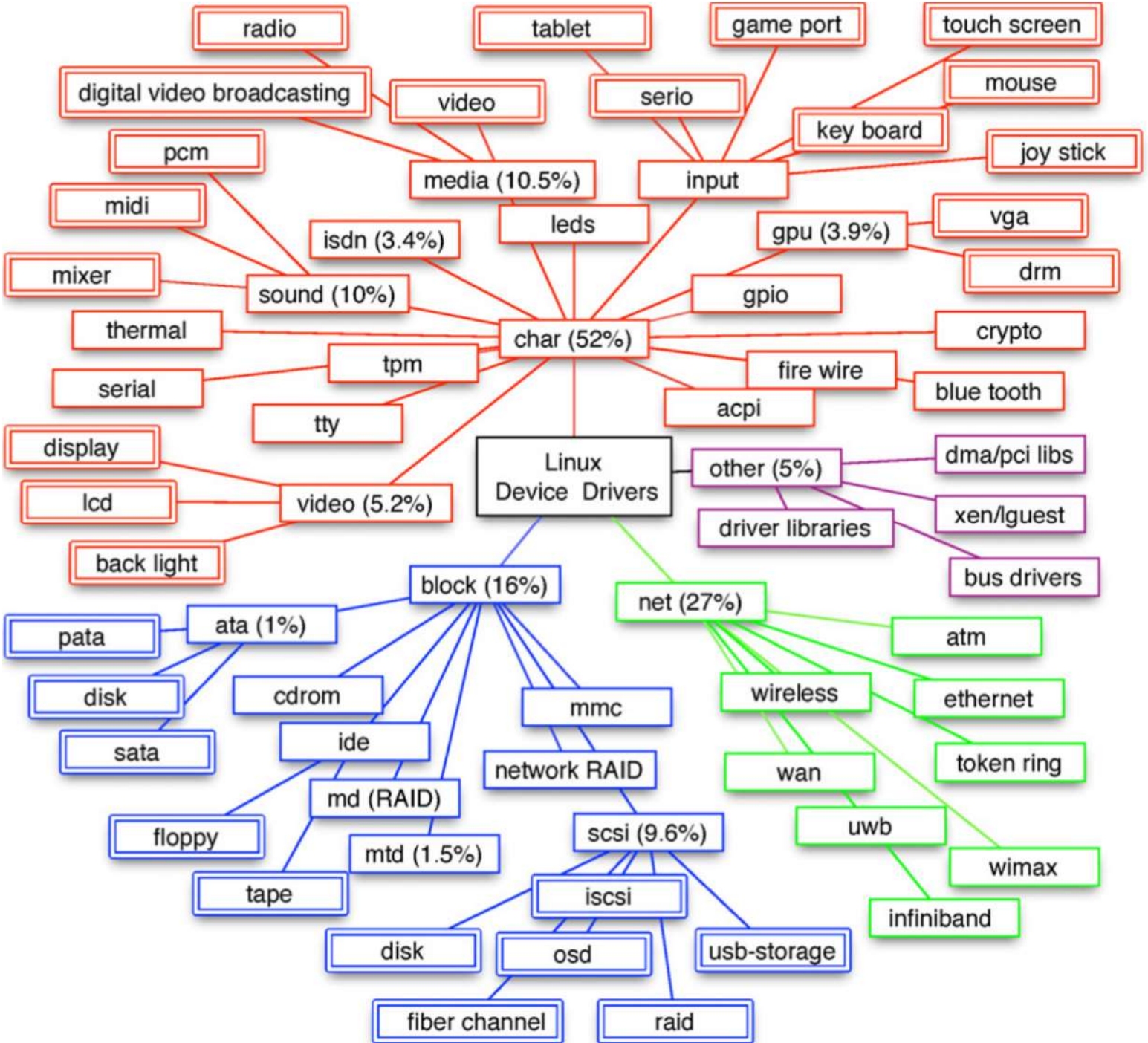
(b)

I/O Architecture

Structure of a disk drive.

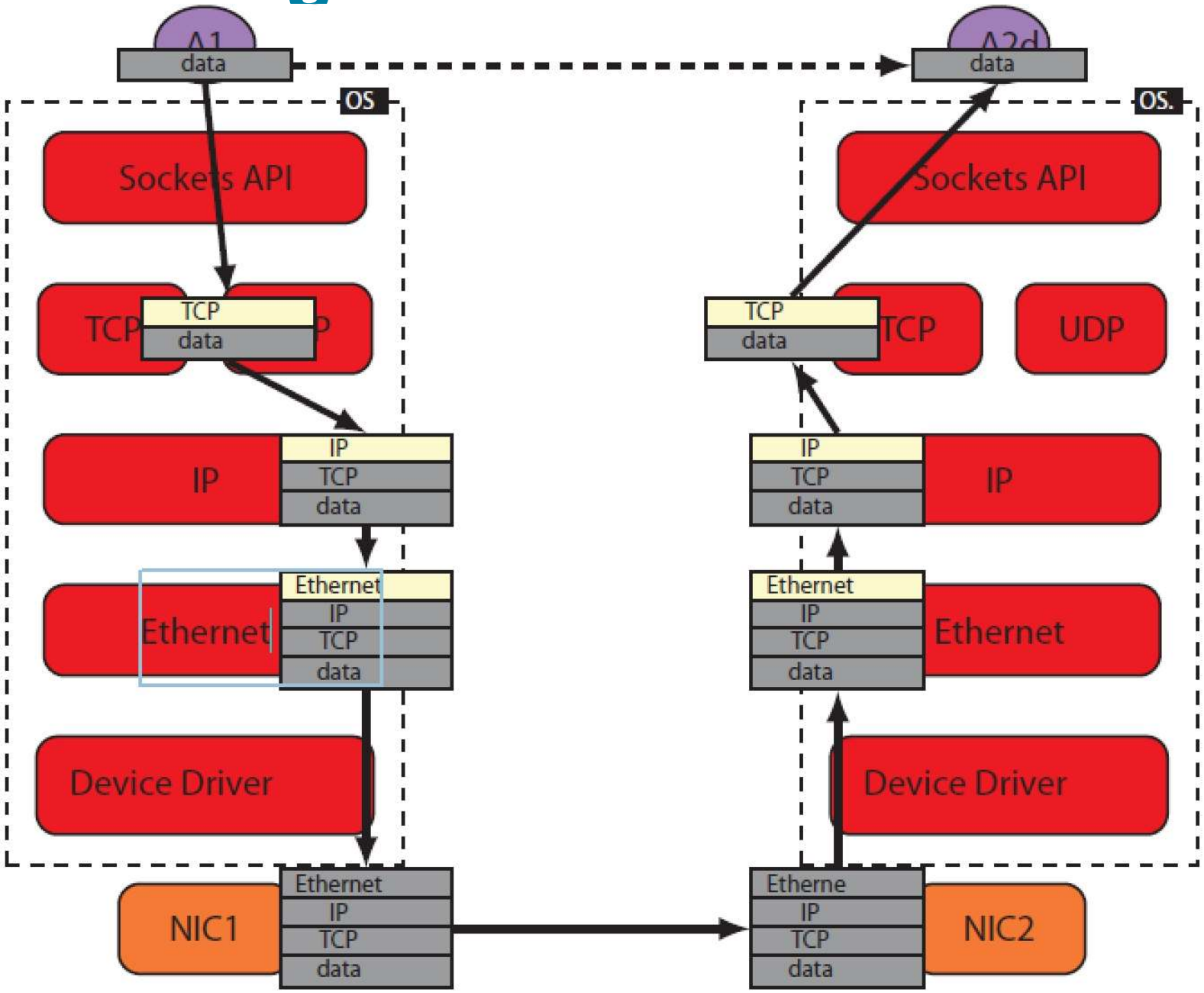


I/O Architecture: Device Drivers (Types)



I/O Architecture: Device Drivers

Networking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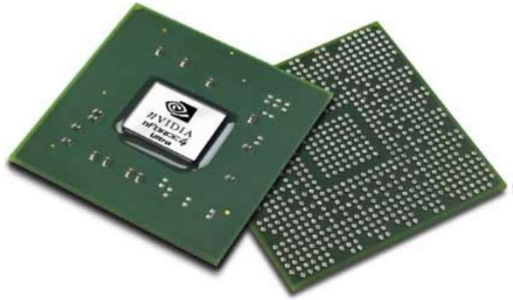
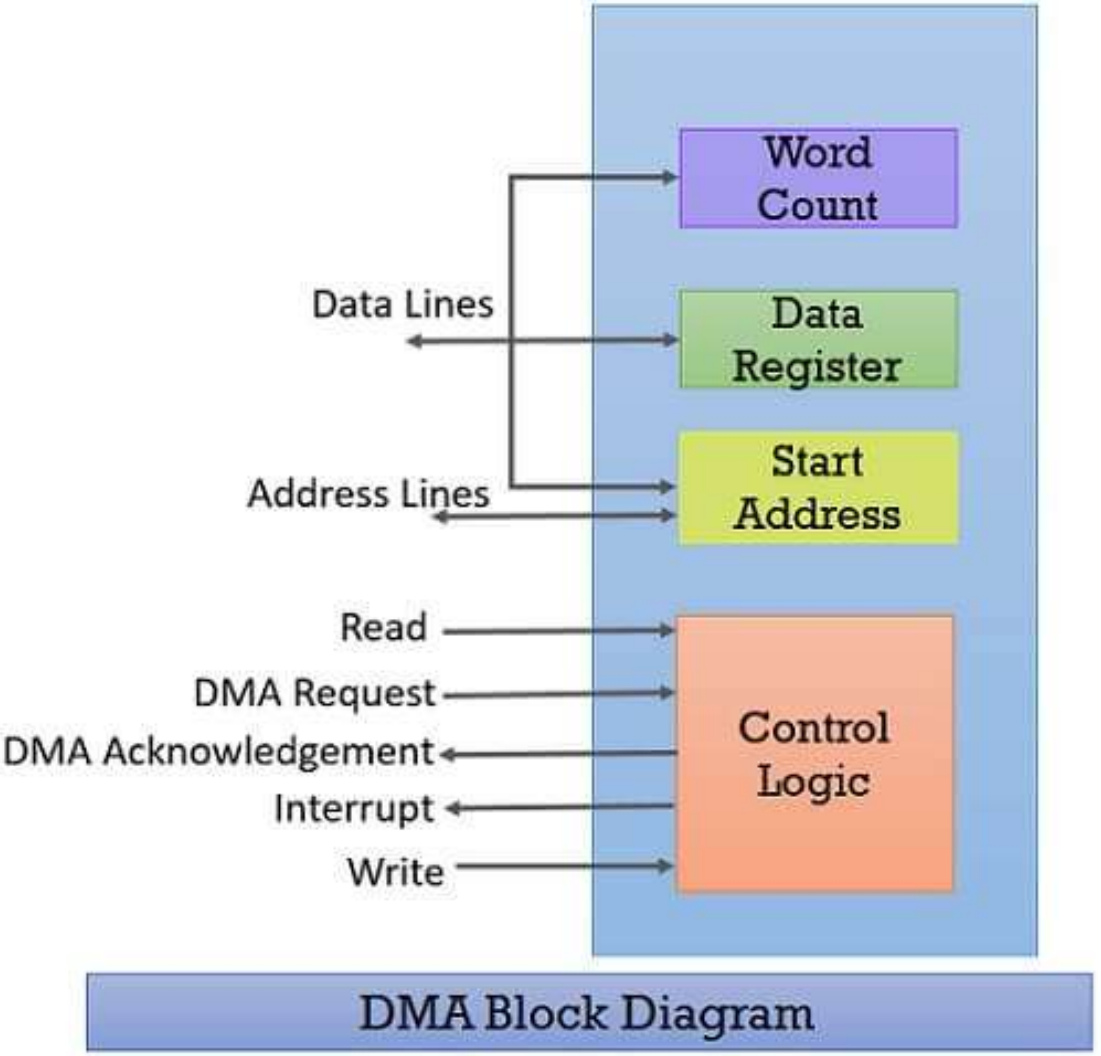
Direct Memory Access (DMA)



DMA releases the CPU from managing a data transfer between peripheral and RAM

- CPU indicates source/dest address and instructs the DMA controller what to do
- CPU continues executing
- DMA manages transfer between device and RAM
- Controller informs CPU when done via interrupt



x86 Architecture

The structure of a large x86 system.