Bucknell UNIVERSITY

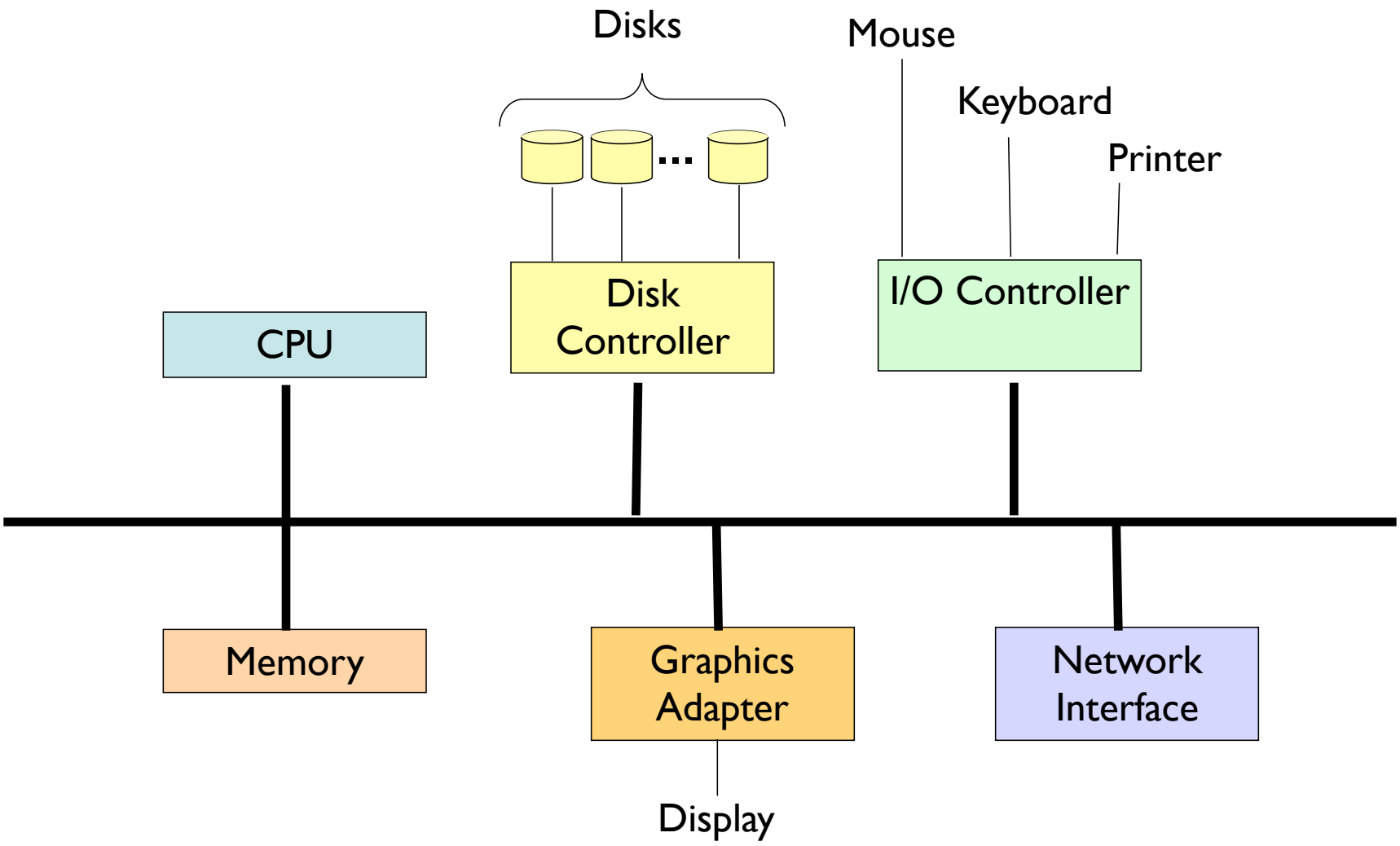
Introduction

CSCI 315 Operating Systems Design

Department of Computer Science

What is an Operating System?

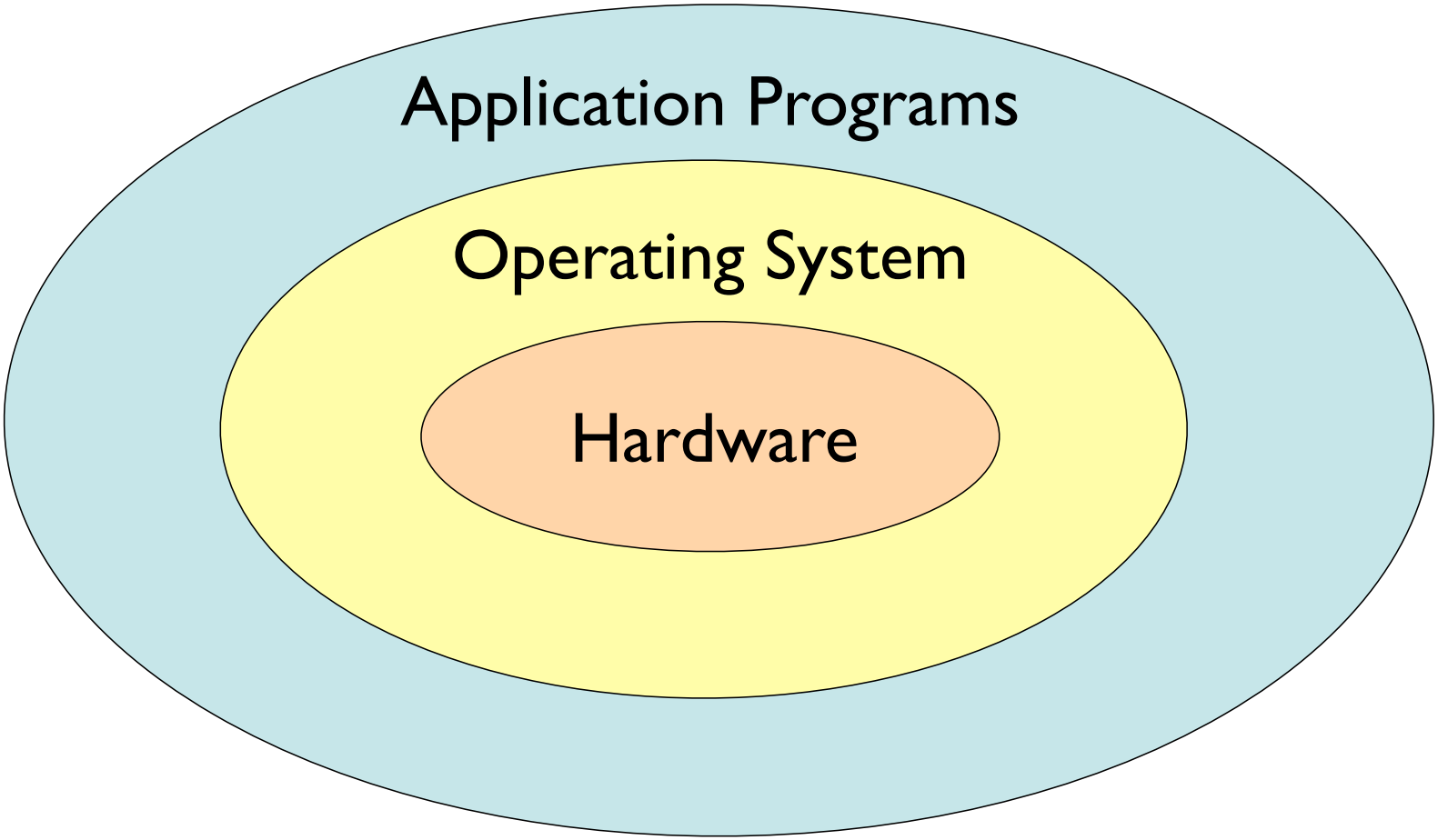
A Modern Computer System



Computer System Components

1. Hardware – provides basic computing resources (CPU, memory, I/O devices).
2. Operating system – controls and coordinates the use of the hardware among the various application programs for the various users.
3. Applications programs – define the ways in which the system resources are used to solve the computing problems of the users (compilers, database systems, video games, business programs).
4. Users (people, machines, other computers).

Macroscopic Abstract View of the Computer System

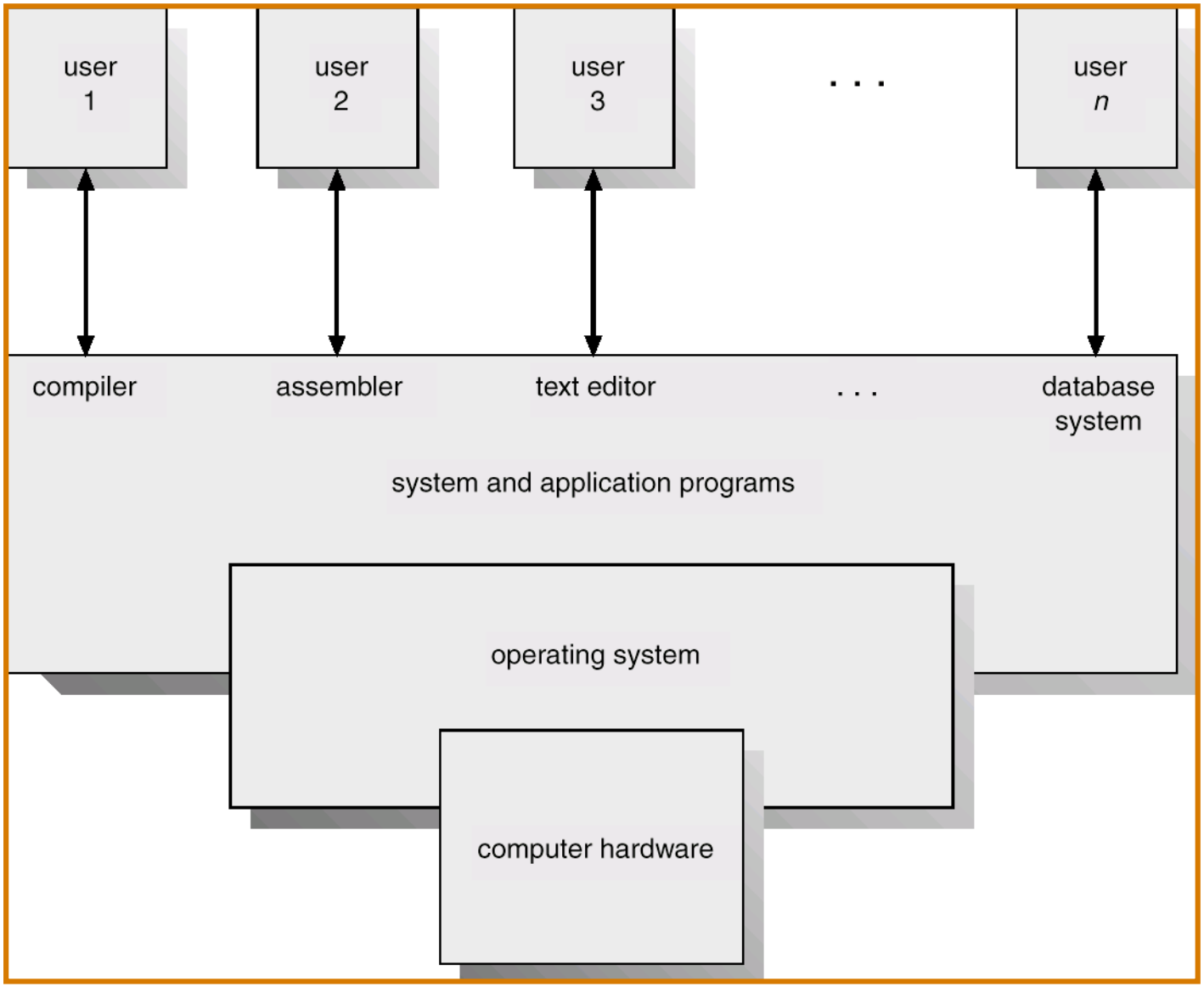


What is an Operating System?

A "program" that acts as an intermediary between a user of a computer and the computer hardware.

- **The OS manages resources in the computer system.**
- **The OS controls the execution of programs.**

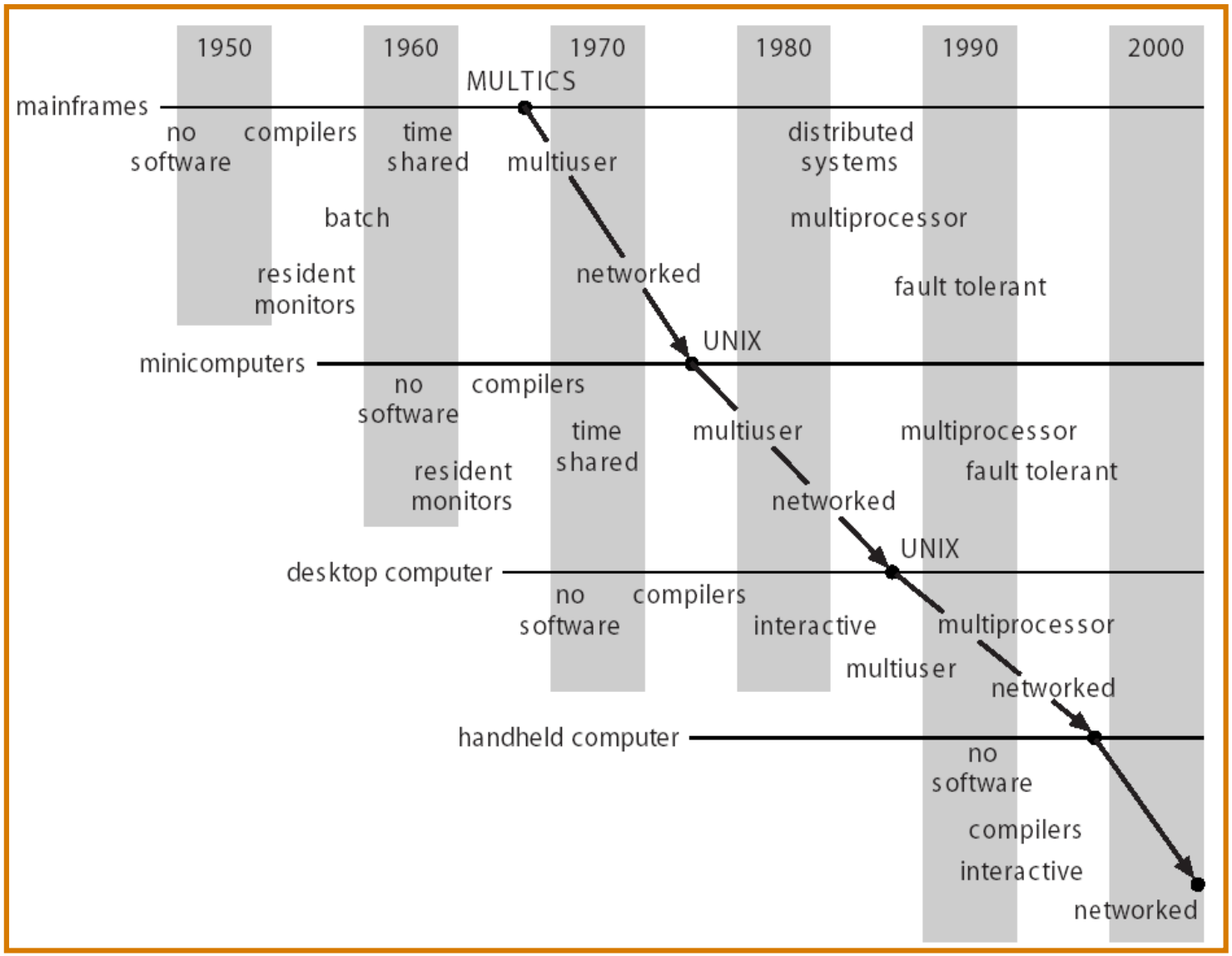
Abstract View of System Components



Operating System Definitions

- **Resource allocator** – manages and allocates resources.
- **Control program** – controls the execution of user programs and operations of I/O devices.
- **Kernel** – the one program "running" at all times (all else being application programs).

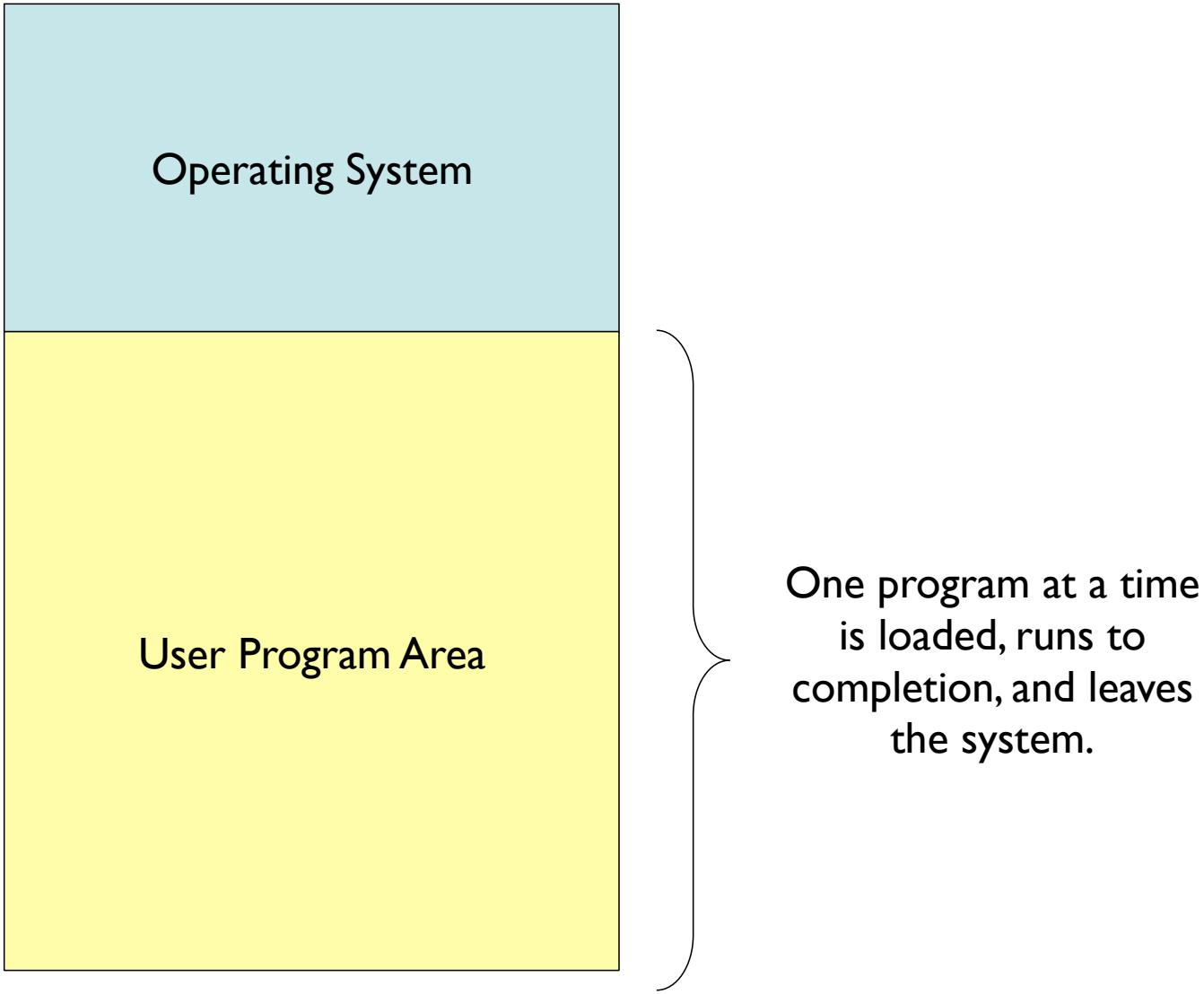
Evolution


1950
1960
1970
1980
1990
2000
MULTICS
mainframes
no software
compilers
time shared
multiuser
distributed systems
batch
multiprocessor
resident monitors
networked
fault tolerant
UNIX
minicomputers
no software
compilers
time shared
multiuser
multiprocessor
fault tolerant
resident monitors
networked
UNIX
desktop computer
no software
compilers
interactive
multiprocessor
multiuser
networked
handheld computer
no software
compilers
interactive
networked

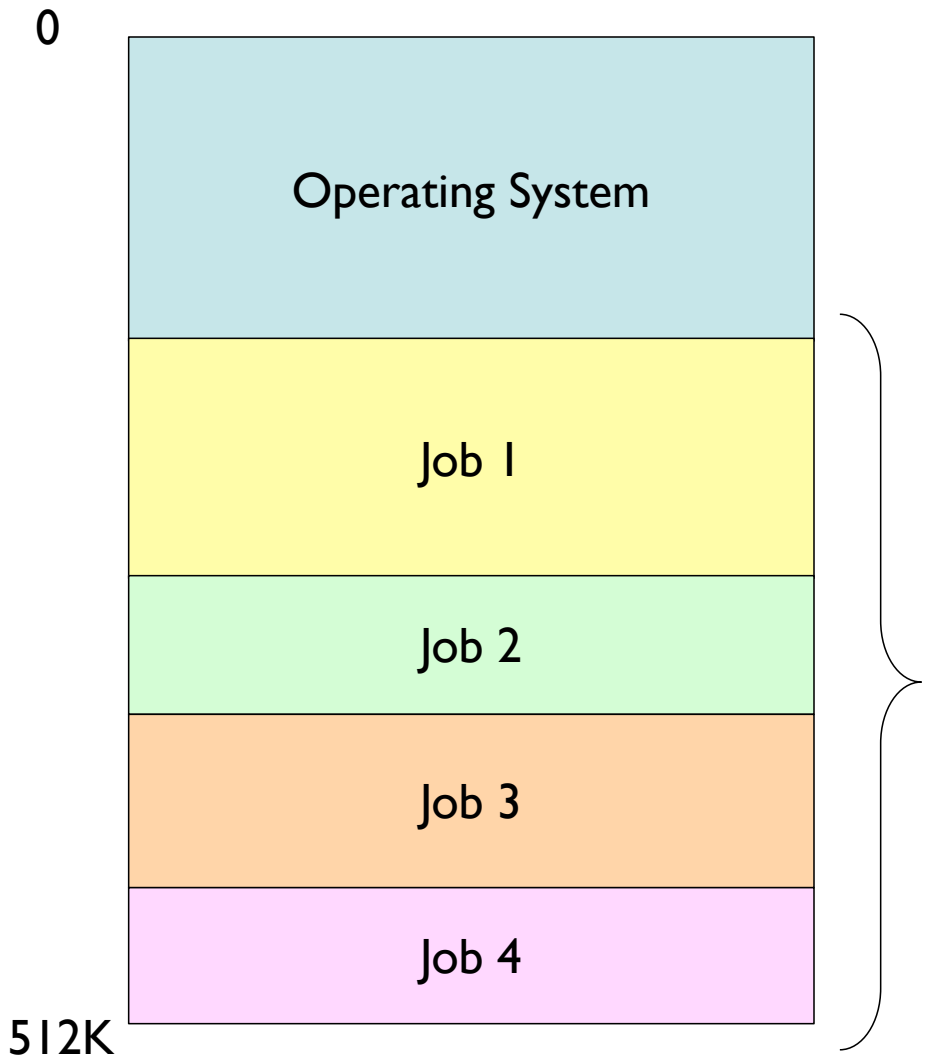
Mainframe Systems

- Reduce setup time by batching similar jobs.
- Automatic job sequencing – automatically transfers control from one job to another. First rudimentary operating system.
- Resident monitor:
  - initial control in monitor,
  - control transfers to job,
  - when job completes control transfers pack to monitor.

Memory Layout for a Simple Batch System



Multiprogrammed Batch Systems



Several jobs are kept in main memory at the same time, and the CPU is multiplexed among them.

OS Features Needed for Multiprogramming

- I/O routines supplied by the system.
- Memory management – allocate memory to each of several jobs.
- CPU scheduling – determine which job runs when.
- Control access to multiple devices.

Time-Sharing Systems
Interactive Computing

- The CPU is multiplexed among several jobs that are kept in memory and on disk (the CPU is allocated to a job only if the job is in memory).
- A job swapped in and out of memory to the disk.
- On-line communication between the user and the system is provided:
  - When the operating system finishes the execution of one command, it seeks the next "control statement" from the user's keyboard
- On-line system must be available for users to access data and code.

Desktop Systems

- *Personal computers* – computer system dedicated to a single user.
- I/O devices – keyboards, mice, display screens, small printers.
- 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, MacOS, UNIX, Linux).

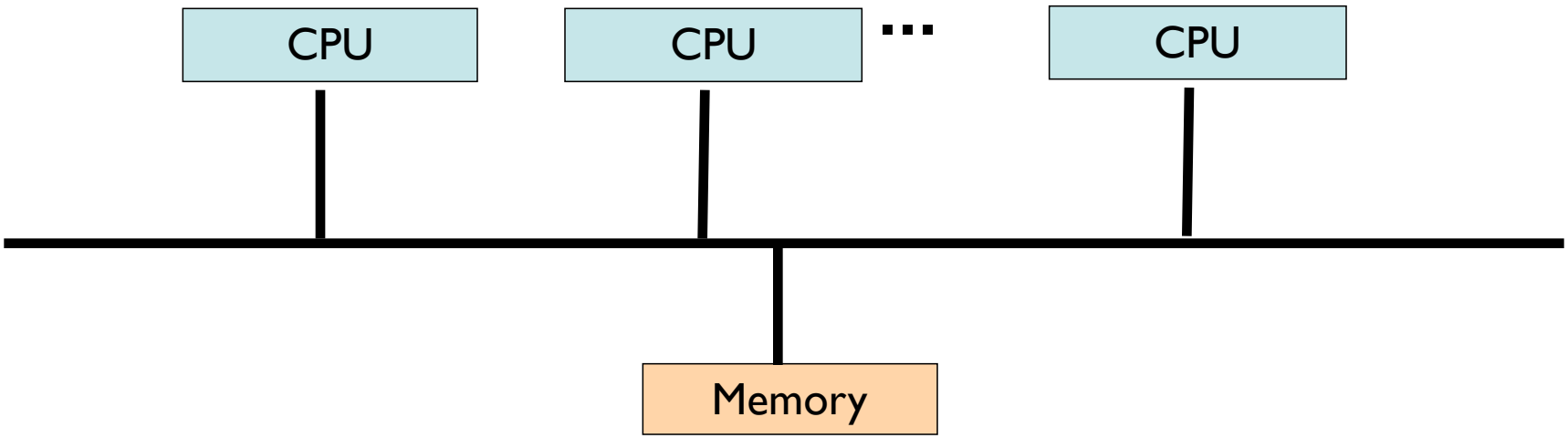
Parallel Systems

- Systems with more than one CPU in close communication (also known as *multiprocessor systems*).
- *Tightly coupled system* – processors share memory and a clock; communication usually takes place through the shared memory.
- Advantages of parallel system:
  - Increased *throughput*
  - Economical
  - Increased reliability (in some cases)
    - graceful degradation
    - fail-soft systems

Parallel Systems (Cont.)

- *Asymmetric multiprocessing*
  - Each processor is assigned a specific task; master processor schedules and allocated work to slave processors.
  - More common in extremely large systems.
- *Symmetric multiprocessing (SMP)*
  - Each processor runs an identical copy of the operating system.
  - Many processes can run at once without performance deterioration.
  - Most modern operating systems support SMP.

Symmetric Multiprocessing Architecture



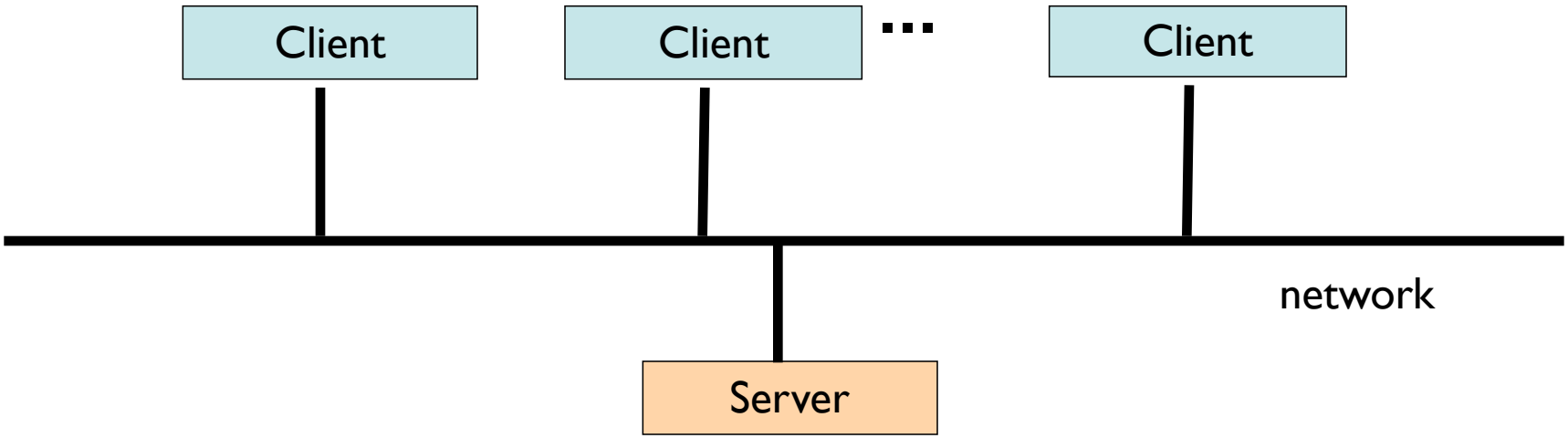
Distributed Systems

- Distribute the computation among several physical processors.
- *Loosely coupled system* – each processor has its own local memory; processors communicate with one another through various communications lines, such as high-speed buses or telephone lines.
- Advantages of distributed systems:
  - Resources Sharing,
  - Computation speed up – load sharing,
  - Reliability,
  - Communications.

Distributed Systems (cont.)

- Requires networking infrastructure.
- Local area networks (*LAN*) or Wide area networks (*WAN*).
- May be either *client-server* or *peer-to-peer* systems.

General Structure of Client-Server System



Clustered Systems

- Clustering allows two or more systems to share storage.
- Provides high reliability.
- *Asymmetric clustering*: one server runs the application or applications while other servers standby.
- *Symmetric clustering*: all N hosts are running the application or applications.

Real-Time Systems

- Often used as a control device in a dedicated application such as controlling scientific experiments, medical imaging systems, industrial control systems, and some display systems.
- Well-defined fixed-time constraints.
- Real-Time systems may be either *hard* or *soft* real-time.

Real-Time Systems (Cont.)

- Hard real-time:
  - Secondary storage limited or absent, data stored in short term memory, or read-only memory (ROM).
  - Conflicts with time-sharing systems, not supported by general-purpose operating systems.
- Soft real-time:
  - Limited utility in industrial control of robotics.
  - Can be integrated with time-shared systems.
  - Useful in applications (multimedia, virtual reality) requiring tight response times.

Embedded Systems

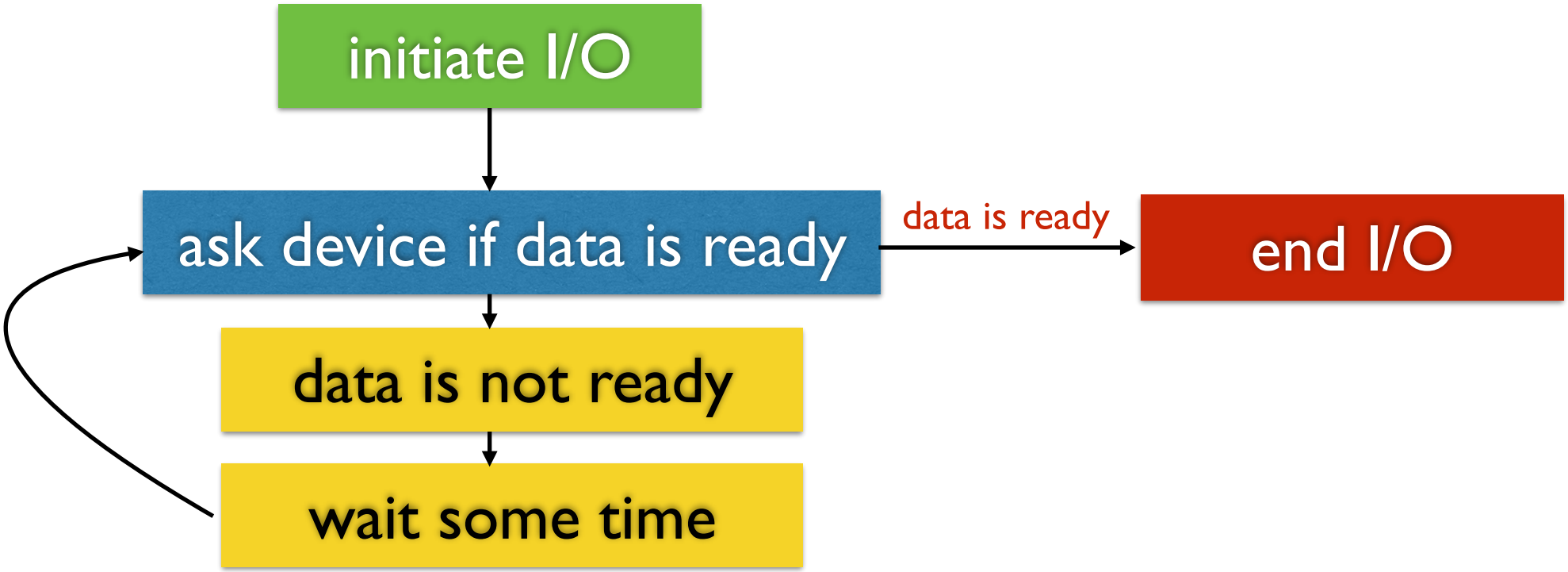
- Appliances.
- Smart sensors.
- Digital control systems.
- Issues:
  - –Limited memory,
  - –Slower processors,
  - –Small display screens (if any).

Operating System Operations

Assumptions:

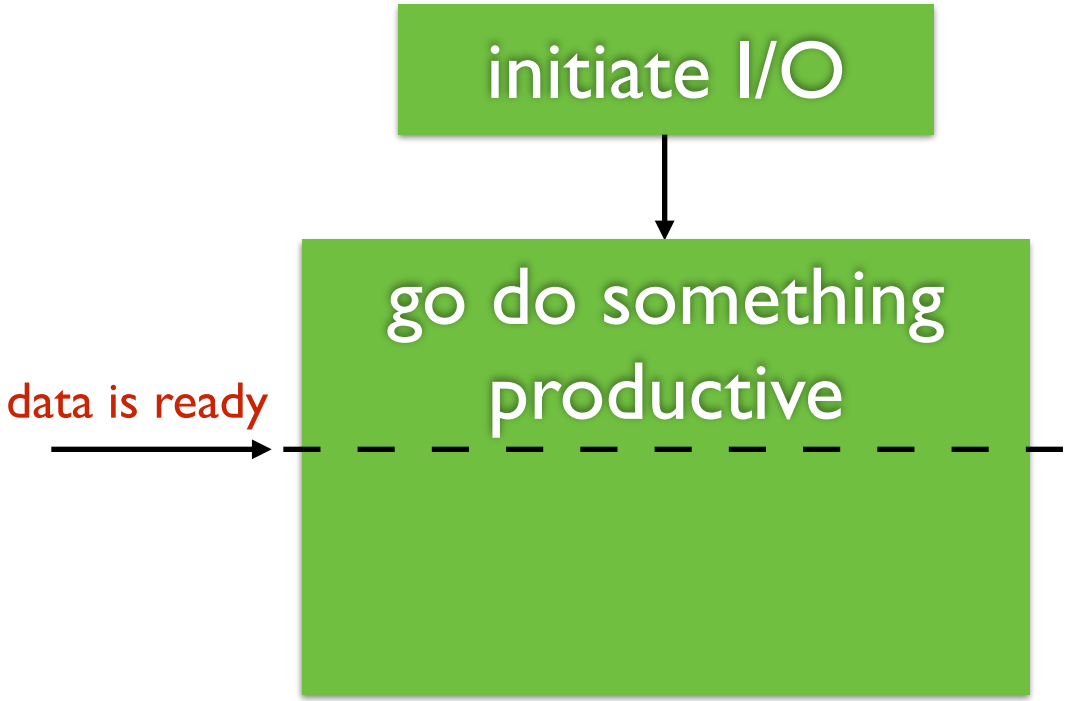
- I/O devices and the CPU can execute **concurrently**.
- Each *device controller* is in charge of a particular device type.
- Each device controller has a *local buffer*.
- There must be some mechanism to move data from/to main memory to/from local buffers.
- I/O operations move data from the device to a controller's local buffer.
- There must be some mechanism for the CPU to learn that an I/O operation has completed.

Option 1: Polling

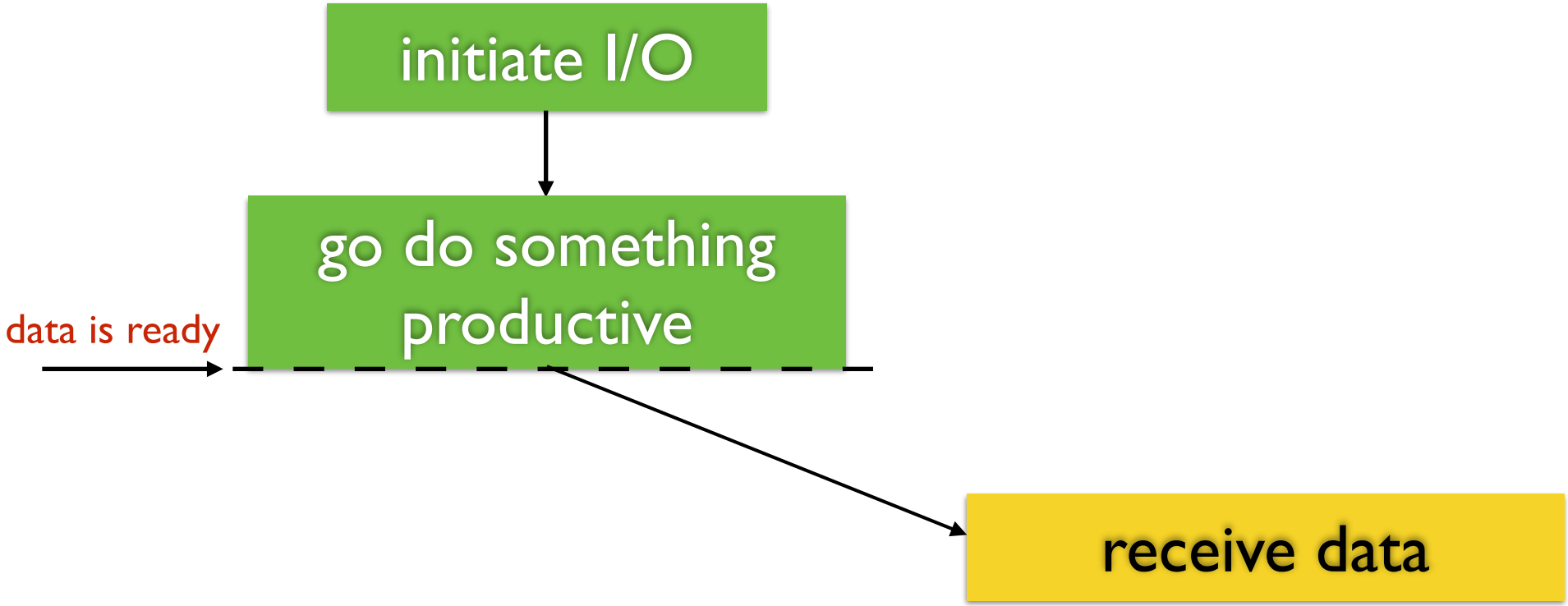


The Simpsons: https://www.youtube.com/watch?v=18AzodTPG5U

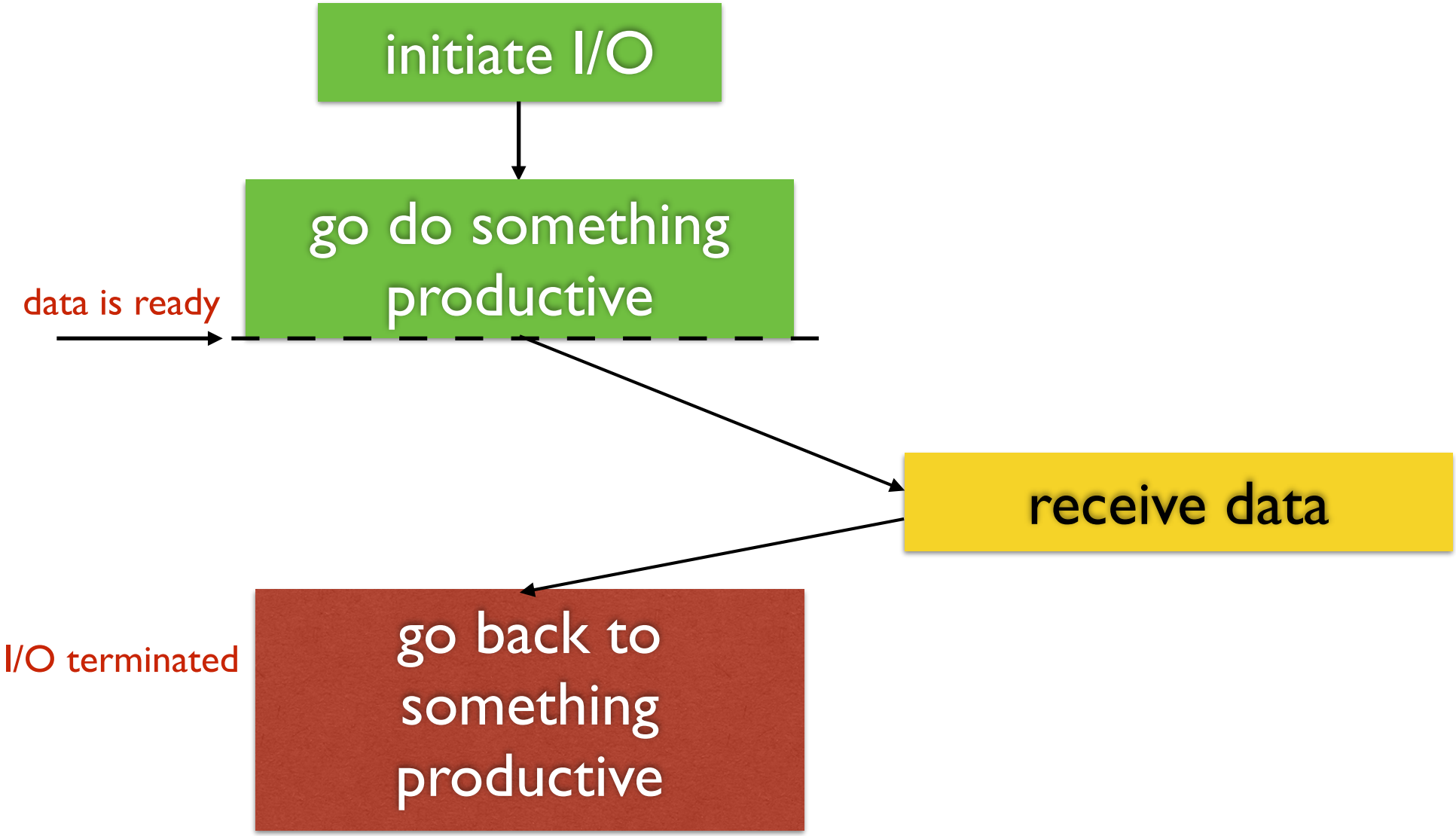
Option 2: Interrupt



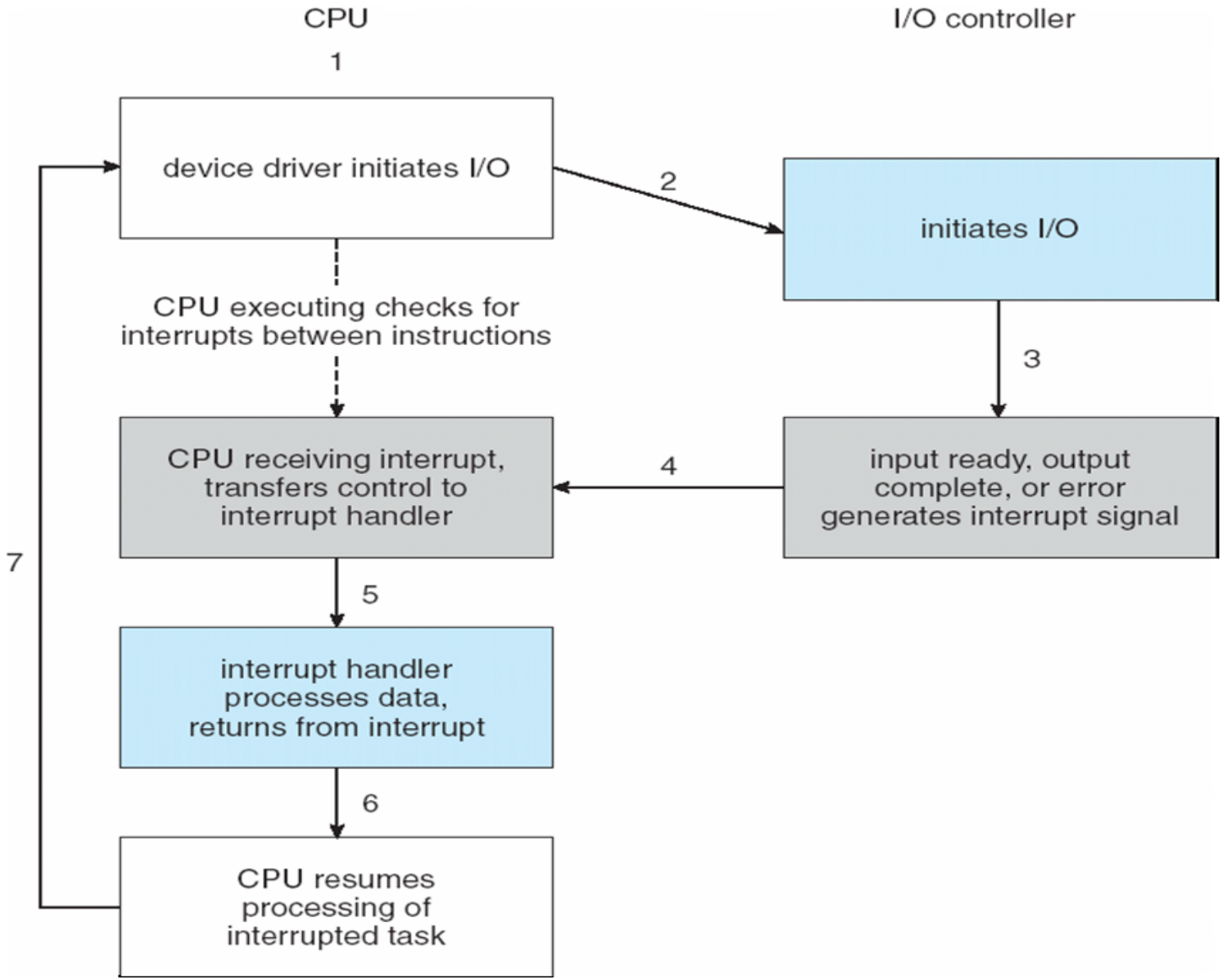
Option 2: Interrupt



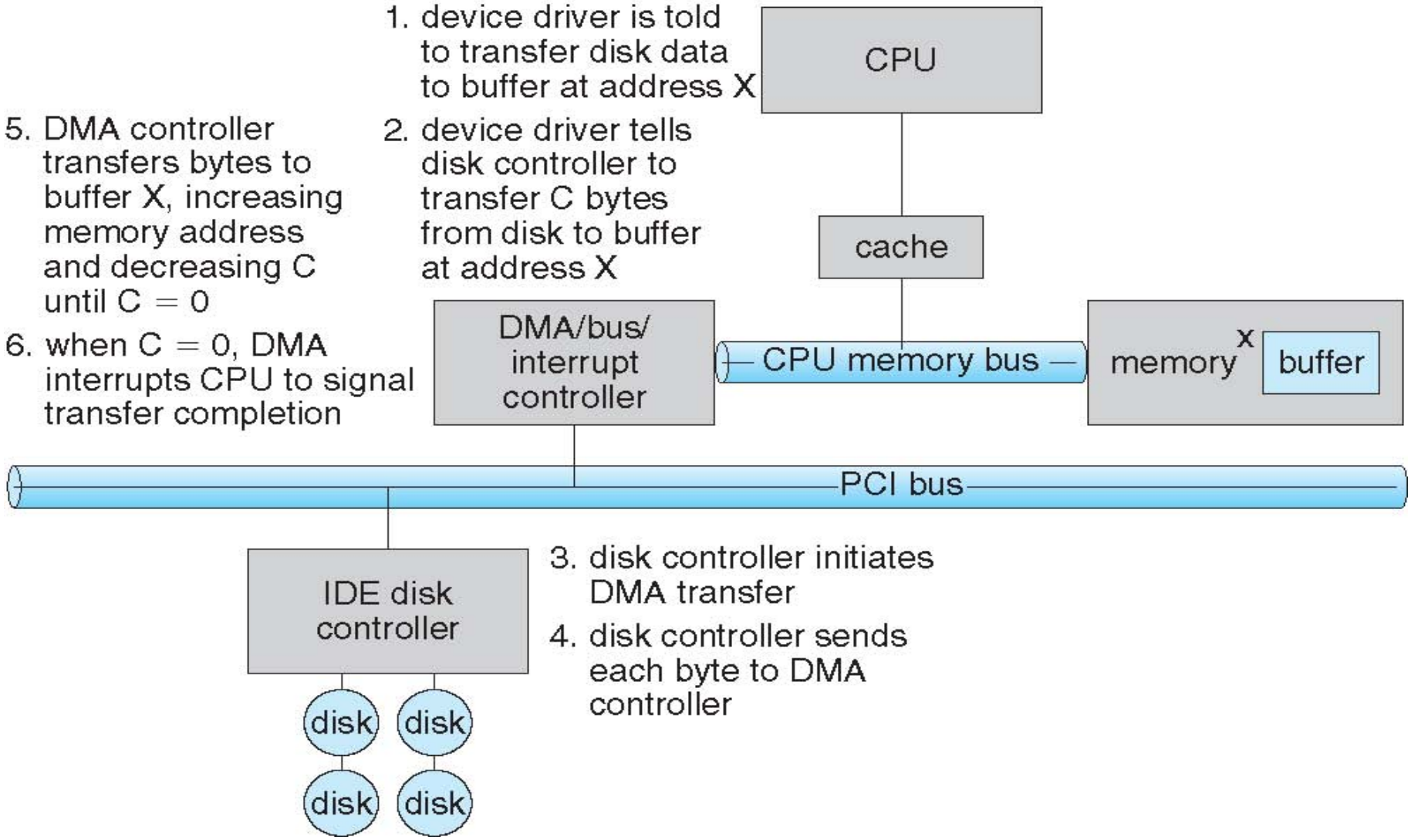
Option 2: Interrupt



Interrupt Driven I/O Cycle

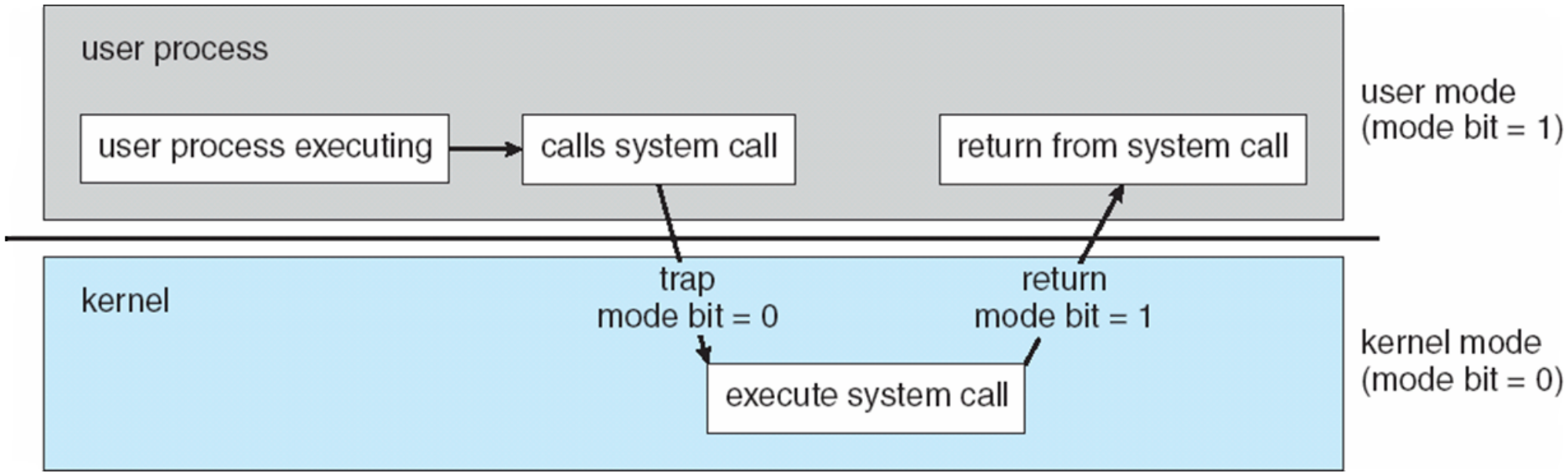


Data Transfer from I/O to RAM

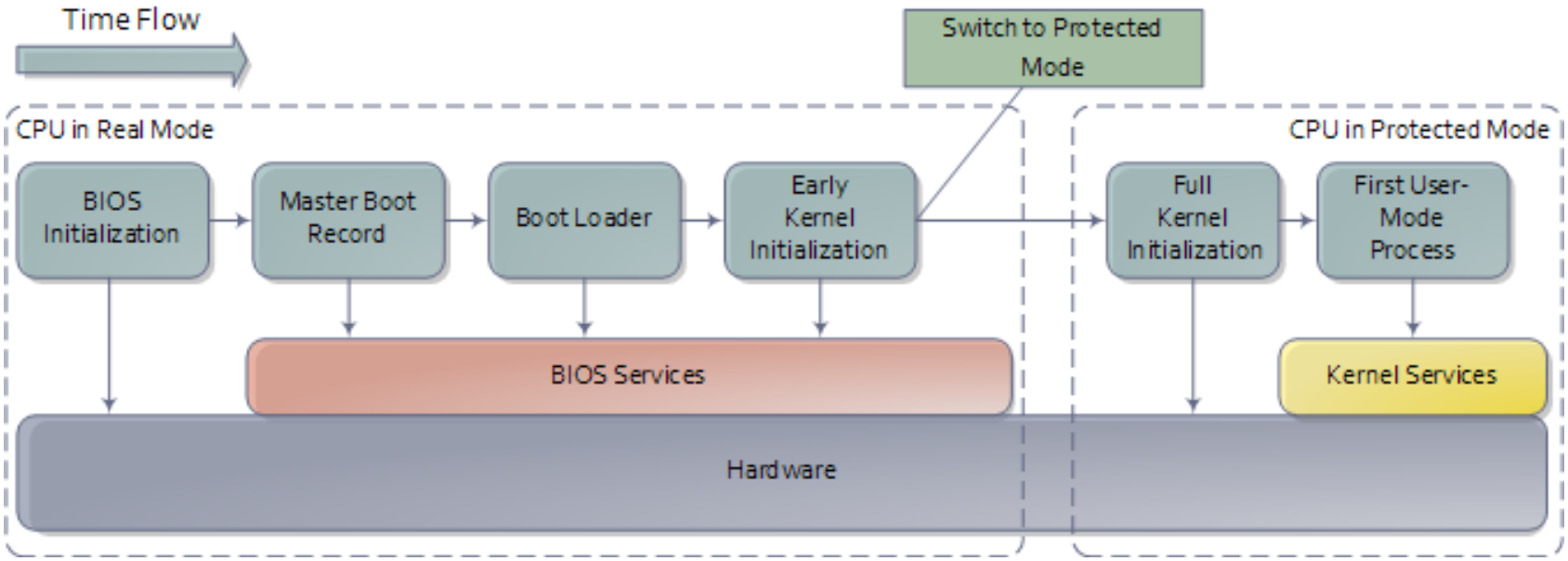


Hardware Support for the OS

- **Two classes of instructions:** one class for anyone to use, others with **privileged** use (for the OS kernel).
- Need to be able to switch between **user mode** and **kernel mode**.
- If a user runs a privileged instruction, an exception is raised.
- To switch to kernel mode, you need to trap to the kernel.



Booting up the OS



- BIOS is firmware (flash memory). Power on self tests (POST) check if machine is in shape to run.
- Every disk has an MBR, which contains a bootstrap program and a partition table. Each partition has a boot sector with the boot loader.
- How does the machine know the address of the first instruction to run???

Source: http://duartes.org/gustavo/blog/post/how-computers-boot-up/