Amirkabir University of Technology
(Tehran Polytechnic)

Operating Systems

Computer System Organization

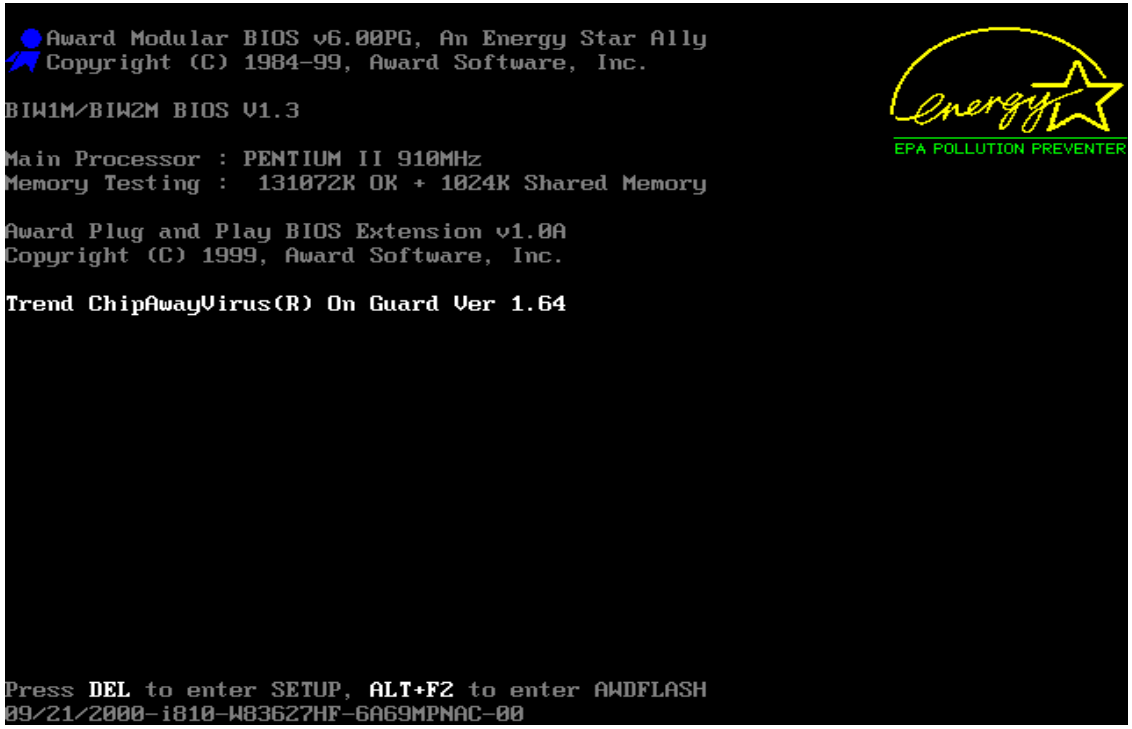
Seyyed Ahmad Javadi

sajavadi@aut.ac.ir

Spring 2023

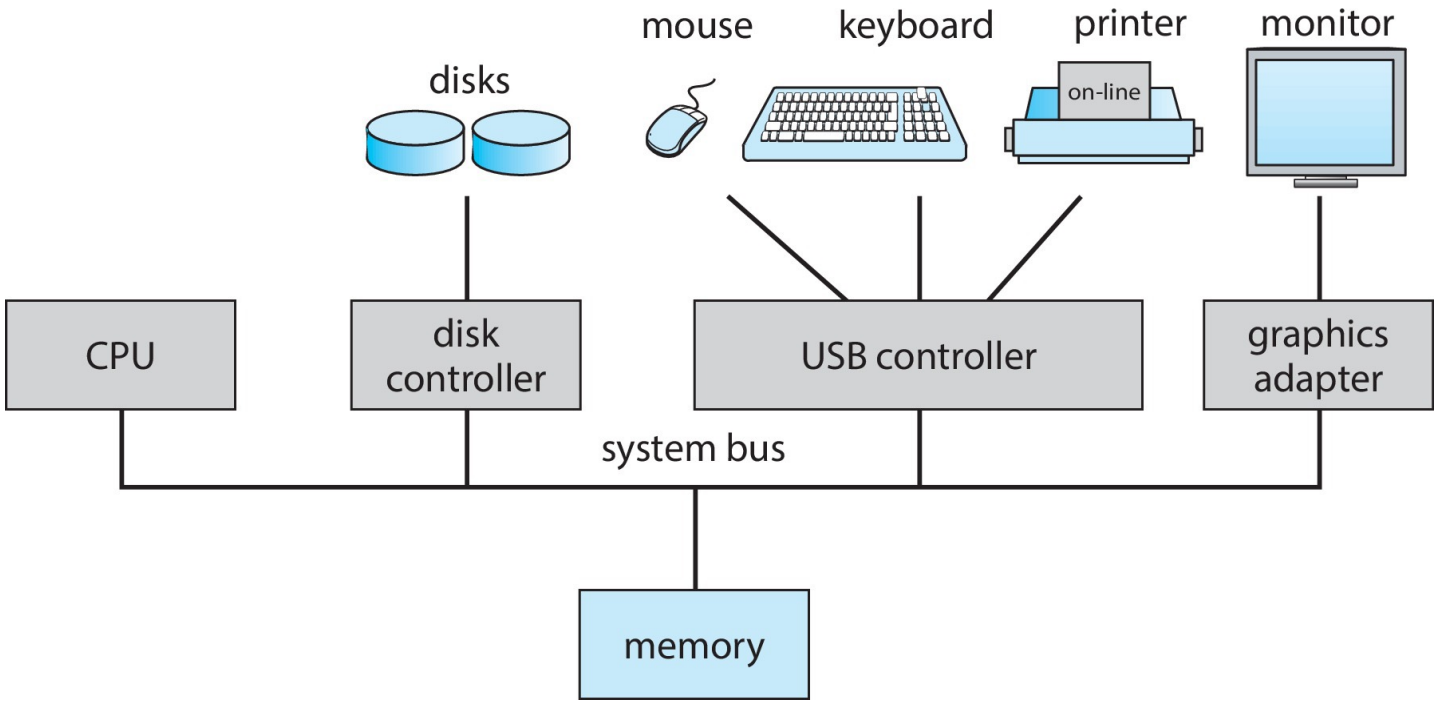
Computer Startup

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



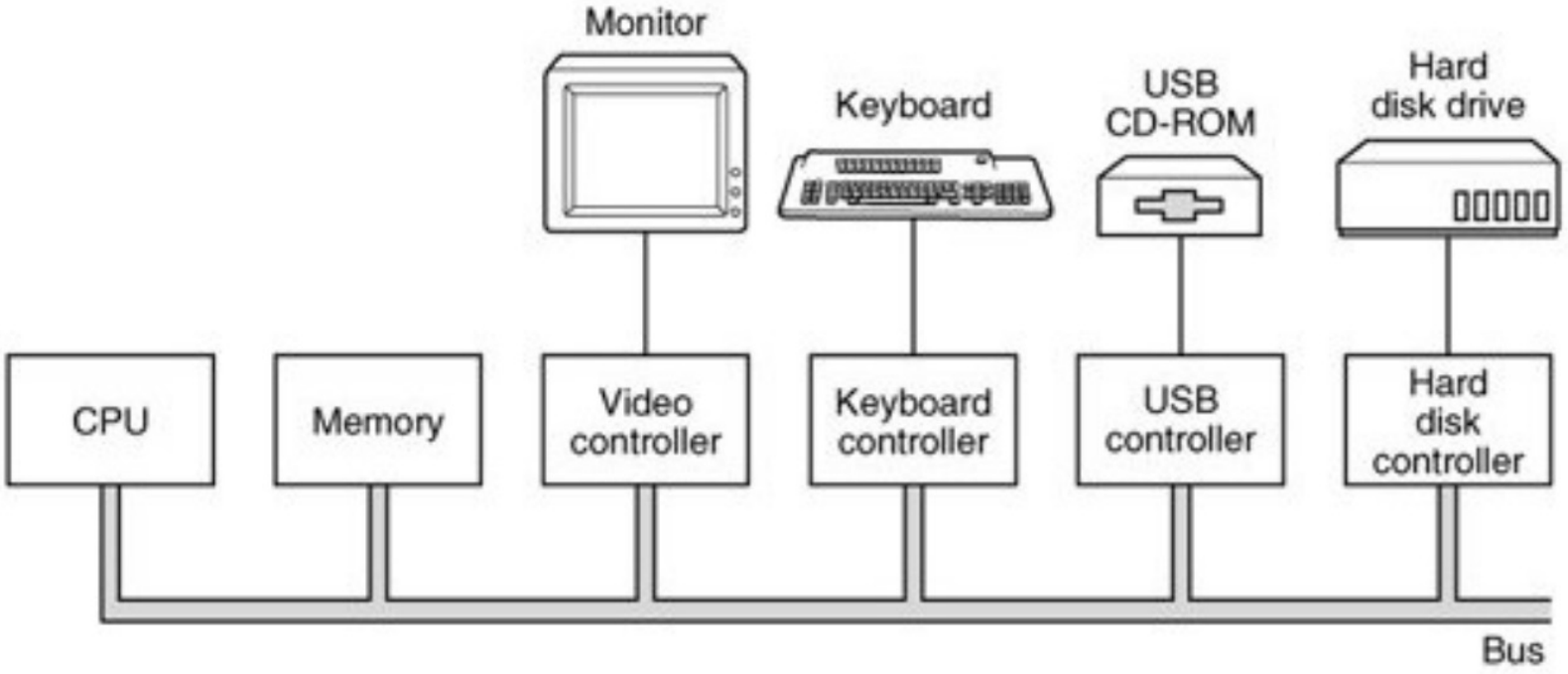
Computer System Organization

- Computer-system operation
  - One or more CPUs, device controllers connect through common **bus** providing access to shared memory.
  - Parallel execution of CPUs and devices competing for memory cycles.



Computer-System Operation

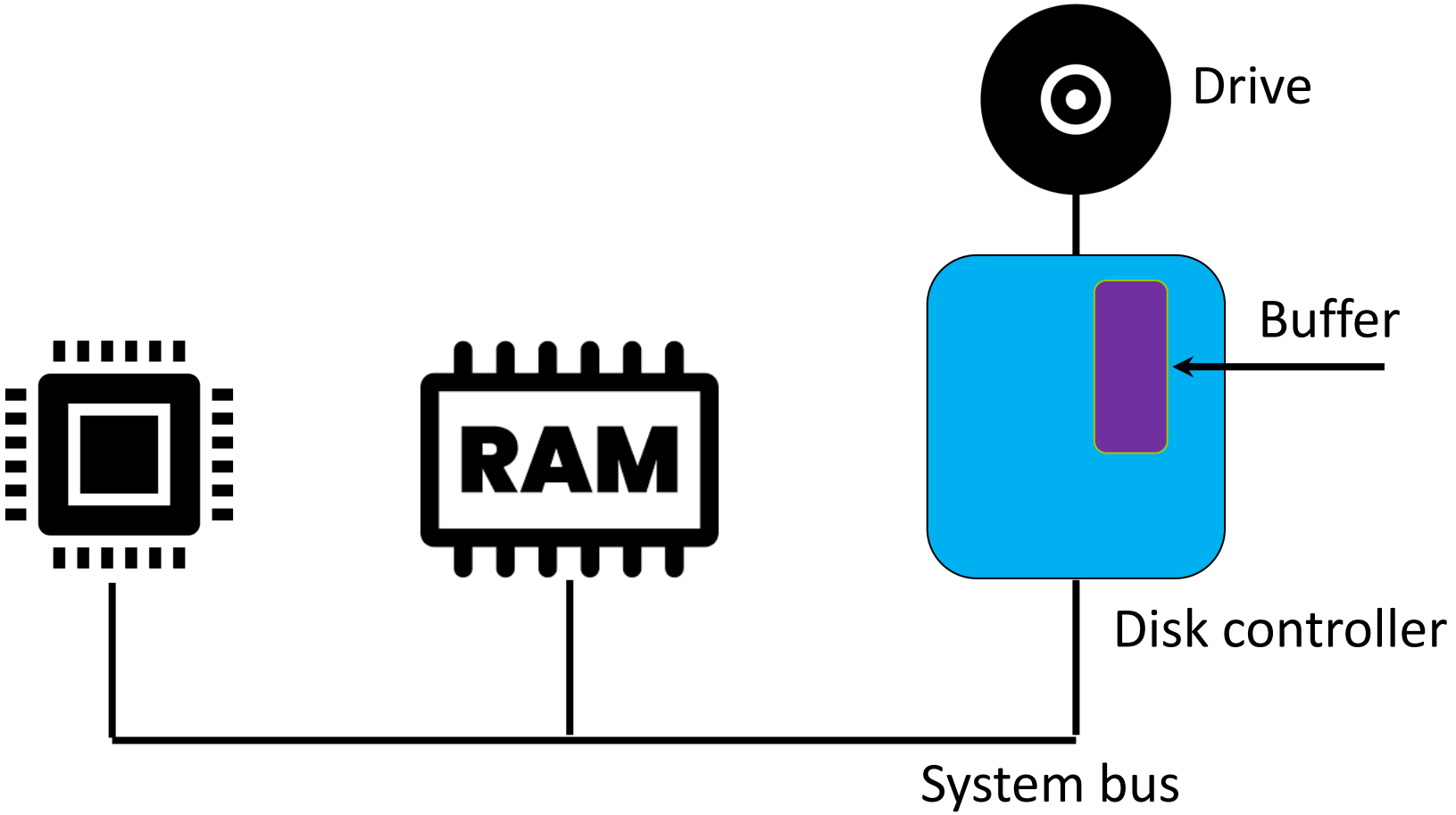
- Each device controller is in charge of a particular device typ.
  - Such as disk drives, audio devices, etc.



http://www.idc-online.com/technical_references/pdfs/information_technology/Device_Controllers_Memory_Mapped_and_Port_Mapped.pdf

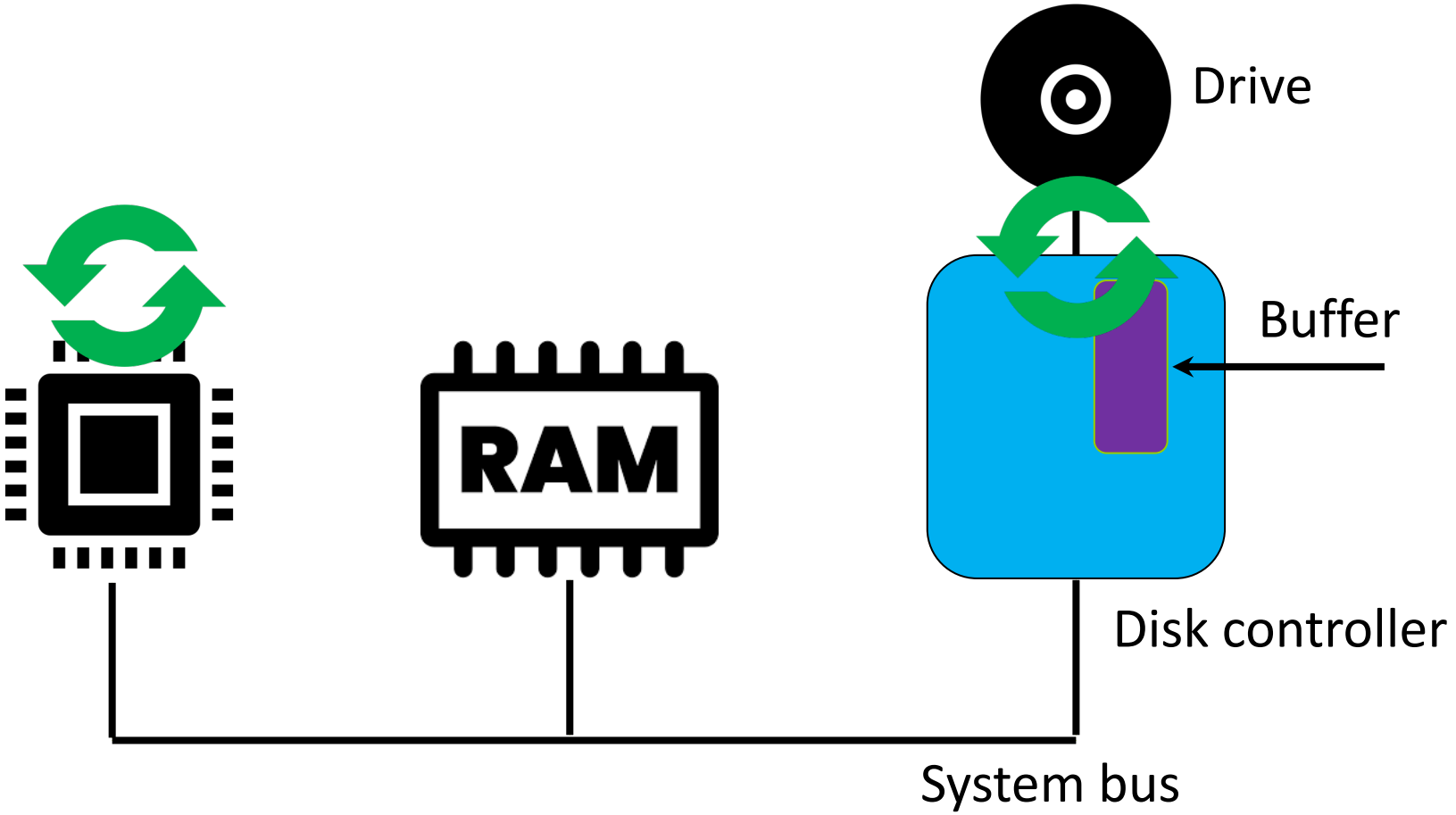
Computer-System Operation (cont.)

- Each device controller has a local buffer.



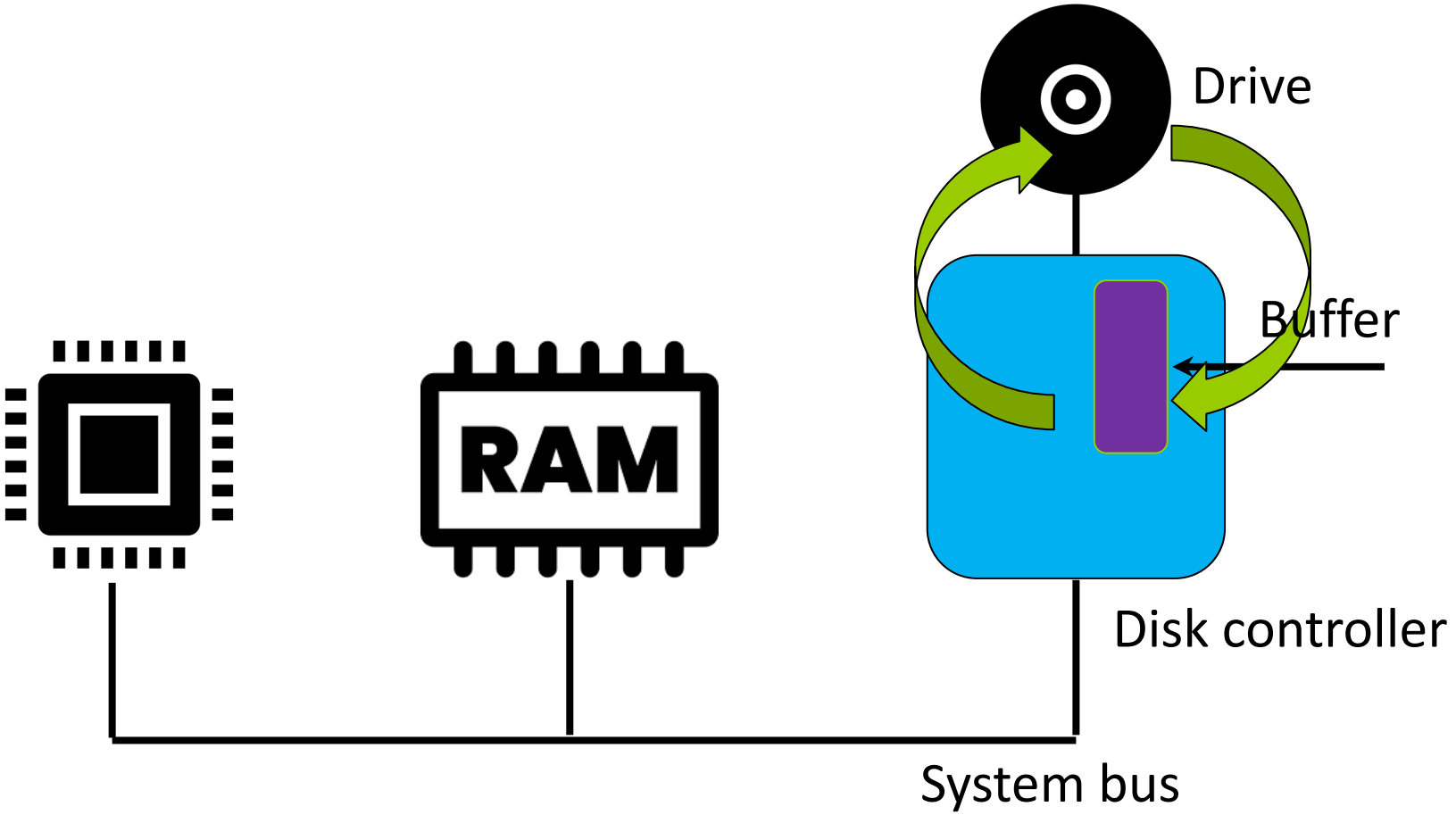
Computer-System Operation (cont.)

- I/O devices and the CPU can execute in parallel



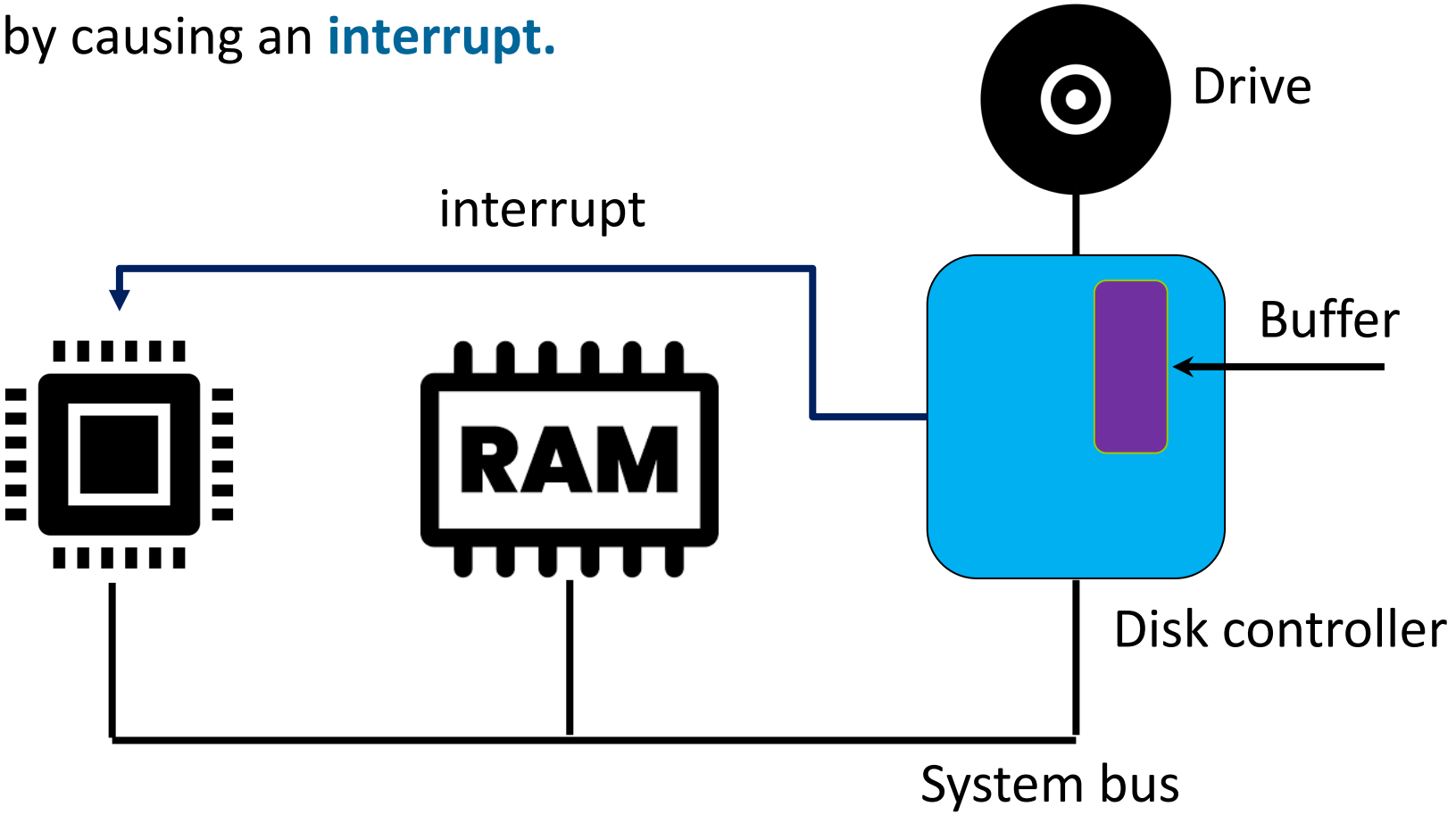
Computer-System Operation (cont.)

- **I/O**: device ←→ local buffer of controller.



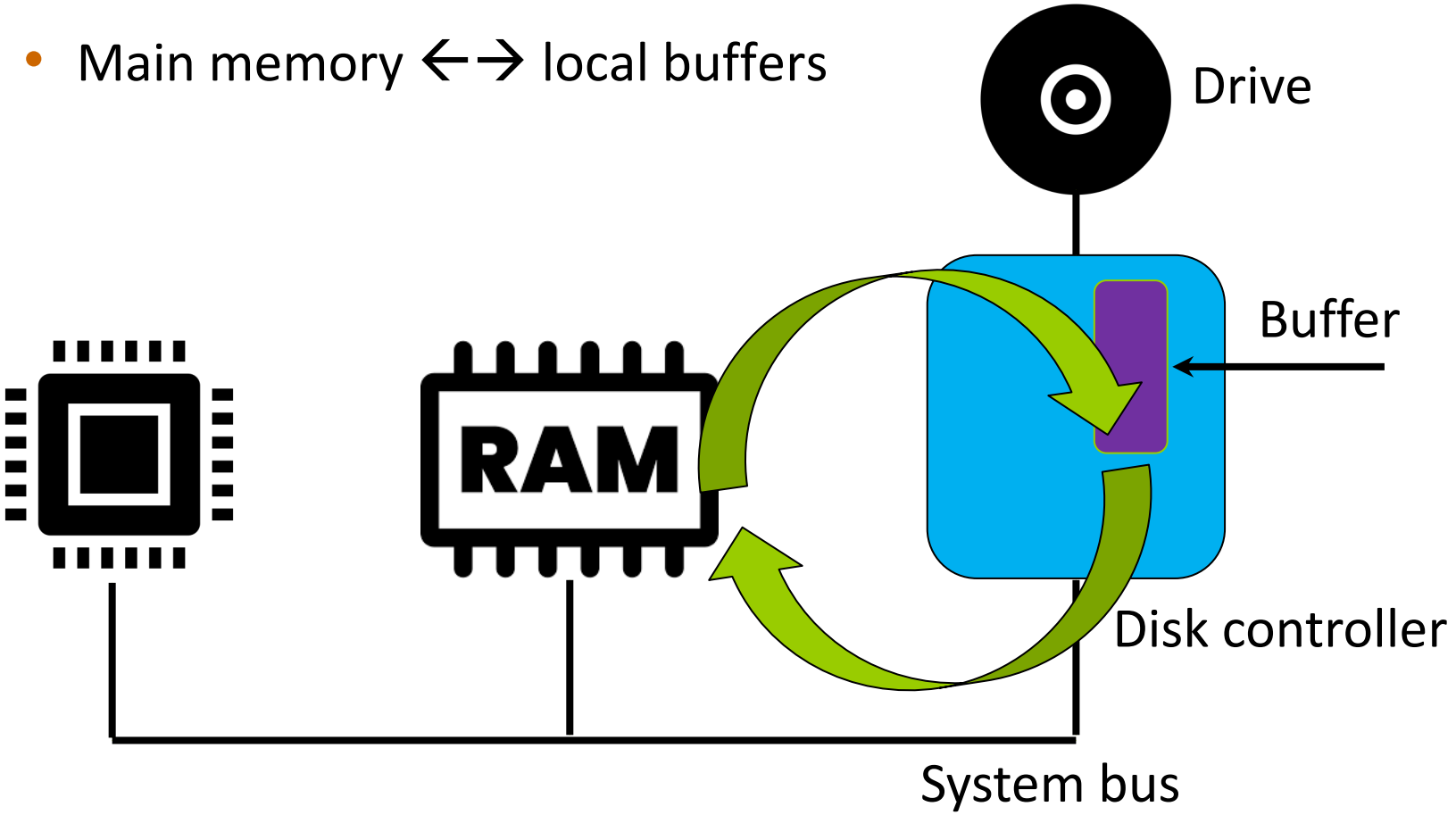
Computer-System Operation (cont.)

- Device controller informs CPU that it has finished its operation by causing an **interrupt.**

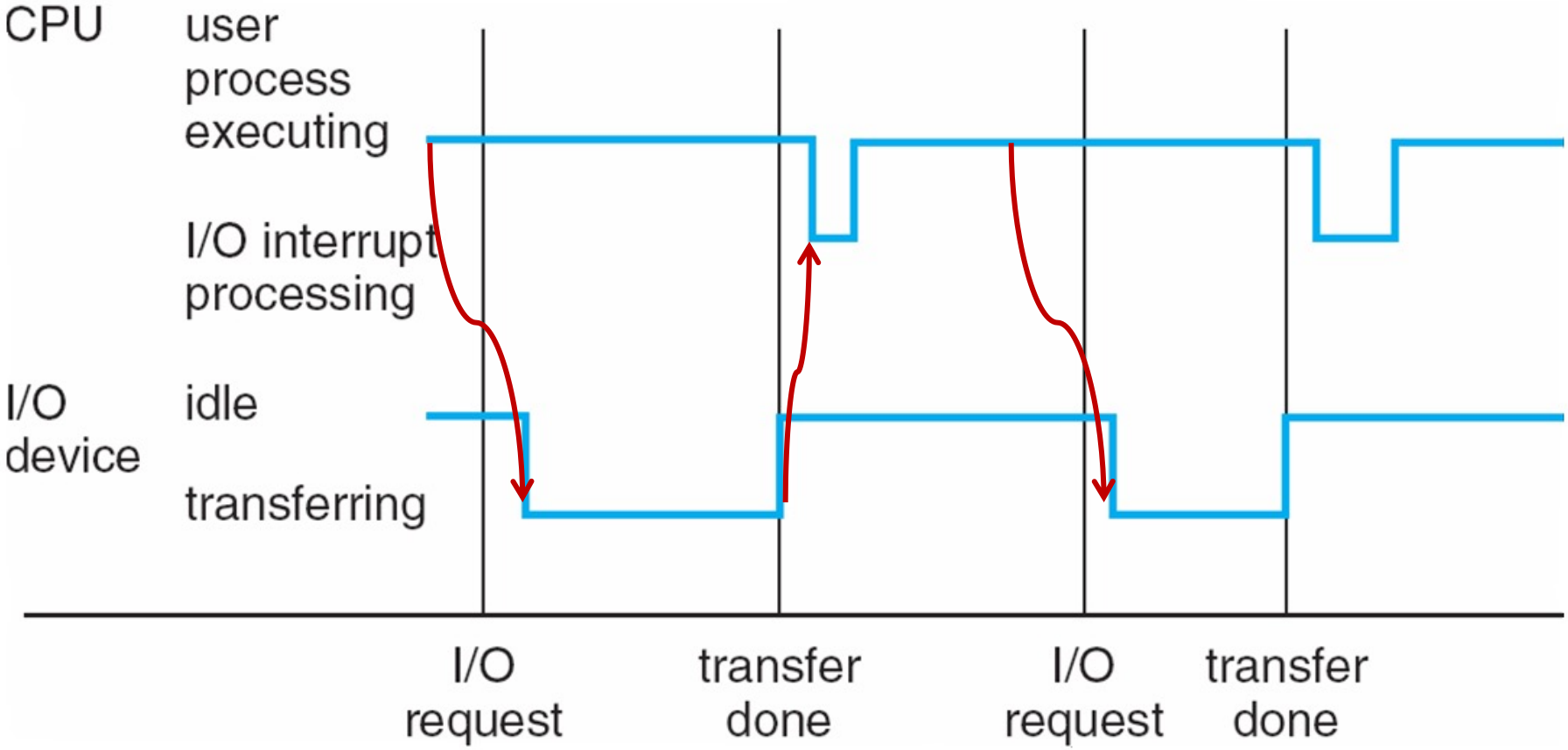


Computer-System Operation (cont.)

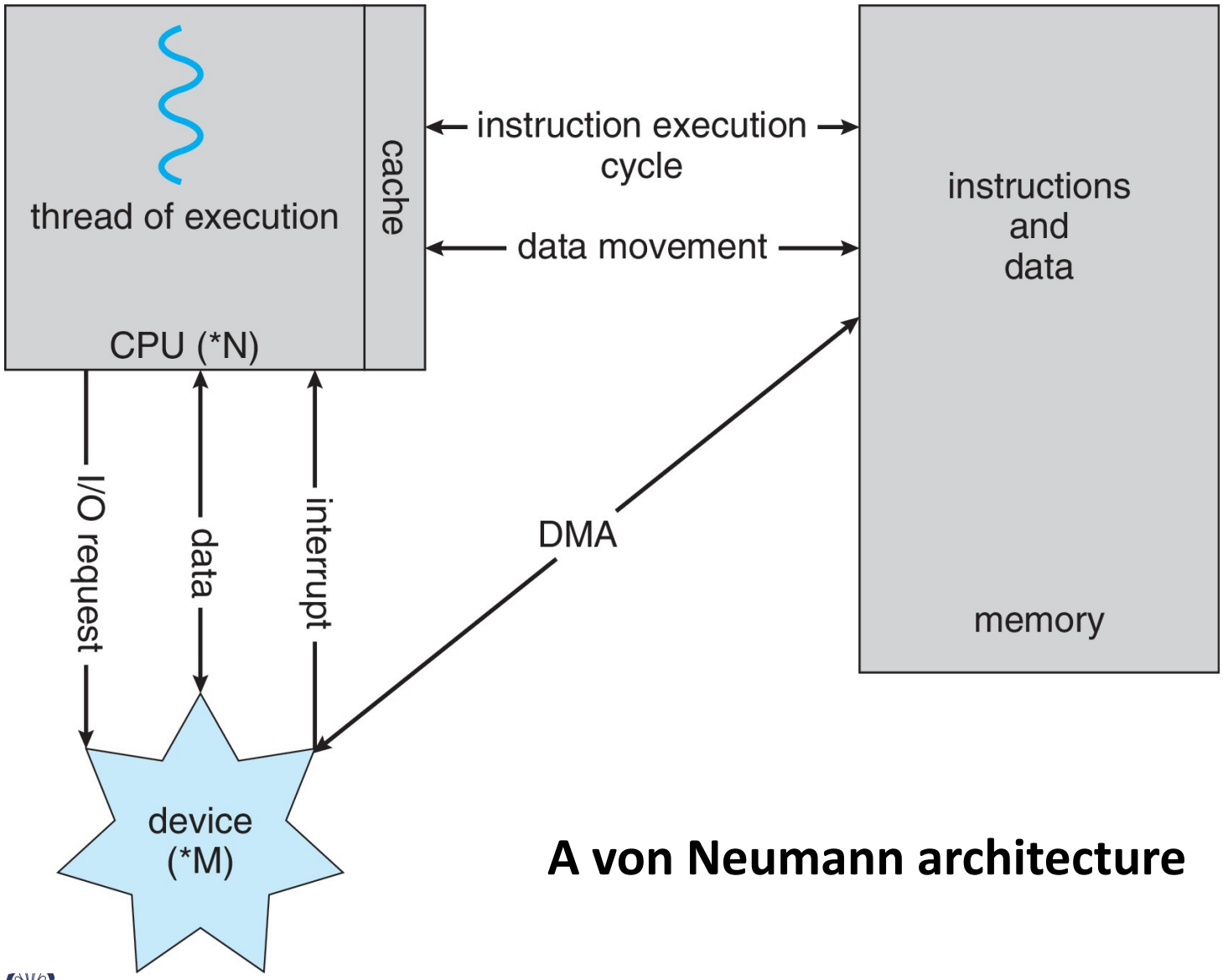
- **CPU moves data**
  - Main memory ←→ local buffers



Interrupt Timeline



How a Modern Computer Works



A von Neumann architecture

Direct Memory Access Structure

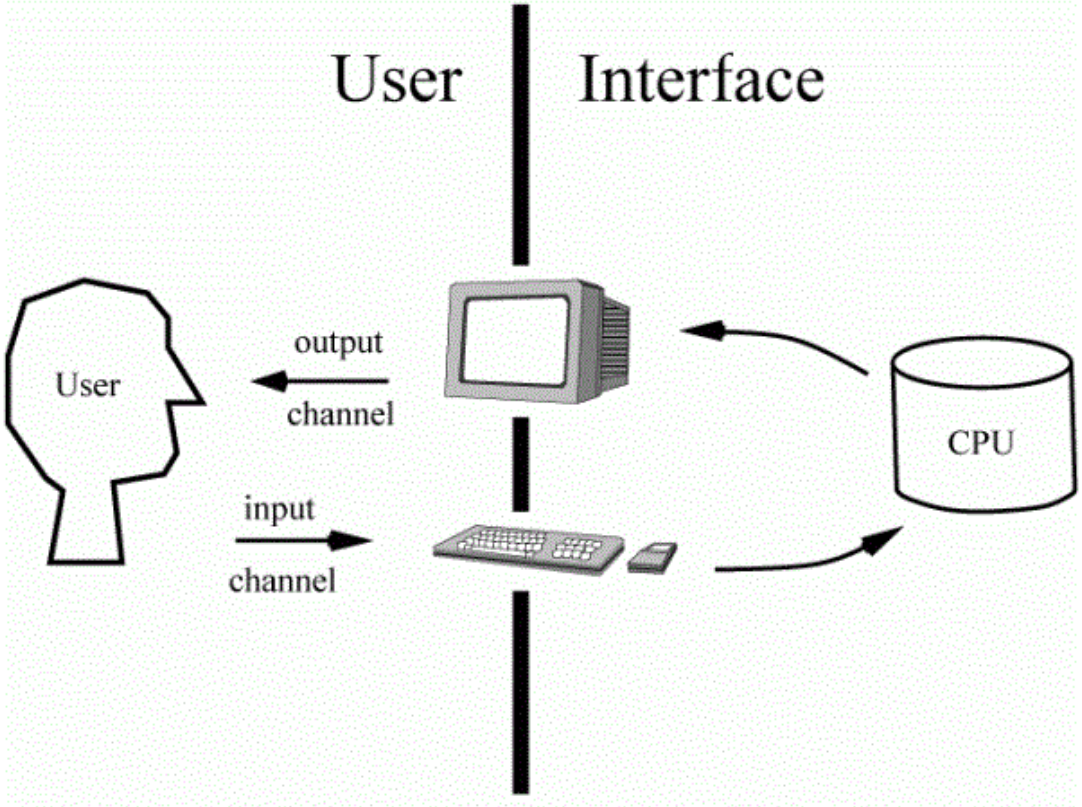
- Used for **high-speed I/O devices** able to transmit information at close to memory speeds.

- 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.

Multiprogramming (Batch System)

- Single user/program cannot always keep CPU and I/O devices busy.



Multiprogramming (Batch System) (cont.)

- Single user/program cannot always keep CPU and I/O devices busy.
- Examples

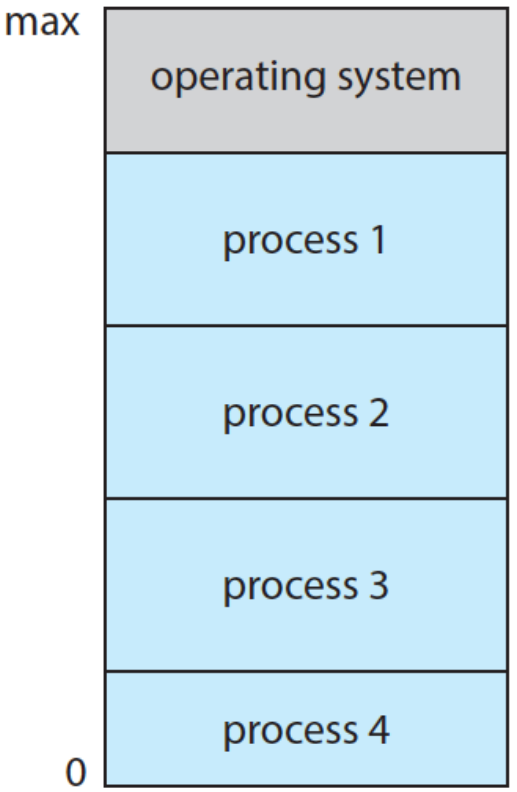
Program	CPU-intensive	Memory-intensive	I/O-intensive
Random Number Generator	?	?	?
Microsoft word	?	?	?
QuickTime Player (a long 4K video)	?	?	?

Multiprogramming (Batch System) (cont.)

- Multiprogramming organizes multiple jobs (code and data) -->
  - CPU always has one to execute.
- A subset of total jobs

  in system is kept in memory.
- One job selected and run via job scheduling.
- When job has to wait (I/O for example),

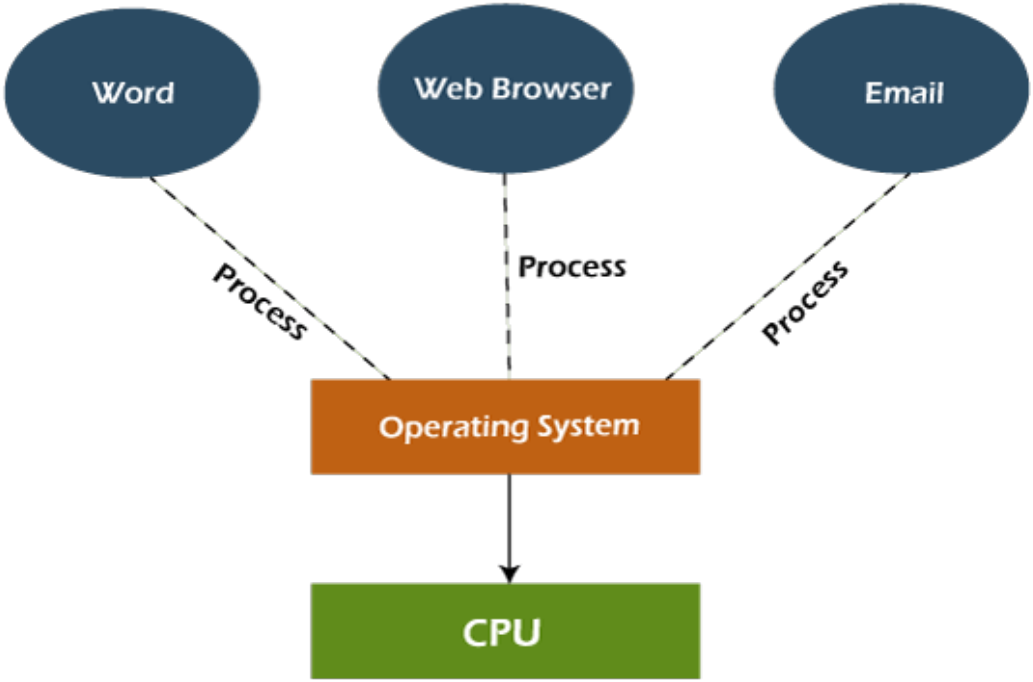
  OS switches to another job.



Memory layout for a multiprogramming system

Multitasking (Timesharing) (cont.)

- A logical extension of Batch systems.
- The CPU ***switches jobs so frequently*** that users can interact with each job while it is running, creating **interactive** computing.



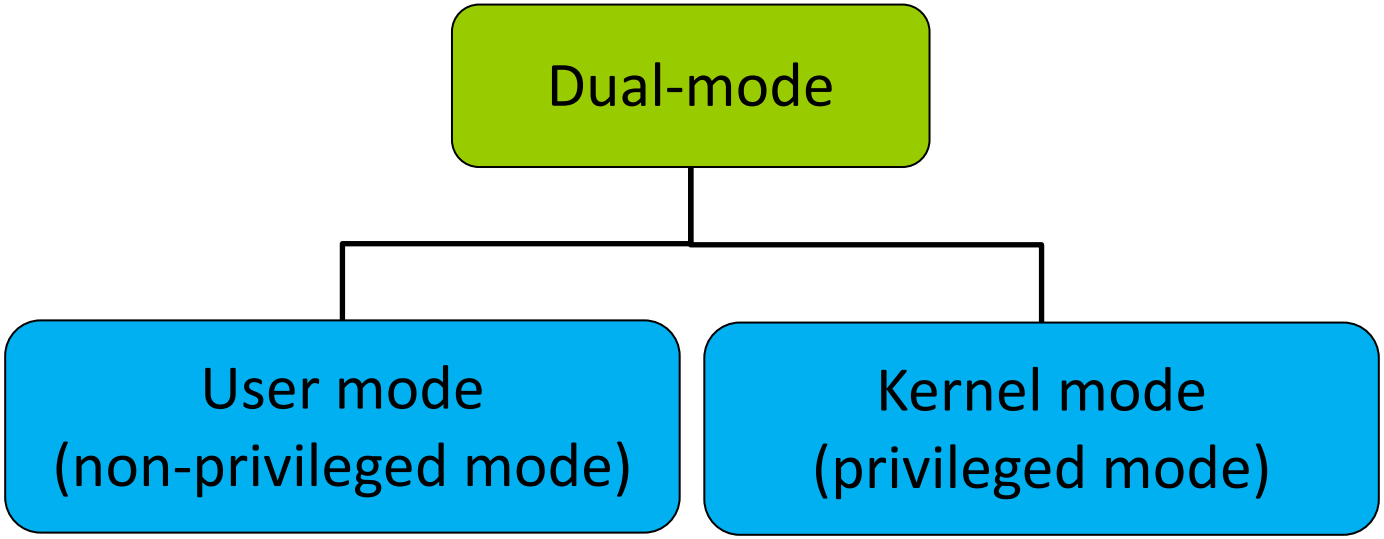
Multitasking (Timesharing) (cont.)

- Response time should be < 1 second.
- Each user has at least one program executing in memory ⇨ process.
- If several jobs ready to run at the same time ⇨ CPU scheduling.
- If processes don't fit in memory, swapping moves them in&out to run.
- Virtual memory allows execution of processes not completely in memory.

https://www.geeksforgeeks.org/difference-between-job-task-and-process/

Dual-mode Operation

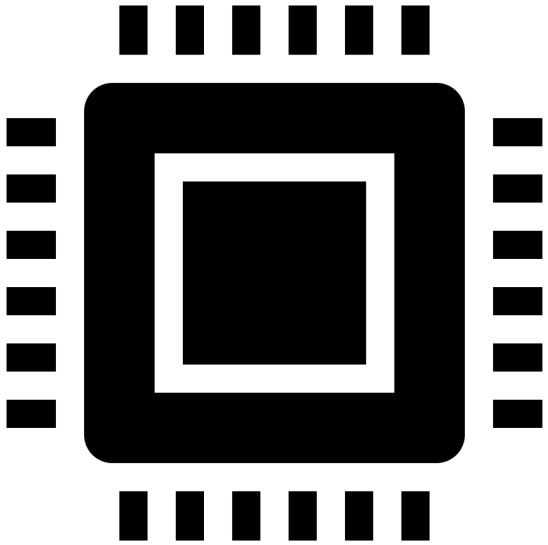
- **Dual-mode** operation allows OS to protect itself and other system components.
  - **User mode** and **kernel mode**



https://allaboutse.com/what-are-the-dual-modes-advantages/

Dual-mode Operation (cont.)

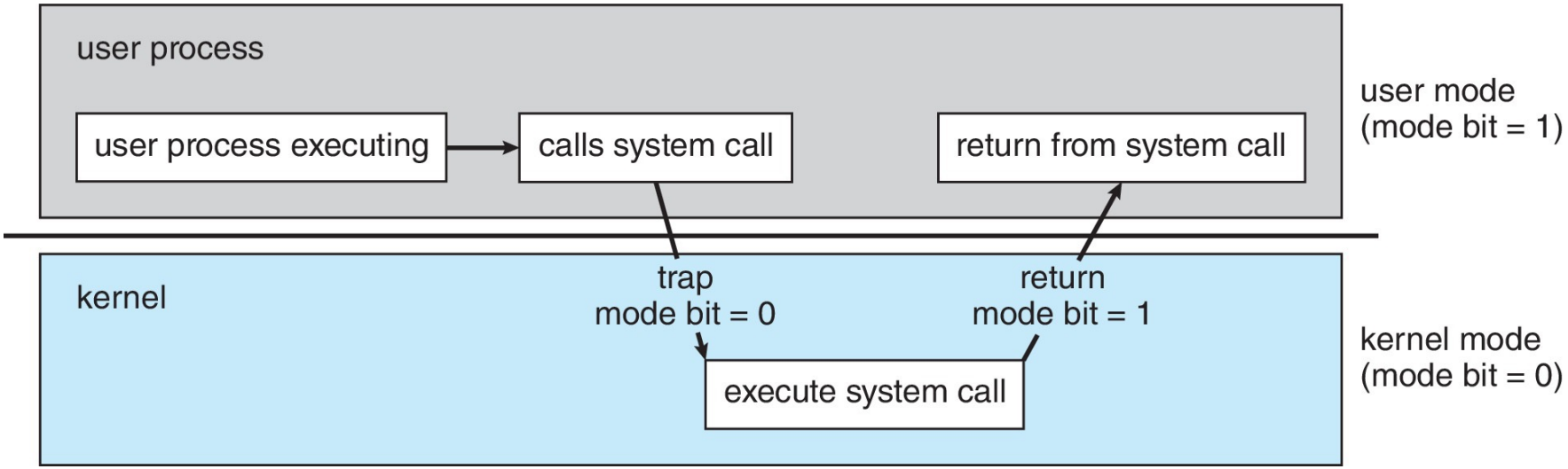
- **Mode bit** provided by hardware
  - To distinguish when system is running ***user code*** or ***kernel code***.
  - When a user is running ⇨ mode bit is “user”.
  - When kernel code is executing ⇨ mode bit is “kernel”.



Mode bit

Dual-mode Operation (Cont.)

- How do we guarantee that user does not explicitly set the mode bit to “kernel”?
  - System call changes mode to kernel, return from call resets it to user.



Types of Instructions

- Instructions are divided into two categories:
  - The ***non-privileged instruction*** instruction is an instruction that ***any application or user can execute***.
  - The ***privileged instruction*** is an instruction that ***can only be executed in kernel mode***.
- Instructions are divided in this manner because privileged instructions ***could harm the kernel***.

http://web.cs.ucla.edu/classes/winter13/cs111/scribe/4a/

Examples of instructions

Instruction	Type
Reading the status of Processor	?
Set the Timer	?
Sending the final printout of Printer	?
Remove a process from the memory	?

Examples of non-privileged instructions

- Reading the status of Processor
- Reading the System Time
- Sending the final printout of Printer

https://www.geeksforgeeks.org/privileged-and-non-privileged-instructions-in-operating-system/

Examples of privileged instructions

- I/O instructions and halt instructions
- Turn off all Interrupts
- Set the timer
- Context switching
- Clear the memory or remove a process from the memory
- Modify entries in the device-status table

https://www.geeksforgeeks.org/privileged-and-non-privileged-instructions-in-operating-system/

Privileged instructions

If an attempt is made to execute a privileged instruction in user mode

The hardware ***does not execute the instruction*** but rather treats it as ***illegal*** and ***traps*** it to the ***operating system.***