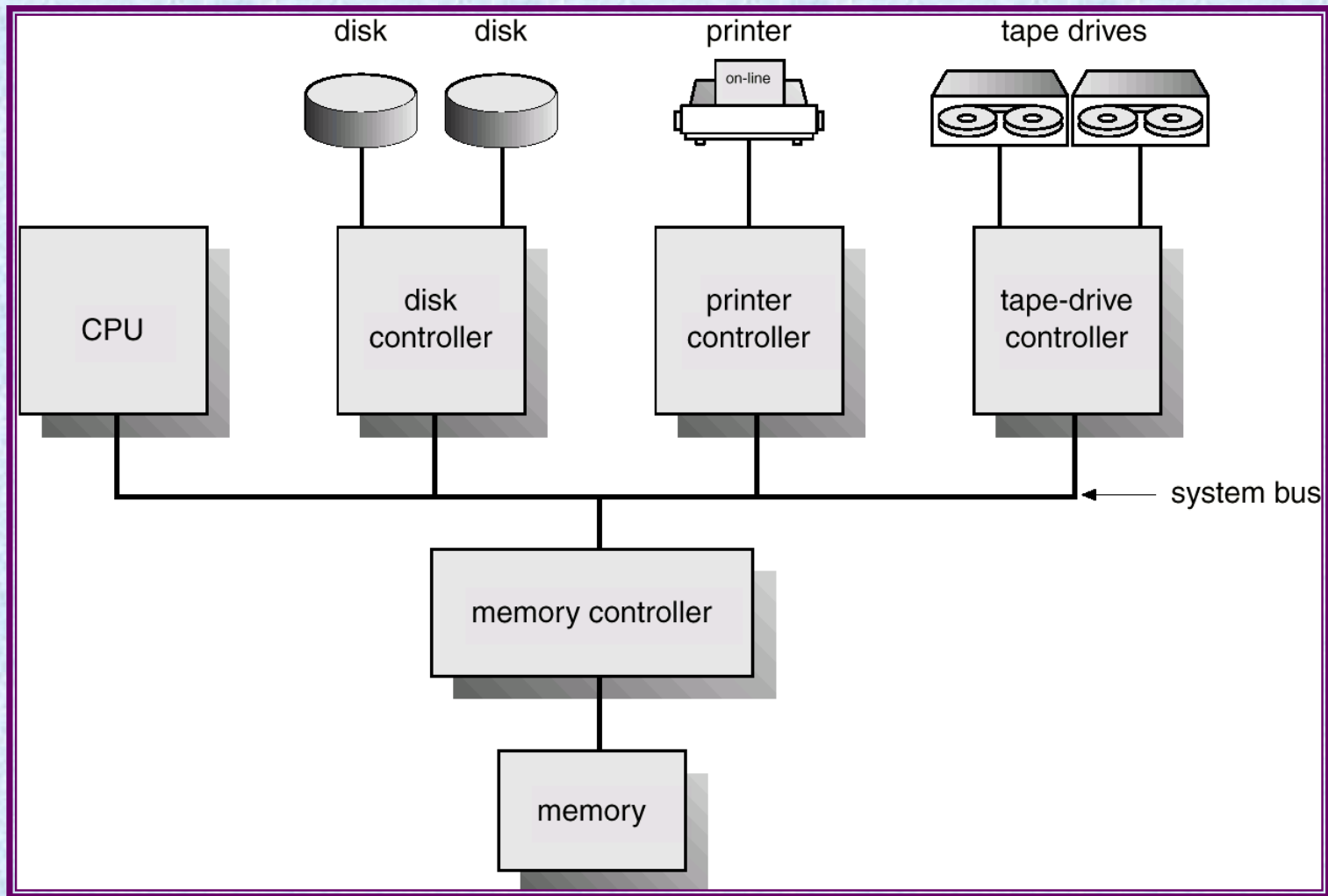


# Chapter 2: Computer-System Structures

- Computer System Operation
- I/O Structure
- Storage Structure
- Storage Hierarchy
- Hardware Protection
- General System Architecture

# Computer-System Architecture



# Computer-System Operation

- 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.
- 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*.

# Common Functions of Interrupts

- Interrupt transfers control to the interrupt service routine generally, through the *interrupt vector*, which contains the addresses of all the service routines.
- Interrupt architecture must save the address of the interrupted instruction.
- Incoming interrupts are *disabled* while another interrupt is being processed to prevent a *lost interrupt*.
- A *trap* is a software-generated interrupt caused either by an error or a user request.

# Interrupt Handling

- The operating system preserves the state of the CPU by storing registers and the program counter.
- Determines which type of interrupt has occurred:
  - ☞ *Polling – in polling CPU waste lots of cpu cycles by repeatedly checking the command ready bit of every device.*
  - ☞ *vectored* interrupt system – an alternative to a polled interrupt, which requires that the interrupt handler to send a signal to each device in turn in order to find out which one sent the interrupt request.
  - ☞ An interrupt can occur at any instant of time whereas, CPU keeps polling the device at the regular intervals.
- Separate segments of code determine what action should be taken for each type of interrupt



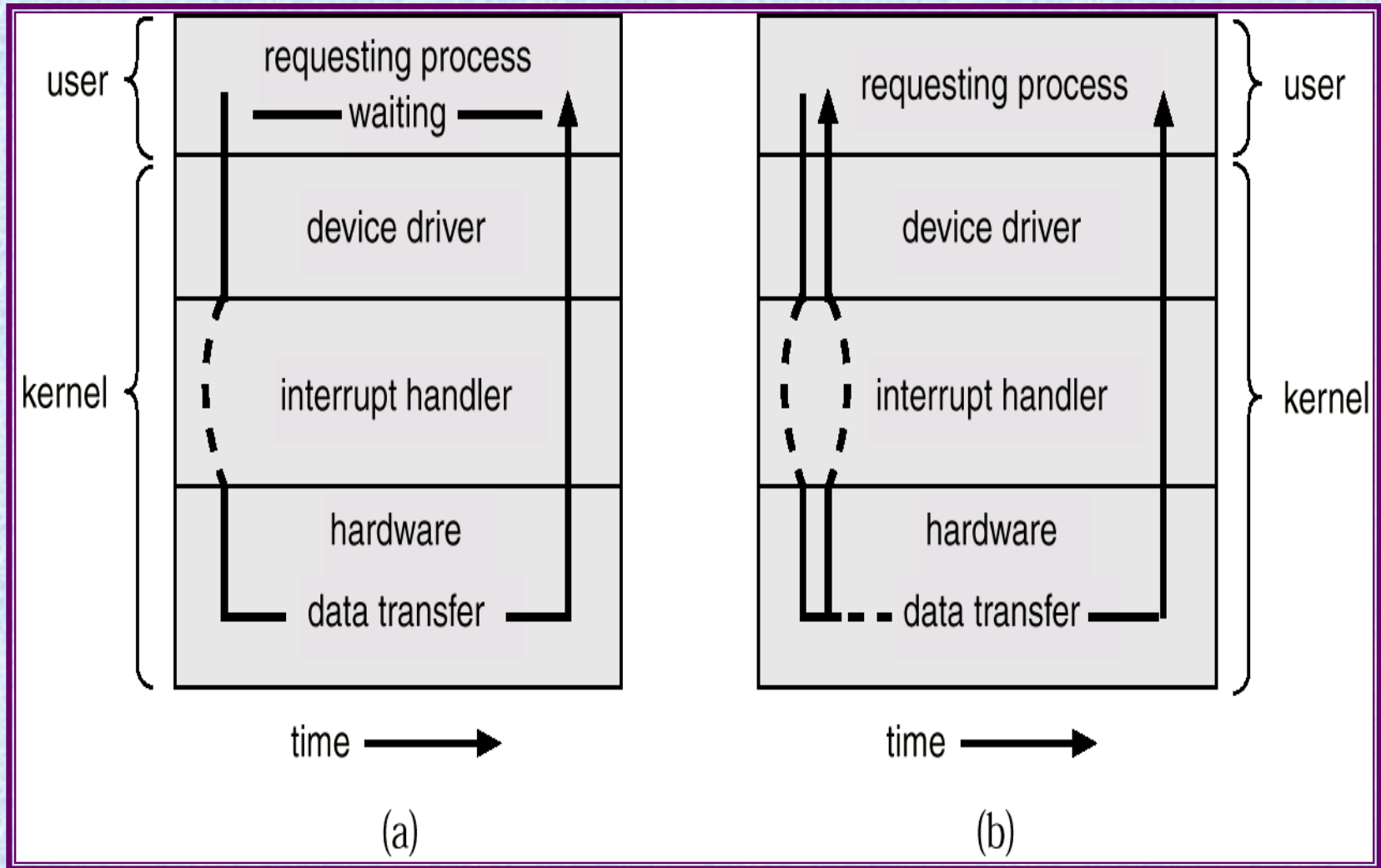
# I/O Structure

- After I/O starts, control returns to user program only upon I/O completion.
  - ☞ Wait instruction idles the CPU until the next interrupt
  - ☞ Wait loop (contention for memory access).
  - ☞ At most one I/O request is outstanding at a time, no simultaneous I/O processing.
- After I/O starts, control returns to user program without waiting for I/O completion.
  - ☞ *System call* – 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



# Direct Memory Access Structure

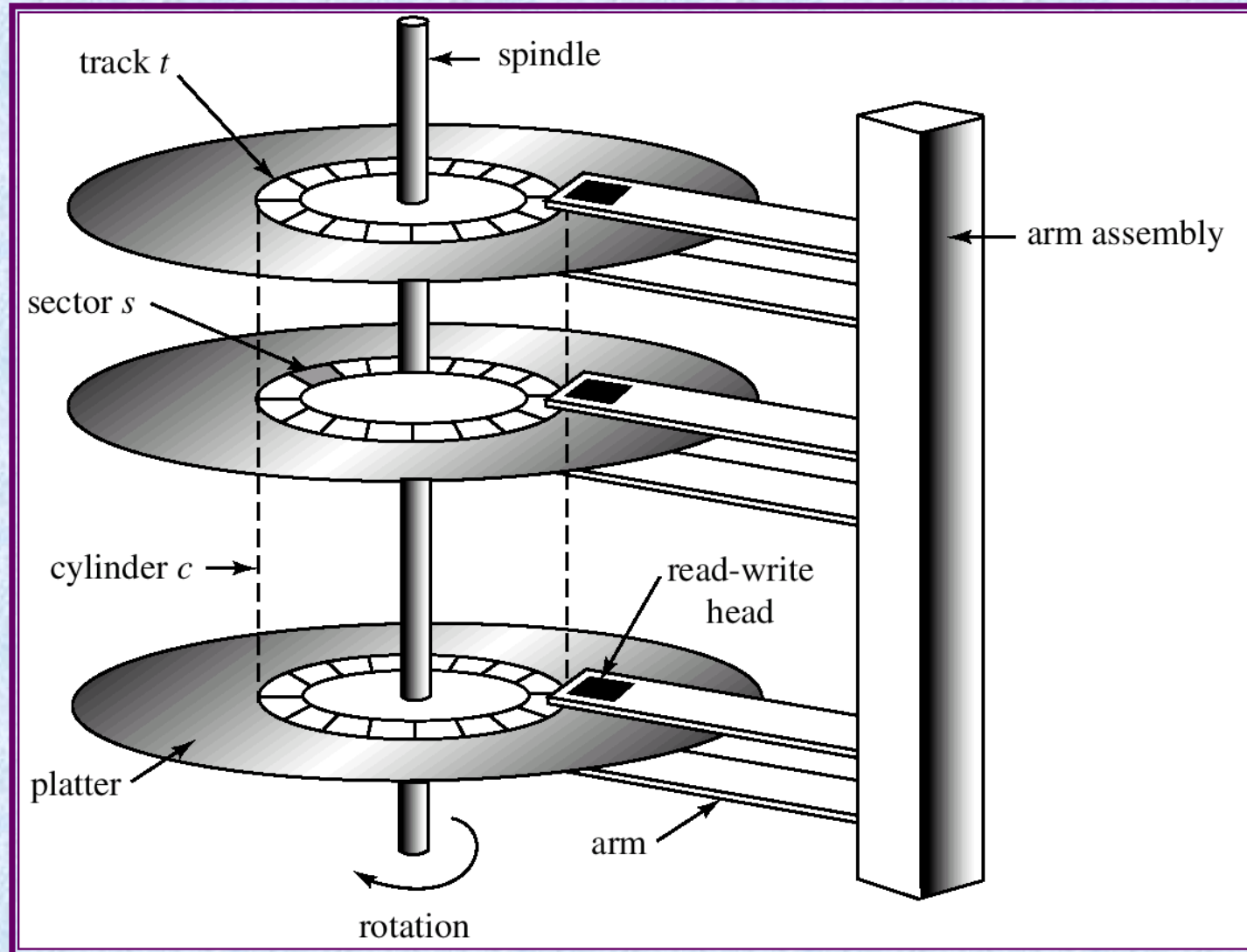
- Used for high-speed I/O devices able to transmit information at close to memory speeds.
- Device controller transfers blocks of data from buffer storage directly to main memory without CPU intervention.
- Only one interrupt is generated per block, rather than the one interrupt per byte.



# Storage Structure

- Main memory – only large storage media that the CPU can access directly.
- Secondary storage – extension of main memory that provides large nonvolatile storage capacity.
- Magnetic disks – 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.

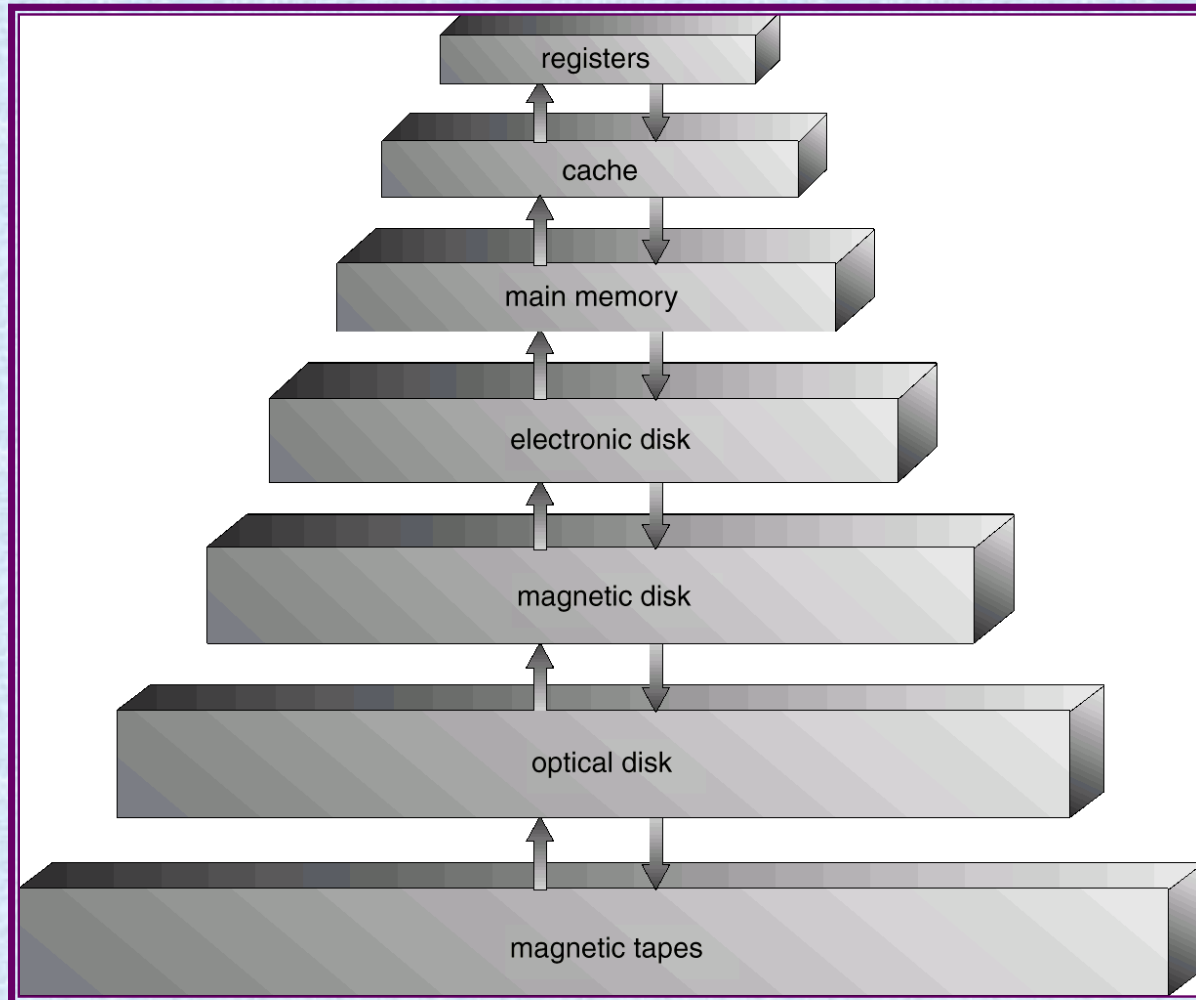
# Moving-Head Disk Mechanism



# Storage Hierarchy

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

# Storage-Device Hierarchy



# Caching

- Use of high-speed memory to hold recently-accessed data.
- Requires a *cache management* policy.
- Caching introduces another level in storage hierarchy. This requires data that is simultaneously stored in more than one level to be *consistent*.



# Hardware Protection

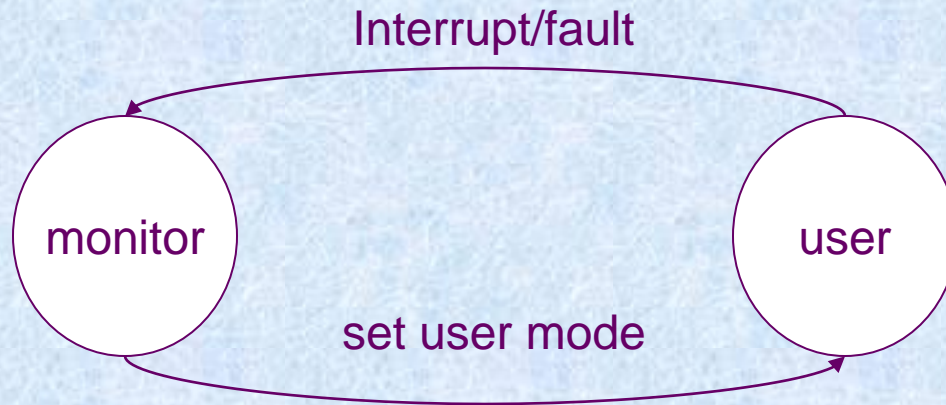
- Dual-Mode Operation
- I/O Protection
- Memory Protection
- CPU Protection

# Dual-Mode Operation

- Sharing system resources requires operating system to ensure that an incorrect program cannot cause other programs to execute incorrectly.
- Provide hardware support to differentiate between at least two modes of operations.
  1. *User mode* – execution done on behalf of a user.
  2. *Monitor mode* (also *kernel mode* or *system mode*) – execution done on behalf of operating system.

# Dual-Mode Operation (Cont.)

- *Mode bit* added to computer hardware to indicate the current mode: monitor (0) or user (1).
- When an interrupt or fault occurs hardware switches to monitor mode.

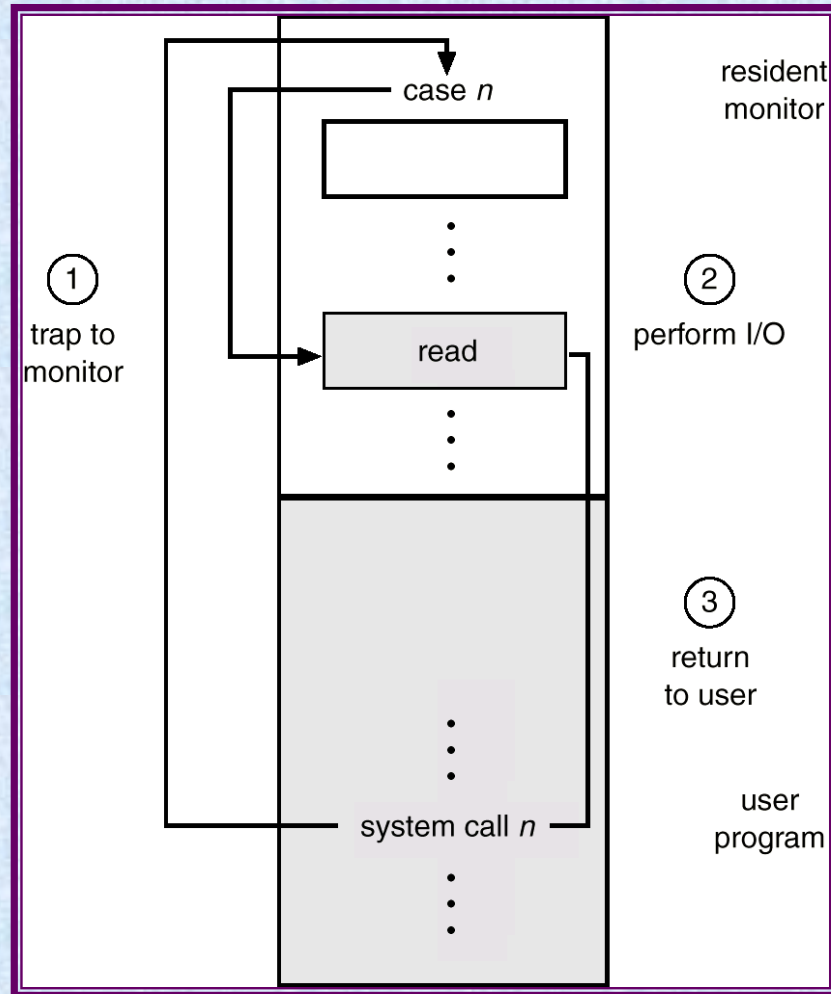


*Privileged instructions can be issued only in monitor mode.*

# I/O Protection

- All I/O instructions are privileged instructions.
- Must ensure that a user program could never gain control of the computer in monitor mode (I.e., a user program that, as part of its execution, stores a new address in the interrupt vector).

# Use of A System Call to Perform I/O

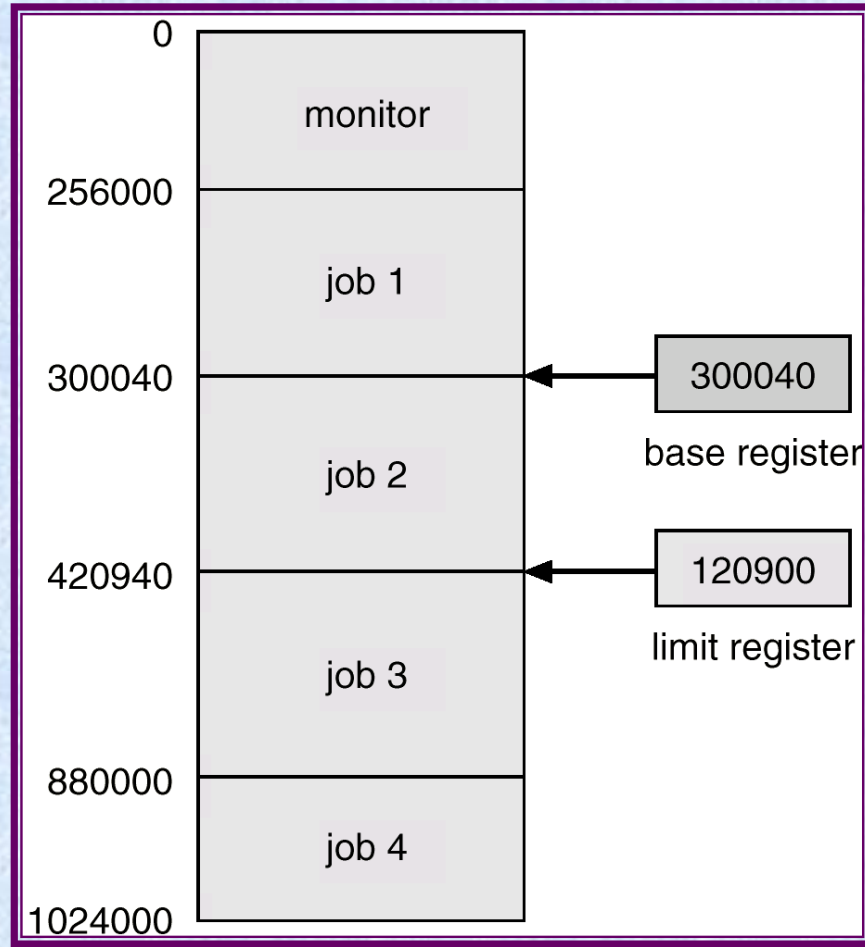




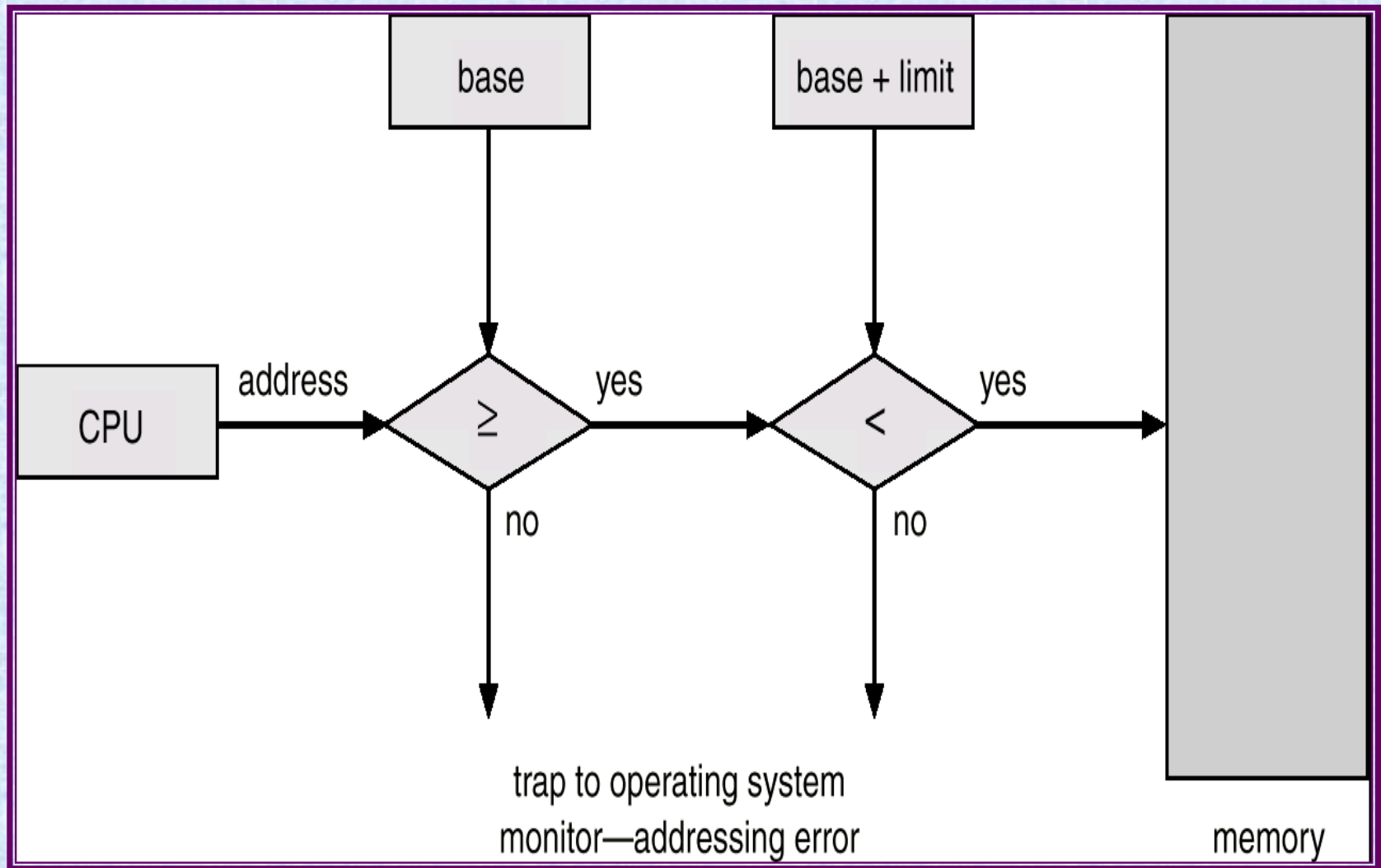
# Memory Protection

- Must provide memory protection at least for the interrupt vector and the interrupt service routines.
- In order to have memory protection, add two registers that determine the range of legal addresses a program may access:
  - ☞ **Base register** – holds the smallest legal physical memory address.
  - ☞ **Limit register** – contains the size of the range
- Memory outside the defined range is protected.

# Use of A Base and Limit Register



# Hardware Address Protection



# Hardware Protection

- When executing in monitor mode, the operating system has unrestricted access to both monitor and user's memory.
- The load instructions for the *base* and *limit* registers are privileged instructions.

# CPU Protection

- *Timer* – interrupts computer after specified period to ensure operating system maintains control.
  - ☞ Timer is decremented every clock tick.
  - ☞ When timer reaches the value 0, an interrupt occurs.
- Timer commonly used to implement time sharing.
- Time also used to compute the current time.
- Load-timer is a privileged instruction.