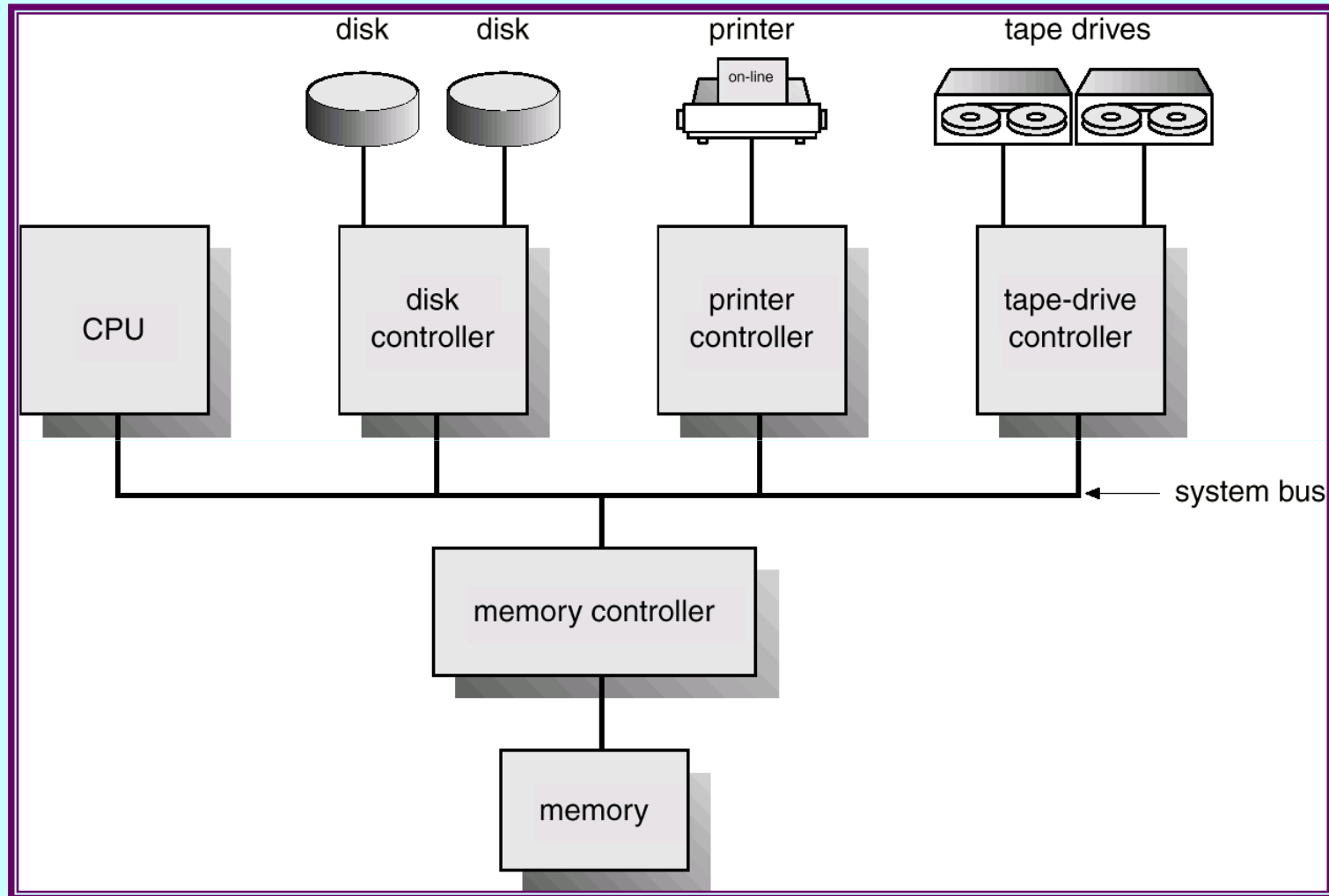


Computer-System Structures

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*.

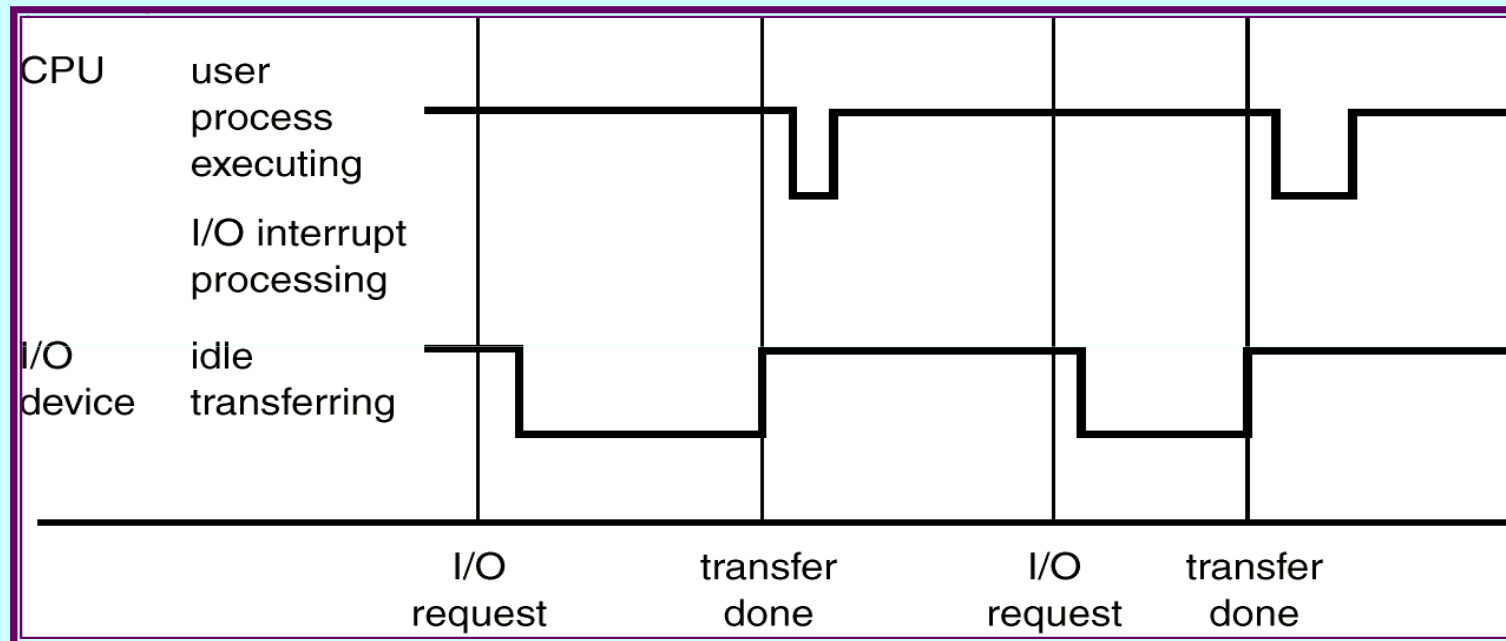
Common Functions of Interrupts

- 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.
- An operating system is *interrupt* driven.

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*
 - ☞ *vectored* interrupt system
- Separate segments of code determine what action should be taken for each type of interrupt

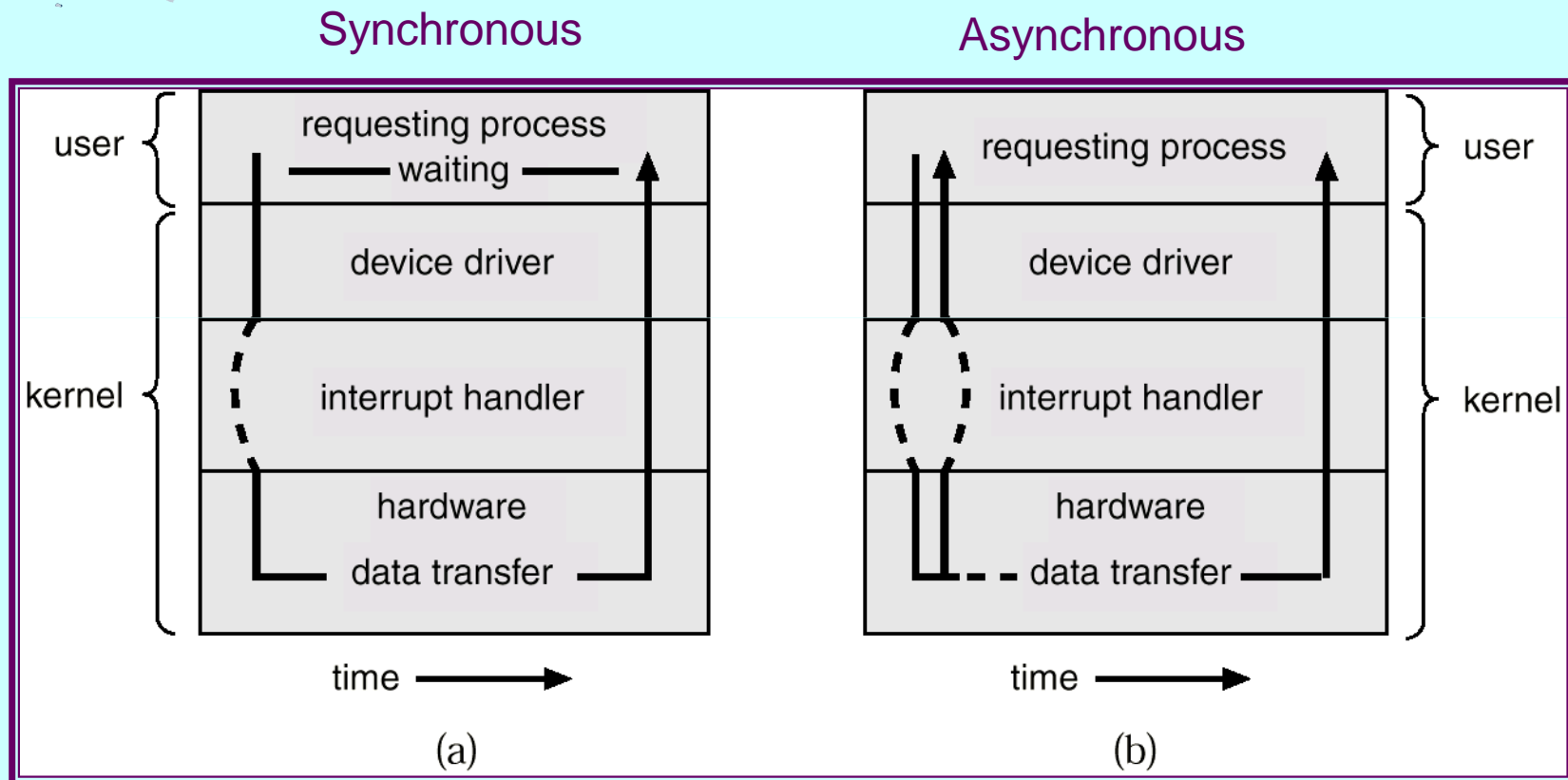
Interrupt Time Line For a Single Process Doing Output



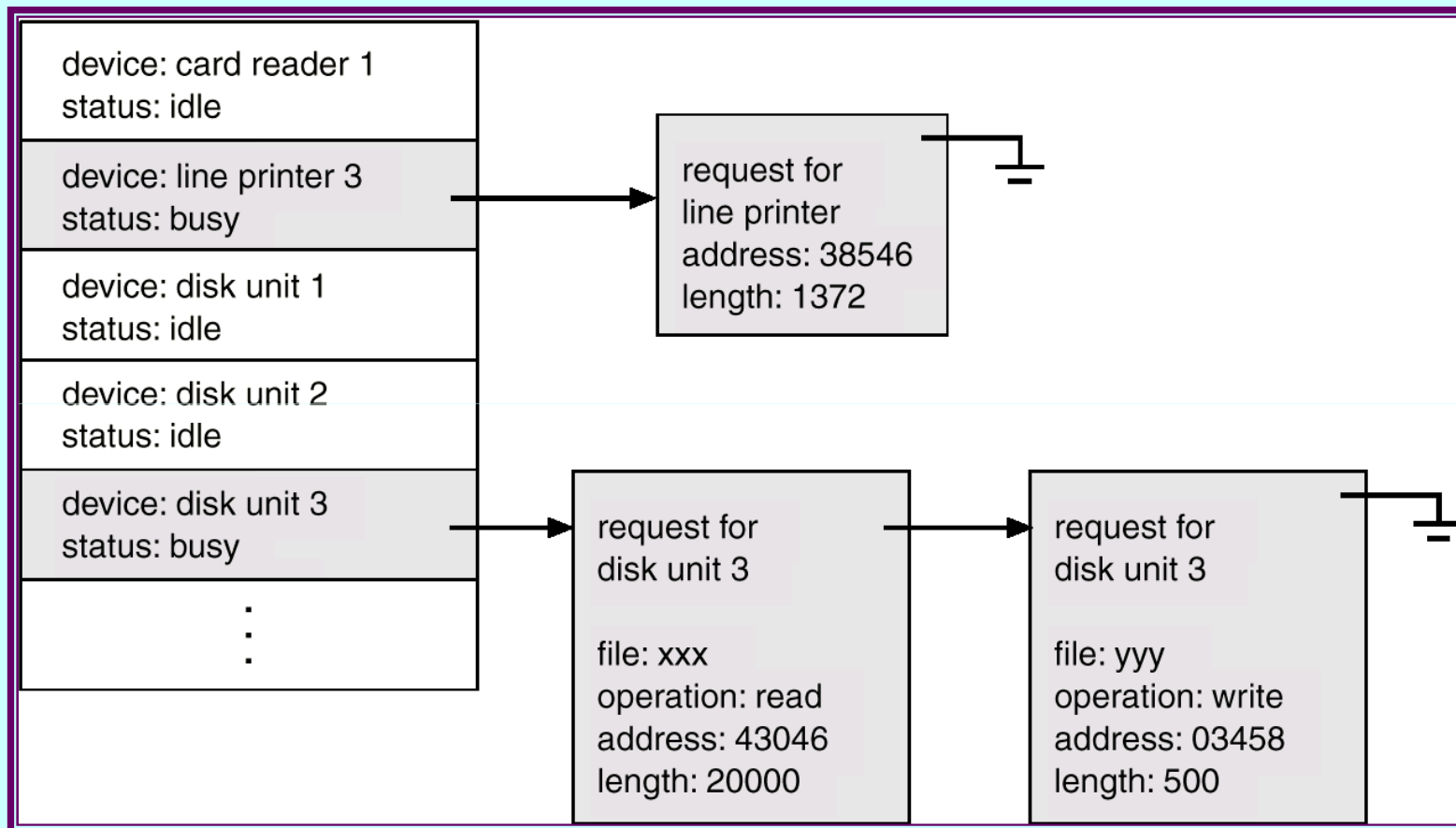
I/O Structure

- 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



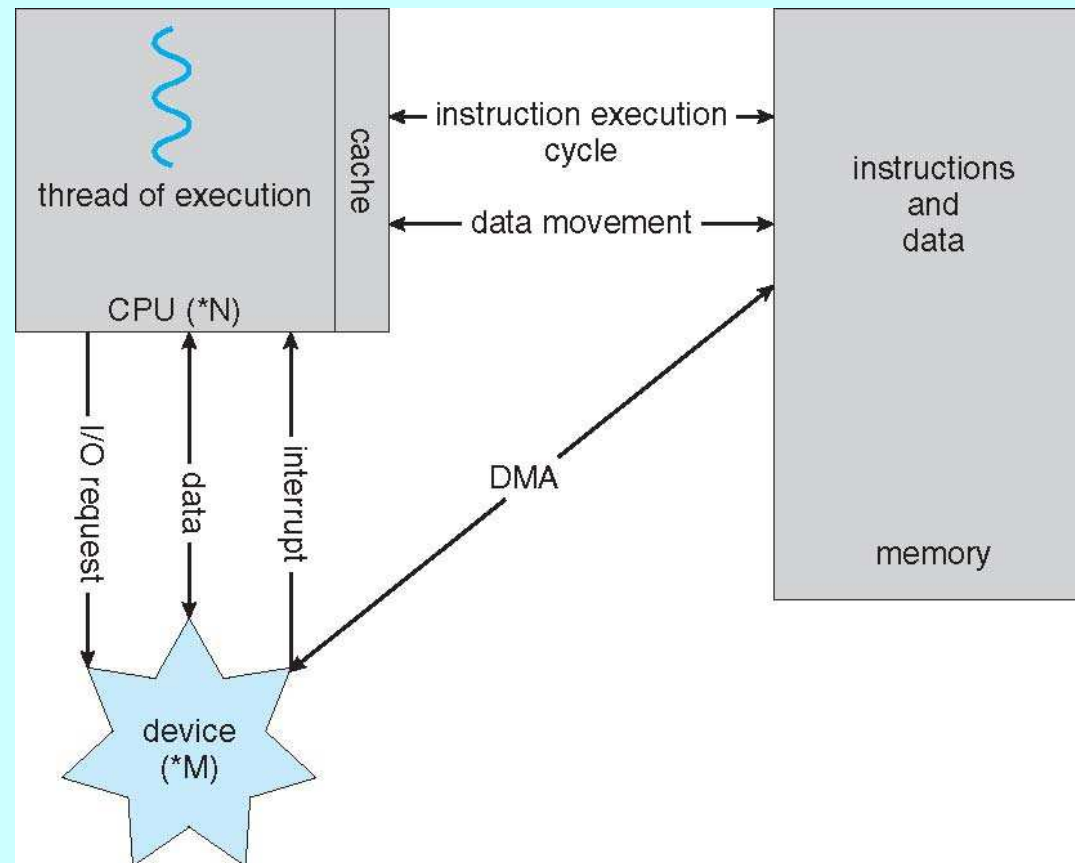
Device-Status Table



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.

How a Modern Computer Works

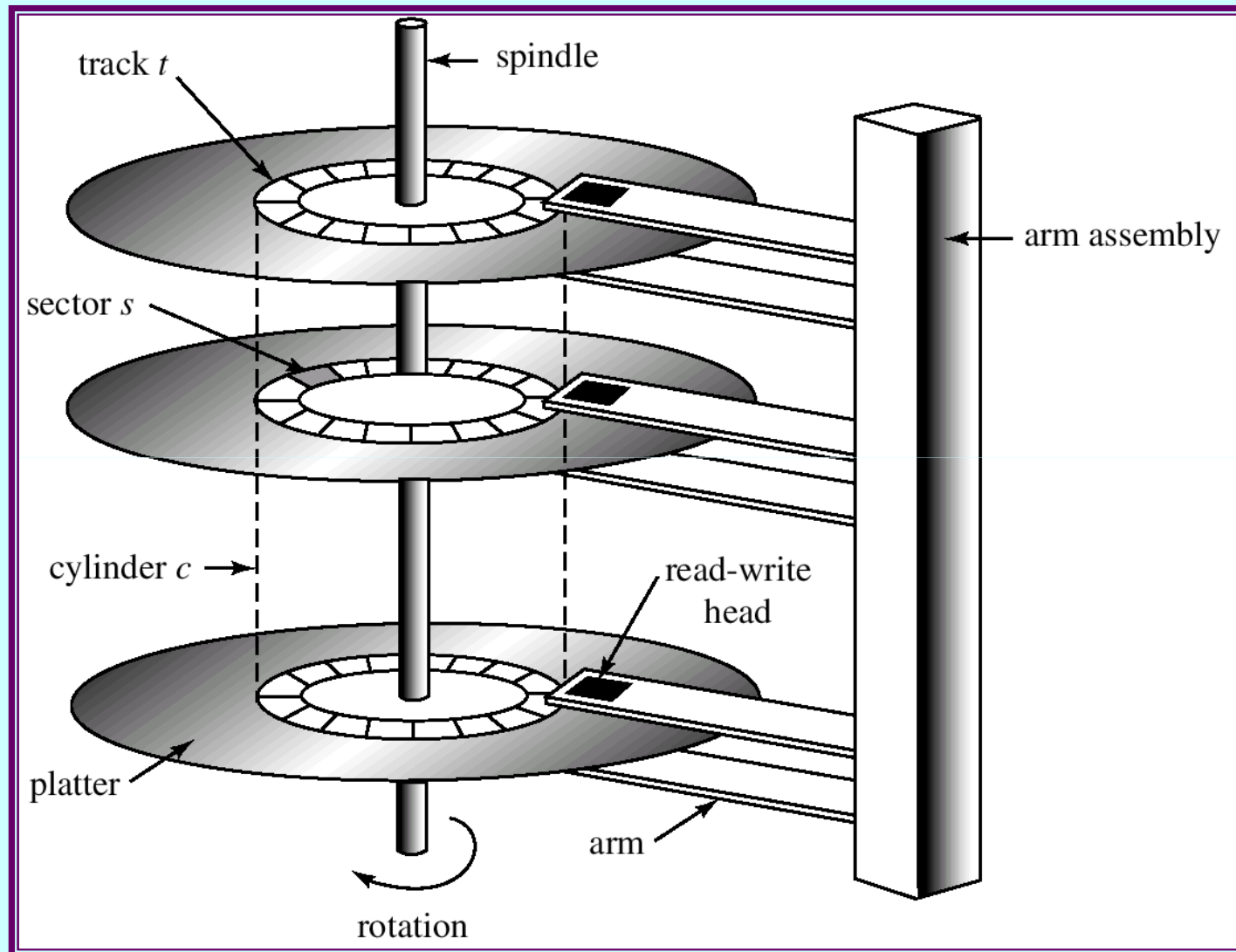


A von Neumann architecture

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.

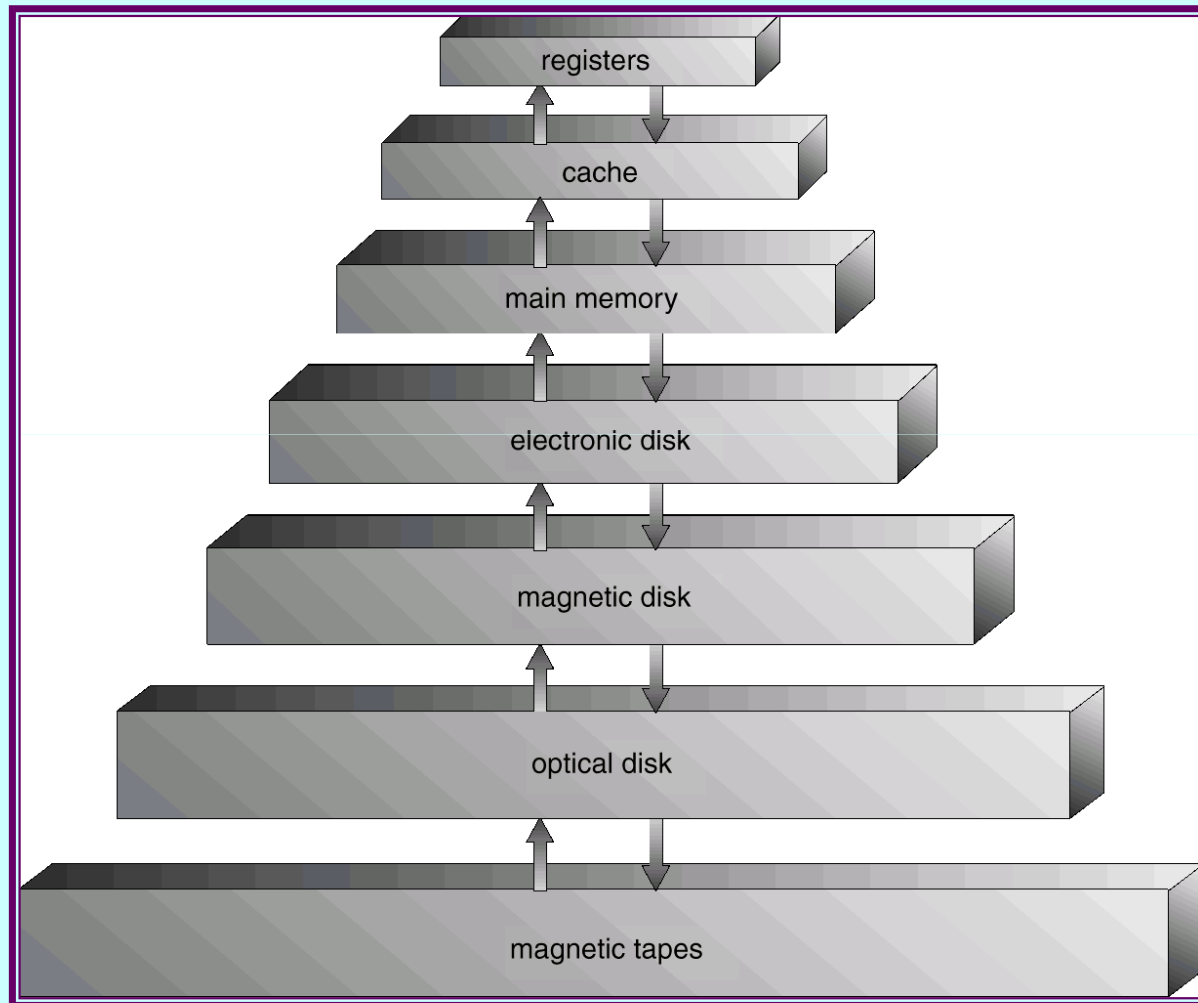
Moving-Head Disk Mechanism



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.

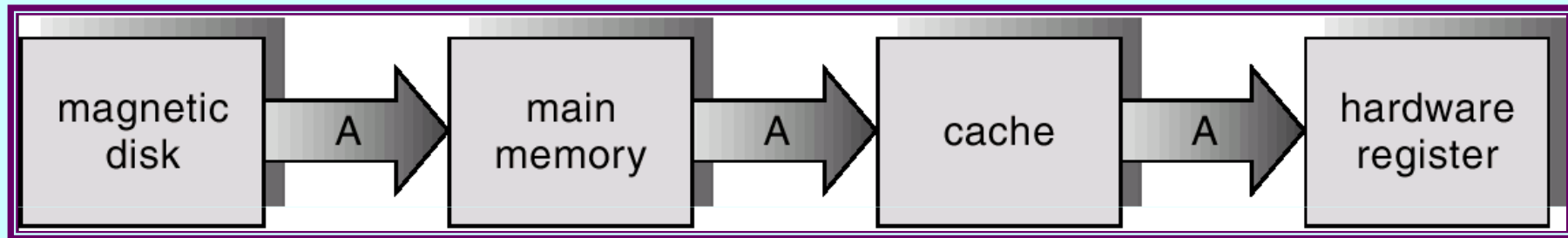
Storage-Device Hierarchy



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*.
- Cache coherency

Migration of A From Disk to Register



Hardware Protection

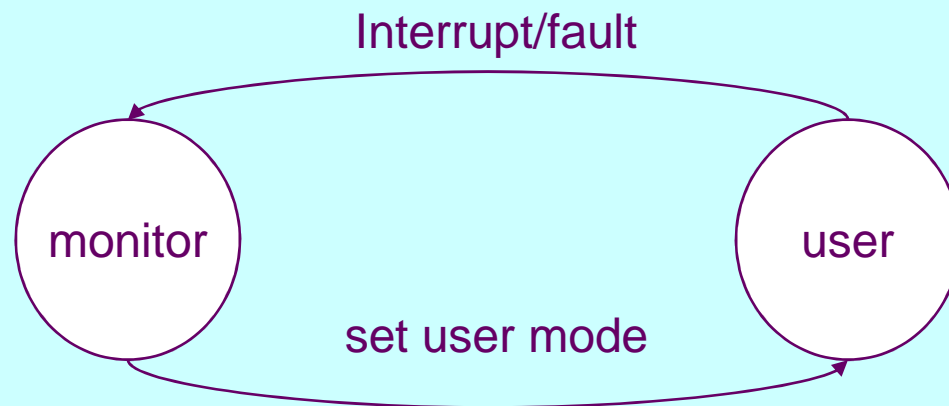
- Dual-Mode Operation
- I/O Protection
- Memory Protection
- CPU Protection

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.)

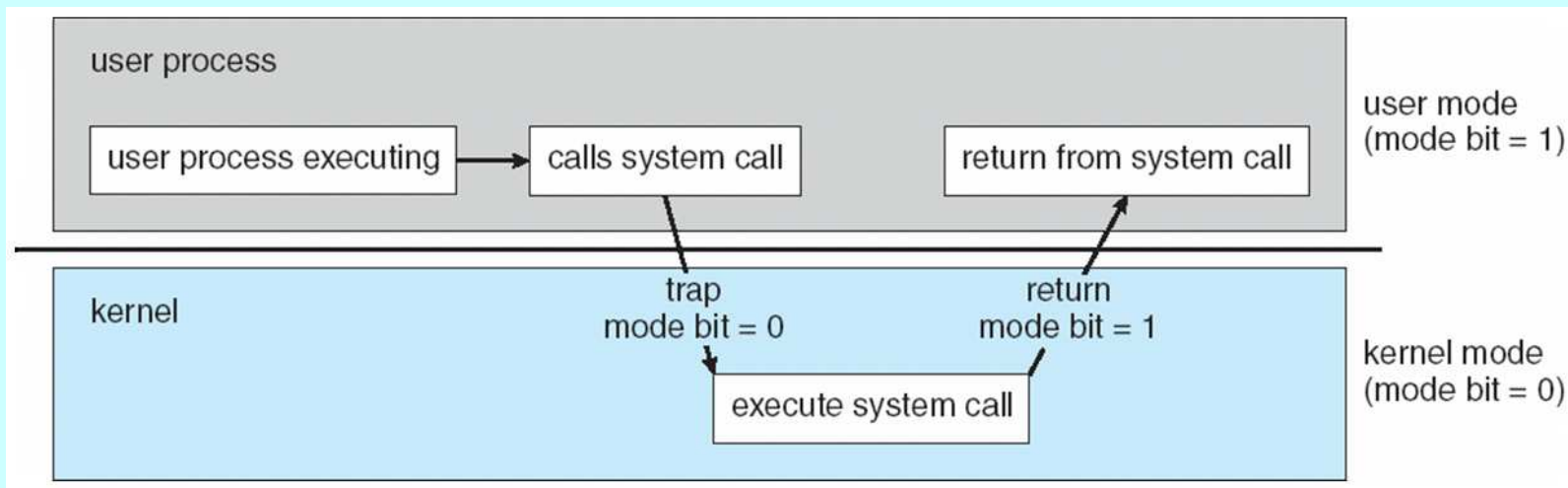
- *Mode bit* added to computer hardware to indicate the current mode: monitor or kernel (0) or user (1).
- When an interrupt or fault occurs hardware switches to monitor mode.



Privileged instructions can be issued only in monitor mode.

Transition from User to Kernel Mode

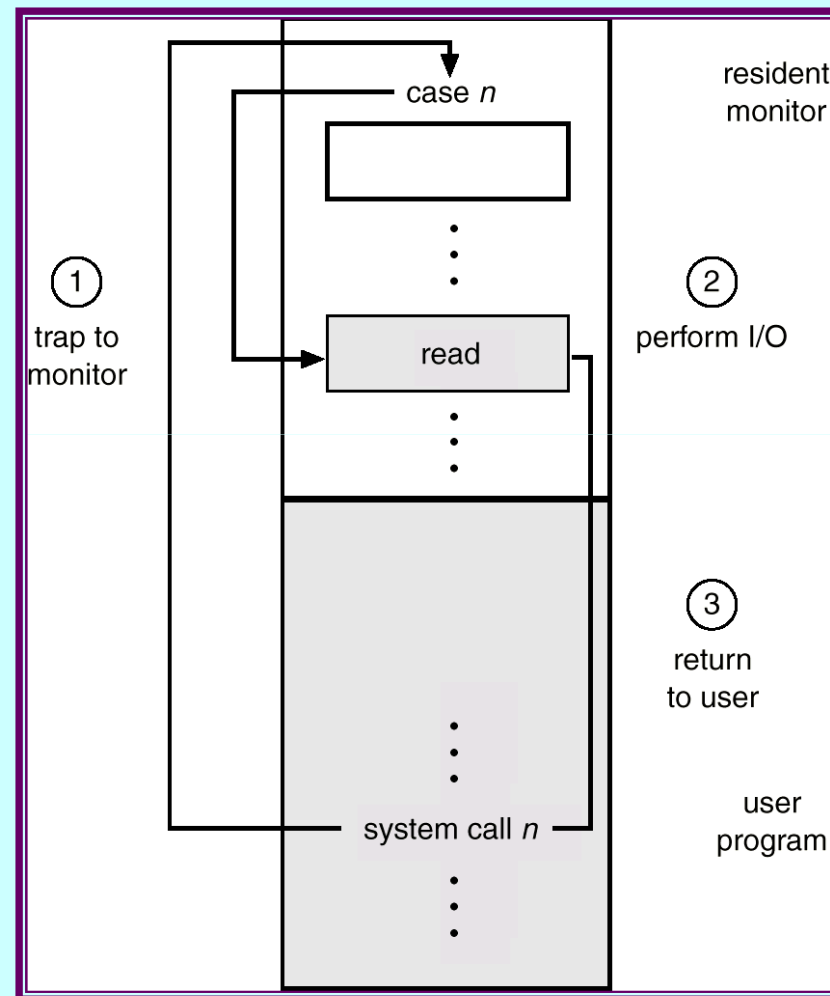
- Timer to prevent infinite loop / process hogging resources
 - 👉 Timer is set to interrupt the computer after some time period
 - 👉 Keep a counter that is decremented by the physical clock.
 - 👉 Operating system set the counter (privileged instruction)
 - 👉 When counter zero generate an interrupt
 - 👉 Set up before scheduling process to regain control or terminate program that exceeds allotted time



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).

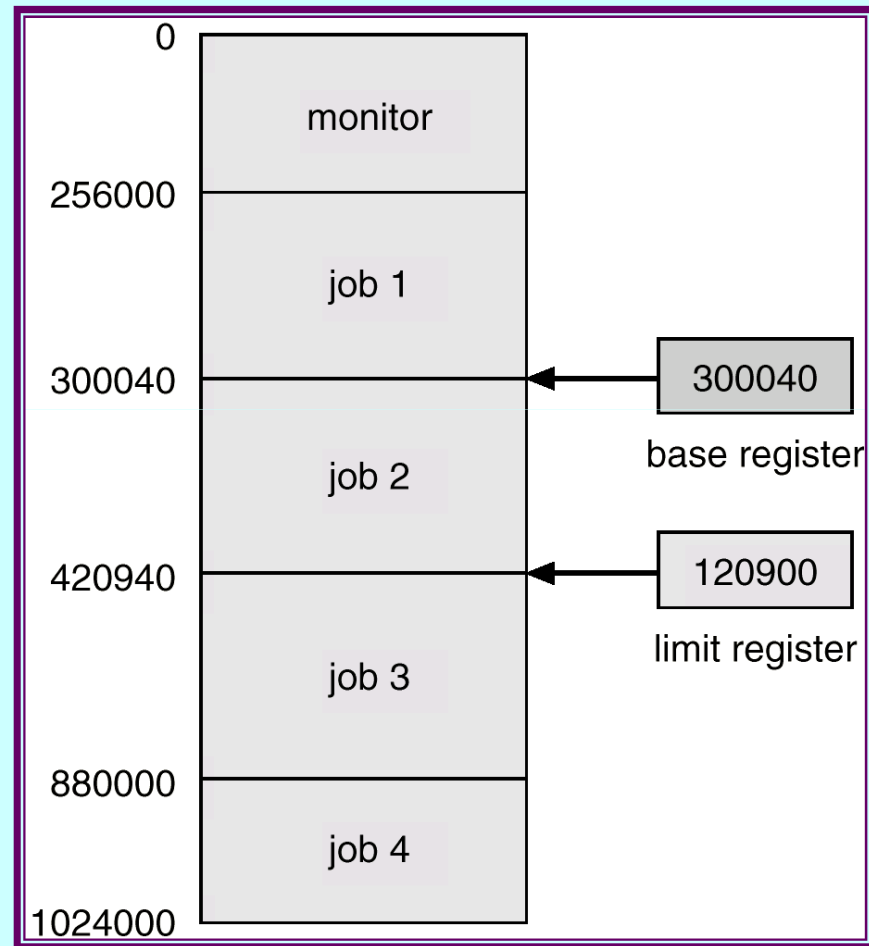
Use of A System Call to Perform I/O



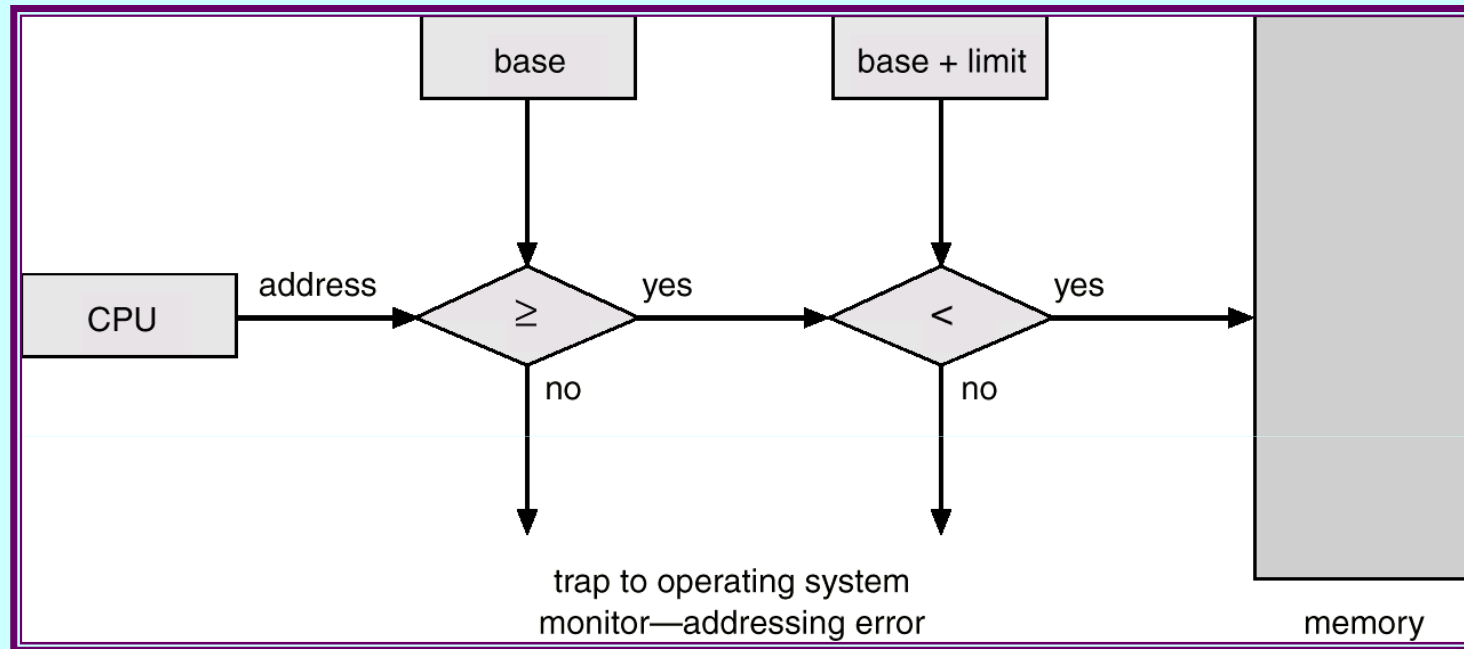
Memory Protection

- 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



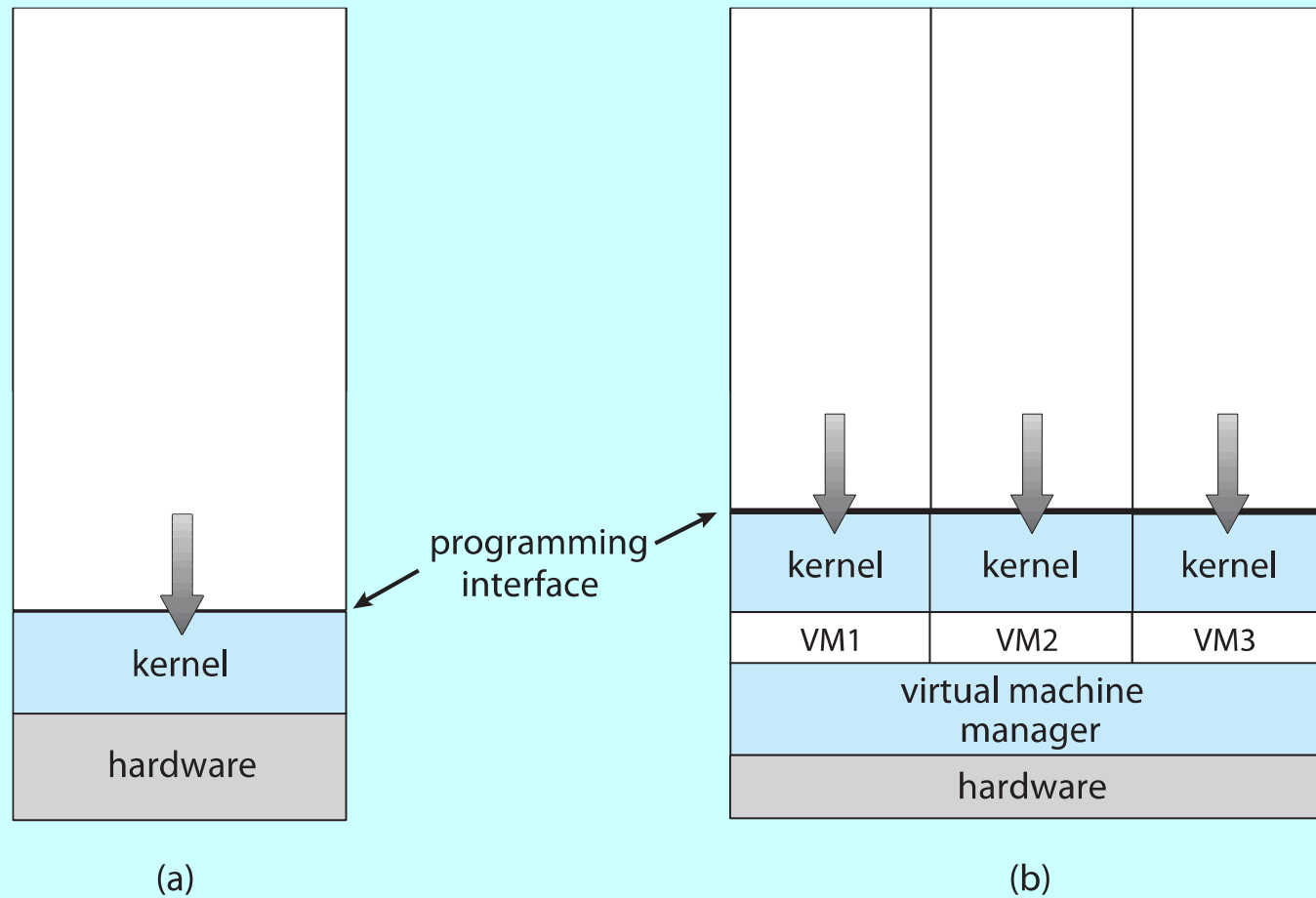
Hardware Protection

- 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.

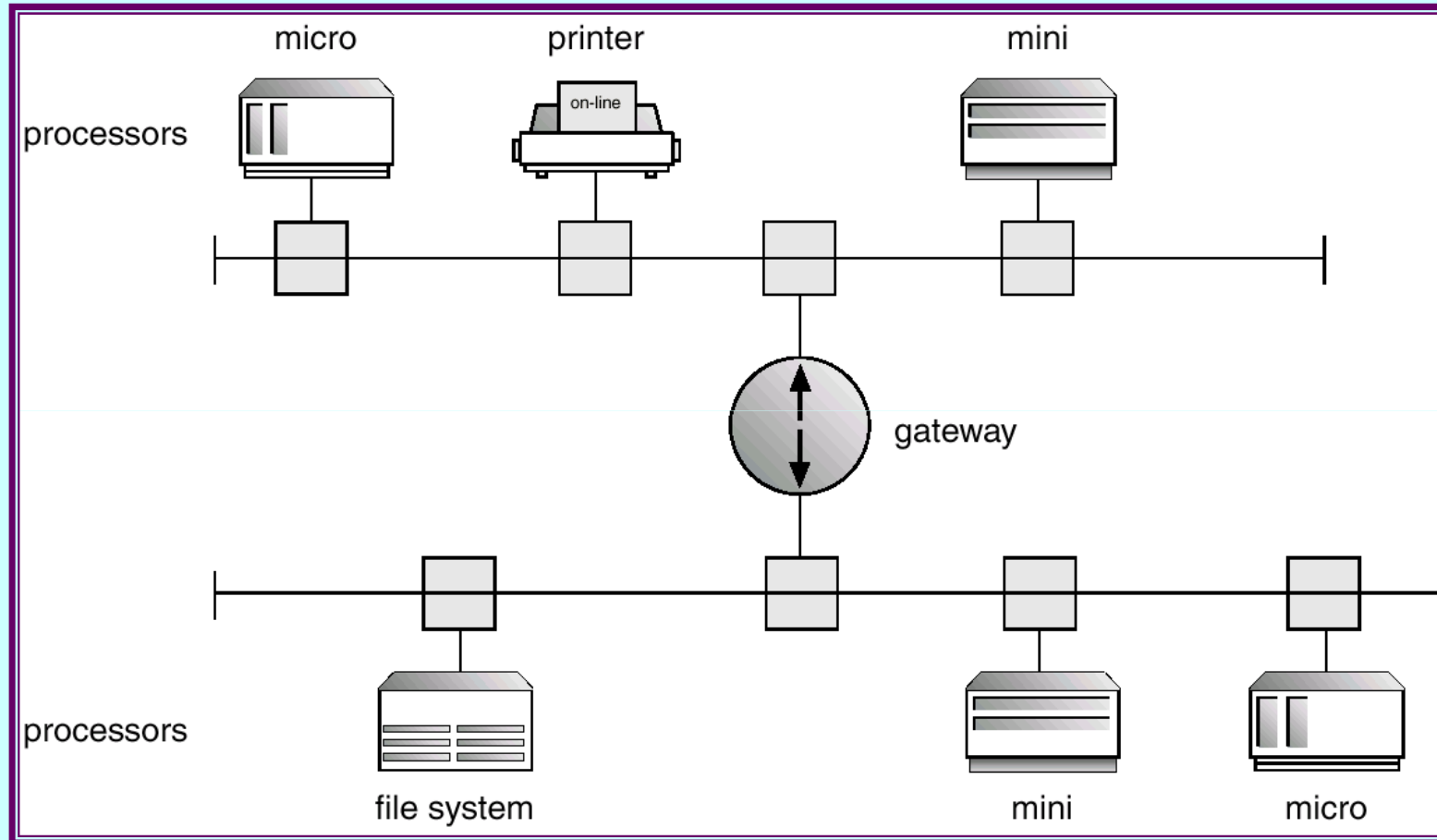
Computing Environments - Virtualization



Network Structure

- Local Area Networks (LAN)
- Wide Area Networks (WAN)

Local Area Network Structure



Wide Area Network Structure

