Computer Fundamentals

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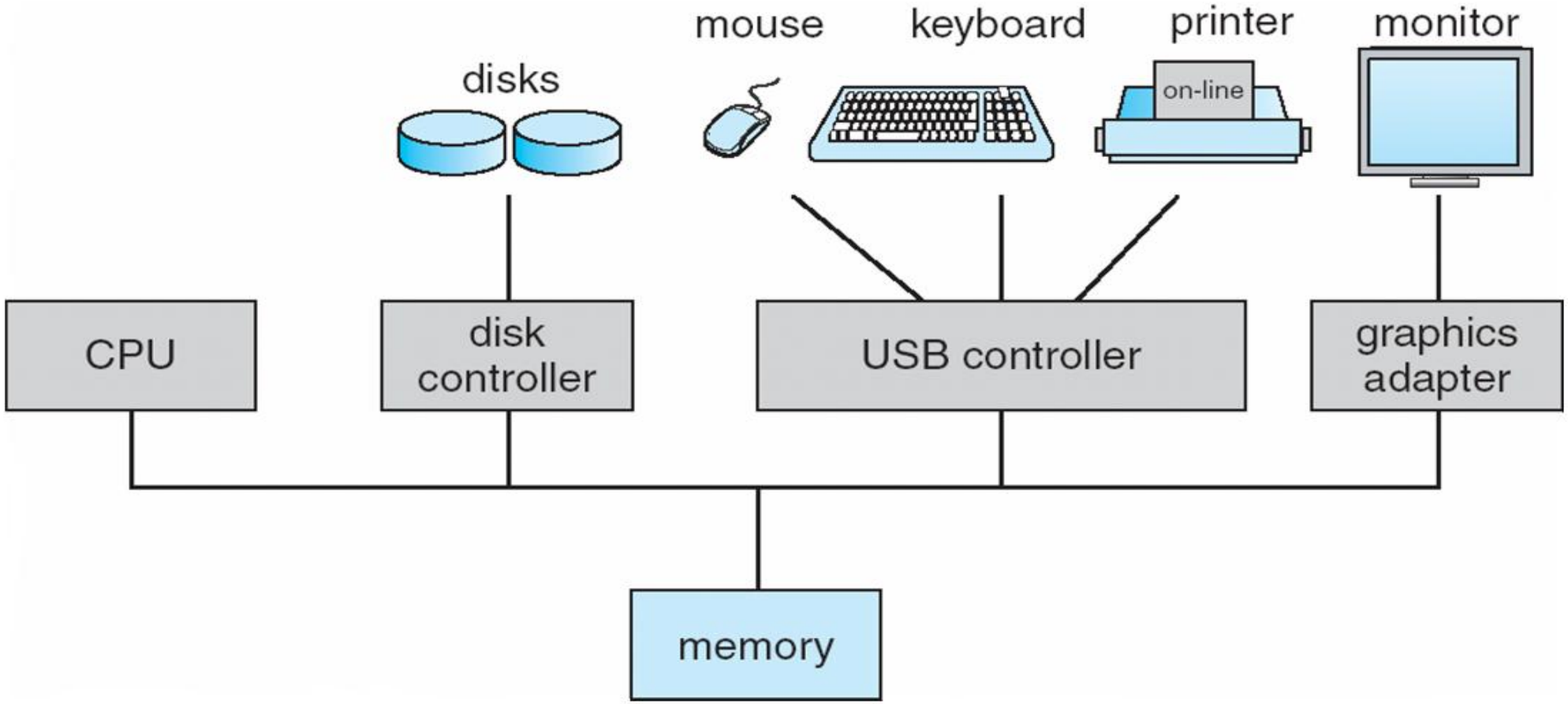
A Computer System

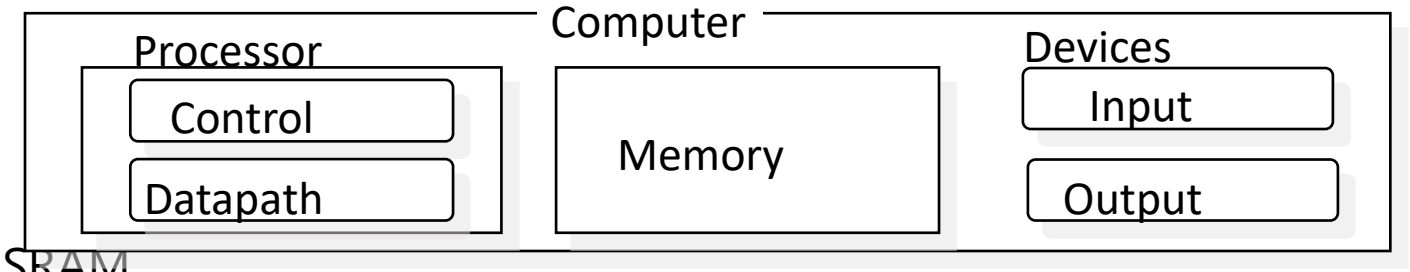


What is computer?

- **Computer is a machine/hardware which does different tasks for the user efficiently and effectively.**
- Since the 1940's, computers have 5 classic components
- Input devices
  - Keyboard, mouse, …
- Output devices
  - Display, printer, …
- Storage devices
  - Volatile memory devices: RAM, DRAM, SRAM, …
  - Permanent storage devices: Magnetic, Optical, and Flash disks, …
- Data path (ALU)
- Control (ROM)

  } Together, they are called the Processor

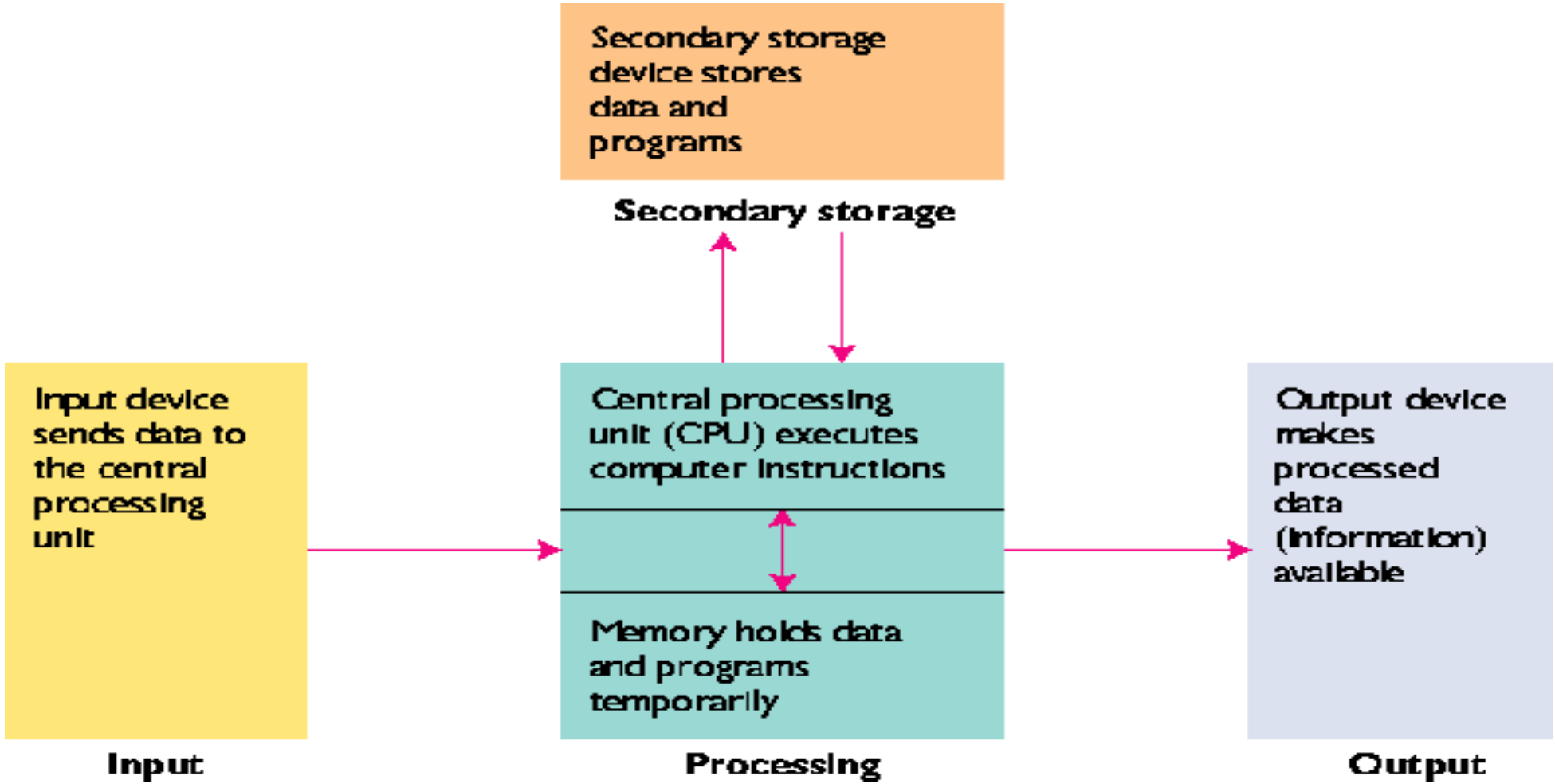
- Newly added 6th component: Network
  - Essential component for communication in any computer system



Computer System Components

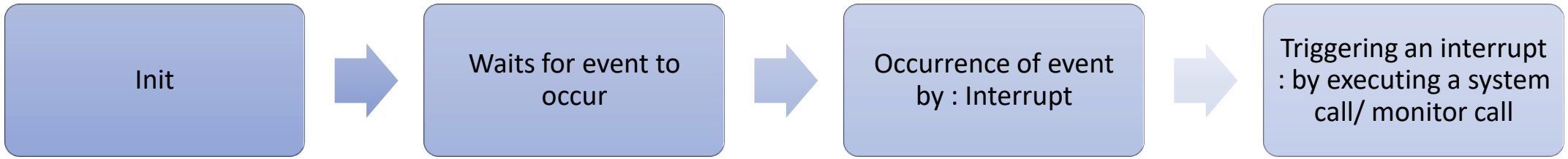
1. **Hardware** – provides basic computing resources (CPU, Memory, I/O devices, Communication).
2. **Operating System** – controls and coordinates use of the hardware among various application programs for various users.
3. **System & Application Programs** – ways in which the system resources are used to solve computing problems of the users (Word processors, Compilers, Web browsers, Database systems, Video games).
4. **Users** – (People, Machines, other computers).

Parts of Computer



What happens when we start a computer?? (Booting Process)

- Hardware doesn't know where the operating system resides and how to load it.
- **Bootstrap Program :**
  - Initial program to run a system
  - Locating and Loading OS Kernel in main memory
- Where it is stored ??? ROM
- What it does???
  - Initialize the system from CPU registers, device controllers and memory controllers



•If any storage device/partition contains one special program called as **"bootstrap program"** in its first sector i.e. in a boot sector then such a device/partition is referred as **bootable device/partition.**

•e.g. hard disk drive, pen drive, CD/DVD

Steps of Booting

1. Machine Boot

- When we switch on the power current gets passed to the motherboard and one program gets invoked named as **"BIOS"** which is exists in the ROM memory on motherboard.
- BIOS -- Basic Input Output System -- which is **a micro-program.**
- A micro-program is a program which is smaller in size and can be stored into the memory with its all possible set of input values.
- first step of BIOS is **"POST" - Power On Self Test**, under POST BIOS checks whether all peripherals are connected properly or not and their working status.
- **"peripherals or peripheral devices" --** devices which are connected to the motherboard externally are called as peripherals.
- after POST BIOS executes **"bootstrap loader",** bootstrap loader searches for available bootable devices and selects any one out of it as per the defined priorities.

2.System boot:

- if hard disk drive got selected as a bootable device and if it contains multiple OS's have installed on it, then "**bootloader**" program gets executes.
- **Boot loader program** displays list of operating system installed onto the machine, so that user can select any one at a time from and it invokes bootstrap program of selected operating system.
- Bootstrap program locates the kernel and load it into the main memory.

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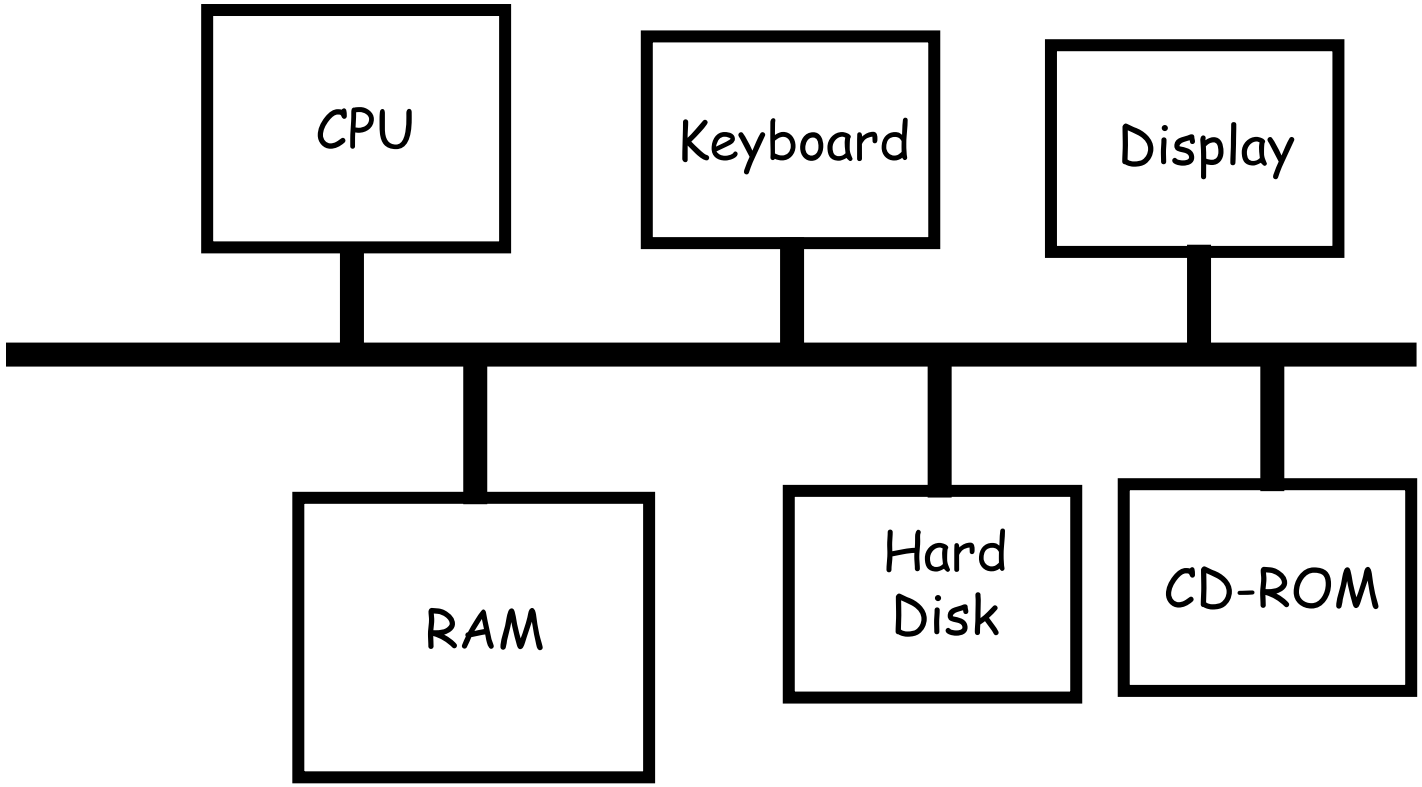
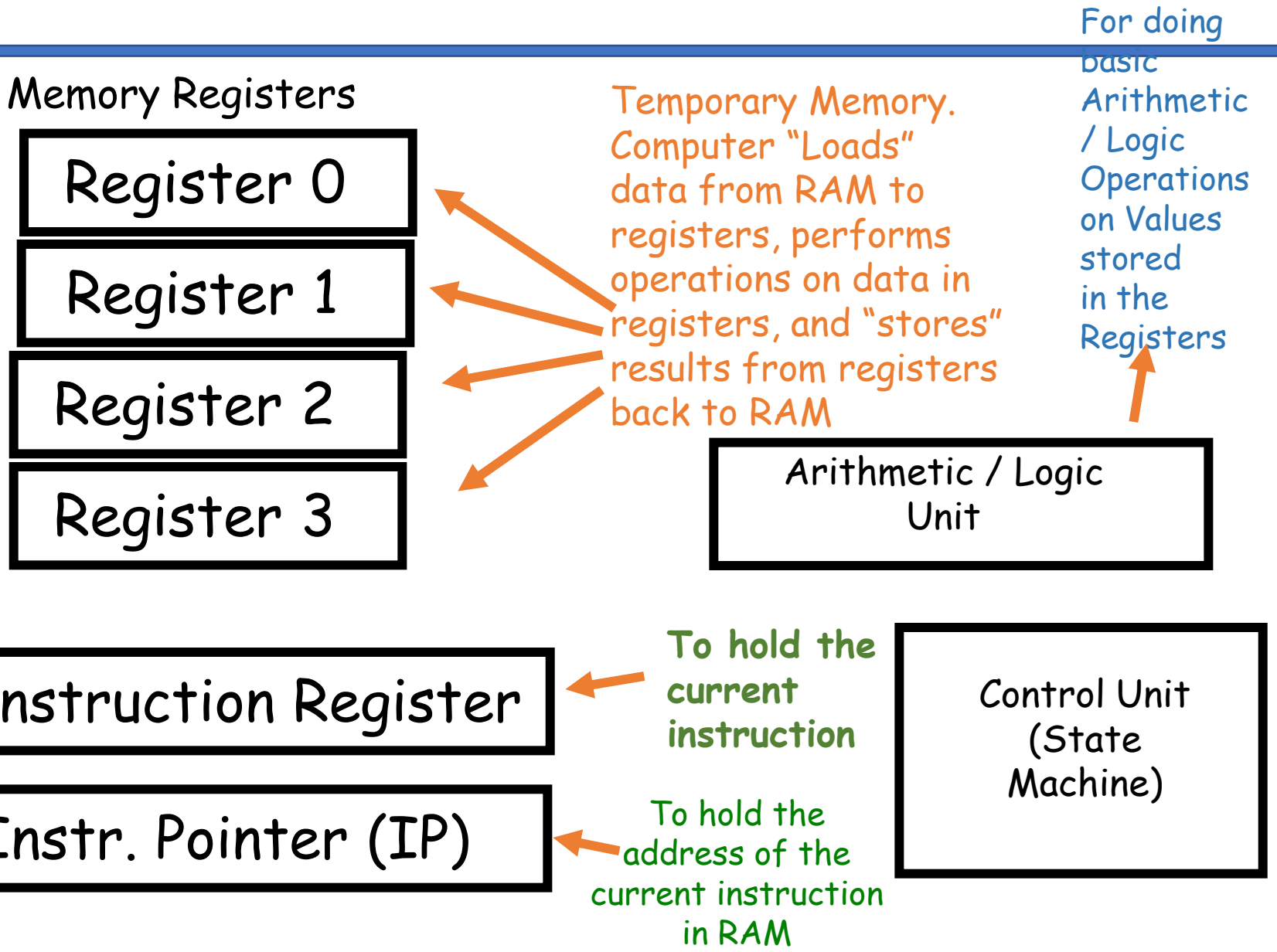


It is a system concept integrating software and hardware to specify the design of computing systems

CPU


Memory Registers
Register 0
Register 1
Register 2
Register 3
Temporary Memory. Computer "Loads" data from RAM to registers, performs operations on data in registers, and "stores" results from registers back to RAM
For doing basic Arithmetic / Logic Operations on Values stored in the Registers
Arithmetic / Logic Unit
Instruction Register
To hold the current instruction
Instr. Pointer (IP)
To hold the address of the current instruction in RAM
Control Unit (State Machine)

Bus,CU,ALU,Memory

Bus

- It is a simplified way for many devices to communicate to each other.
- It is internal arrangement of computer system which includes design of the processor , memory and input/output units.

Control Unit

- Control is responsible for determining what action is to be performed on what data.
- controls all operations and it controls devices which are connected to the computer system by coordinating with device controllers.
- Fetch-Decode-Execute

ALU (Arithmetic Logic Unit)

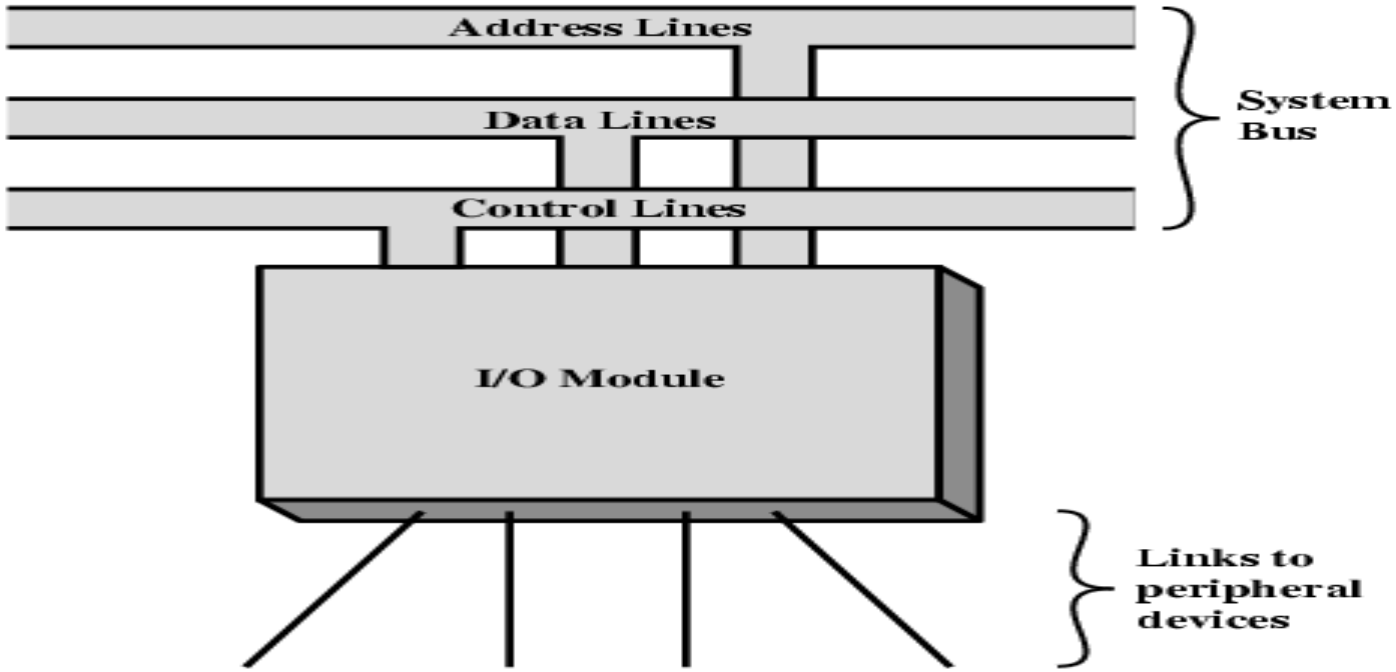
- ALU is mainly comprised of **logic gates**, circuits made from transistors that take inputs.
- ALU performs all arithmetic and logical operations.

Memory

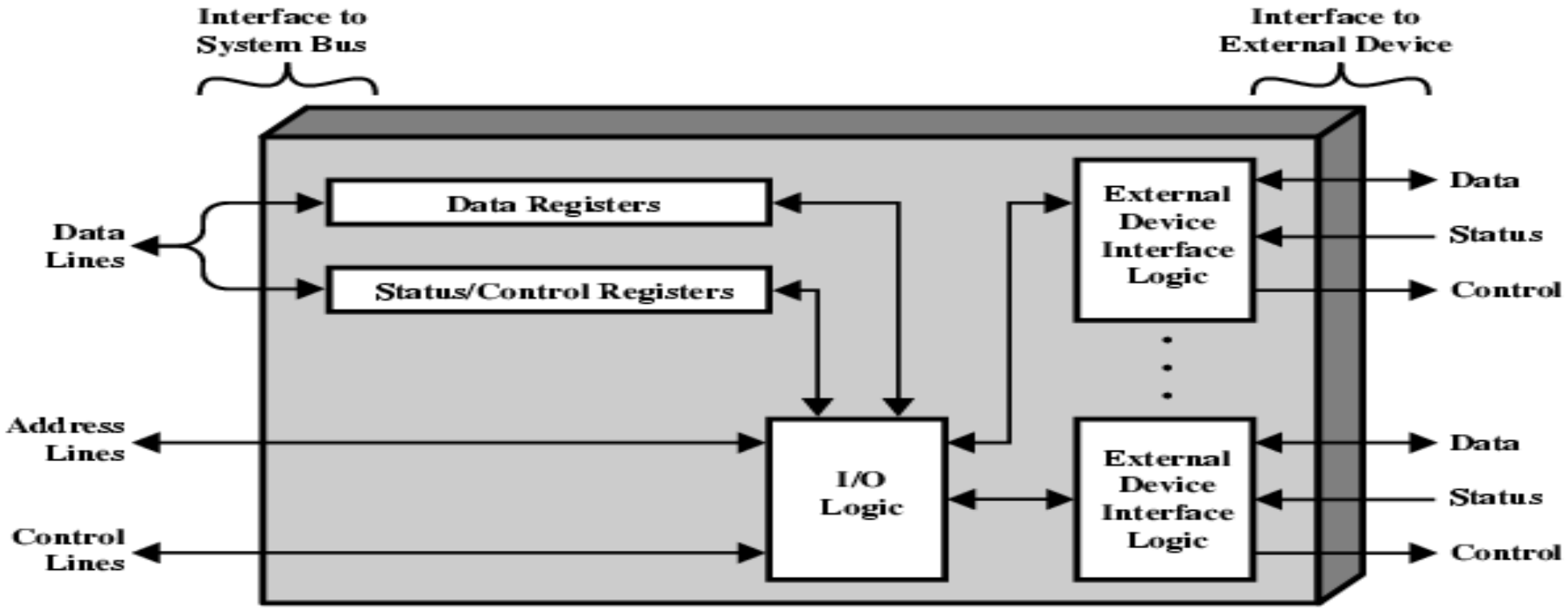
- Memory consists of circuits whose primary purpose is to **hold information**, but only temporarily.
- When you talk about the memory of a computer, most often you're talking about its RAM.

Input/Output

- The Input unit allows programs and data to be entered into the computer.
- The Output unit allows the results of processing to be exported to the outside world or other devices or saved to be used later.



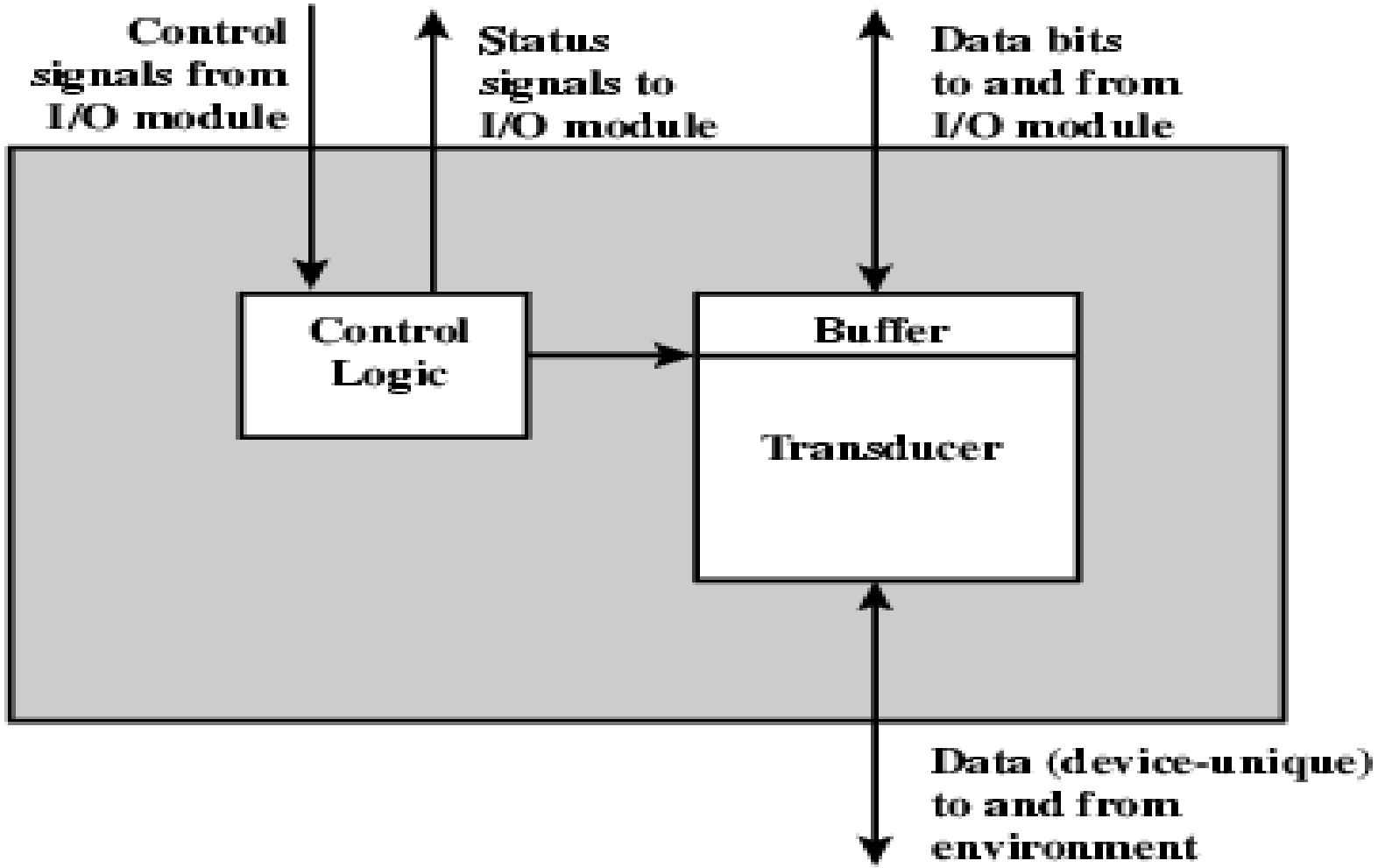
IO Module Diagram



IO Module Functions and Steps

- IO Module Functions
  - Control & Timing
  - CPU Communication
  - Device Communication
  - Data Buffering
  - Error Detection
- IO Steps
  - CPU checks I/O module device status
  - I/O module returns status
  - If ready, CPU requests data transfer
  - I/O module gets data from device
  - I/O module transfers data to CPU

External Device Interface Components



Device Interface Components

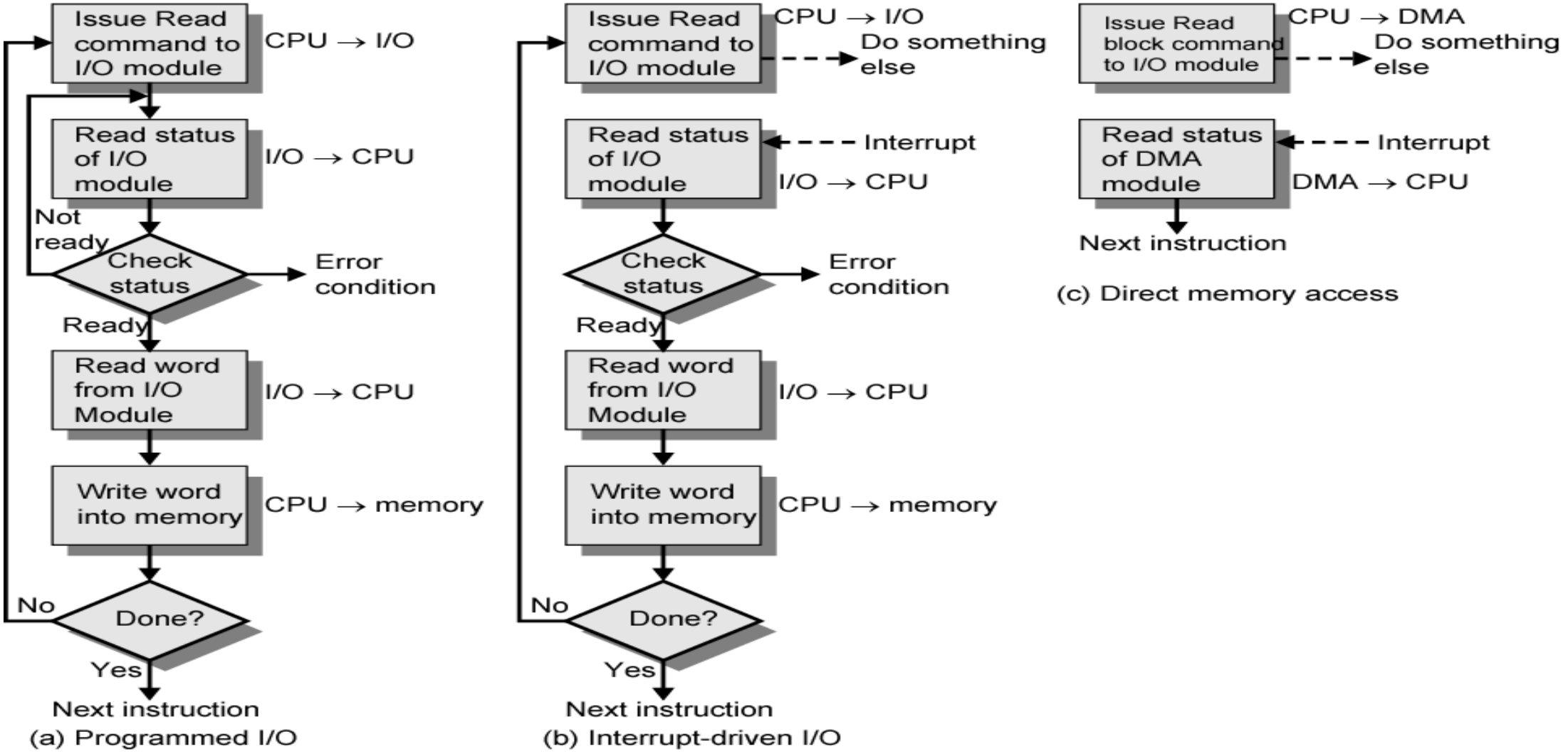
- The **control logic** is the I/O module's interface to the device
- The **data channel** passes the collected data from or the data to be output to the device. On the opposite end is the I/O module, but eventually it is the processor.
- The **transducer** acts as a converter between the digital data of the I/O module and the signals of the outside world.
  - Keyboard converts motion of key into data representing key pressed or released
  - Temperature sensor converts amount of heat into a digital value
  - Disk drive converts data to electronic signals for controlling the read/write head

Input Output Techniques

- Communication between memory and IO devices.

- IO Techniques:
  - Programmed IO:
    - CPU waits for IO operations to be completed
    - As CPU is faster so time is wasted
  - Interrupt driven IO
    - CPU issues a command, and proceed for its work until interrupt by IO device
  - Direct Memory Access (DMA)
    - transferring data within main memory and external device without passing it through the CPU.

IO Techniques for Input of a Block of Data



Programmed I/O

- CPU has direct control over I/O
  - Sensing status
  - Read/write commands
  - Transferring data
- CPU waits for I/O module to complete operation
- Four IO Commands : Control, Test, Read, Write

CPU requests I/O operation

I/O module performs operation

I/O module sets status bits

CPU checks status bits periodically

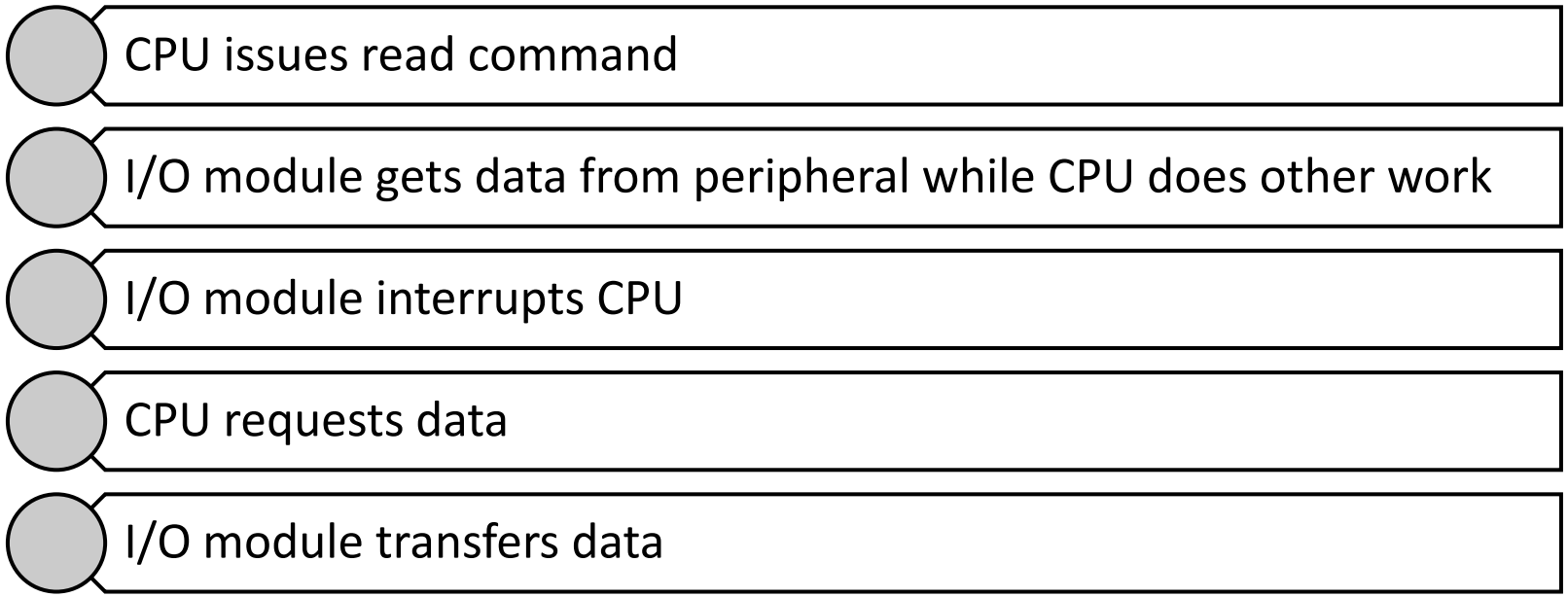
I/O module does not inform CPU directly

I/O module does not interrupt CPU

CPU may wait or come back later

Interrupt Driven I/O

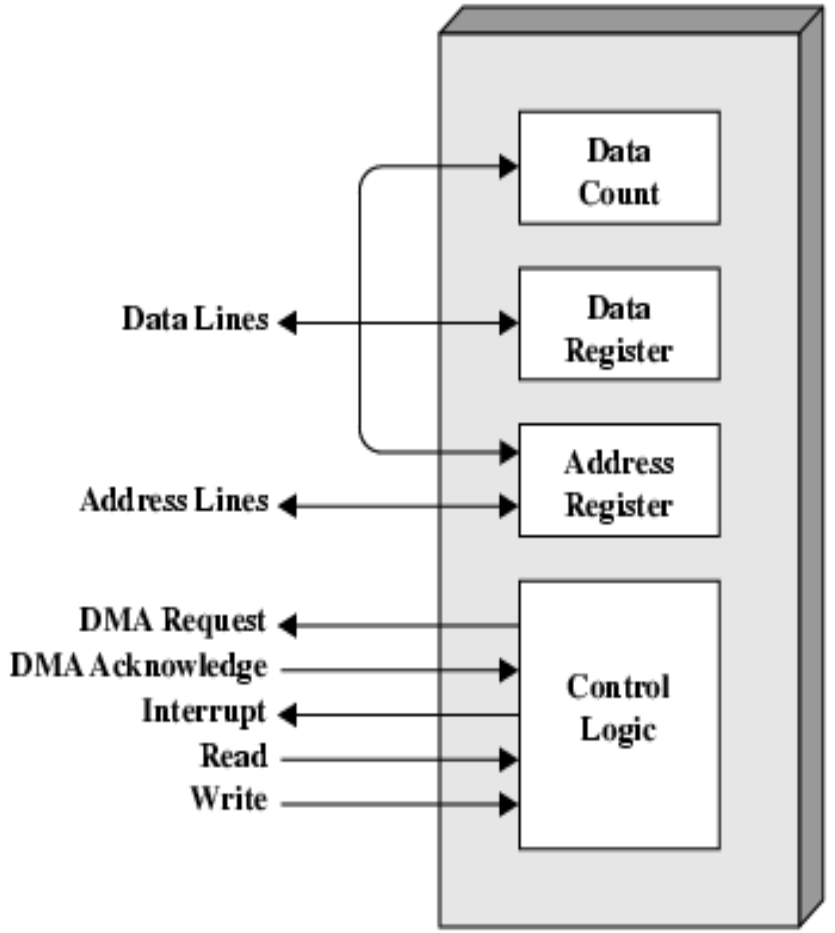
- Overcomes CPU waiting
- No repeated CPU checking of device
- I/O module interrupts when ready
- ISR (Interrupt Service Routine)
  - the processors enter an ISR
- **IVT and ISR**



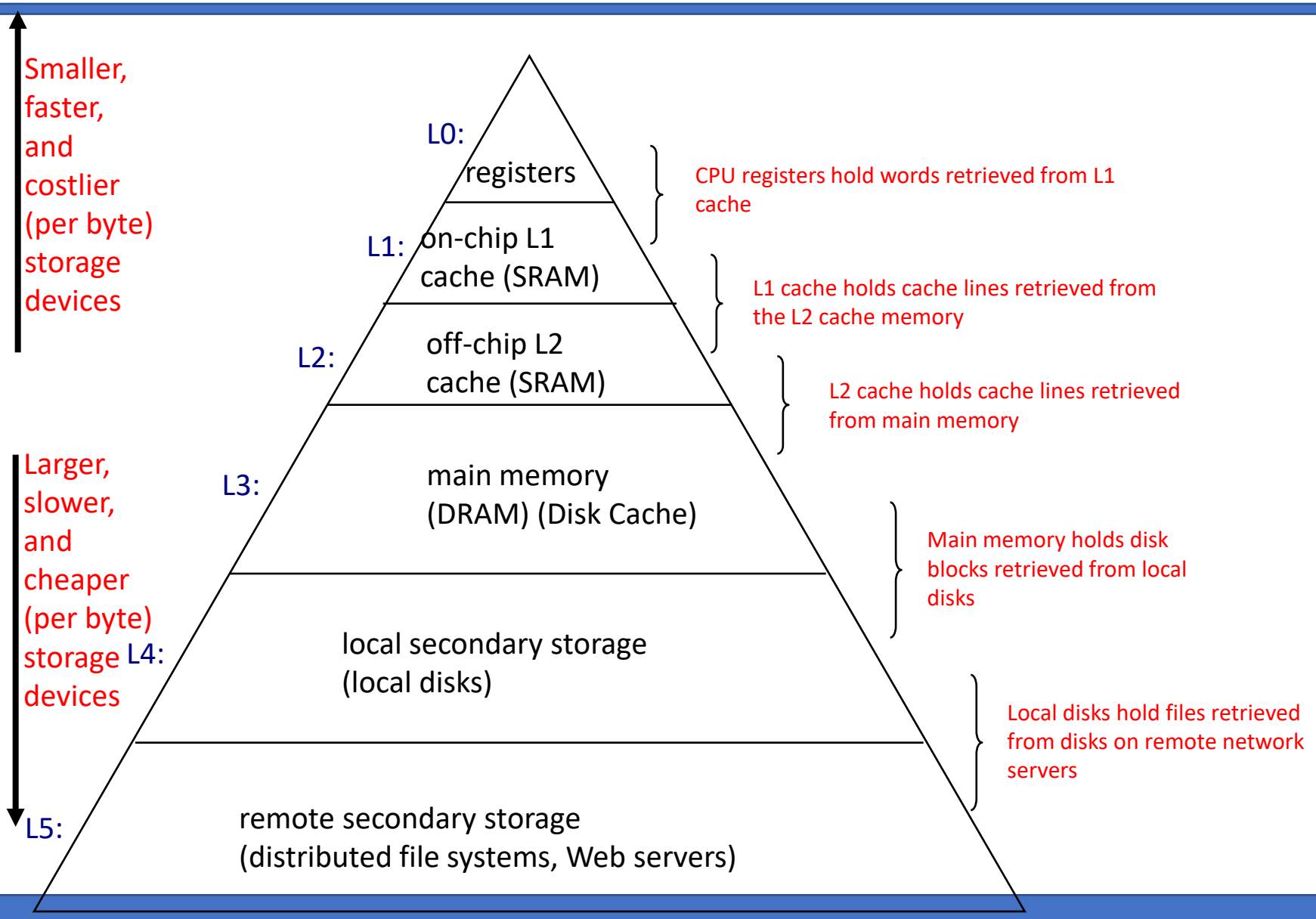
Direct Memory Access

- Interrupt driven and programmed I/O require active CPU intervention
  - Transfer rate is limited
  - CPU is tied up
- DMA Operations:
  - When the processor wishes read or send a block of data, it issues a command to the DMA module by sending some information to DMA module.
  - The information includes:
    - read or write command, sending **through read and write control lines**.
    - number of words to be read or written, communicated on the **data lines** and stored in the **data count register.**
    - starting location in memory to read from or write to, communicated on data lines and stored in the **address register**.
    - **address of the I/O device** involved, communicated on the **data lines**.

  When the transfer is complete, the DMA module sends an interrupt signal to the processor to inform that it has finish using the system bus



Memory Hierarchy



Hierarchy List

- Registers
- L1 Cache
- L2 Cache
- Main memory
- Disk cache
- Disk
- Optical
- Tape

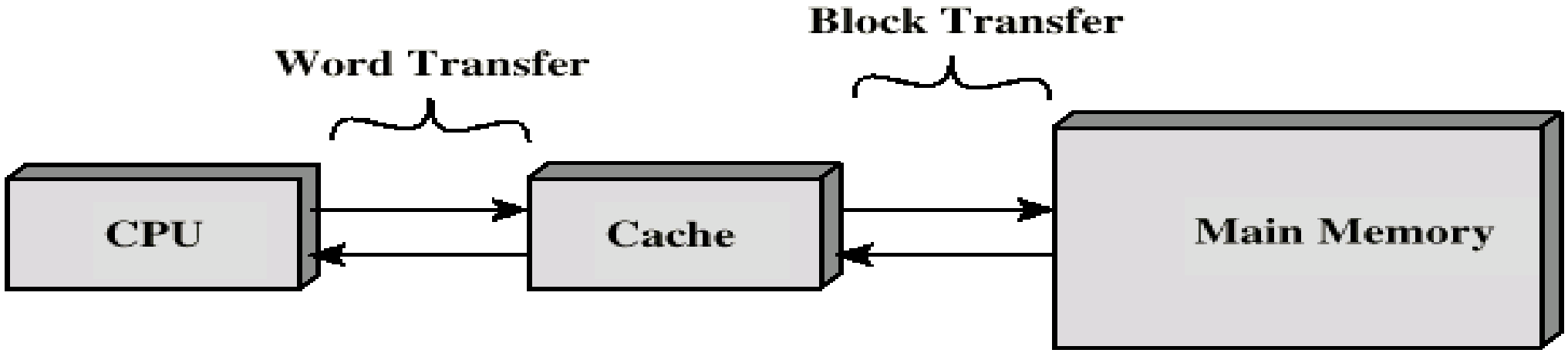
- As one goes down the hierarchy
  - Decreasing cost per bit
  - Increasing capacity
  - Increasing access time
  - Decreasing frequency of access of the memory by the processor – locality of reference

Memory Access Method

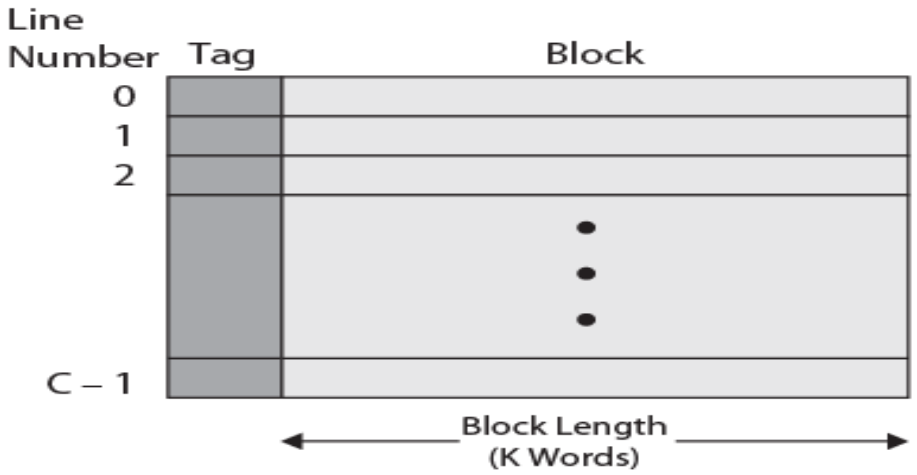
Sequential	Direct	Random	Associative
• Start at the beginning and read through in order • Access time depends on location of data and previous location • e.g. tape	• Individual blocks have unique address • Access is by jumping to vicinity plus sequential search • Access time depends on location and previous location • e.g. disk	• Individual addresses identify locations exactly • Access time is independent of location or previous access • e.g. RAM	• Data is located by a comparison with contents of a portion of the store • Access time is independent of location or previous access • e.g. cache

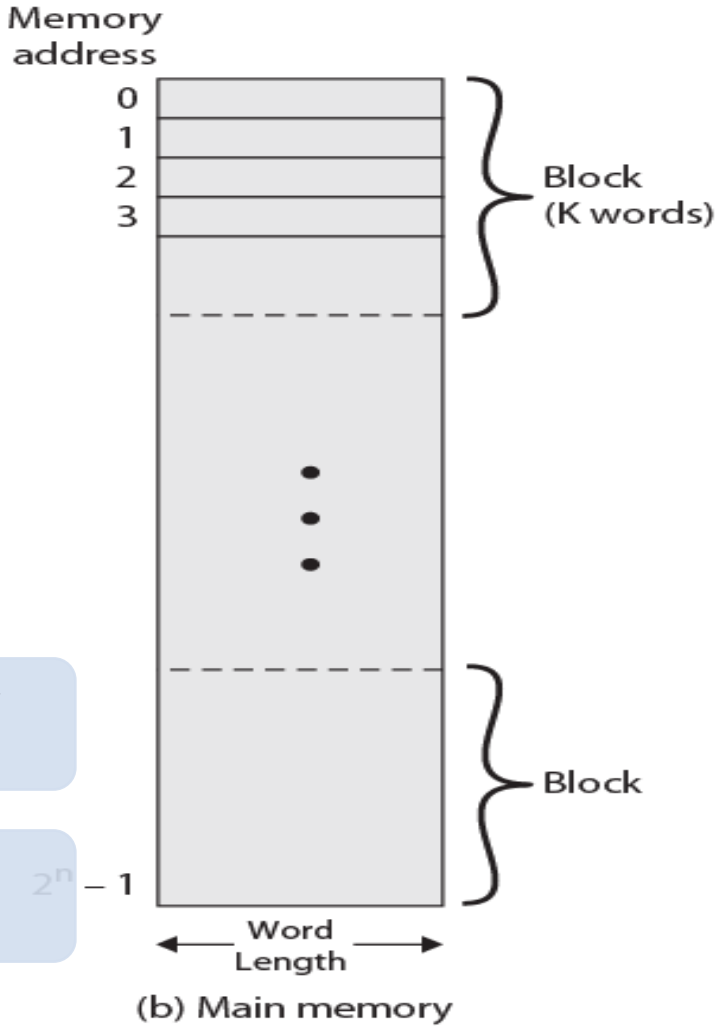
Cache & Main Memory

- Small amount of fast memory
- Sits between normal main memory and CPU
- May be located on CPU chip or module
  - An entire blocks of data is copied from memory to the cache because the principle of locality tells us that once a byte is accessed, it is likely that a nearby data element will be needed soon.



Cache/Main Memory Structure





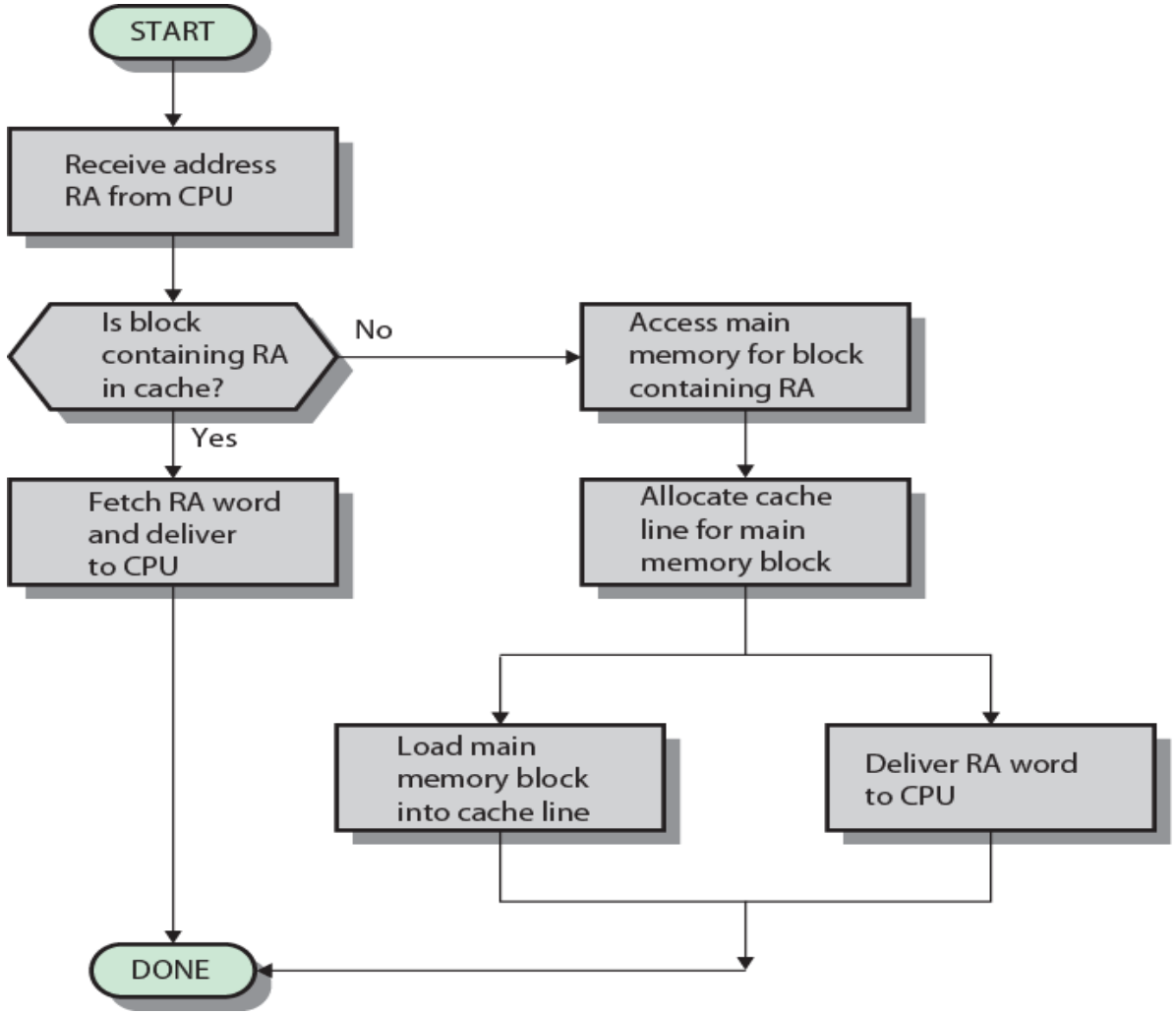
A Hit

- is when data is found at a given memory level.

A *miss*

- is when it is not found.

Cache Operations



- CPU requests contents of memory location
- Check cache for this data
- If present, get from cache (fast)
- If not present, read required block from main memory to cache
- Then deliver from cache to CPU
- Cache includes tags to identify which block of main memory is in each cache slot

Random-Access Memory (RAM)

- Key features
  - RAM is packaged as a chip, Basic storage unit is a cell (one bit per cell)
  - Its internal memory of the CPU for storing data, program, and program result
  - Used for Read/ Write
  - Volatile (Temporary Storage)

Static RAM (SRAM)
• memory retains its contents as long as power is being supplied. • Made up of transistor • Static because it doesn't need to be refreshed • SRAM is more often used for system cache. • SRAM is faster than DRAM

Dynamic RAM (DRAM)
• memory must be constantly refreshed or it will lose its contents. • This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second • Made up of memory cells composed of capacitors and one transistor. • DRAM is typically used for the main memory in computing devices

ROM(Read Only Memory)

- The memory from which we can only read but cannot write on it.
- This type of memory is non-volatile.
- The information is stored permanently in such memories during manufacture.
- A ROM stores such instructions that are required to start a computer. This operation is referred to as **bootstrap.**
- **Different Types of ROM:**
  - MROM (Masked ROM)
  - PROM (Programmable Read Only Memory)
  - EPROM (Erasable and Programmable Read Only Memory)
  - EEPROM (Electrically Erasable and Programmable Read Only Memory)

Thank You