Computer Fundamentals and C Programming

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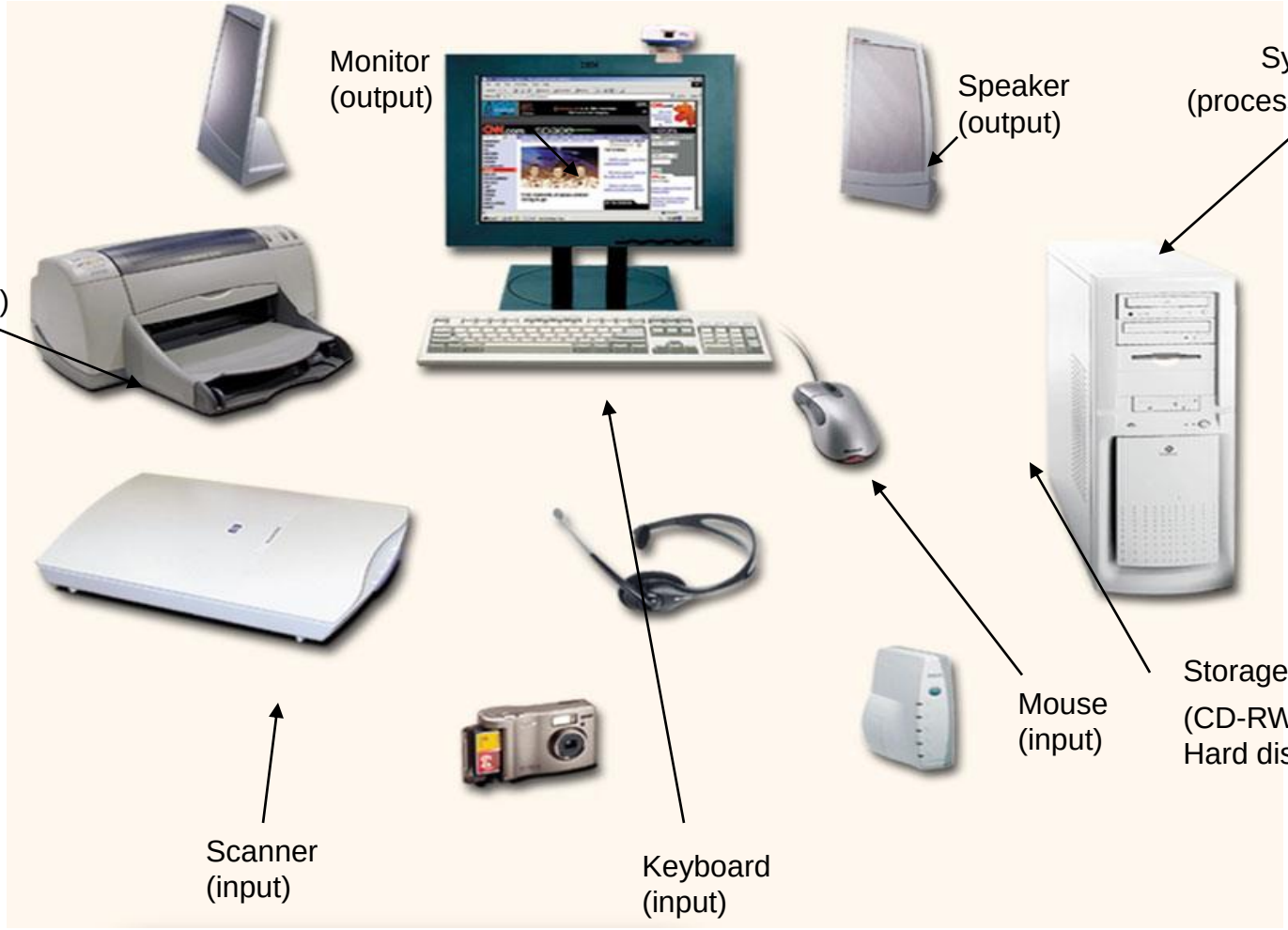
What Is A Computer?

A computer is an electronic device,

- Accepts input
- Processes data
- Stores data
- Produces output

Hardware Devices that comprise a computer system



Types of Computers

Different Types of Computer

Super Computer

- PARAM 10000 which was developed in India by C-DAC ,Pune
- IBM Deep Blue which was specially designed for playing chess
- Tianhe-2 which was developed in china

Mainframe Computer

- IBM Z890
- Hitachi's Z800

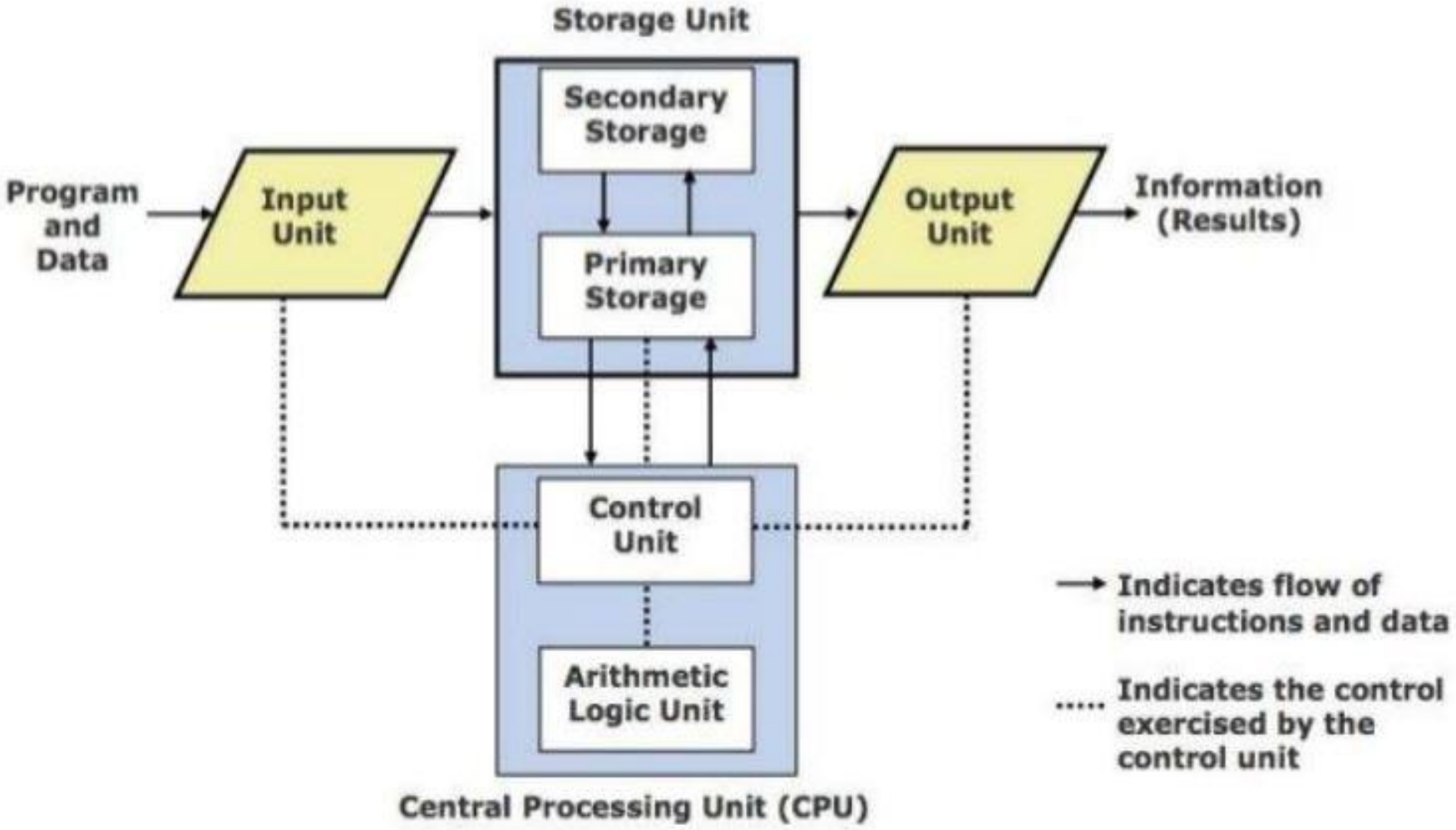
Mini Computer

- VAX
- Texas Instrument TI-990

Micro Computer

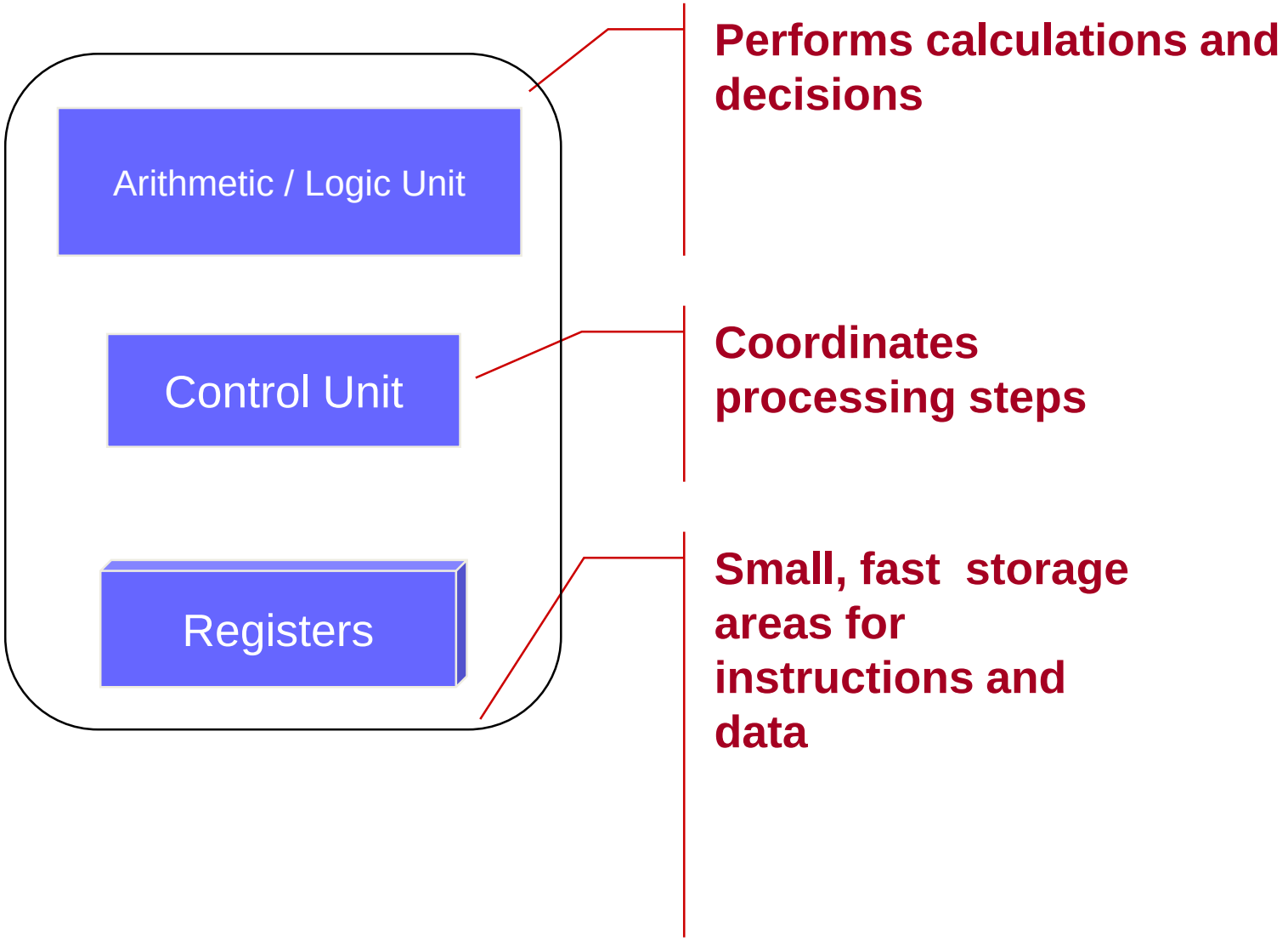
- Desktop Computers [PC]
- Laptop
- PDA | Palmtop
- Tablet PC

Basic Organization of a Computer System



CPU

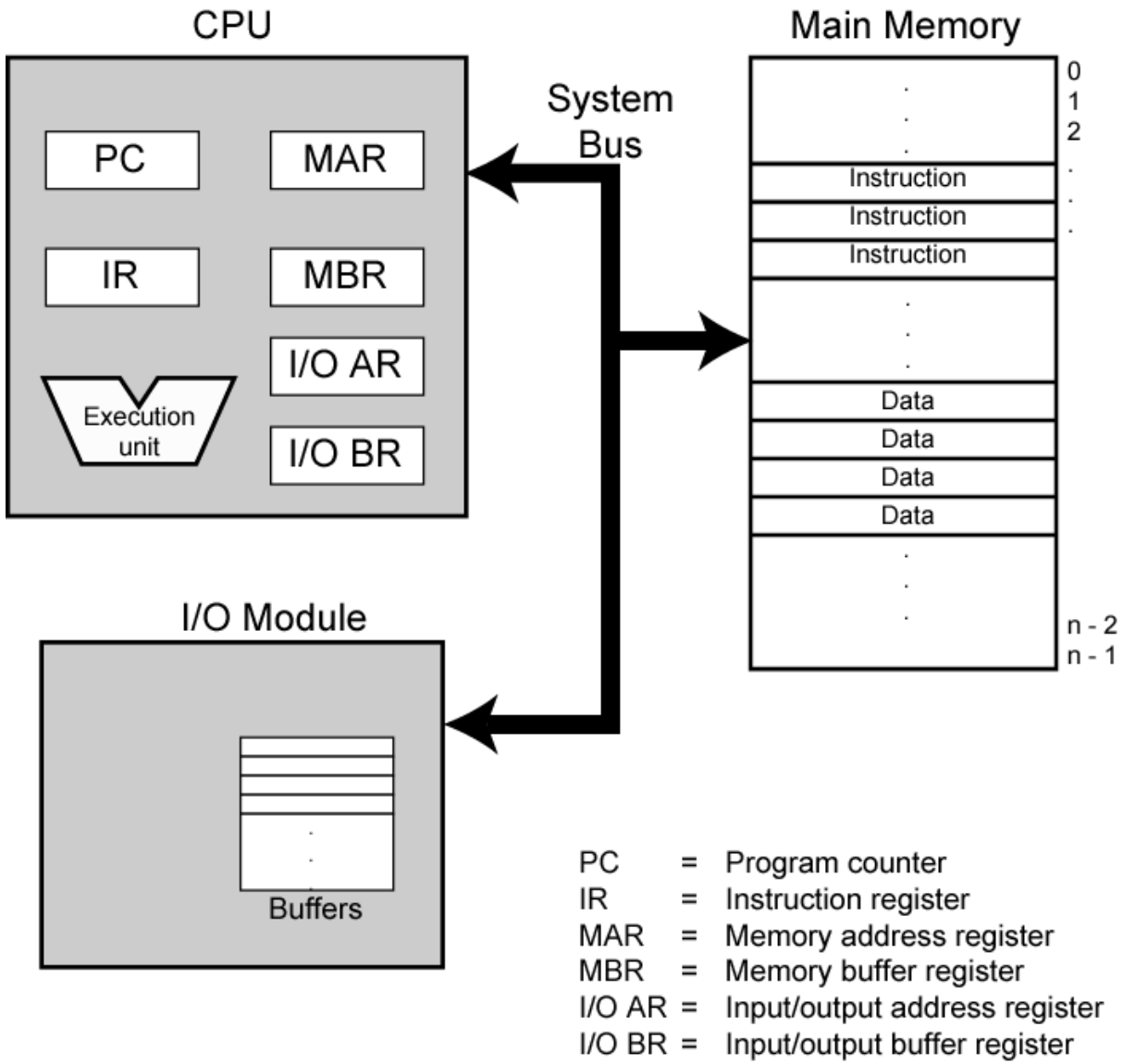
- The **CPU** is a silicon chip that contains millions of tiny electrical components.
- The **CPU's** three main parts are:
  - Control Unit
  - Arithmetic Logic Unit (ALU)
  - Registers


Arithmetic / Logic Unit
Control Unit
Registers
Performs calculations and decisions
Coordinates processing steps
Small, fast storage areas for instructions and data

Inside the CPU of a computer

1. Power Supply
2. Motherboard
3. CD/DVD Drive
4. Cooling Fan
5. Processor
6. RAM
7. Sound Card
8. Video Card
9. Hard Disk Drive

Computer Components: Top Level View



Registers

- **Registers** are small, fast memory **within the CPU**
- Different registers hold different things like instructions and addresses of instructions, data (operands) and results of operations

Two types

1. Special Purpose Registers contain specific information the CPU needs.

- Instruction Register (IR) contains the actual instruction which is currently being executed by the CPU.
- The Program Counter (PC) contains the address of the next instruction to be executed by the program.

2.General Purpose Registers hold:

- the operands for arithmetic and logical operations (ie. the values on which the operation will be performed)
- the results of such operations
- So General Purpose Registers are used for holding and manipulating data used by the CPU

Memory

Memory

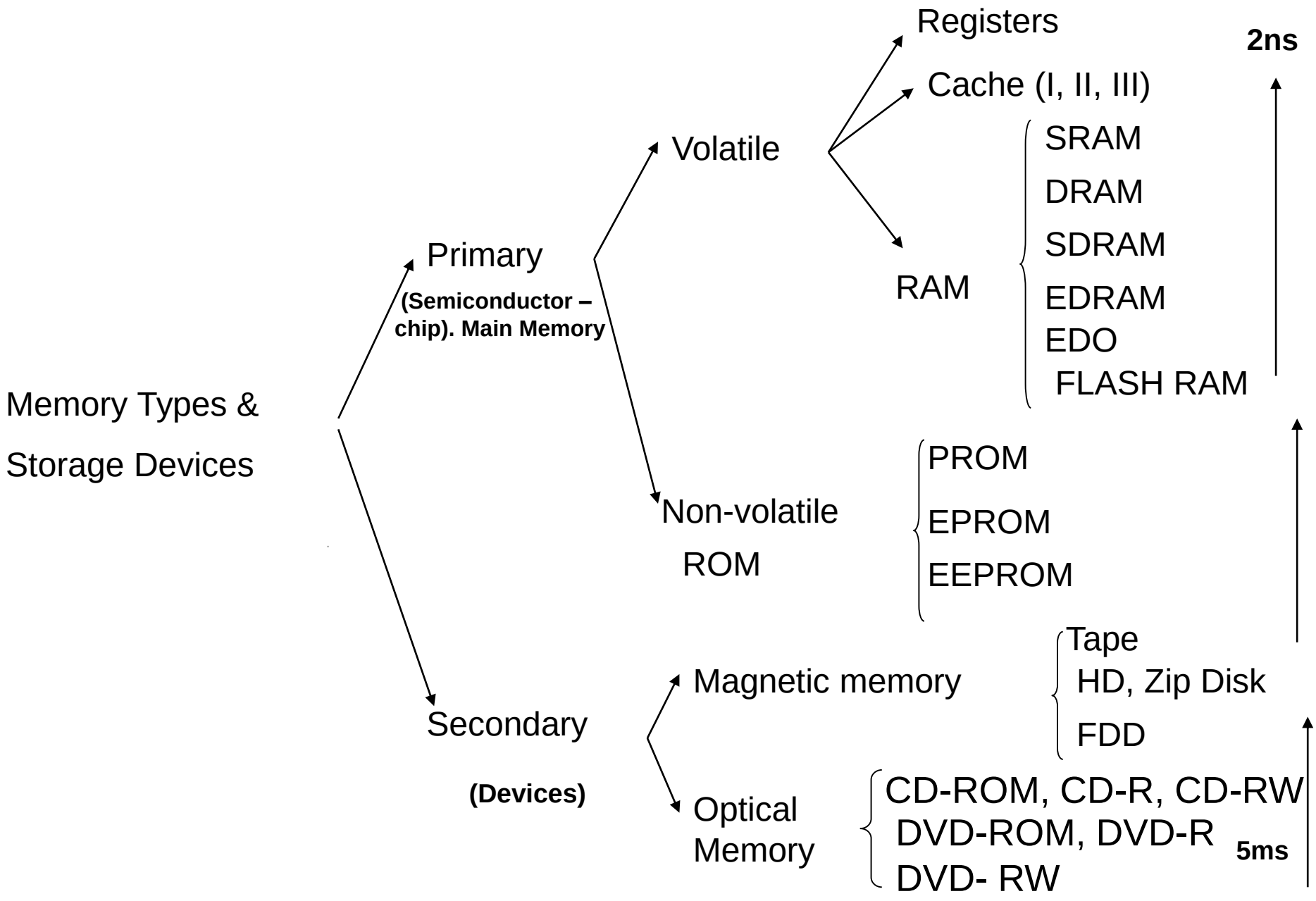
Computer Memory : millions/billions of on/off charges

- **Bits:** 0 or 1
- **Bytes**: Groups of 8 bits, A byte is the smallest unit of storage. (Can hold one text character)
- **Words:** Groups of bits/bytes (8, 16, 32, 64-bits)

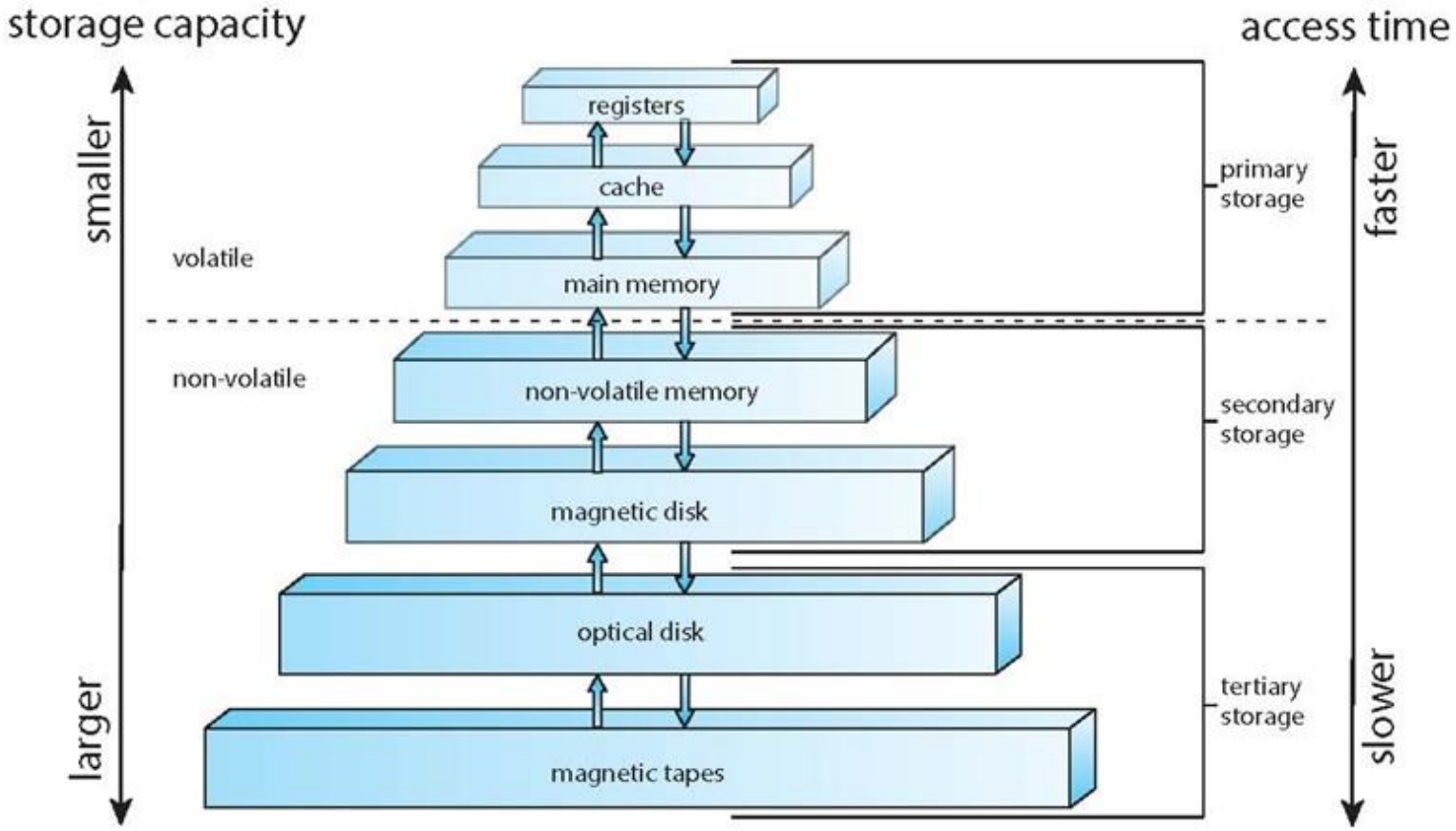
Storage is usually too large to be expressed in bytes or words.

- **Kilobyte (KB)** = 1024 bytes (2^{10} bytes)
- **Megabyte (MB)** = 1024 x 1024 bytes or one million bytes (2^{20} bytes)
- **Gigabyte (GB)** = 1024 x 1024 x 1024 bytes or 1 trillion bytes (2^{30} bytes)
- **Terabyte (TB)** = 1024 x 1024 x 1024 x 1024 bytes one quadrillion bytes (2^{40} bytes)

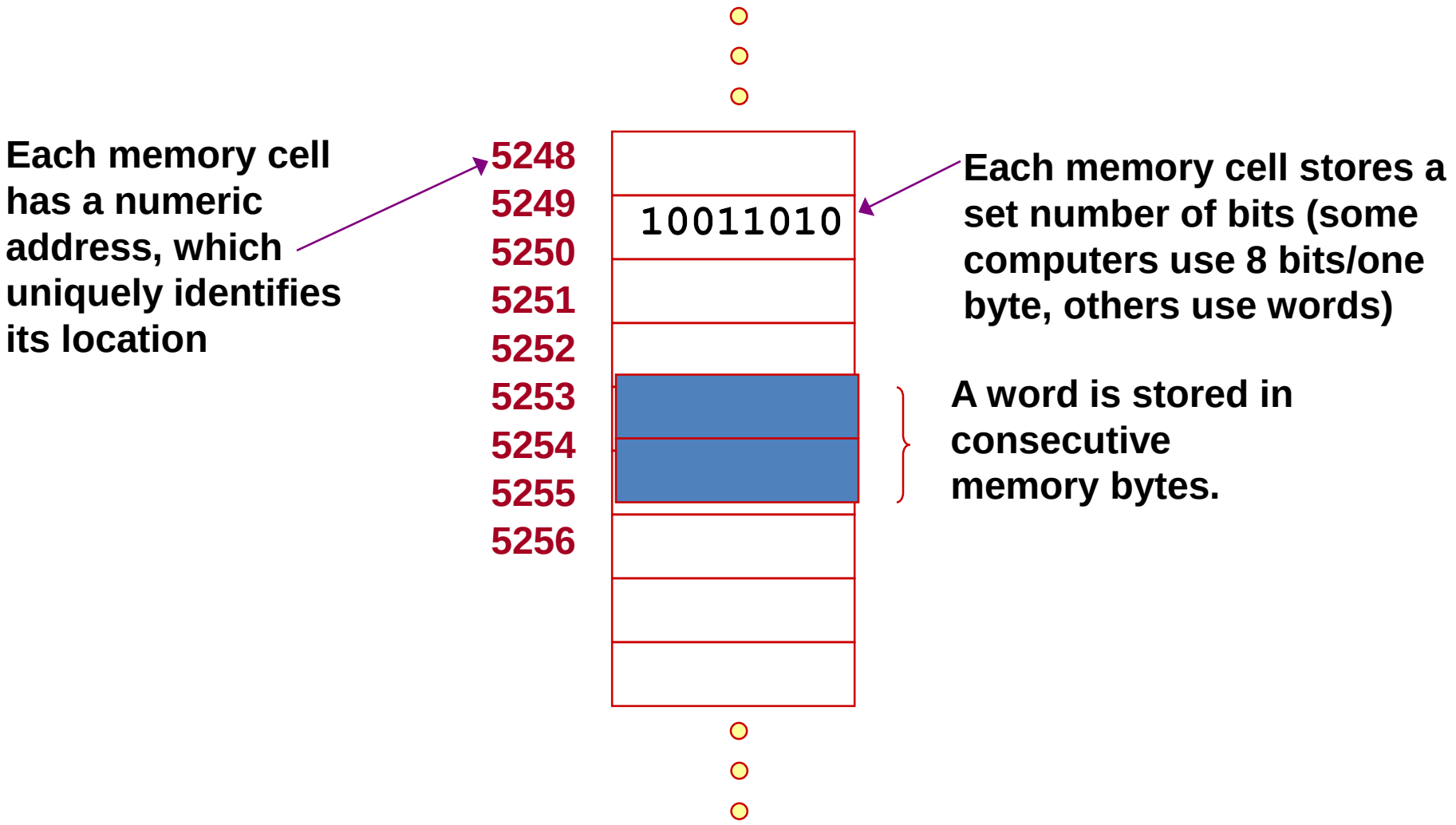
MEMORY CLASSIFICATION



Memory


storage capacity
access time
smaller
larger
faster
slower
volatile
non-volatile
registers
cache
main memory
non-volatile memory
magnetic disk
optical disk
magnetic tapes
primary storage
secondary storage
tertiary storage

Main Memory


Each memory cell has a numeric address, which uniquely identifies its location
5248
5249
5250
5251
5252
5253
5254
5255
5256
10011010
Each memory cell stores a set number of bits (some computers use 8 bits/one byte, others use words)
A word is stored in consecutive memory bytes.

Random Access Memory (RAM) –

- It is also called as ***read write memory*** or the ***main memory*** or the ***primary memory***.
- The programs and data that the CPU requires during execution of a program are stored in this memory.
- It is a volatile memory as the data loses when the power is turned off.
  - RAM is further classified into two types- *SRAM (Static Random Access Memory)* and *DRAM (Dynamic Random Access Memory)*.

DRAM	SRAM
1. Constructed of tiny capacitors that leak electricity.	1.Constructed of circuits similar to D flip-flops.
2.Requires a recharge every few milliseconds to maintain its data.	2.Holds its contents as long as power is available.
3.Inexpensive.	3.Expensive.
4. Slower than SRAM.	4. Faster than DRAM.
5. Can store many bits per chip.	5. Can not store many bits per chip.
6. Uses less power.	6.Uses more power.
7.Generates less heat.	7.Generates more heat.
8. Used for main memory.	8. Used for cache.

Difference between SRAM and DRAM

Read Only Memory (ROM) –

- Stores crucial information essential to operate the system, like the program essential to boot the computer.
  - It is not volatile.
  - Always retains its data.
- Used in embedded systems or where the programming needs no change.
- Used in calculators and peripheral devices.

Types of Read Only Memory (ROM) –

- **PROM (Programmable read-only memory)** – It can be programmed by user. Once programmed, the data and instructions in it cannot be changed.

- **EPROM (Erasable Programmable read only memory)** – It can be reprogrammed. To erase data from it, expose it to ultra violet light. To reprogram it, erase all the previous data.

- **EEPROM (Electrically erasable programmable read only memory)** – The data can be erased by applying electric field, no need of ultra violet light. We can erase only portions of the chip.

RAM	ROM
1. Temporary Storage.	1. Permanent storage.
2. Store data in MBs.	2. Store data in GBs.
3. Volatile.	3. Non-volatile.
4.Used in normal operations.	4. Used for startup process of computer.
5. Writing data is faster.	5. Writing data is slower.

Difference between RAM and ROM

Cache Memory

Cache Memory

- But as CPU speeds became faster, the main memory couldn't provide the CPU with the instructions at a fast enough rate.
- So even faster memory (cache memory) is now placed between the CPU and main memory to provide the instructions at an quicker rate to the CPU.

Cache Memory

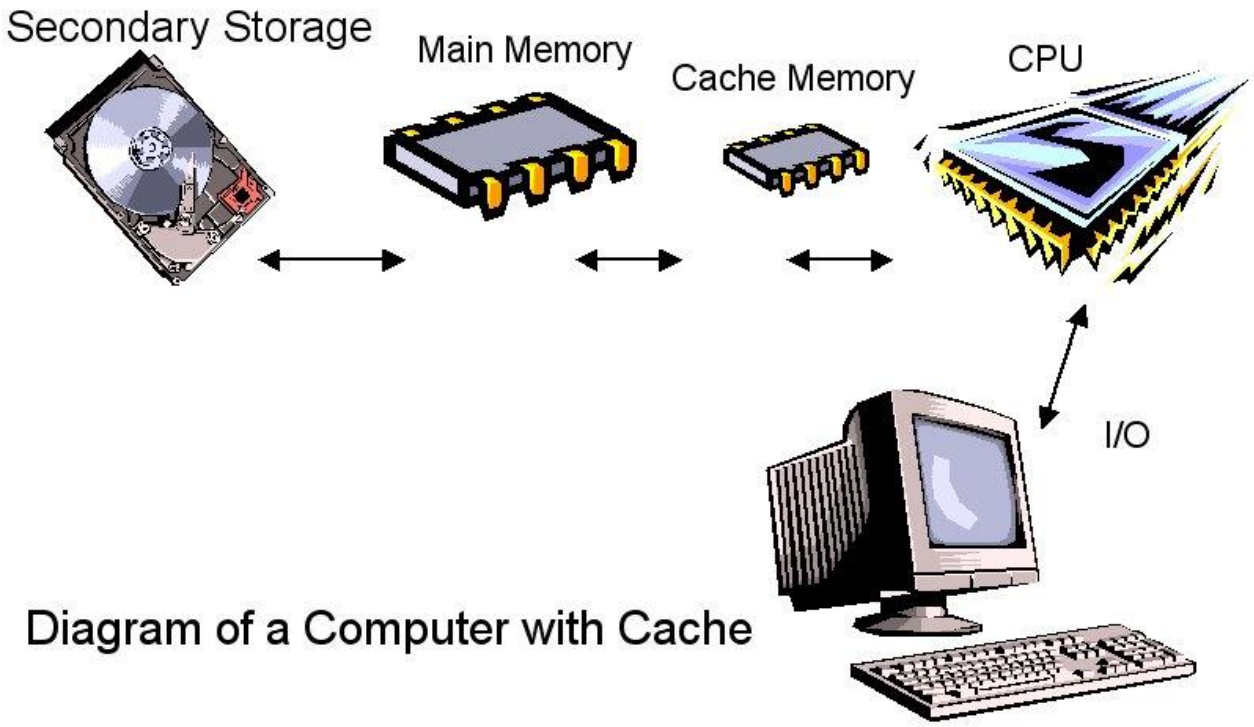
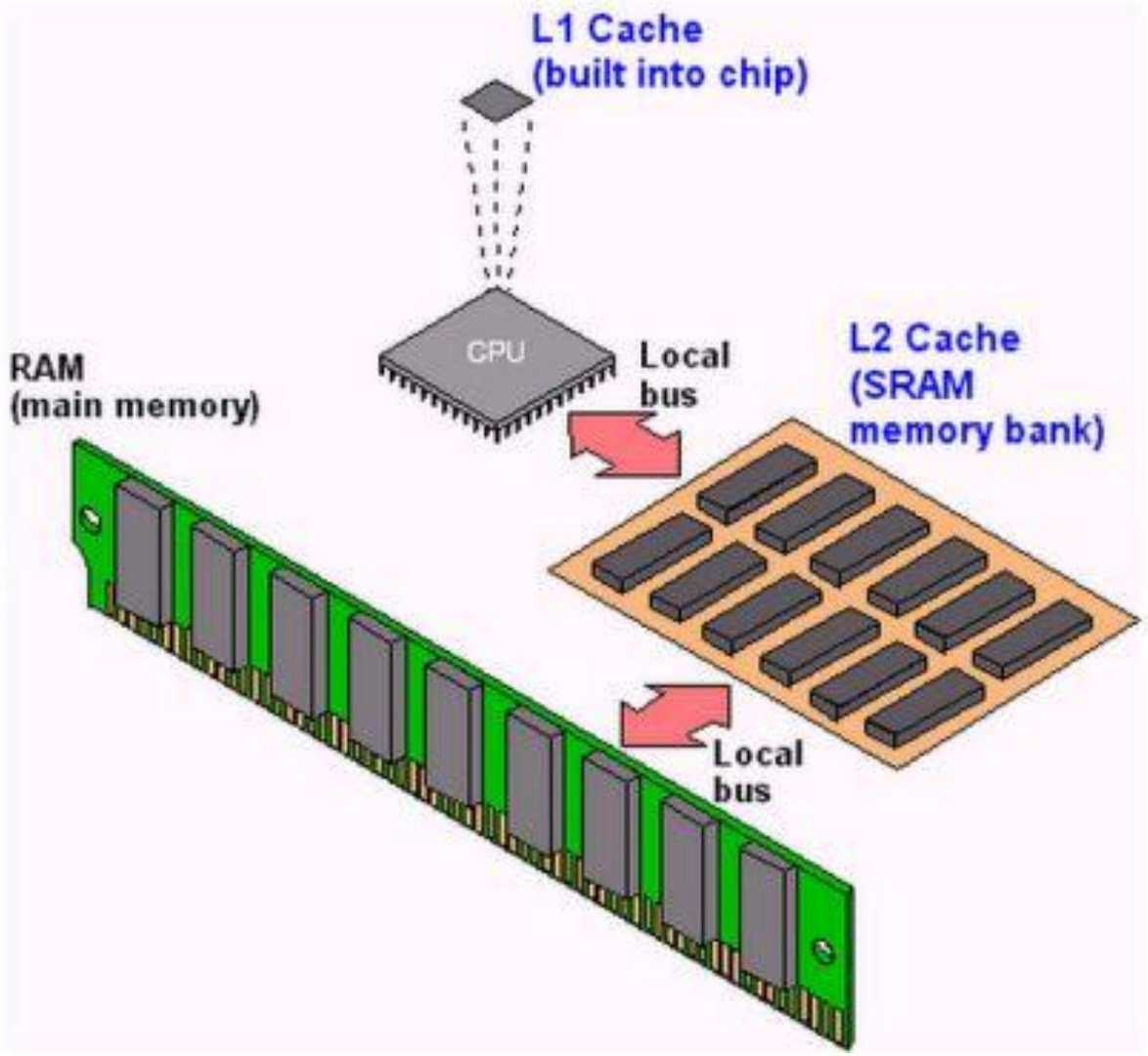


Diagram of a Computer with Cache

When an instruction or data is accessed from main memory, it is placed in the cache. Second and subsequent use of the same instruction/data will then be faster, since it is accessed directly from the cache.

Cache


L1 Cache
(built into chip)
CPU
Local
bus
L2 Cache
(SRAM
memory bank)
RAM
(main memory)
Local
bus

L1 and L2 Cache

- Most modern CPUs now have a cache memory (L1), on the same silicon wafer as the CPU, to provide the CPU with instructions at the same clock speed as the CPU.

- An additional off-the-chip secondary cache (L2) may also interact with the CPU at a slower speed.

Main Memory Characteristics

- Very closely connected to the CPU.
- Contents are quickly and easily changed.
- Holds the programs and data that the processor is actively working with.
- Interacts with the processor millions of times per second.
- Nothing permanent is kept in main memory.

Secondary Storage Devices

- Storage devices hold data, even when the computer is turned off.
- The physical material that actually holds data is called a storage medium. The surface of a floppy disk is a storage medium.
- The two primary storage technologies are magnetic and optical.

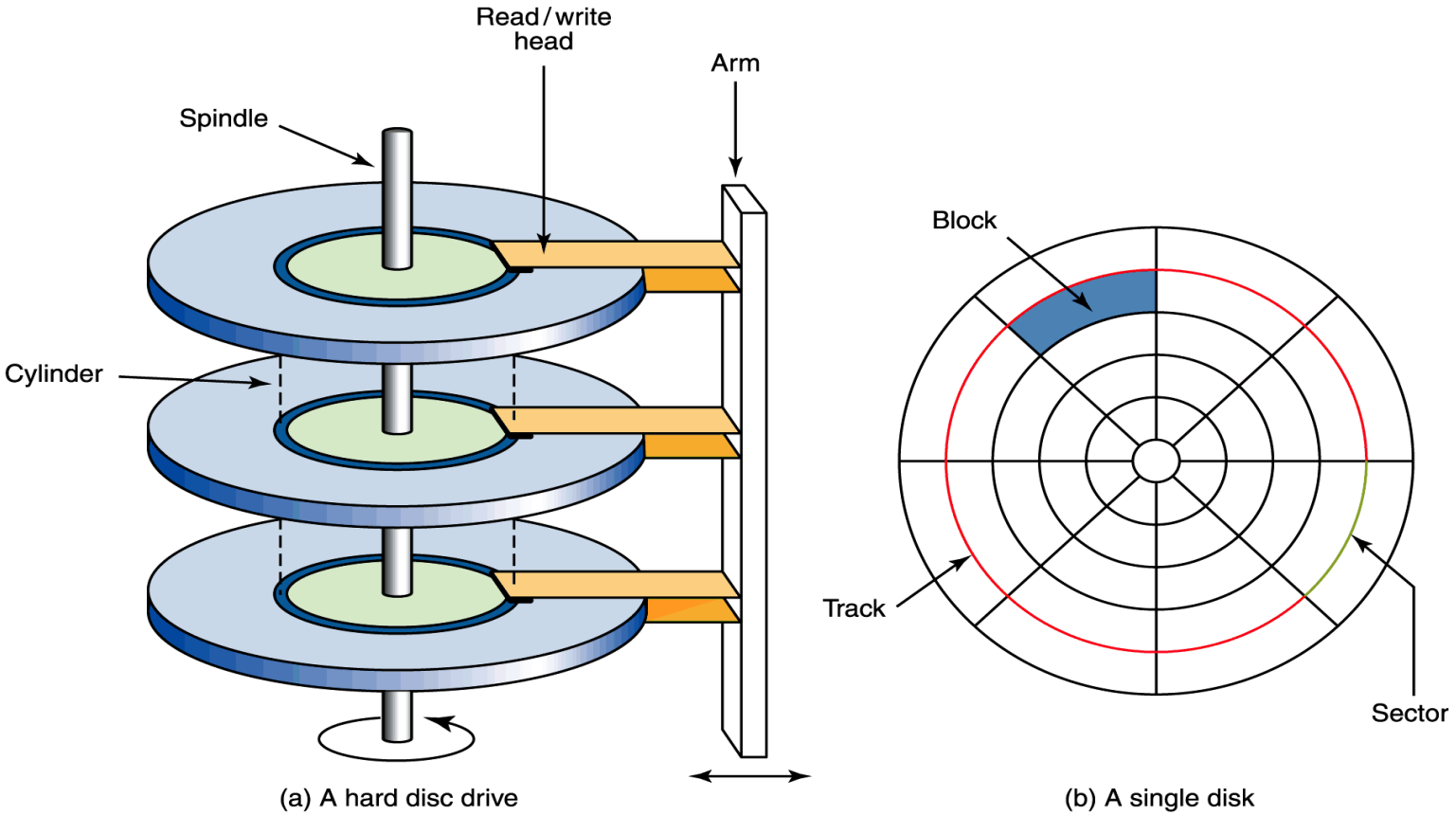
Secondary Storage Devices

- Magnetic Storage Devices
  - Diskettes (floppy disks) (FDD)
  - Hard disks (HD)
  - USB flash drive
  - Magnetic tape

- Optical Storage Devices
  - Compact Disk Read-Only Memory (CD-ROM)
  - Digital Video Disk Read-Only Memory
  - (DVD-ROM
  - CD-Recordable (CD-R)
  - CD-Rewritable (CD-RW)

Magnetic Disks

- A read/write head travels across a spinning magnetic disk, retrieving or recording data



The organization of a magnetic disk

Secondary Storage Characteristics

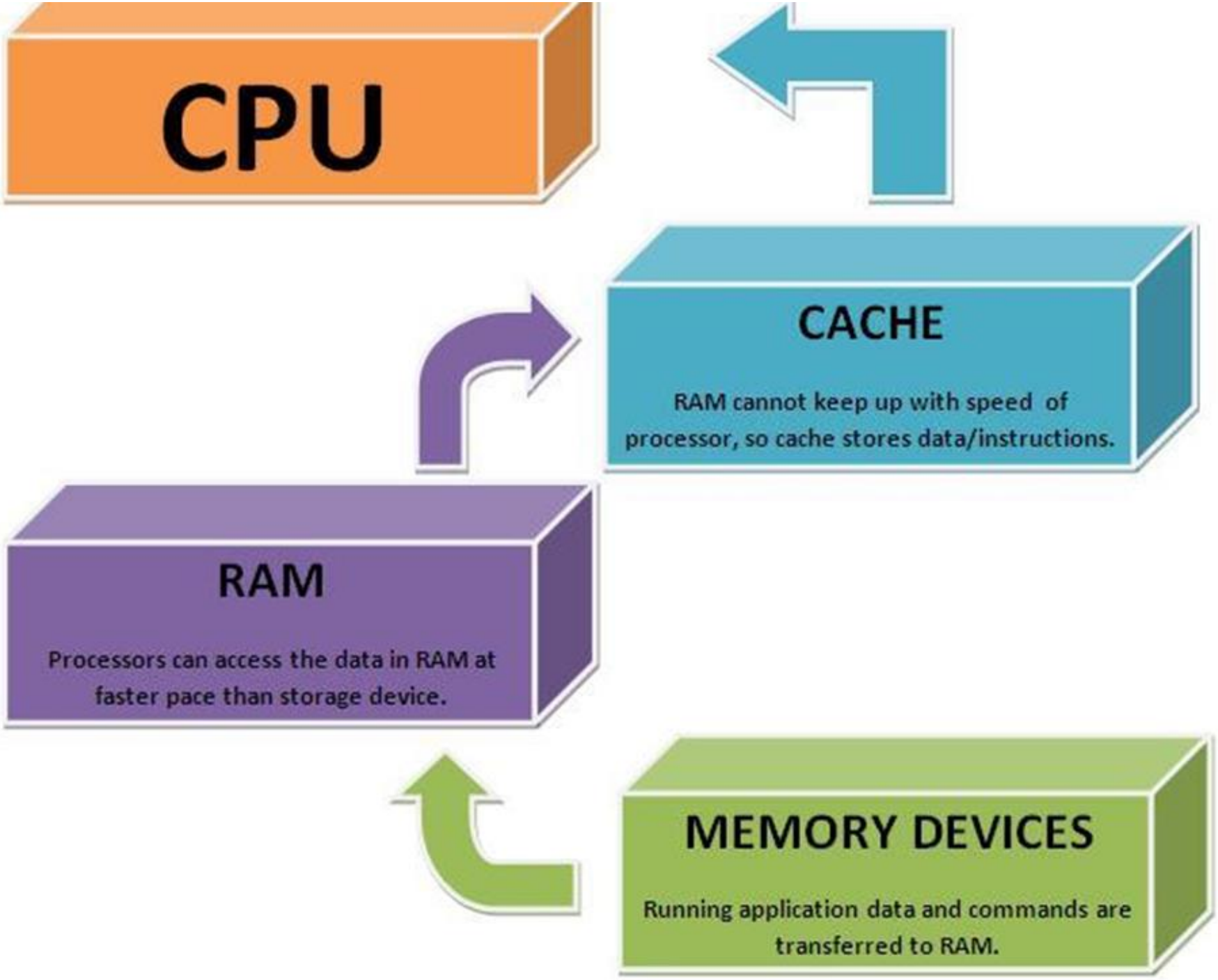
- Connected to main memory through a bus and a device controller.
- Contents are easily changed, but access is very slow compared to main memory.
- Only occasionally interacts with CPU.
- Used for long-term storage of programs and data.
- Much larger than main memory (GBs vs. MBs).

Level	1	2	3	4	5
Name	registers	cache	main memory	solid state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25 - 0.5	0.5 - 25	80 - 250	25,000 - 50,000	5,000,000
Bandwidth (MB/sec)	20,000 - 100,000	5,000 - 10,000	1,000 - 5,000	500	20 - 150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape

CPU interaction with Memory

CPU and Memory

- CPU can interact with main memory in two ways:
  - It can **write** a byte/word to a given memory location.
    - The previous bits that were in that location are destroyed
    - The new bits are saved for future use.
  - It can **read** a byte/word from a given memory location.
    - The CPU copies the bits stored at that location and stores them in a CPU register
    - The contents of the memory location are NOT changed.


CPU
CACHE
RAM cannot keep up with speed of processor, so cache stores data/instructions.
RAM
Processors can access the data in RAM at faster pace than storage device.
MEMORY DEVICES
Running application data and commands are transferred to RAM.

How Does a Computer Know what to do?

- It must be given a detailed list of instructions, called a **compute program** or **software**, that tells it exactly what to do.
- Before processing a specific job, the computer ***program*** corresponding to that job must be stored in memory.
- Once the program is stored in memory the compute can start the operation by executing the program instructions one after the other.

Program

Program

- A **computer program** is a collection of instructions that performs a specific task when executed by a computer.
- Most computer devices require programs to function properly.

- **Program is a sequence of instruction along with data**

Programming Language

- A **programming language** is a formal language, which comprises a set of instructions that produce various kinds of output.

- Programming languages are used in computer programming to implement algorithms.

Programming paradigms (models)

- **Unstructured**
- **Structured**
- **Object oriented**

Unstructured programming

- Writing small and simple programs consisting of only one main function in the program.

- Uses goto statement to jump from any statement to any other statement (spagetti code)

Structured programming

- A program is broken down into small independent tasks that are small enough to be understood easily, without having to understand the whole program at once.

- When these tasks are completed, they are combined together to solve the problem.

- Example – C language

Object oriented programming

- A style of computer programming which focuses on objects (actors) and their private functionality.

- Objects are variables of user defined data types known as classes which contain functions and variables. Objects interact by using message passing.

- C++ and Java are examples of OOP.

Components in Programming

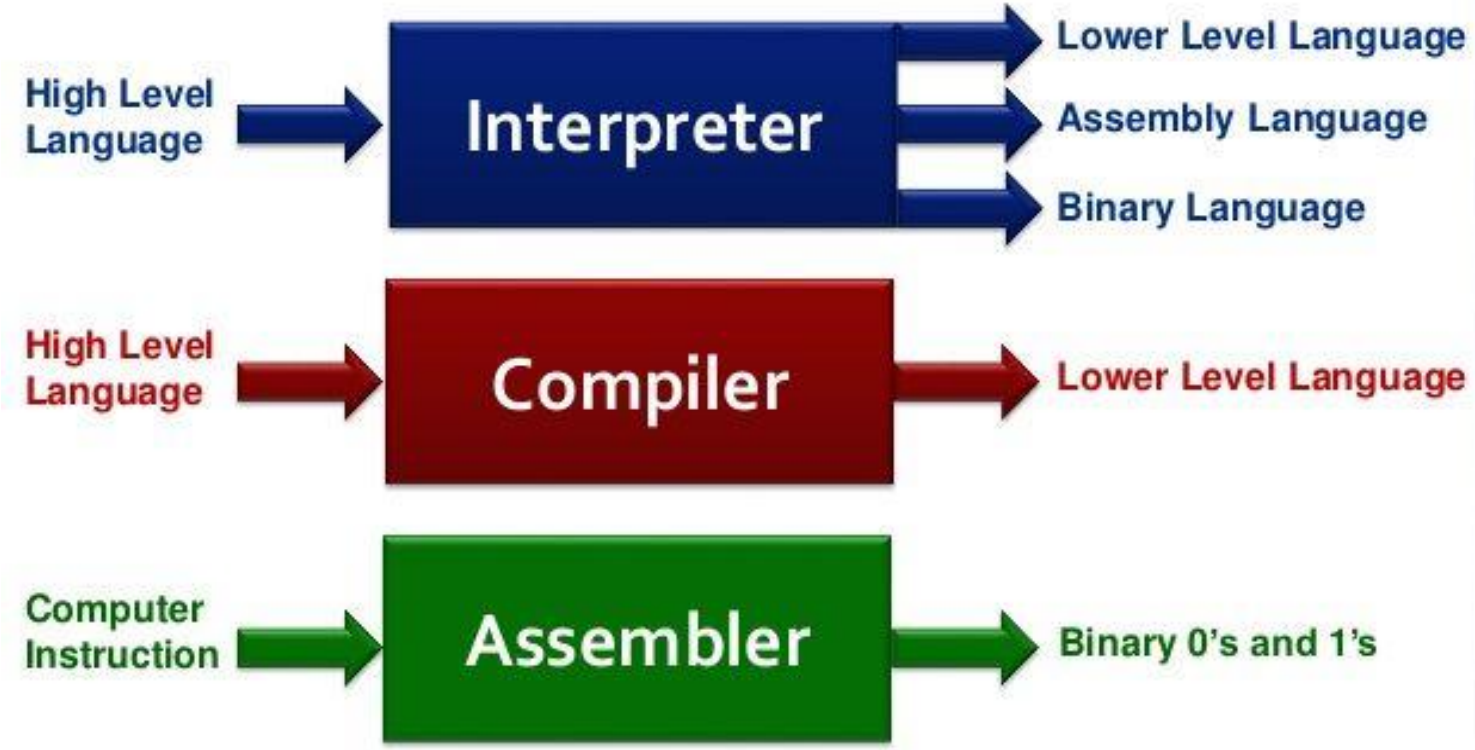
What is?

- Editor
- Translator
  - Complier
  - Assembler
  - Interpreter
- Linker
- Loader

Translator

- A translator is a programming language processor
  - that converts a computer program from one language to another.
- It takes a program written in source code and converts it into machine code.
- It discovers and identifies the error during translation.

Interpreter, Compiler and Assembler



Read more Pages 3 and 4

Complier

- A **compiler** is a program that accepts a source program in a “high-level language “and produces a corresponding object program.

Assembler

- Input to an assembler is an assembly language program.
- Output is an object program plus information that enables the loader to prepare the object program for execution.

Loader

- A Loader is a routine that loads an object program and prepares it for execution.
- In general, the loader must load, relocate and link the object program.
- Loader is a program that places programs into memory and prepares them for execution. The loader places into memory the machine language version of the user's program and transfers control to it.

First Program

```
#include<stdio.h>
/*first program*/
int main()
{
    printf(“Hello-CP”);
    return 0;
    }
```

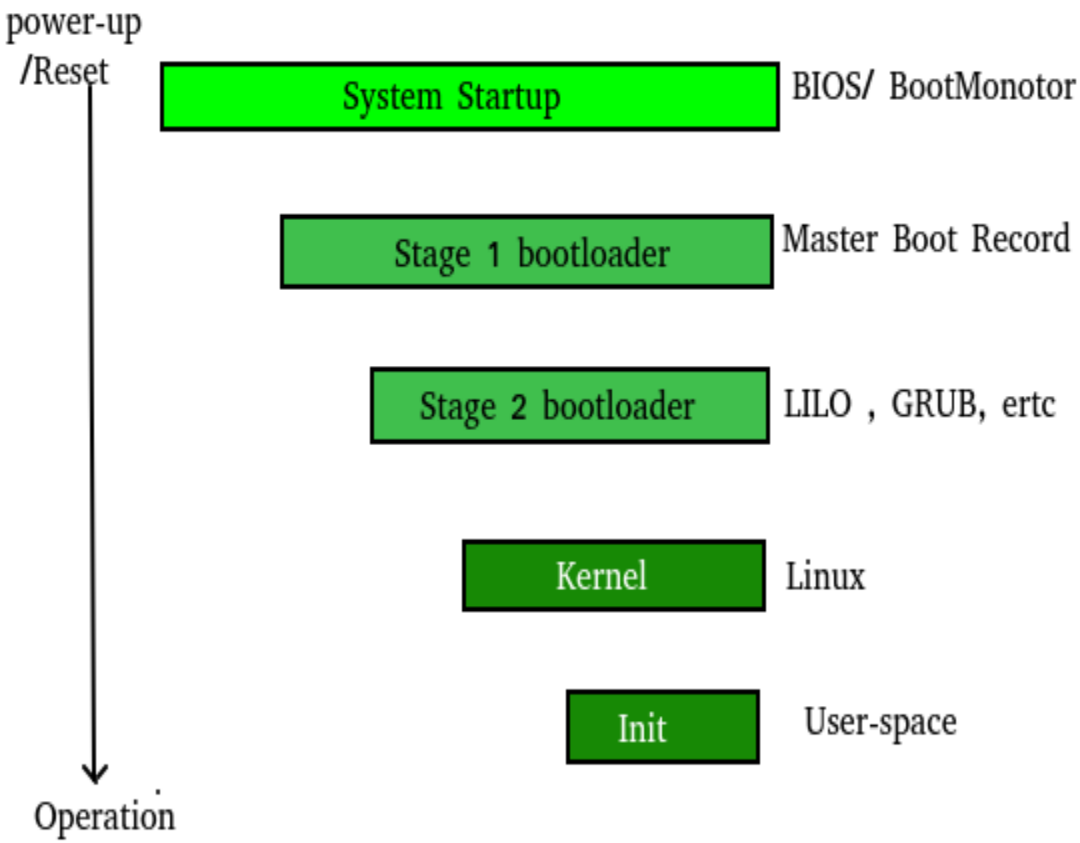
Second Program

```
#include<stdio.h>
/*first program*/
int main()
{
        int a;
        a=4+7;
        printf(“value=%d”,a);
        return 0;
    }
```

Extra Slides

Some Basics about CS

What happens when we turn on computer?


power-up
/Reset
System Startup
BIOS/ BootMonotor
Stage 1 bootloader
Master Boot Record
Stage 2 bootloader
LILO , GRUB, ertc
Kernel
Linux
Init
User-space
Operation

- **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

System Boot

- When power initialized on system, execution starts at a fixed memory location
  - Firmware ROM used to hold initial boot code
- Operating system must be made available to hardware so hardware can start it
  - Small piece of code – **bootstrap loader**, stored in **ROM** or **EEPROM** locates the kernel, loads it into memory, and starts it
  - Sometimes two-step process where **boot block** at fixed location loaded by ROM code, which loads bootstrap loader from disk
- Common bootstrap loader, **GRUB**, allows selection of kernel from multiple disks, versions, kernel options
- Kernel loads and system is then **running**

HP Pavilion x360 14-cd0053TX Laptop(8th Gen i5-8250U/8GB DDR4/1TB HDD/16GB Optane/NVIDIA MX130 2GB Graphics/Win 10/MS Office H&S 2016) Mineral Silver

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What is the difference between 32 bit and 64 bit OS??

Answer

- When talking about CPUs, the number of bits usually refers to the size of a CPU's register. Each register bit can reference a byte in memory.
- 16 bit computers can reference up to 64KB of RAM and 32 bit computers can reference up to 4GB of RAM.
- A 64 bit CPU can reference up to 16EB (8TB) of RAM.

Answer

- In computing, 32-bit and 64-bit are two different types of processors. The bit number (usually 8, 16, 32, or 64) refers to how much memory a processor can access from the CPU register.
- A 32-bit system can access 2^{32} (4,294,967,296) memory addresses. Practically speaking, a 32-bit computer is limited to accessing 4,294,967,296 bytes (4 GB) of RAM.
- A 64-bit processor can access 2^{64}memory addresses. This means a 64-bit machine could theoretically access 18,446,744,073,709,551,616 memory addresses or more than 18 billion GB of RAM.

What is Clock speed?

- The GHz represents the number of clock cycles (calculations) a processor can manage in a second.
- Putting simply, a bigger number means a faster processor.

Computer Memory Hierarchy