

Introduction to Memory and Memory parameters. Classifications of primary and secondary memories. Types of RAM and ROM, Allocation policies, Memory hierarchy and characteristics. Cache memory: Concept, architecture (L1, L2, L3), mapping techniques. Cache Coherency, Interleaved and Associative memory

MODULE 5- Memory Organization


INTRODUCTION

Memory unit is an essential component in digital computers since it is needed for storing programs and data. Two or three levels of memory such as

- Main memory
- Secondary memory and
- Cache memory

are provided in a digital computer.

The main memory is a fast memory.

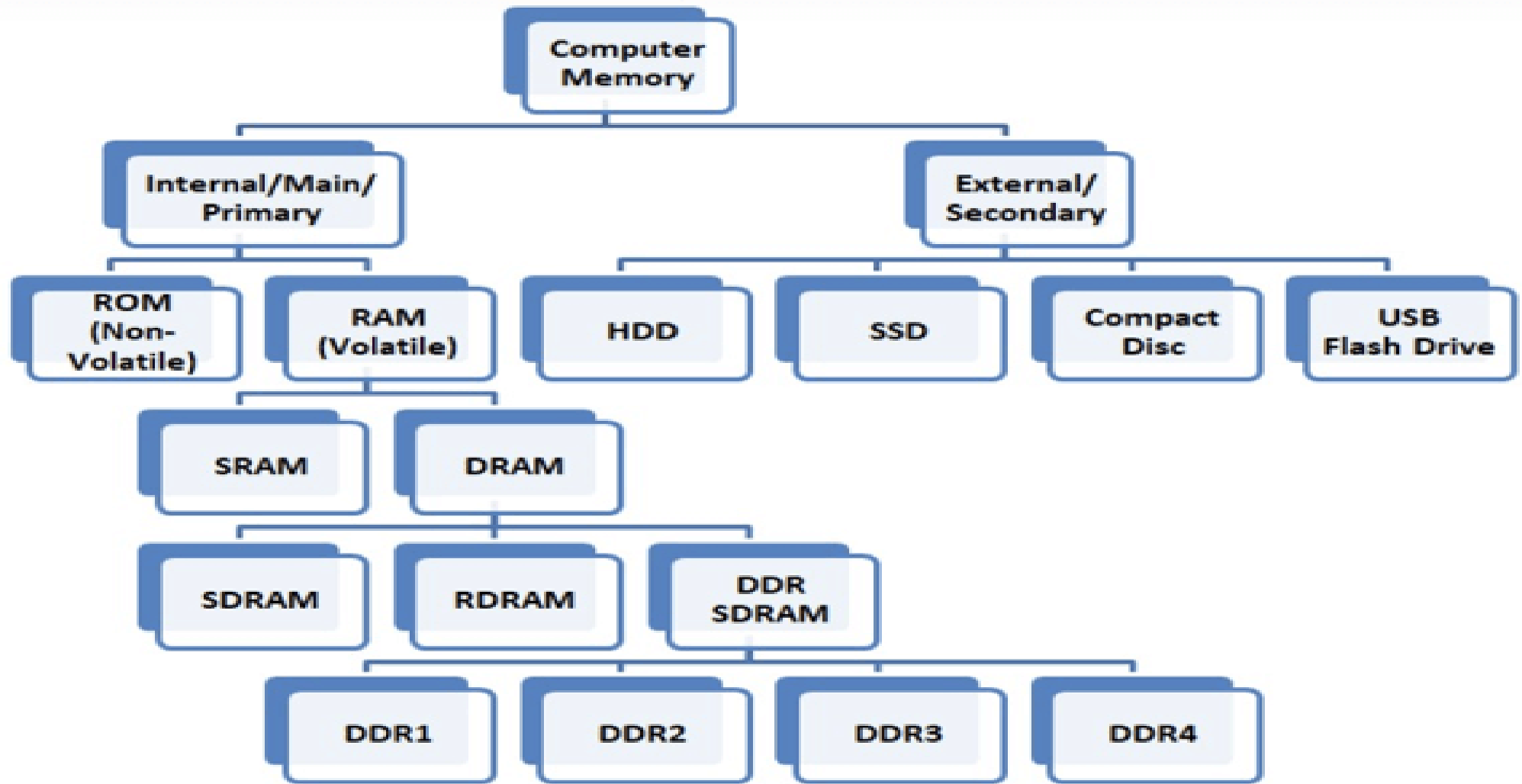


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Main memory stores the programs along with data, which are to be executed. It also stores necessary programs of system software. The cache memory is placed in between the CPU and the main memory. Secondary memory is permanent storage used to store programs and data that are used infrequently.

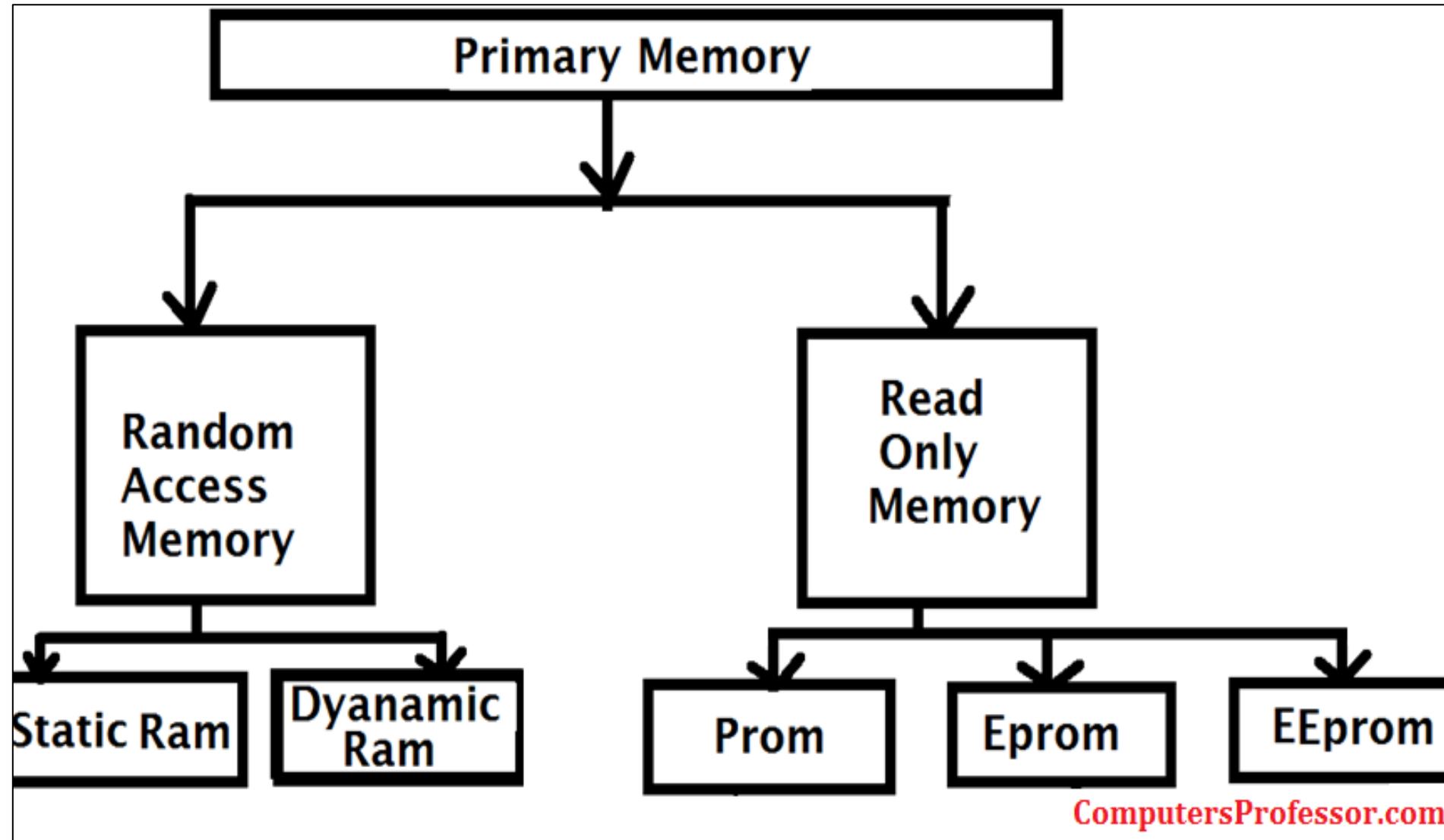
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- **Secondary Memory**: This memory has larger in capacity but slower than main memory. Secondary memory stores system programs, large data files and like the data are not continually required by the CPU. It also acts as an overflow memory when the capacity of the main memory is exceeded. Information in secondary storage is accessed indirectly via input output processor that transfer information between main and secondary memory.



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- ▶ Sequential Access: If storage locations can be accessed only in a certain predetermined sequence, the access method is known as serial or sequential access.
- ▶ Direct Access: In this access information is stored on tracks and each track has a separate read/write head. This features makes it a semi random mode which is generally used in magnetic disks.



Primary Memory

- **Primary storage or memory:** Is where the data and program that are currently in operation or being accessed are stored during use.
 - Consists of electronic circuits: Extremely fast and expensive.
 - Two types:
 - **RAM** (non-permanent)
 - Programs and data can be stored here for the computer's use.
 - Volatile: All information will be lost once the computer shuts down.
 - **ROM** (permanent)
 - Contents do not change.

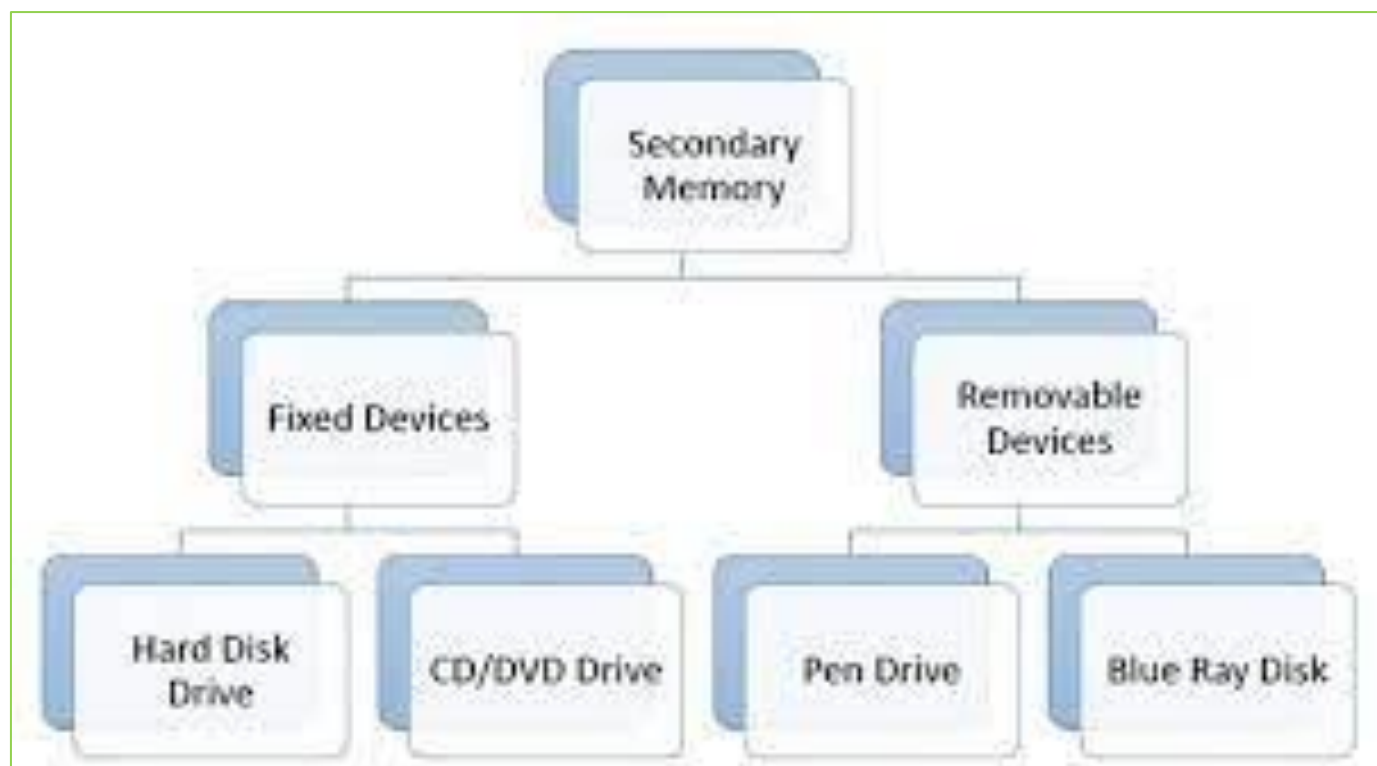
Secondary Memory

- This type of memory is also known as external memory or non-volatile
- It is slower than main memory.
- These are used for storing data/Information permanently.

Characteristic of Secondary Memory are:

- These are magnetic and optical memories
- It is known as backup memory.
- It is non-volatile memory.
- Data is permanently stored even if power is switched off.
- It is used for storage of data in a computer.
- Computer may run without secondary memory
- Slower than primary memories.

For Example; Hard disk, Floppy disk, Tape drive, CD-ROM, Flash Memory and others.

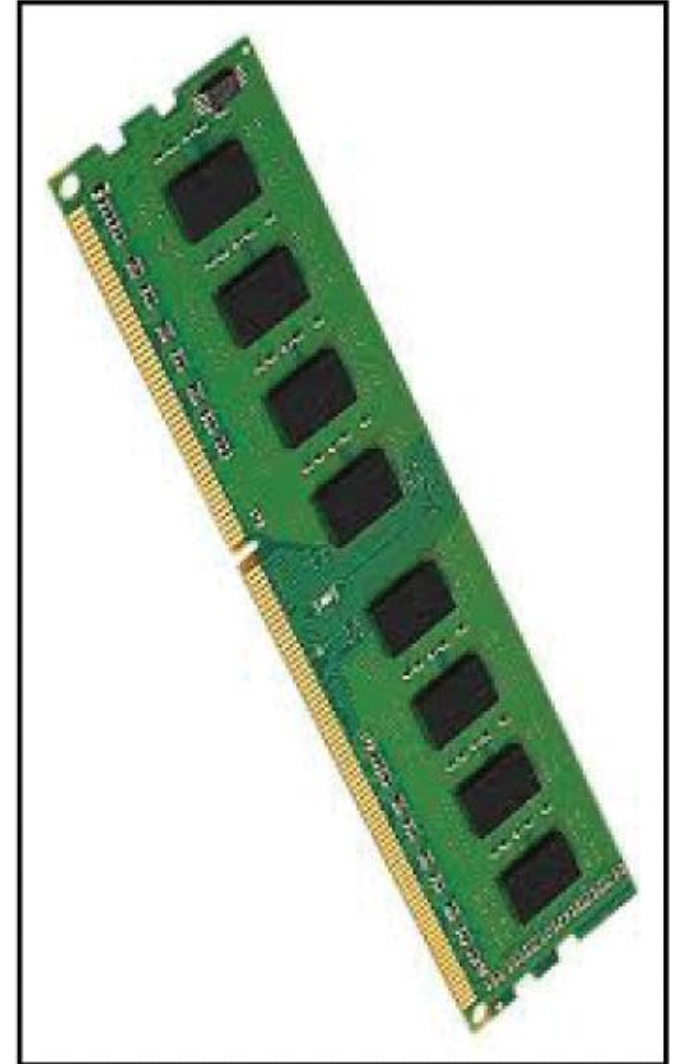


Types of main memory

- There are two types of main memory, Random Access Memory (RAM) and Read Only Memory (ROM)
- Random Access Memory (RAM) holds its data as long as the computer is switched on
- All data in RAM is lost when the computer is switched off
- Described as being volatile
- It is direct access as it can be both written to or read from in any order
- Its purpose is to temporarily hold programs and data for processing. In modern computers it also holds the operating system

Random Access Memory (RAM)

- RAM is a type of memory that can be read from or written to. This is therefore a read/write random access memory. This memory stores the input data and the program that users give to the computer for immediate execution.
- RAM is **volatile**, meaning that it loses its contents when the power is shut off. Random access means that the storage cells of a RAM memory are organised so that the access time of any cell is the same for all.



Types of RAM 1. Dynamic Random Access Memory (DRAM)

- Contents are constantly refreshed 1000 times per second
- Access time 60 – 70 nanoseconds
- Note: a nanosecond is one billionth of a second!
- Synchronous Dynamic Random Access Memory (SDRAM) Quicker than DRAM
- Access time less than 60 nanoseconds
- Direct Rambus Dynamic Random Access Memory (DRDRAM) New type of RAM architecture
- Access time 20 times faster than DRAM
- More expensive

Types of RAM 2. Static Random Access Memory (SRAM)

- Doesn't need refreshing
- Retains contents as long as power applied to the chip
- Access time around 10 nanoseconds
- Used for cache memory
- Also, for date and time settings as powered by small battery

Cache memory

- Small amount of memory typically 256 or 512 kilobytes
- Temporary store for often used instructions
- Level 1 cache is built within the CPU (internal)
- Level 2 cache may be on chip or nearby (external)
- Faster for CPU to access than main memory

Read Only Memory (ROM)

- ROM is a type of memory that can be read from but cannot be written to. ROM is **non-volatile**, meaning that it retains its contents even when the power is shut off.
- These programs are written permanently into the memory during manufacture.
- Such programs are called the **firmware**.

Types of ROM

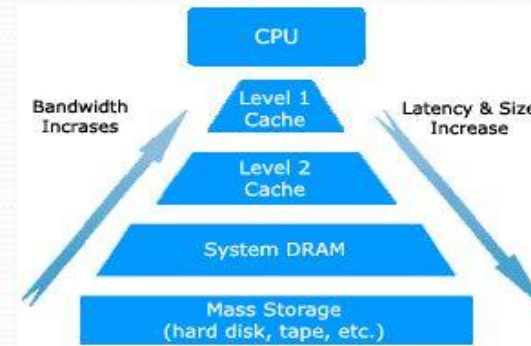
- **1. Programmable Read Only Memory (PROM)**
 - Empty of data when manufactured
 - May be permanently programmed by the user
- **2. Erasable Programmable Read Only Memory (EPROM)**
 - Can be programmed, erased and reprogrammed
 - The EPROM chip has a small window on top allowing it to be erased by shining ultra-violet light on it
 - After reprogramming the window is covered to prevent new contents being erased
 - Access time is around 45 – 90 nanoseconds

Types of ROM

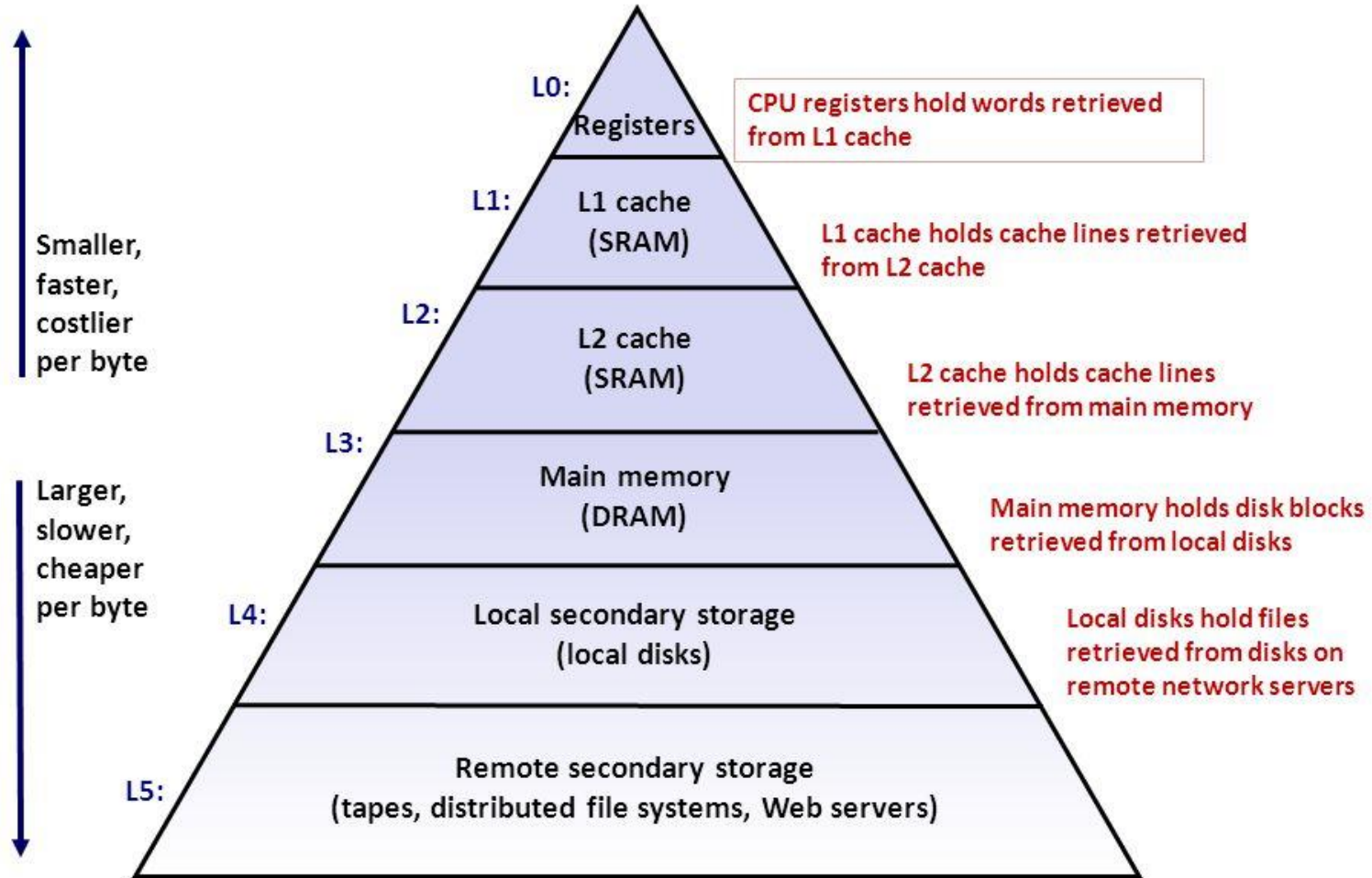
- **3. Electrically Erasable Programmable Read Only Memory (EEPROM)**
 - Reprogrammed electrically without using ultraviolet light
 - Must be removed from the computer and placed in a special machine to do this
 - Access times between 45 and 200 nanoseconds
- **4. Flash ROM**
 - Similar to EEPROM
 - However, can be reprogrammed while still in the computer
 - Easier to upgrade programs stored in Flash ROM
 - Used to store programs in devices e.g. modems
 - Access time is around 45 – 90 nanoseconds
- **5. ROM cartridges**
 - Commonly used in games machines
 - Prevents software from being easily copied

What is memory hierarchy?

- **Memory hierarchy** is the hierarchical arrangement of storage in current computer architectures.
- It is designed to take advantage of memory locality in computer programs.
- Each level of the hierarchy has the properties of higher bandwidth, smaller size, and lower latency than lower levels.
- For example, L1 Cache is closer to the CPU, so it can be accessed quickly, is more expensive, and holds less data. A mass storage device like a Hard Drive is accessed the slowest, is the least expensive, and holds large amounts of data.



An Example Memory Hierarchy



Memory Hierarchy

- Computer Memory Hierarchy is a pyramid structure that is commonly used to illustrate the significant differences among memory types.
- The memory unit that directly communicate with CPU is called the *main memory*
- Devices that provide backup storage are called *auxiliary memory*
- The memory hierarchy system consists of all storage devices employed in a computer system from the slow by high-capacity *auxiliary* memory to a relatively faster main memory, to an even smaller and faster *cache* memory

