Memory System Characteristics

Computer Organization and architecture

By

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Memory Capacity

- Number of bytes that can be stored

Term	Normal Usage	Usage as Power of 2
K (Kilo)	10^3	$2^{10} = 1,024$
M (Mega)	10^6	$2^{20} = 1,048,576$
G (Giga)	10^9	$2^{30} = 1,073,741,824$
T (Tera)	10^{12}	$2^{40} = 1,099,511,627,776$

Memory System Characteristics

1. **Location**
   - CPU
   - Internal (main)
   - External (secondary)
2. **Capacity**
   - Word size
   - Number of words
3. **Unit of transfer**
   - Word
   - Block
4. **Access methods**
   - Sequential access
   - Direct access
   - Random access
   - Associative access
5. **Performance**
   - Access time
   - Cycle time
   - Transfer rate

Key Characteristics contd.,

6. **Physical Type**
   - Semiconductor
   - Magnetic surface
   - Optical
7. **Physical Characteristics**
   - Volatile / Non-Volatile
   - Erasable / Non-erasable
8. **Organization**

1. Location

- Three locations of memories
  - CPU
    - Registers – used by CPU as its local memory
  - Internal memory
    - Main memory
    - Cache memory
  - External memory
    - Peripheral devices – disk, tape – accessible to CPU via I/O controllers

2. Capacity

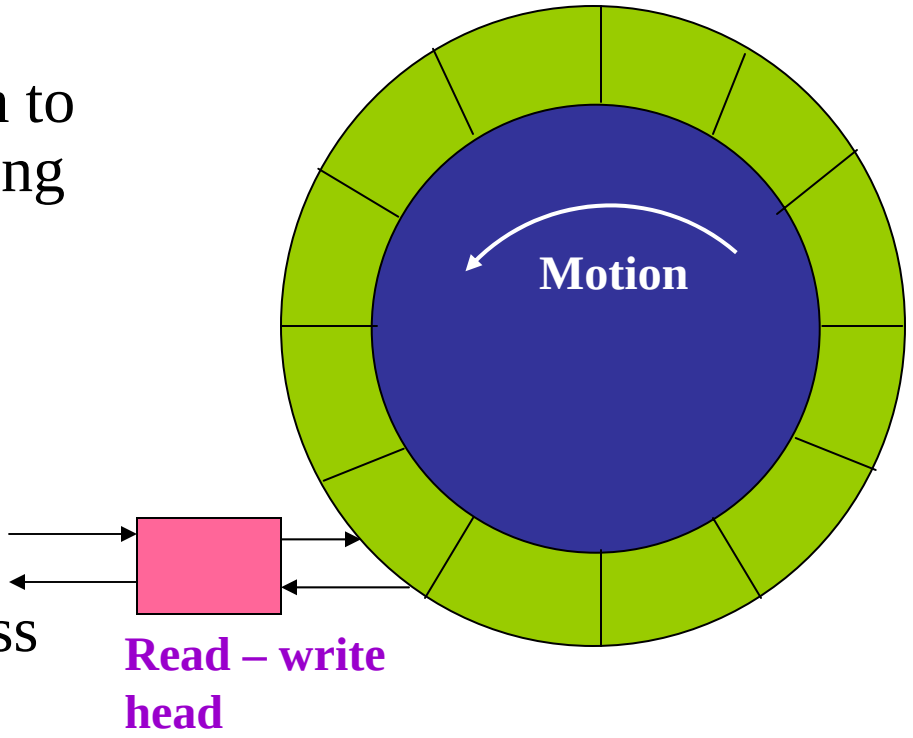
- Internal memory capacity is expressed in terms of bytes or words.
- External memory capacity is expressed in terms of bytes (depends on words in memory)
- Total memory = number of words × word length
- Number of words = $2^{\text{address bus width}}$
- Word length = Data bus width

3.Unit of transfer

- Internal memory
  - number of data lines into and out of the main memory module
- External memory
  - blocks
  - longer units than a word

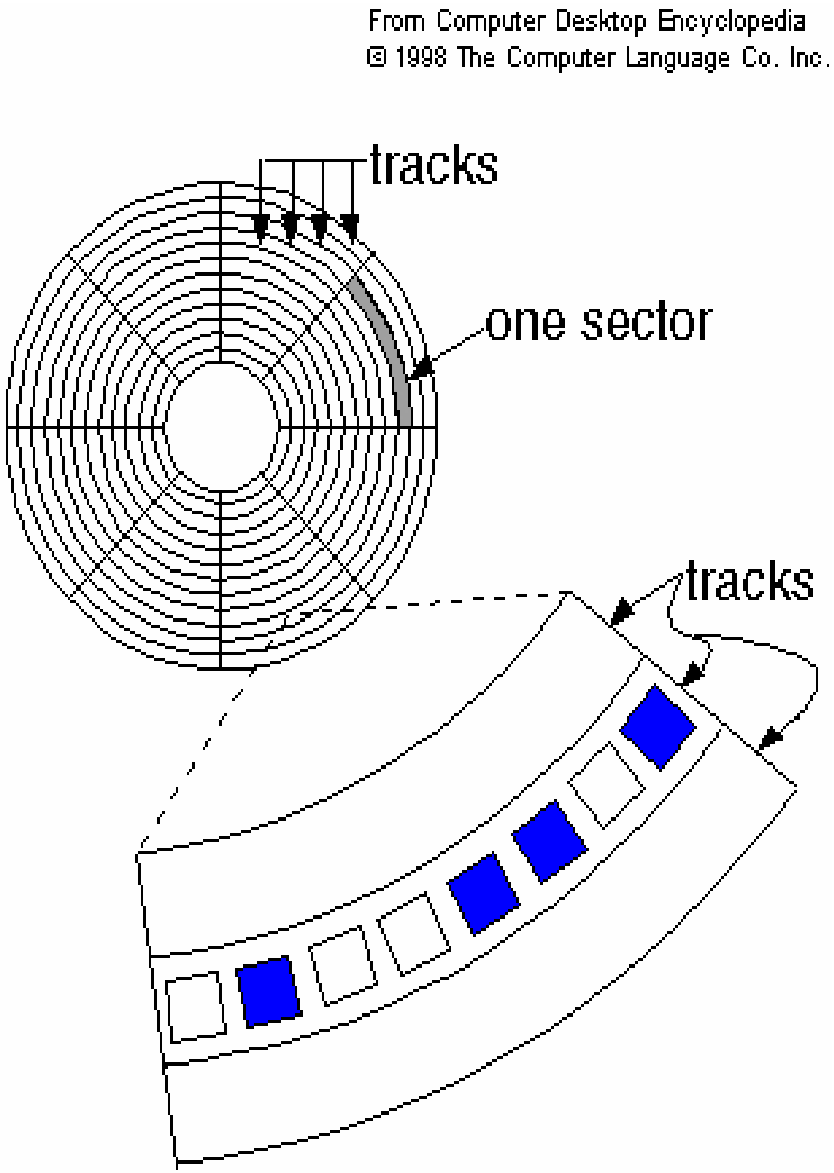
4. Access Methods

- Four types
  - **Sequential Access**
    - Shared read/write head is used, and this must be moved its current location to the desired location, passing and rejecting each intermediate record.
    - Access time is variable
    - Accesses the memory in predetermined sequence
    - Slower than random access memory
    - Ex: Magnetic Tapes



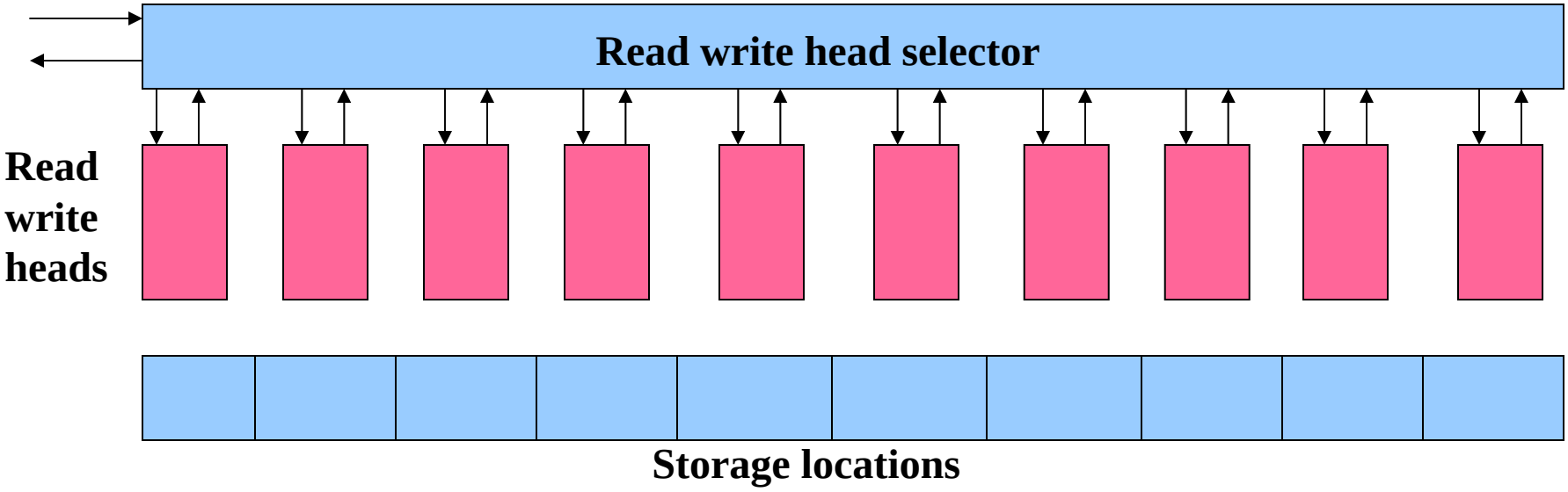
4. Access Methods contd.,

- **Direct access**
  - Also referred as semi random access memory
  - Shared read/write head is involved.
  - Access time is variable
  - The track is accessed randomly but access within each track is serial
  - Ex: Magnetic Disk



4. Access methods contd.,

- Random Access
  - Each addressable location in memory has unique, physically wired – in addressing mechanism
  - Time to access a location is independent of the sequences of prior access and is constant.
  - Main memory systems are a random access.
  - Storage locations can be accessed in any order.
  - Semi conductor memories



4. Access Methods contd.,

- **Associate Access**
  - Word is retrieved based on portion of its contents rather than its address
  - Has own addressing mechanism.
  - Retrieval time is constant.
  - Access time is independent of location or prior access patterns.
  - Cache memories.

5. Performance

- Access time
  - Time required to read/write the data from/into desired record.
  - Depends on the amount of data to be read/write.
  - Random access memory
    - Time from the instant that an address is presented to the memory to the instant that data have been stored or made available for use.
  - Non-random access memory
    - Time it takes to position read-write head at the desired track (seek time) + transfer time + to position read-write head at the desired sector (rotational latency)
- Memory Cycle time
  - Access time + time required before a second access can commence
  - Access + latency

5. Performance cont..,

- Transfer rate
  - Rate at which the data can be transferred into or out of a memory unit
  - Random access memory
    - 1/cycle time
  - Non-Random access memory
    - $T_n = T_a + (N/R)$, where
      - T_n – average time to read or write N bits
      - T_a – average access time
      - N – Number of bits
      - R – Transfer rate, in bits per second (BPS)

6. Physical characteristics

- Volatile memory
  - Information decays naturally or lost when electrical power is switched off
- Non-volatile memory
  - Once recorded is retained until deliberately changed
  - No electrical power is needed to retain information
  - Magnetic surface memories
- Semiconductor memories may be either volatile or non-volatile
- Non-erasable memory
  - Cannot be altered, except by destroying the storage unit (ROM)
  - A practical non-erasable memory must also be non-volatile

Characteristics	**CPU (Registers)**	**Main Memory (RAM)**	**Storage device (Hard disk)**
Physical type	Semiconductor (Fixed)	Semiconductor (expandable)	Magnetic (expandable)
Capacity	< 2KB	256 MB to 8 GB+	40 GB to 500 GB+
Speed (access time)	< 1 ns	2 ns	5 – 10 ms
Volatility	Contents lost	Contents lost	Contents not lost

7. Organization

- Physical arrangement of bits to form words
- 2 types
  - 1 dimensional
  - 2 dimensional

8. Byte Storage Methods

- **Big-Endian**
  - Assigns MSB to least address and LSB to highest address.
  - Sun SPARC
  - IBM 360 / 370
  - Motorola 68000
  - Motorola 88000
- **Little Endian**
  - Assigns MSB to highest address and LSB to least address
  - Intel × 86 family
  - Digital equipment corporation architectures (PDP – 11, VAX, Alpha)