William Stallings Computer Organization and Architecture 10th Edition

Chapter 5 & 6

Internal Memory and External Memory

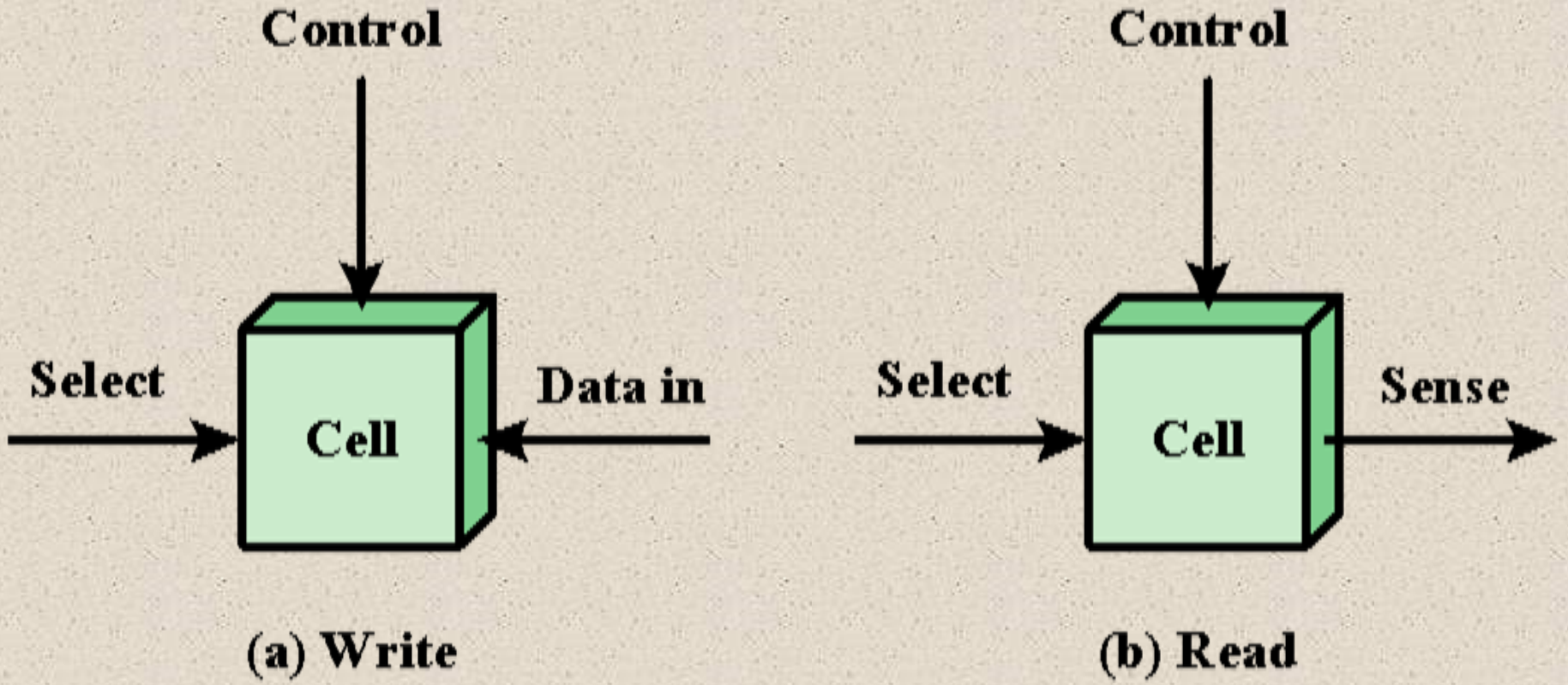


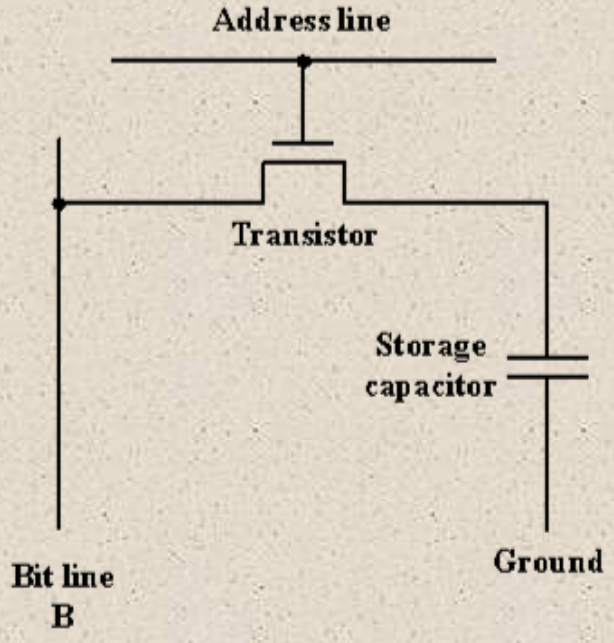
Figure 5.1 Memory Cell Operation

Memory Type	Category	Erasure	Write Mechanism	Volatility
Random-access memory (RAM)	Read-write memory	Electrically, byte-level	Electrically	Volatile
Read-only memory (ROM)	Read-only memory	Not possible	Masks	Nonvolatile
Programmable ROM (PROM)				
Erasable PROM (EPROM)		UV light, chip-level	Electrically	
Electrically Erasable PROM (EEPROM)	Read-mostly memory	Electrically, byte-level		
Flash memory		Electrically, block-level		

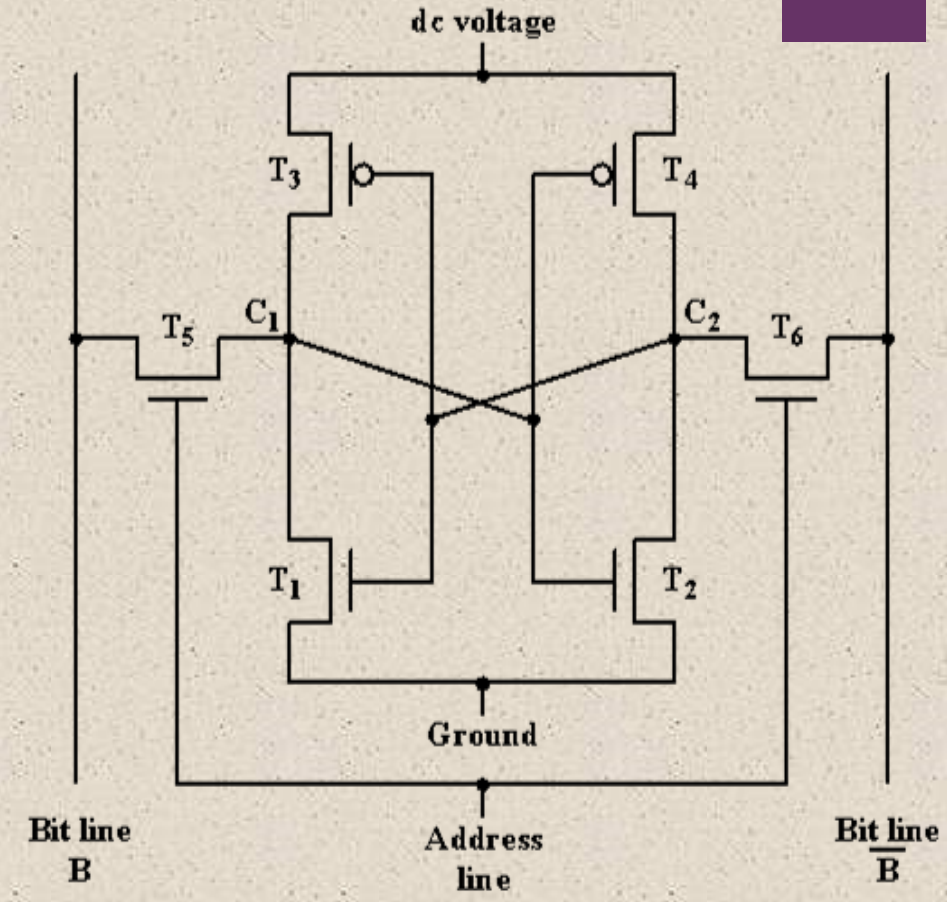
Table 5.1
Semiconductor Memory Types

Dynamic RAM (DRAM)

- RAM technology is divided into two technologies:
  - Dynamic RAM (DRAM)
  - Static RAM (SRAM)
- DRAM
  - Made with cells that store data as charge on capacitors
  - Presence or absence of charge in a capacitor is interpreted as a binary 1 or 0
  - Requires periodic charge refreshing to maintain data storage
  - The term *dynamic* refers to tendency of the stored charge to leak away, even with power continuously applied



(a) Dynamic RAM (DRAM) cell

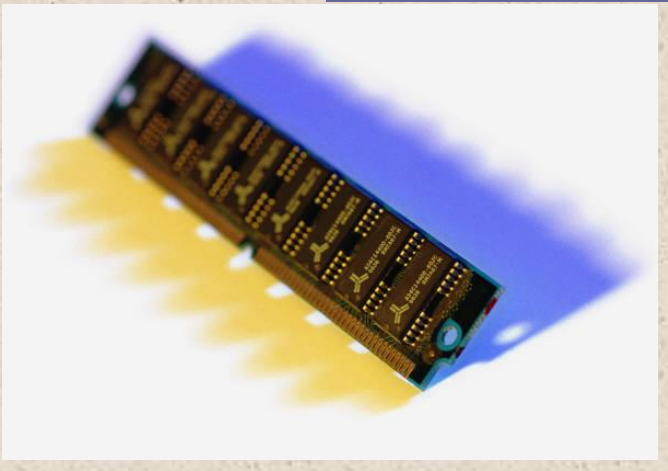


(b) Static RAM (SRAM) cell

Figure 5.2 Typical Memory Cell Structures

Static RAM (SRAM)

- Digital device that uses the same logic elements used in the processor
- Binary values are stored using traditional flip-flop logic gate configurations
- Will hold its data as long as power is supplied to it



SRAM versus DRAM

- Both volatile
  - Power must be continuously supplied to the memory to preserve the bit values
- Dynamic cell
  - Simpler to build, smaller
  - More dense (smaller cells = more cells per unit area)
  - Less expensive
  - Requires the supporting refresh circuitry
  - Tend to be favored for large memory requirements
  - Used for main memory
- Static
  - Faster
  - Used for cache memory (both on and off chip)

SRAM

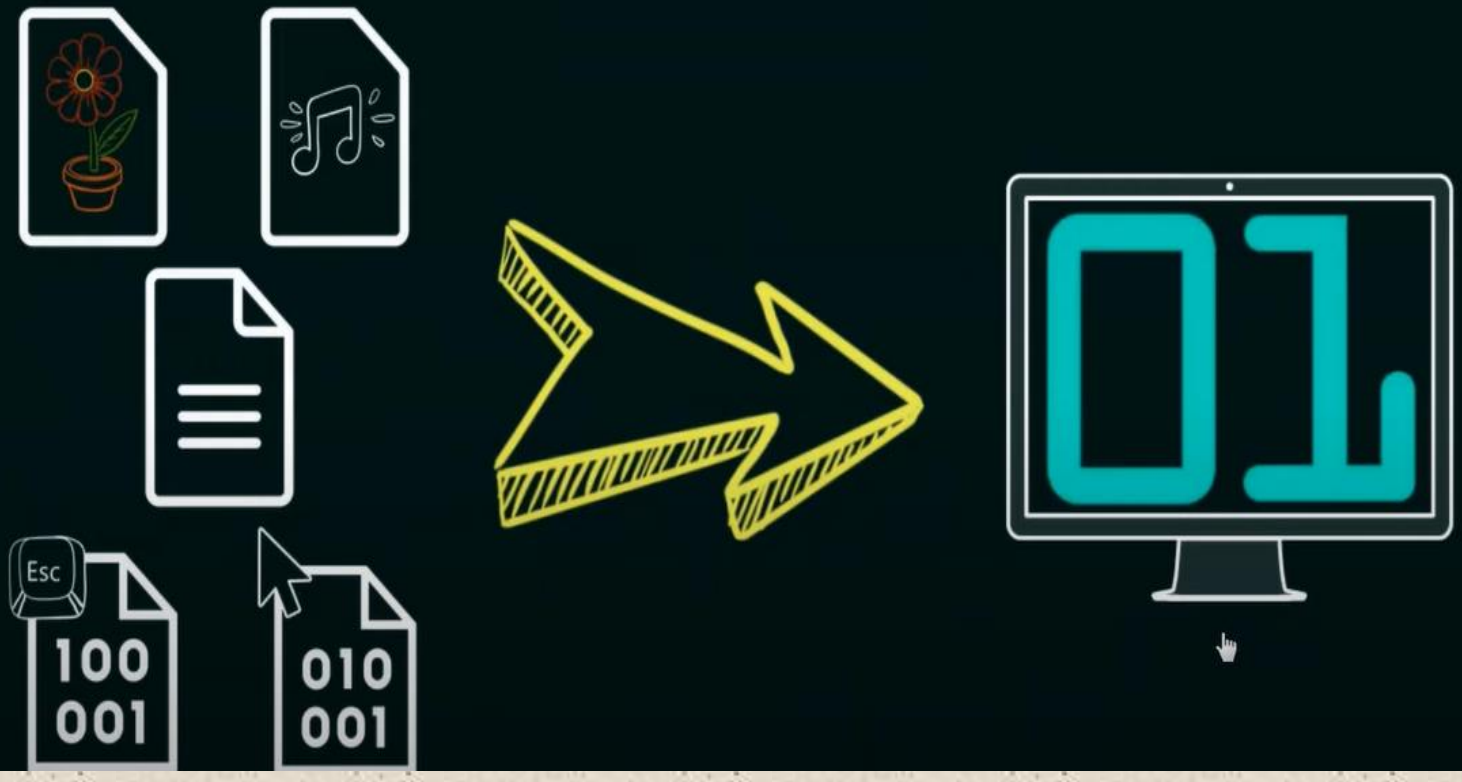
DRAM

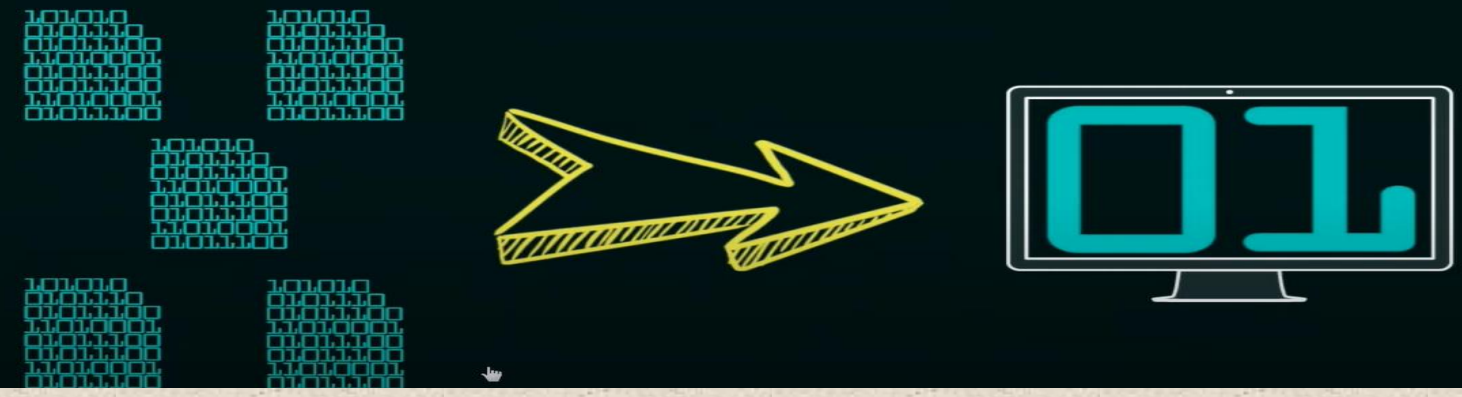
Read Only Memory (ROM)

- Contains a permanent pattern of data that cannot be changed or added to
- No power source is required to maintain the bit values in memory
- Data or program is permanently in main memory and never needs to be loaded from a secondary storage device
- Data is actually wired into the chip as part of the fabrication process
  - Disadvantages of this:
    - No room for error, if one bit is wrong the whole batch of ROMs must be thrown out
    - Data insertion step includes a relatively large fixed cost

"**Memory** is the faculty of the brain by which data or information is encoded, stored, and retrieved when needed."

-- Wikipedia





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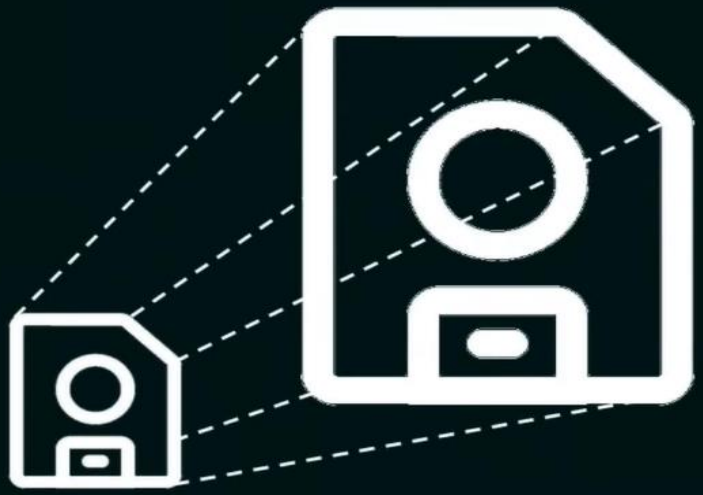
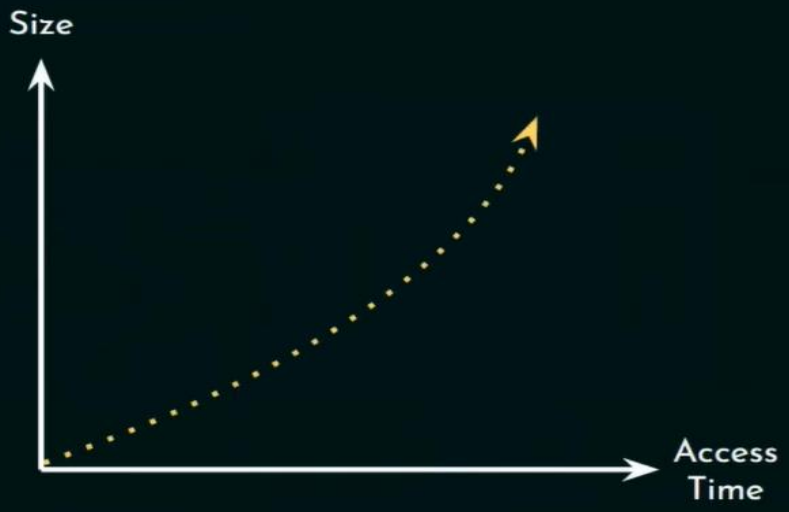
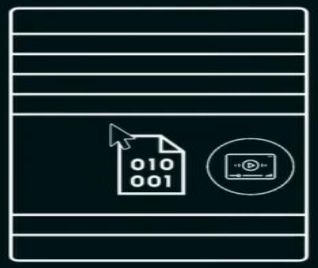




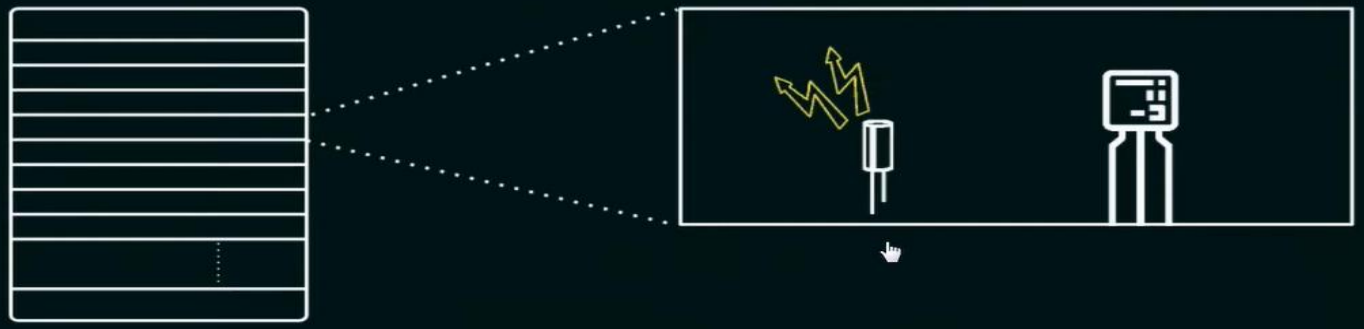
Primary Memory

Secondary Memory



Primary Memory

Dynamic Random Access Memory
D.R.A.M.



Primary Memory

Dynamic Random Access Memory
D.R.A.M.

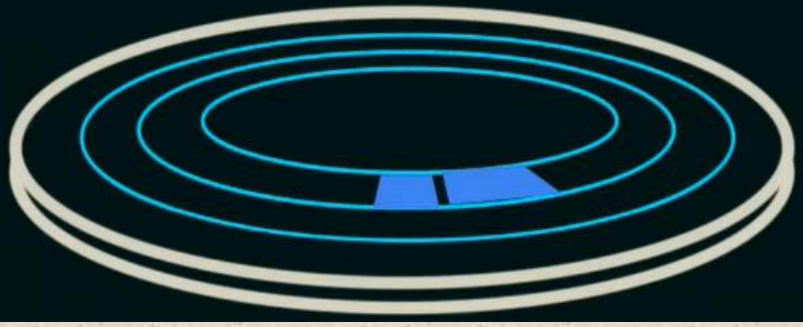
Primary
Memory

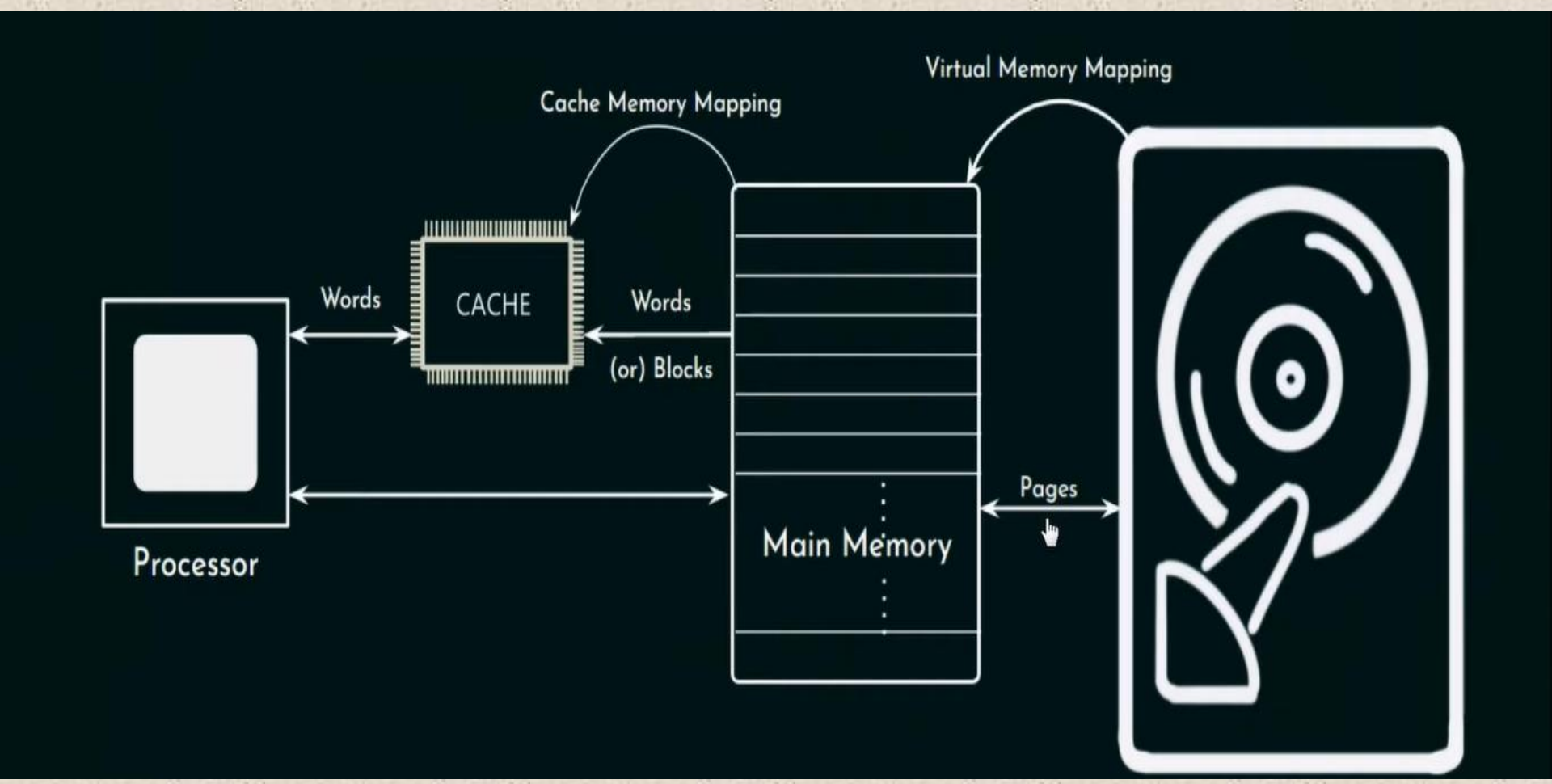
Dynamic Random Access Memory
D.R.A.M.

Static Random Access Memory
S.R.A.M.

Secondary Memory :

- Slower than Primary Memory.
- Retains Data Permanently.
- Bigger in size.
- Cost-effective.
- Semi-Random accessibility.




Virtual Memory Mapping
Cache Memory Mapping
Words
CACHE
Words
(or) Blocks
Pages
Main Memory
Processor

Magnetic Disk

- A disk is a circular *platter* constructed of nonmagnetic material, called the *substrate,* coated with a magnetizable material
  - Traditionally the substrate has been an aluminium or aluminium alloy material
  - Recently glass substrates have been introduced

Working

- A spinning disk (called a **platter**) is coated with a magnetic material.
- A **read/write head** moves over the disk to store or retrieve data.
- Data is stored in the form of **0s and 1s** (magnetic charges).

Examples

- **Hard Disk Drives (HDDs)** – Used in computers for data storage.
- **Floppy Disks** (Old technology, now obsolete).

RAID

Redundant Array of Independent Disks

- Consists of 7 levels
- Levels do not imply a hierarchical relationship but designate different design architectures that share three common characteristics:
  1) Set of physical disk drives viewed by the operating system as a single logical drive
  2) Data are distributed across the physical drives of an array in a scheme known as striping
  3) Redundant disk capacity is used to store parity information, which guarantees data recoverability in case of a disk failure

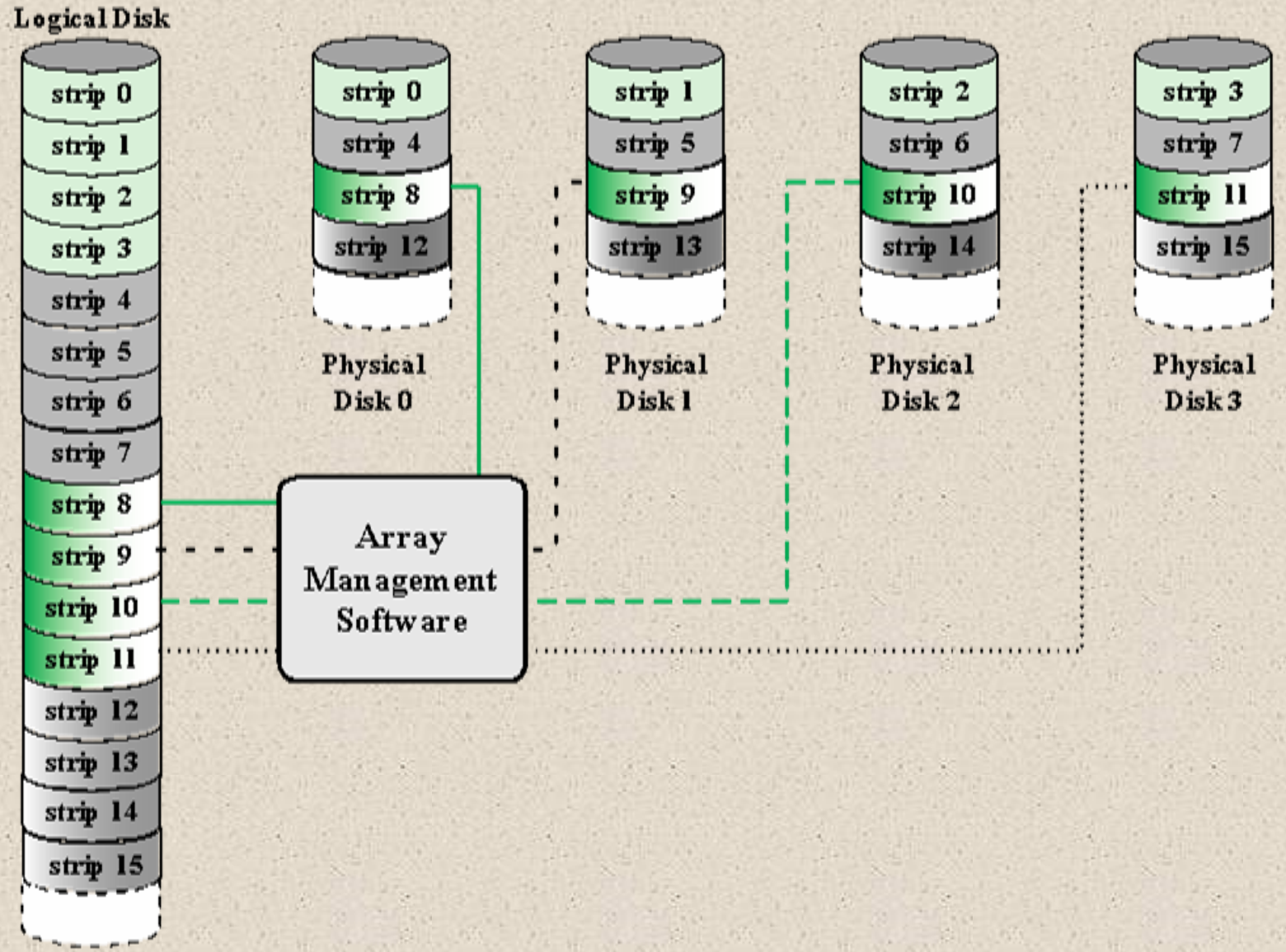


Figure 6.7 Data Mapping for a RAID Level 0 Array

Magnetic Tape

- Tape systems use the same reading and recording techniques as disk systems

A **magnetic tape** is a storage device that stores data **sequentially** on a plastic tape coated with magnetic material.

Working:

- A **tape drive** reads and writes data on a long strip of magnetic tape.
- Data is stored **in order (sequential access)**, meaning you must **fast-forward or rewind** to access specific data.

Uses

- **Backup storage** (used in big data centers).
- **Archiving old data** (government records, historical data).