



Al-Mustaqbal University
College of Science
Intelligent Medical System Department



جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

College of Sciences
Intelligent Medical System Department

Lecture 10

External Memory

Subject: Computer Fundamentals

Level: First

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What is an external storage device?

An external storage device, also referred to as auxiliary storage and secondary storage, is a device that contains all the addressable data storage that is not inside a computer's main storage or memory. An external storage device can be removable or nonremovable, temporary or permanent, and accessible over a wired or wireless network. External storage enables users to store data separately from a computer's main or primary storage and memory at a relatively low cost. It increases storage capacity without having to open up a system.

External storage often stores information that's accessed less frequently by applications running on a desktop, laptop, server or mobile device, such as an Android or iOS smartphone or tablet. For PCs, an external storage device often consists of stationary or portable hard disk drives (HDDs) or solid-state drives (SSDs), possibly attached through a USB or wirelessly.

Magnetic Disk Memory

A **magnetic Disk** is a type of secondary memory that is a flat disc covered with a magnetic coating to hold information. It is used to store various programs and files. The polarized information in one direction is represented by 1, and vice versa. The direction is indicated by 0. Magnetic disks are less expensive than RAM and can store large amounts of data, but the data access rate is slower than main memory because of secondary memory. Data can be modified or can be deleted easily in the magnetic disk memory. It also allows random access to data.





Advantages:

1. These are economical memory
2. Easy and direct access to data is possible.
3. It can store large amounts of data.
4. It has a better data transfer rate than magnetic tapes.
5. It has less prone to corruption of data as compared to tapes.

Disadvantages:

1. These are less expensive than RAM but more expensive than magnetic tape memories.
2. It needs a clean and dust-free environment to store.
3. These are not suitable for sequential access.

RAID (Redundant Arrays of Independent Disks)

RAID is a technique that combines multiple hard drives or SSDs into a single system to improve performance, data safety or both. If one drive fails, data can still be recovered from the others.

How RAID Works?

In RAID (Redundant Array of Independent Disks), data is not stored on just one hard drive but is distributed across multiple drives.

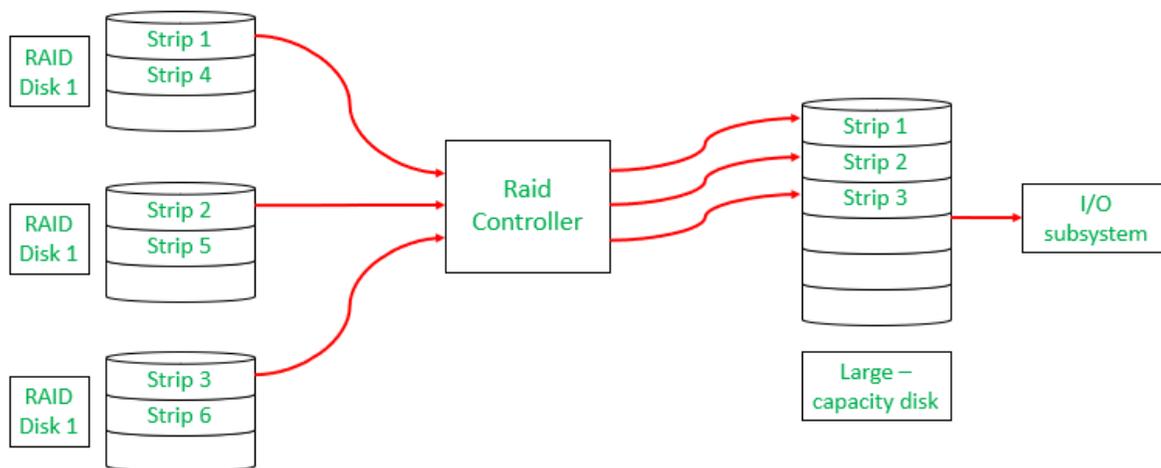
- The data is split into small blocks (like dividing a file into chunks). These blocks are written across multiple drives in parallel.
- **Mirroring (RAID 1):** Exact copy of data is kept on another drive.



- **Parity (RAID 5, RAID 6):** A calculated value (parity block) is stored to allow data recovery in case of failure.
- **Fault Tolerance:** If one drive fails, RAID uses the redundant data (mirror or parity) to reconstruct missing data.

RAID Controller

A RAID controller manages multiple hard drives, making them work together as one system. It helps improve speed and adds data protection by handling drive failures. Think of it as a smart manager that boosts performance and keeps your data safe.



Types of RAID Controller

There are three types of RAID controller:

1. Hardware-Based:

Uses a dedicated physical controller to manage hard drives.

- Offers high speed and reliability
- Can work independently from the computer's processor
- Often built into the motherboard or as a separate card



- Think of it as a captain managing the drives smoothly.

2. Software-Based:

Uses the computer's processor and memory to manage RAID.

- No special hardware needed
- Cost-effective, but may reduce overall system performance
- Slower than hardware RAID
- Acts like a helpful assistant, but shares the load with other tasks.

3. Firmware-Based (Fake RAID):

Built into the computer's BIOS/firmware and works during boot-up.

- Needs a driver after the OS loads
- Cheaper than hardware RAID, but still uses CPU resources
- Also known as hybrid RAID or fake RAID
- A startup helper that hands over the job to software once the system runs.

Why Data Redundancy?

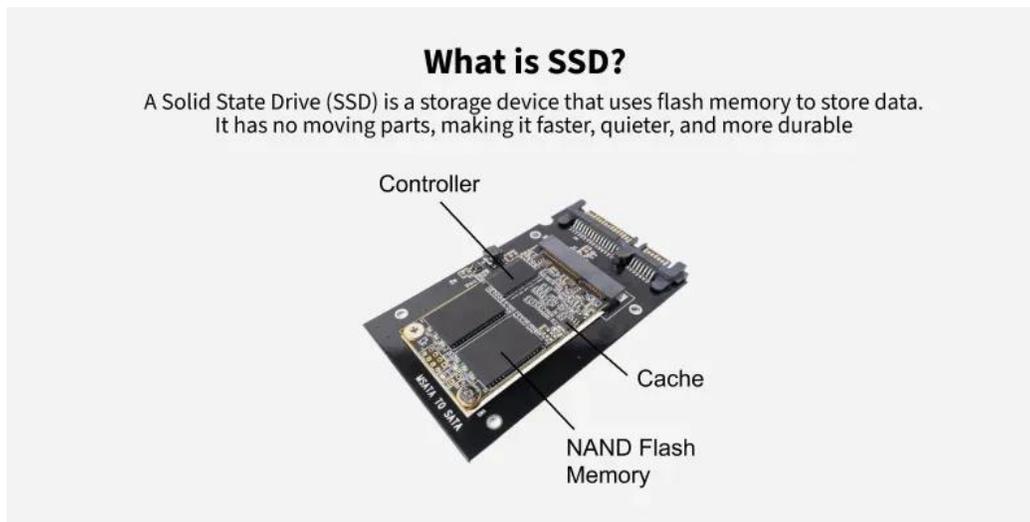
Data redundancy, although taking up extra space, adds to disk reliability. This means,

- That in case of disk failure, if the same data is also backed up onto another disk, we can retrieve the data and go on with the operation.
- On the other hand, if the data is spread across multiple disks without the RAID technique, the loss of a single disk can affect the entire data.



Introduction to Solid-State Drive (SSD)

A Solid-State Drive (SSD) is a non-volatile storage device that stores data without using any moving parts, unlike traditional Hard Disk Drives (HDDs), which have spinning disks and mechanical read/write heads. Because of this, SSDs are much faster, more durable and quieter than HDDs. They load files, programs and operating systems quickly, making computers more responsive.



How do SSDs work

Solid state drives (SSDs) use a combination of NAND flash memory technology and advanced controller algorithms. NAND flash memory is the primary storage component, divided into blocks and pages.

- An SSD contains a controller chip that manages data storage, retrieval and optimization.
- The controller's major duties are wear leveling, which evenly distributes write and erase cycles to extend the SSD's lifespan which consolidates empty blocks to maintain optimal performance.
- SSDs also use features like the TRIM command to increase efficiency by telling the drive about wasted data blocks.



- Furthermore, data compression and error correction techniques are used to increase storage capacity while maintaining data integrity.

Features of SSD

- **Start-up Time:** SSDs do not use any mechanical component hence it takes almost negligible startup time.
- **Random Access Times:** Accessing data directly from the Flash memory creates a lag-free experience for its users.
- **Read Latency time:** Accessing data from Flash memory also reduces the read latency time to very low.
- **Data transfer rates:** Higher Data Transfer rates of about 100-600 Mb/sec.
- **Fragmentation:** There is no such concept of Fragmentation in SSDs.
- **Noise:** As they have no mechanical part they create zero noise.
- **Reliability:** SSDs are reliable as there are no moving parts that can wear over time.
- **Operating Temperature Range:** SSDs can operate effectively in a wider temperature range compared to HDDs.
- **Shock and Vibration Resistance:** They are highly resistant to shock and vibration, making them ideal for use in portable devices like laptops, tablets and rugged environments.
- **Boot Time and Application Load Times:** SSDs reduce boot time of Operating systems and other applications.
- **Security features:** SSDs offer advanced security features like hardware encryption and secure erase functions to protect data from unauthorized access.



Types of non-volatile memory in SSD

SSDs use non-volatile memory (NVM) to store data permanently, even without power. The main types of NVM used in SSDs are:

1. **Single-Level Cell (SLC):** Stores 1 bit per cell, offering the fastest speed, longest lifespan and highest reliability, but is expensive.
2. **Multi-Level Cell (MLC):** Stores 2 bits per cell, balancing speed, cost and durability. Commonly used in consumer and enterprise SSDs.
3. **Triple-Level Cell (TLC)** – Stores 3 bits per cell, making it more affordable but with slower speeds and a shorter lifespan than SLC and MLC.
4. **Quad-Level Cell (QLC):** Stores 4 bits per cell, offering the highest storage capacity at a lower cost but with reduced performance and endurance.
5. **3D NAND (V-NAND):** A technology that stacks memory cells vertically to increase storage density, improve speed and extend lifespan.

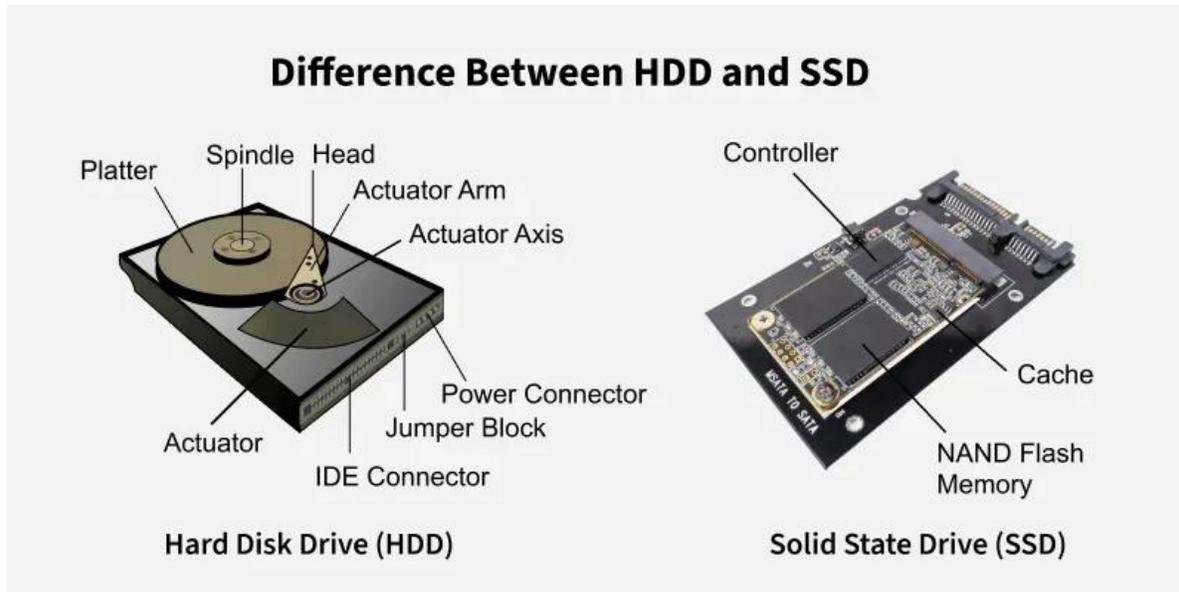
Types of Solid-State Drives

- **PCIe-based Flash SSDs:** These SSDs use the PCI Express (PCIe) connection, which allows for high-speed data transfer. They have very fast read and write speeds, shorter delays (latency) and handle multiple tasks efficiently.
- **NVMe SSDs:** These SSDs use the Non-Volatile Memory Express (NVMe) protocol, designed for super-fast performance. They work with PCIe to achieve speeds over 3000 MB/s, making them perfect for gamers and high-performance tasks. Many come with heatsinks to prevent overheating.
- **Flash DIMMs:** These SSDs are designed as memory modules (DIMMs) instead of traditional storage drives. They are even faster than PCIe SSDs because they avoid PCIe bus conflicts, but they require special drivers and motherboard modifications.



- **Hybrid DRAM-Flash Storage:** These combine flash storage with server [DRAM \(Dynamic Random Access Memory\)](#) for improved performance. This setup helps balance speed and storage capacity efficiently.

Difference Between SSD and HDD



| Parameter | HDD | SSD |
|--------------------------|--|---|
| Long term storage | HDDs are more reliable for long-term storage. | SSDs are comparatively less reliable for long-term storage due to data leaks that can occur if kept unpowered for more than a year. |
| Access speed | The data accessing speed is slower as compared to SSD. | The data accessing speed is much higher as compared to HDD. |



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| Parameter | HDD | SSD |
|---------------------|---|--|
| Performance | The performance suffers because of fragmentation. | The performance does not suffer because of fragmentation. |
| Suitable for | <ul style="list-style-type: none">• Extensive storage• Long-term storage | <ul style="list-style-type: none">• Fast data retrieval• Laptop or desktop because of low power consumption and size. |