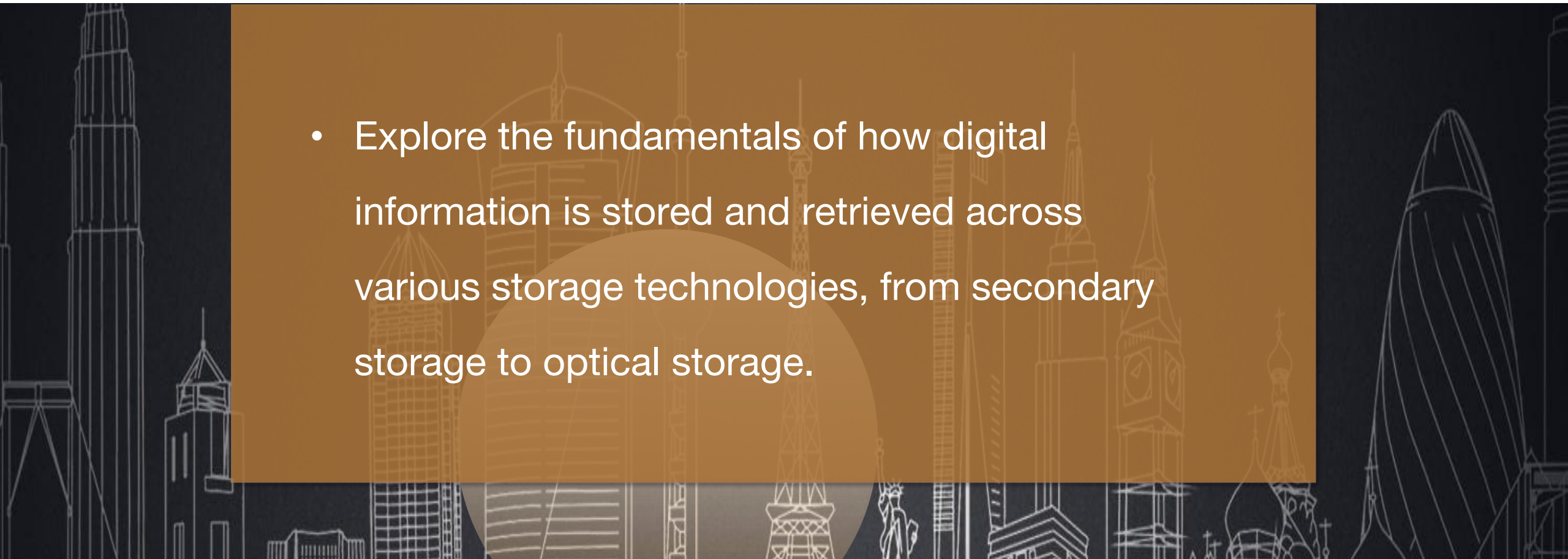
Data Storage



- Explore the fundamentals of how digital information is stored and retrieved across various storage technologies, from secondary storage to optical storage.

Primary Storage&Secondary Storage

Primary Storage

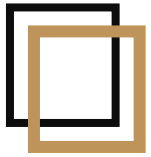
Secondary Storage

- CPU

- Your body&your phone?

Secondary Storage

Primary Storage	Secondary Storage
Very Fast, higher cost, typically smaller	**Slower compared to primary storage,lower cost, typically larger**
RAM (Random Access Memory), ROM (Read-Only Memory), Cache	HDD (Hard Disk Drive), SSD (Solid State Drive), CD, DVD, USB Drives
Temporary storage for currently running programs and data (RAM), permanent firmware storage (ROM)	Long-term storage for files, applications, and system data



Primary Storage

RAM: Random Access Memory

SRAM and DRAM

ROM: Read Only Memory

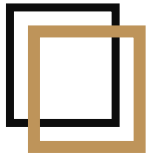
Key Comparison

Volatile

Write&Read

RAM&ROM

RAM	ROM
temporary	can only be read
volatile	non-volatile
store files currently in use	store BIOS(basic input/output system)



Examples

- System settings
- Nintendo game cartridge
- Frequently accessed files
- Models/graphics used in video games during runtime

DRAM&SRAM

DRAM	SRAM
transistors&capacitors	flip-flops
needs to be refreshed	no need for that
cheaper, higher memory capacity	

Review

1.What is the main purpose of RAM in a computer system?

- A) To store the operating system permanently
- B) To provide temporary storage for data and instructions currently being used
- C) To store the BIOS
- D) To archive old files

Review

3.A big difference between SRAM and DRAM is _____

SRAM doesn't need to be constantly refreshed.

4.The primary difference between RAM and ROM is that RAM is _____, while ROM is _____.

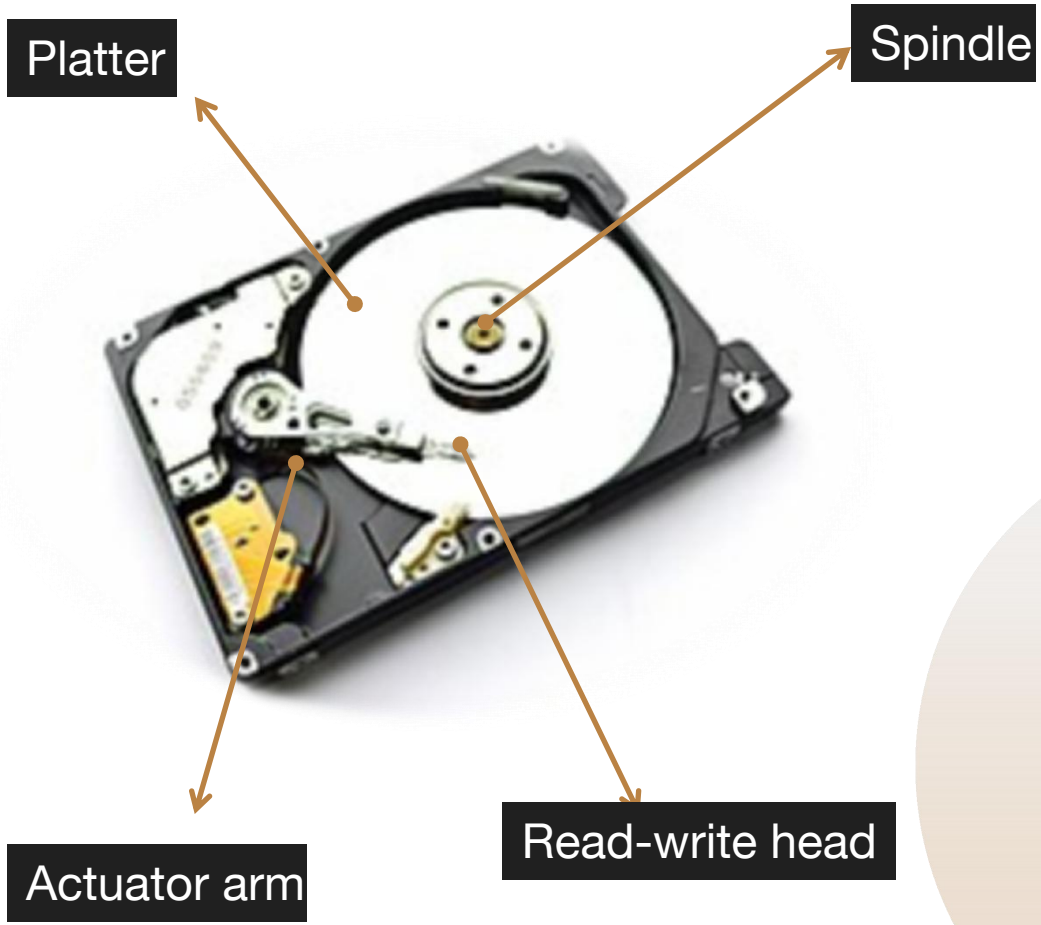
RAM is volatile, while ROM is non-volatile.

Review of Last Lesson

Describe a situation in which data stored in RAM would be lost.

For example, if you are working on a document and have not saved your changes, and then the computer suddenly loses power or is shut down, all unsaved data in RAM will be lost.

Hard Disk Drive

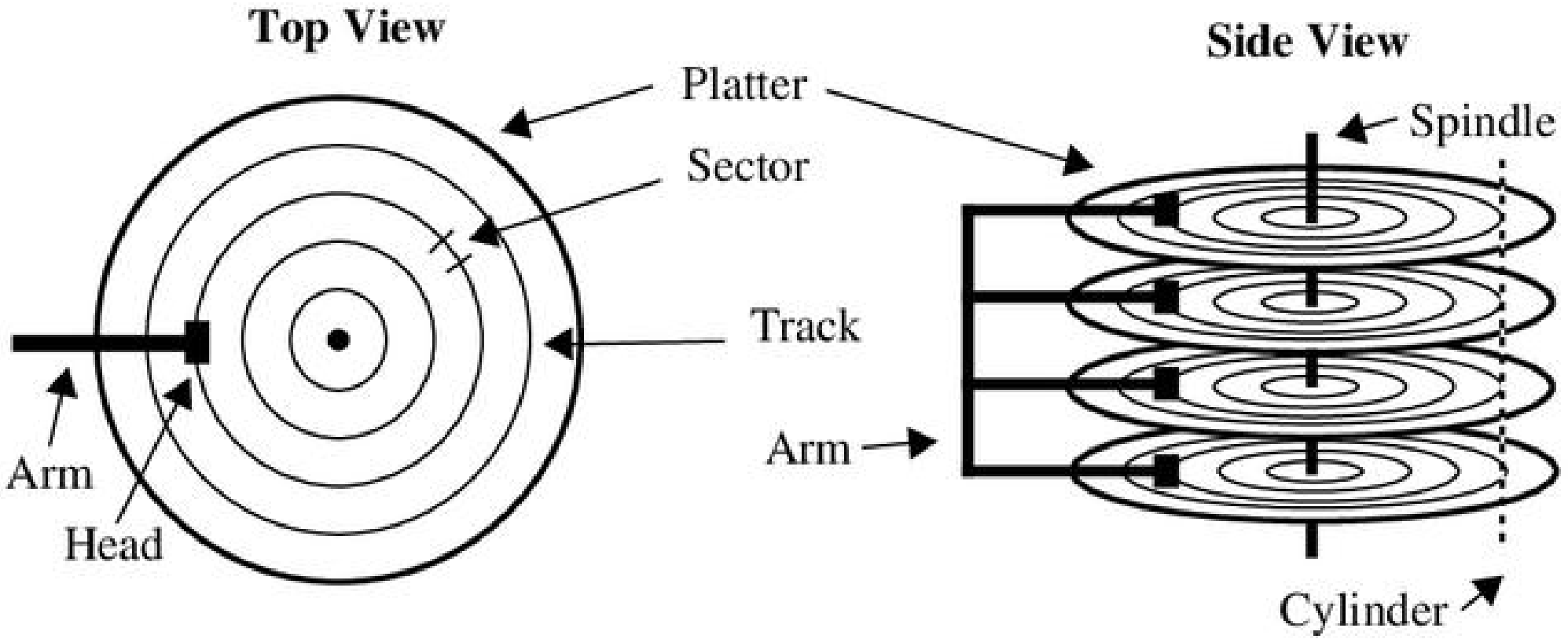


- The platter is a circular, rigid disk coated with a ***magnetic material***. We all know that magnetic poles have positive and negative sides, which correspond to the two different forms in binary.
- The spindle is responsible for ***spinning the platters*** at high speeds, around 7000 times a second.
- The read/write heads, which are positioned by the actuator arm, ***move across the platter surfaces to access different data tracks*** and transform it into 0/1s.

Hard Disk Drive

1. The computer wants data
2. Turn the platter around the spindle
3. Use the read-write head to reach the data
4. Read the data and process it into 0/1s

Platter


Top View
Side View
Platter
Sector
Track
Arm
Head
Arm
Spindle
Cylinder

Latency

- The data is often scattered across different sectors and tracks on the platters due to the way the file system manages storage.
- ***The read/write heads need to move to multiple locations to access all the necessary data***. Each movement, takes time.
- Additionally, ***the platters must spin to align the desired sector under the heads***, which also contributes to the delay.

- You wait and wait and wait.....

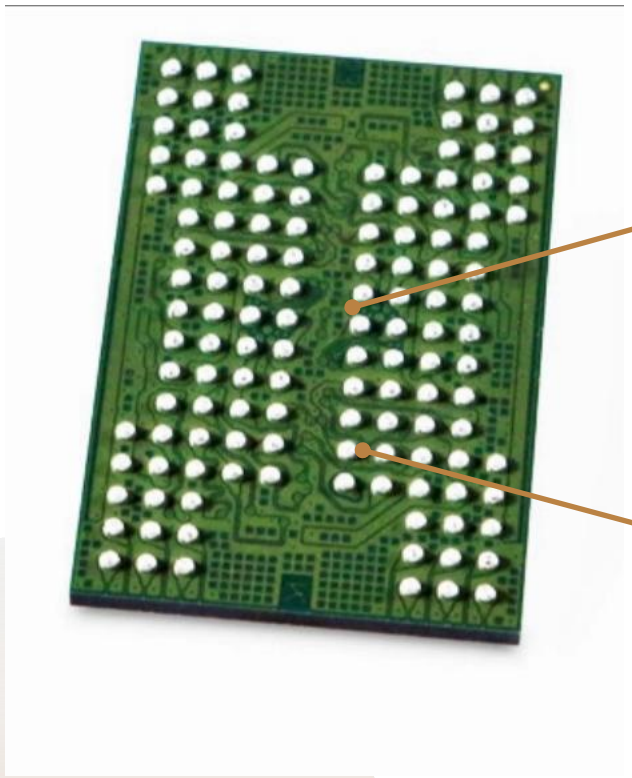
Think about it

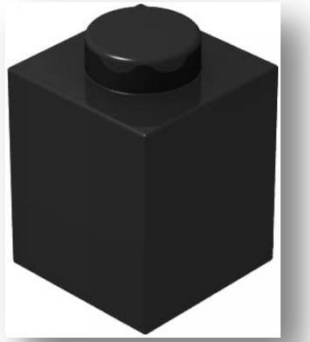
Why couldn’t we build super large RAM/ROM?

- High cost

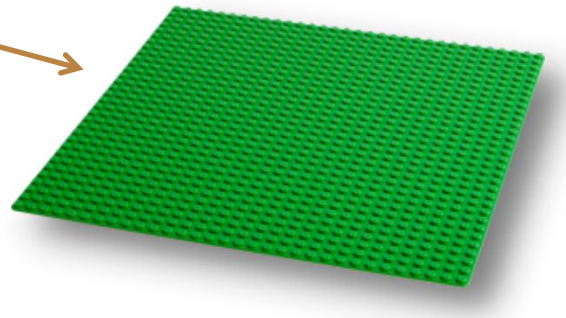
- RAM: High energy consumption, possible cooling problem
- ROM: Cannot write data

Flash Memory





Each transistor stores ***electrical charges***, representing binary data (0s and 1s). When data is written to the flash memory, these transistors trap electrons, and when data is read, the presence or absence of these electrons is detected.

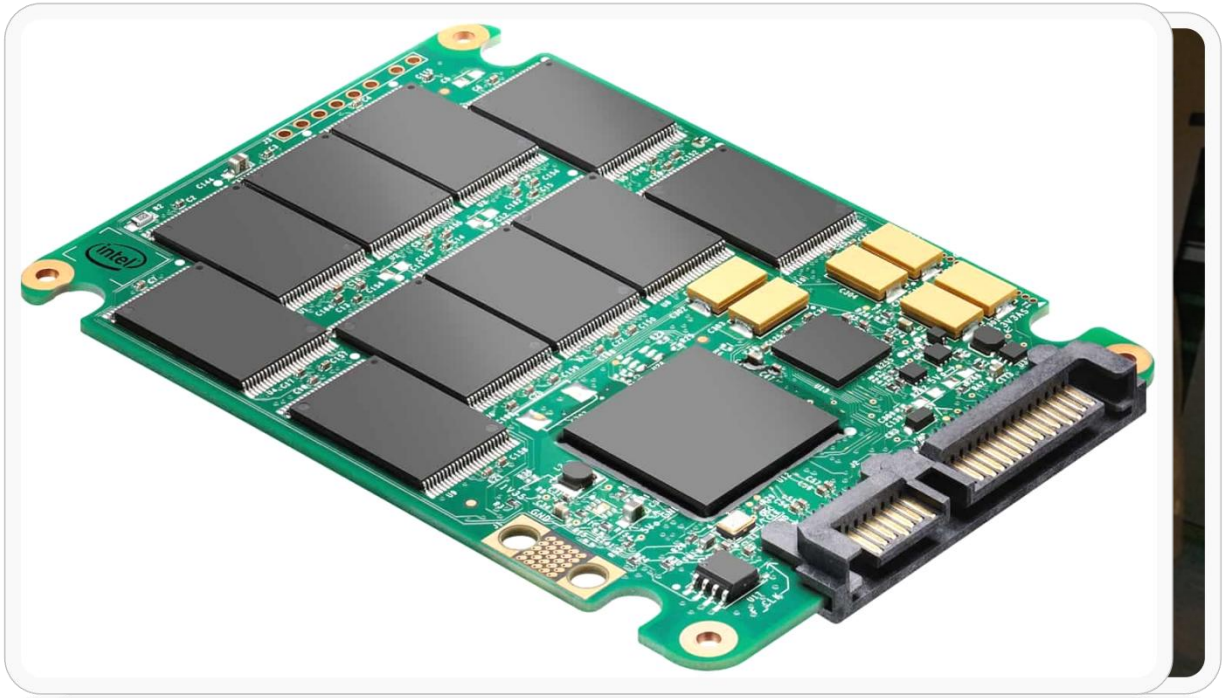


Provide the foundation

Gather units into ***pages and blocks***

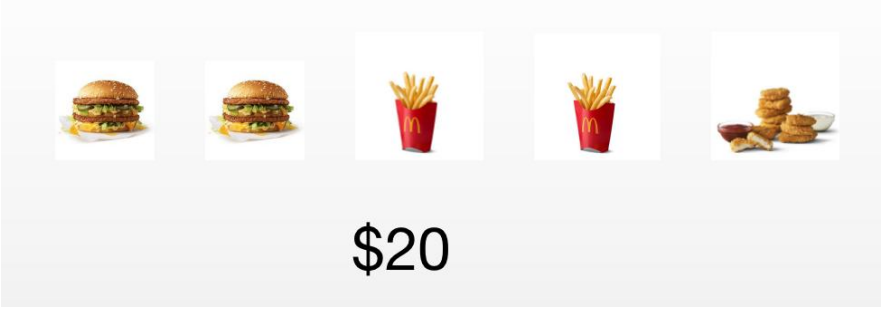
Solid-state Drive

1. The computer wants data
2. It searches the flash based on the tag
3. It finds the exact spot within the flash memory



NAND VS EEPROM

NAND	EEPROM
Uses NAND technology	Uses NOR technology
Less expensive, more cost-effective	More expensive
Blocks of data are read or erased	***Data can be read or erased one byte at a time***
Commonly used in SSDs, USB drives, memory cards	Useful in applications requiring frequent small updates, like firmware
Usually referred to as "Flash" storage	Specifically called EEPROM

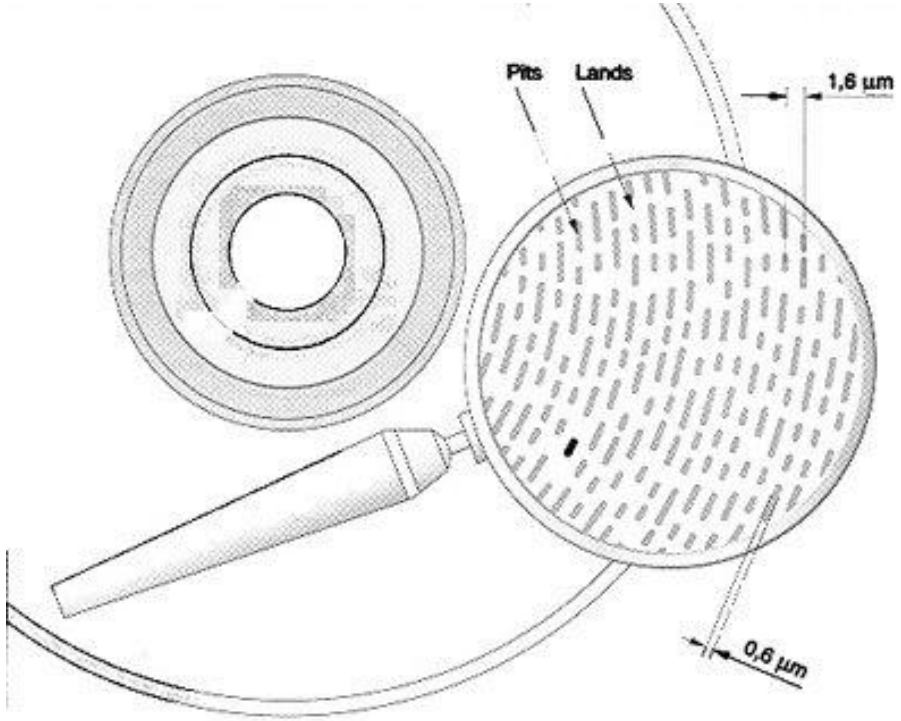


Difference between HDD and SSD

HDD	SSD

Carry a Computer?

Optical Storage

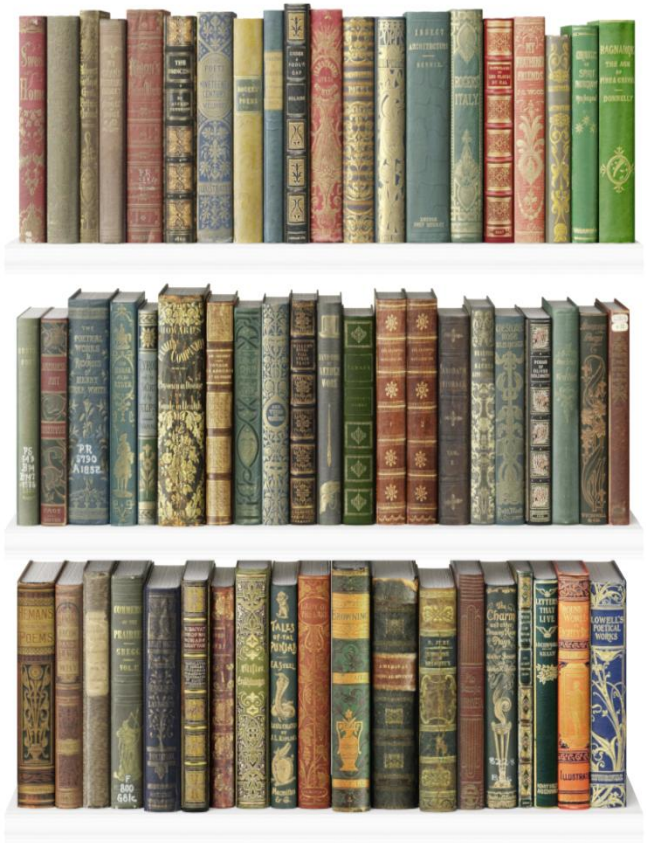


Optical Storage

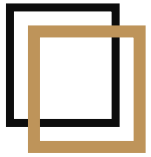
- 'pits' and 'bumps (0s and 1s)

- A red laser is used to read and write the data.

CD/DVD



- CD only has ***one layer*** while DVD has ***multiple layers***.
- The red laser reads different layers based on adjusting its focus to the appropriate depth for each layer.



Blue-ray disk

CD/DVD	Blue-ray disk
Red light	Blue light
Single/two layers	Single layer
Large pits&bumps, low capacity	Small pits&bumps, high capacity

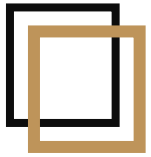
Virtual Memory

virtual memory= RAM+swap space on the HDD or SSD

HW today:
1.Search for virtual memory, what's the meaning of this equation.
2. ***What's Disk Thrashing***

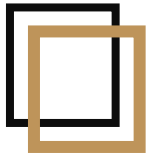
Cloud Storage

A method of storage where data is stored on remote servers



Cloud storage

Benefits	Drawbacks



Extra Material

- TED Talks about HDD(https://www.youtube.com/watch?v=wteUW2sL7bc)
- TED Talks about DNA Storage(https://www.youtube.com/watch?v=r8qWc9X4f6k)
- Google Data Center Vitrual Tools Blog(https://cloud.google.com/blog/products/gcp/google-data-center-360-tour)
- File System Simulator(https://github.com/ttsugriy/File-System-Simulator)

Key Terms

- HDD (Hard Disk Drive): A data storage device that uses ***magnetic storage*** to store and retrieve digital information using rotating disks (platters) coated with magnetic material.
- SSD (Solid State Drive):A storage device that uses ***flash memory*** to store data. It has no moving parts, making it faster and more reliable than HDDs.
- Optical Storage: Data storage technology that uses ***lasers*** to read and write data on optical discs like CDs, DVDs, and Blu-ray discs. Data is stored as tiny pits and lands on the surface of the dis

Key Terms

- Cloud Storage: A way to store data on the internet using remote servers managed by service providers(Google Drive, Dropbox).
- Latency: The delay before data starts moving after an instruction is given.
- Flash Memory: A type of memory that can be electronically erased and reprogrammed.
- Cloud Storage:A method of storage where data is stored on remote servers.
- Virtual Memory:?

- A company needs to store large amounts of data, including multimedia files (such as high-resolution images and videos) and text-based documents. They are considering using either primary storage (RAM), secondary storage (hard disk or solid-state drives), or cloud storage solutions for different purposes.

- a) Explain the differences between primary storage and secondary storage, giving examples of each. (4 marks)

- b) Discuss the advantages and disadvantages of using cloud storage compared to traditional secondary storage (such as hard disk drives or solid-state drives) for storing large amounts of data. (6 marks)

- c) The company is planning to archive data that will be rarely accessed but must be stored for at least 10 years. Recommend the most suitable storage solution for this purpose, explaining your choice. (5 marks)