Module 6
Device Subsystems
Part 1

What is a Storage Device?

- According to Oxford Dictionary

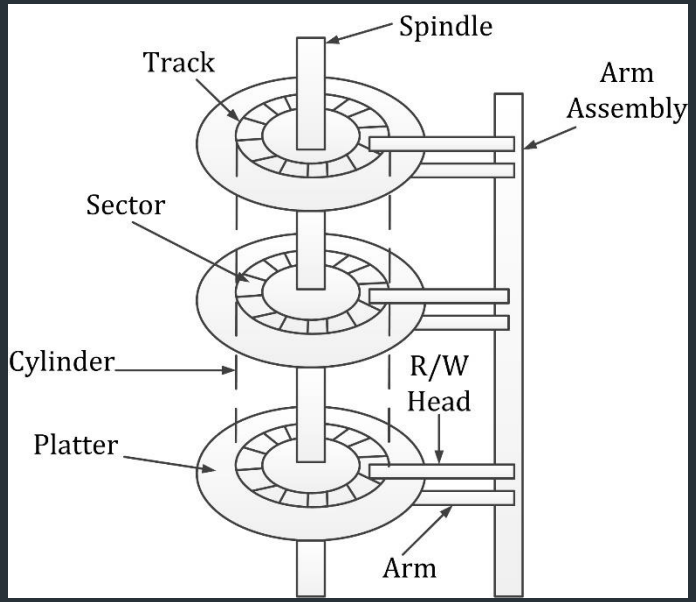
  A piece of computer equipment on which information can be stored.

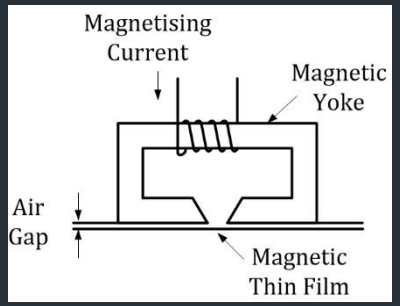
External Storage Systems

- The Semi-conductor memories (Flash, RAM, EEPROM) are limited to small capacity storage.
- Secondary storage -> Store large amount of data.
- Secondary storage devices included:-
  - Magnetic Disk (Hard Disk).
  - CD, DVD (Optical Drive).
  - Magnetic Tapes.

Magnetic Disk

- Several disks are placed in a spindle.
- Magnetic film is coated on both sides of the disk.
- The rotary drive is used in which the disk is placed.
- The read write head is in closed proximity with the surface of the disk.
- The head consists of the magnetic yoke and coil.



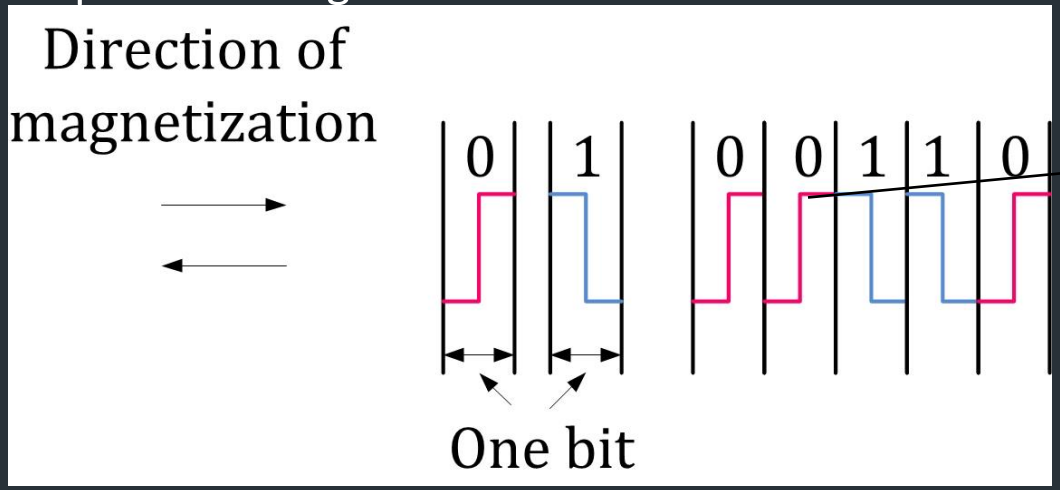


Magnetic Disk

- A pulse of electric current of suitable polarity is applied to the coil to store digital information.
- Upon applying the current, the film is magnetized and switch its direction parallel to the applied field.
- The change of magnetic field between the head and the movement of the film causes a voltage in the coil, thus the coil acts as a sensing agents.
- A control circuit monitored the polarity of this voltage.

Magnetic Disk

- The voltage is caused in the head only when the transitions of 0-1 or 1-0 occurs.
- Clock is used for synchronization to read information of long bit stream. Clocking information is combine with the data.
- Example: Encoding schemes such as Phase or Manchester encoding.



Clocking information at midpoint of each bit

Winchester Hard Disk

- It is a sealed unit that is developed by IBM in Winchester (USA).
- It consists of more platter.
- When the disk is spinning, the head is not contact with the surface.
- A very small gap is maintained between the disk and the head.
- When power is switched off the head rest gently on the disk,
- Robust.
  - Error Correction is automated.
  - Remapping of bad sectors

Advantages

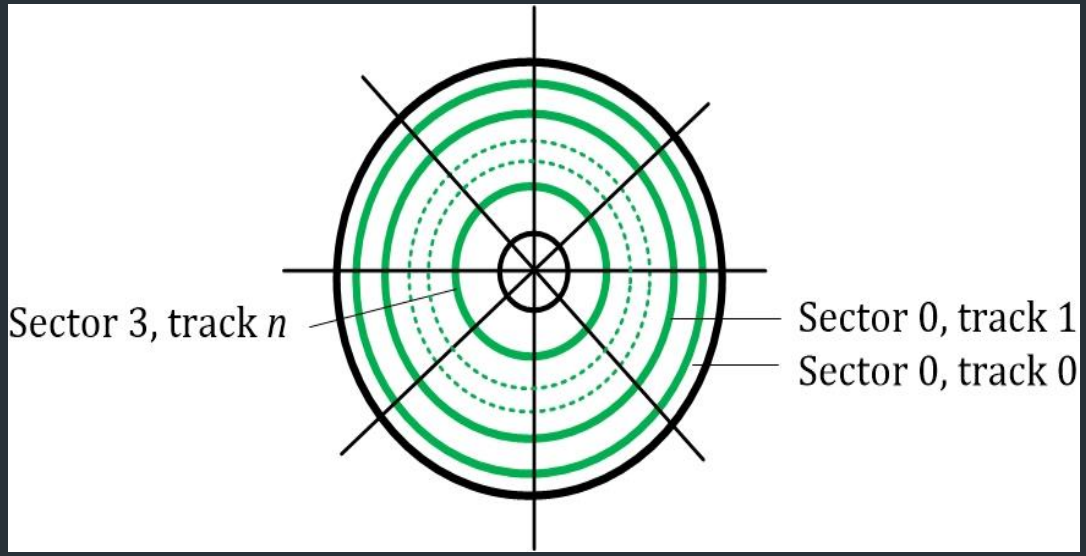
- It is used widely.
- Price is cheap.
- The speed is relatively fast as compared to its predecessor.
- The size is getting larger with times.
  - 1TB and 2TB is relatively prevalent nowadays.

Parts of the disk system

- Disk Platter – The disk itself.
- Disk drive – This is used to spin the disk and moves the R/W heads.
- Disk Controller
  - Circuit to handle the operation of the disk.
  - Can be implemented as a separate module.

Organization

- Division is as follow
  - Surface -> Concentric Track -> Sectors
- Logical cylinder
  - Disk stacks together -> set of the corresponding tracks.
- Data accessed
  - Which surface? Surface Number
  - Which Track? Track Number
  - Which Sector? Sector Number
- Initially the R/W starts at the boundaries of the sector.

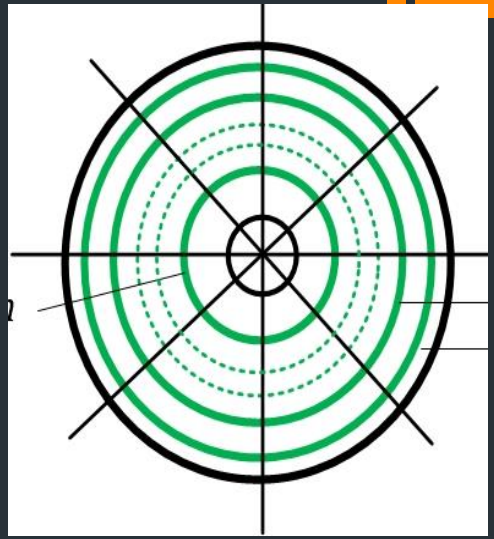


Sector Head & Error Code Checking

- Storage of bits- Serially on each track. Sector size ~ 512 bytes.
- **Sector header includes:**
  - Identification information.
  - Sector header – Used to go to the intended sector on the track.
- **Error checking code (ECC)**-
  - Error detection and correction.
  - Initially he disk is unformatted and has no information in it.
  - Upon Formatting:-
    - The disk is divided into track and sectors.
    - The bad sectors on tracks are identified by the disk controller to keep such records.

Organization

- Disk -> Logical partitions
  - Primary partition
  - Secondary partition
- Same number of sectors on each track.
- Which mean all track have same capacity of storage.
- Inner track is more densely packed.



Access Time

- The two parameters are used to calculate the time elapse to receive an address and the starting of the data transfer.
- Seek time – The total time required for the head to move to the desired track. (Average ~ 5 to 8 ms).
- Rotational delay / Latency time - The time taken to be in the address sector after the R/W head is placed in the right track.

  (Av. ~ Half Rotation of the disk).
- Access Time = Seek Time + Latency

Problem 1 : Capacity

- A disk has the following specification
  - # of Surface (S)= 8
  - # of Tracks on each surface (T)= 64 T/S,
  - # of Sectors on each tracks (Sec)= 128 Sec/T
  - # of Bytes on each sector (B) = 512 B/Sec.
- Total Capacity = S * T * Sec * B

  = 8 * 64 * 128 * 512

  $=2^3 * 2^6 * 2^7 * 2^9$

  $= 2^{25}$ Bytes = 32 MB

Problem 2: Data Transfer Rate

- Consider
  - Disk is rotating at 3600 rpm
  - Su= 8 surfaces
  - T= 64 tracks per surface,
  - Sec= 128 sectors per track
  - B= 512 bytes per sector.
- Data Transfer Rate

  = # of Head * Total Capacity of a track * # of rotations in 1 sec.

- Number of Heads = Number of Surface = 8
- Capacity of one track = Sec * B = 128 * 512
- Number of rotation in one sec = (3600 / 60) rotations per sec.
- 60 rotations/sec
- Data Transfer Rate = 8 * (128 * 512) * 60 bytes/sec
- $2^3 * 2^7 * 2^9 * 60$ bytes/sec.
- $2^{19} * 2 * 30 = 30$ MBps

Problem 3: Average Access Time

- Consider
  - Rotational speed = 1800 RPM.
  - Seek time (ST) = 5.5 ms.
- Av. Access Time.
  - Time reqd. for a full rotation.
    - (60/1800) = (1/3) = 0.0333 = 33.33 ms.
  - Av. rotational Time
    - ½ * Time reqd. for a full rotation
    - ½ * 33.33 msec = 16.665 ms.
  - Av. Access time = Av. ST + Av. rotational time
    = 5.5 ms + 16.665 ms
    = 22.165 ms

Problem 4: Average Access Time

- Consider
  - Rotational speed = 1800 RPM.
  - Seek time = 5.5 msec.
  - Amount of Data to be transferred = 1 Kbytes
  - Data Rate = 80 KB/sec
- Time taken for one full rotation=(60/1800)=0.0333sec= 33.33 ms
- Av. Rot. Delay = ½ * time taken for one full audition = ½ * 33.33 = 16.665 ms
- Transfer time = (1KB / 80 KB) sec = 12.5 ms.
- Av. Access Time = Av. Seek Time + Av. Rot. Delay + Transfer time

  = 5.5 ms + 16.665 ms + 12.5 ms

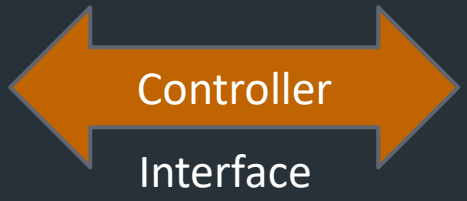
  = 34.665 ms

Data Buffer or Data Cache

- The disk drive is coupled to other components of the computer using connection type such as SCSI or SATA
- This scheme enables faster transfer rate of as compared to which the data can be read from the disk.
- This is achieved by using a data buffer. It is a semiconductor storage device.
- Cache mechanism

Disk Controller

- The disk controller circuit is responsible for controlling the operation of the disk drive.

- Disk drive 

Rest of the computer

- Same communication as IO interface is used between OS and disk controller.
- Transfer of Data : Controller used DMA scheme
  - Disk  Main Memory

How does the transfer works?

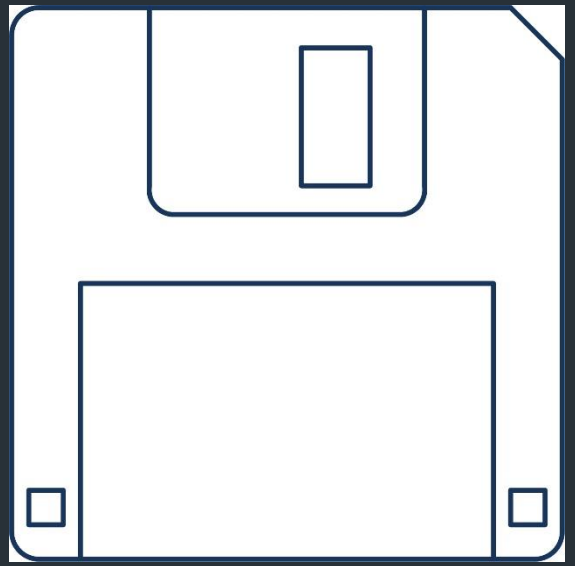
- The buffer in the disk controller holds the data to be written/read to other/itself.
- OS -> transfers by issuing R and write request.
- Controller registers are loaded with the necessary addressing and control information.
  - Address of 1st main memory of the block required to transferred.
  - Disk address- Sector location containing the initial of the intended blocks of words
  - Words count – Amount of words required to transferred.

Disk Controller Major Functions

- Seek – The read write head -> intended track.
- Read- Starts a read operation. The data from disk are put in the buffer for transfer in the main memory. The word count kept track of the number of words to be transferred.
- Write- Transfers data to the disk
- Error Checking – Computes Error checking codes (ECC)

Floppy Disks

- Shutter – opens when inserted in the computer.
- Write protect can be enable by opening the notch
- Tracks – closed concentric circle
- Sectors- wedge shaped sections on the disk.



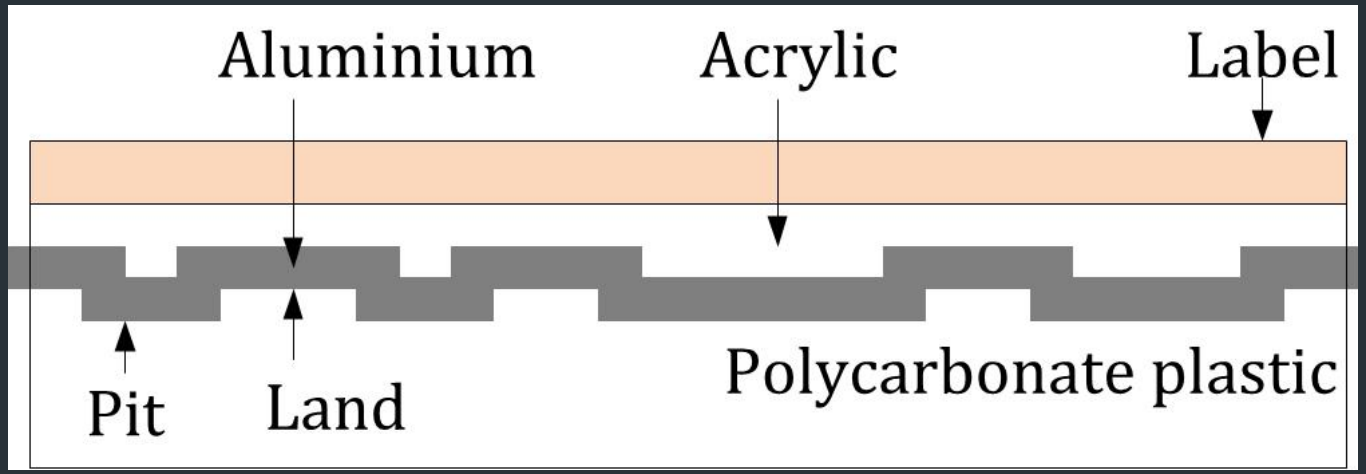
RAID Disk Arrays

- University of California-Berkeley first proposed to use multiple disks operating in parallel to reduce access time
- It is called as Redundant Array of Inexpensive Disks (RAID).
- Basic configuration -> RAID 0 -> Data stripping -> large files into number of pieces spread across different disks
- RAID 1- storing identical copies -> improve reliability.

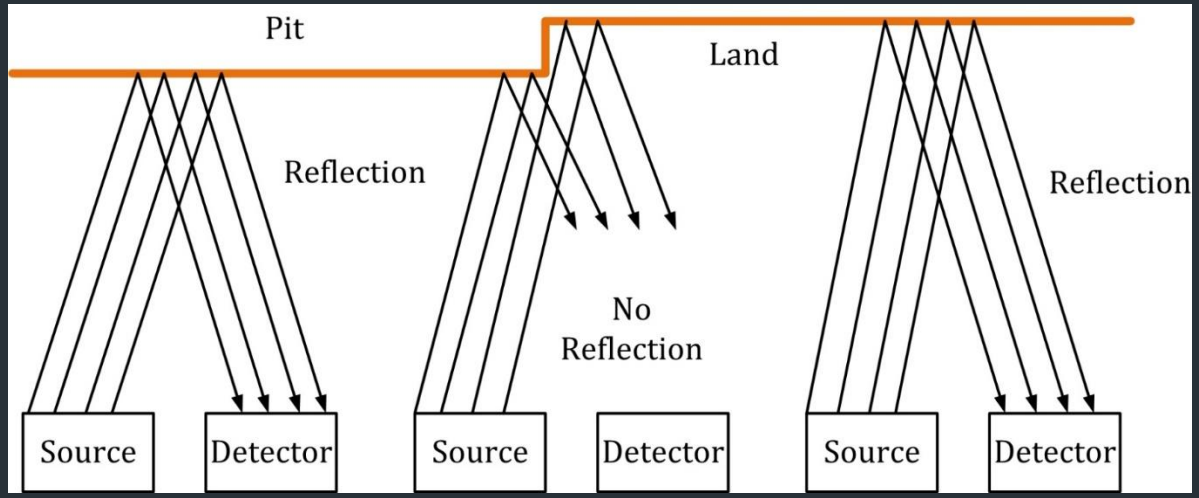
Optical Disks

- Laser beam and photodetector are used
- Encodes binary data (bits) in the form of pits and lands.
- Pits:- 0 or OFF, No/Lack of reflection
- Lands:- 1 or ON, reflection when read.

Cross Section



Transition from Pit to Land



Magnetic Tapes

- Magnetic tape primarily used for magnetic recording.
- A thin narrow plastic film is coated with magnetizable element.
- The concept originated in Germany in 1928.
- Examples: Tape Recorder, video tape recorder, and on computer a tape drive.

Thank you

References

- Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Naraig Manjikian - Computer organization and embedded systems (2011, McGraw-Hill)