Disk Storage

COMP375 Computer Architecture and Organization

Goals

- Understand how information is stored on a disk drive.
- Be able to calculate how long it will take to read data from a disk.
- Understand how data is stored on a CD and how this impacts its use.

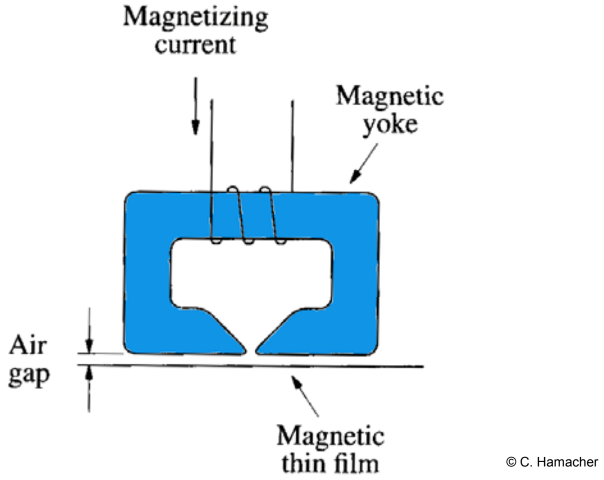
Disk Drives

- There are several types of rotating media storage devices.
  - Hard drives
    - 36 GB to 2 TB
  - Floppy disk
    - 1.4 MB
  - CD ROM
    - 600 MB to 750 MB
  - DVD
    - 4.7 GB to 8.5 GB

Hard Drive Storage

- A hard drive contains several flat platters covered with a smooth iron coating like that of a tape cassette.
- Data can be stored by magnetizing small areas of the iron coating.
- The disk surface is polished to be very flat.
- The disk head floats over the platter spinning at 4.3 million inches/sec or 70 mph.

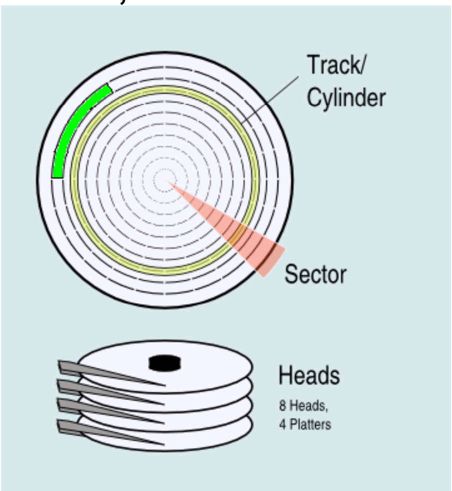
Disk Read/Write Head



Disk Tracks

- Data is written on the disk drive in concentric circles called **tracks**.
- A track is composed of blocks of data called **sectors**. Each sector has a header including address and checksum.
- An arm containing the read/write head can move closer or farther from the center of the disk.
- All of the tracks on both sides of all platters that can be read without moving the heads is called a **cylinder**.

Cylinder, Heads and Sectors



Terminology

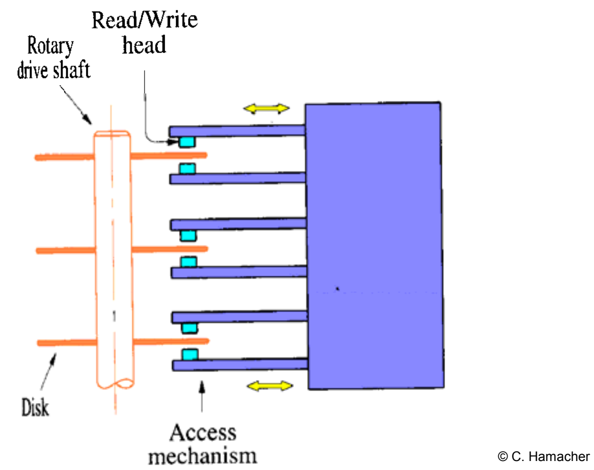
- **Sector** or **Block** – the smallest unit that can be read or written. Often 512 bytes.
- **Track** – all blocks that form a ring on a disk surface that can be read without moving the head.
- **Cylinder** – all tracks on all surfaces, one on top of another, that can be read without moving the head.

Disk Operation

To read (or write) data to the disk:

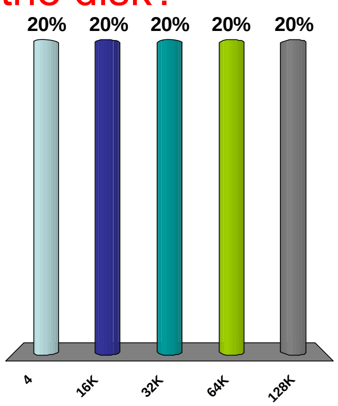
- The arm containing the read/write heads must be moved to the proper radius from the center.
- The system must wait for the data to rotate under the read head.
- The data is read as it passes under the read head.
- The data is checked and then passed to the I/O controller.

Disk Drive Side View



If a disk has 4 platters and 16K tracks per surface, how many tracks are on the disk?

1. 4
2. 16K
3. 32K
4. 64K
5. 128K



Disk Performance Parameters

Disk read or write involves three factors

1. **Seek time**
   - time it takes to position the head at the desired track
2. **Rotational delay** or rotational latency
   - time its takes for the beginning of the sector to reach the head
3. **Transfer time**
   - time required for the data to move under the head

Seek Time

- Seek Time is fixed by the design of the disk.
- Manufacturers will usually tell you the
  - average seek time
  - maximum seek time *(from center to edge)*
  - time to seek to the next adjacent track.

Rotational Delay

- Best case is when the data comes under the head just as it is needed (delay is zero).
- Worst case is you just missed it and have to wait a whole revolution. If you know the rotational speed, you can calculate the time per revolution.

$$\frac{60\text{sec/min} * 1000\text{ms/sec}}{\text{rev/min}} = \text{ms/rev}$$

- Average is half a revolution or above/2

How many sectors?

- Files are stored in sectors or blocks on the disk.
- The number of bytes in a sector varies per disk but is often 512 bytes/sector or ½K / sector

$$sectors = \frac{FileSize}{bytes/sector}$$

Transfer Time

- The transfer time is determined by how long it takes the data to travel under the head.
- The fraction of sectors on the track that are being read times the rotation time gives the transfer time.

$$\frac{\text{sectors\_read}}{\text{sectors/rev}} * \text{ms/rev} = \text{transfer\_time}$$

WD Caviar® 80 GB 7200 RPM

Rotational Speed	7,200 RPM
Average Read Seek Time	8.9 ms
Track-To-Track Seek Time	2.0 ms (average)
Full Stroke Seek	21.0 ms (average)
Cylinders	16,383
Number of Heads (Physical)	6
Sectors Per Track	63
Bytes Per Sector	512

Performance Example

How long does it take to read a 512 byte block from the disk?

Rotation Time $8.33\text{ms} = \dfrac{60\text{sec/min} * 1000\text{ms/sec}}{7200\text{rev/min}}$

Average Seek time	8.9 ms
Average Rotational Delay	8.33ms / 2 = 4.17 ms
Transfer time	$\dfrac{1\text{sector}}{63\text{sectors/rev}} * 8.33\text{ms} = 0.13\text{ms}$
Total	13.2 ms

Performance Example

How long does it take to read two 512 byte blocks from the disk?

Rotation Time $8.33\text{ms} = \dfrac{60\text{sec/min} * 1000\text{ms/sec}}{7200\text{rev/min}}$

Average Seek time	8.9 ms
Average Rotational Delay	8.33ms / 2 = 4.17 ms
Transfer time	$\dfrac{2\text{sector}}{63\text{sectors/rev}} * 8.33\text{ms} = 0.26\text{ms}$
Total	13.3 ms

Performance Notes

- The largest component of the time to read a block is the seek time.
- Spinning the disk faster reduces the rotational delay and transfer time.
- It is very advantageous to be able to read data without moving the heads.
- Disk fragmentation causes a significant reduction in speed.
  - 2 consecutive blocks takes 13.3 ms
  - 2 randomly located blocks takes 26.4 ms

How long does it take to read one block of data on the average?

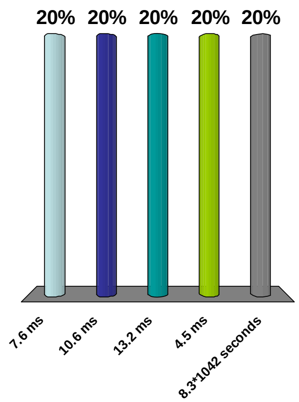
Rotational Speed 10,000 RPM

Average Seek Time 4.5 ms

Bytes / sector 512

Sectors / track 63

1. 7.6 ms
2. 10.6 ms
3. 13.2 ms
4. 4.5 ms
5. $8.3*10^{42}$ seconds



Logical vs. Physical

- Many disks present the OS with a logical layout that is different from the physical layout.
- Most modern disks use Logical Block Addressing (LBA) to hide the physical layout.
- LBA represents the disk as a sequential list of blocks.

CD ROM

Early *Laserdisk* and current DVD

CD ROM

- A CD contains an aluminum layer sandwiched between layers of clear plastic
- An infrared laser is used to read the CD.
- Bits are recorded as pits or spots in the aluminum. These affect the reflectance of the laser light.
- Each pit is approximately 100 nm deep by 500 nm wide, and varies from 850 nm to 3.5 μm in length.
- The data on a CD is written as one long 5.38 km spiral

CD Data Format

A CD contains 2352 byte blocks with:

- 2048 bytes of data
- 16 byte header containing the address
- 288 bytes of error correcting codes

Music CDs

- 16 bit samples
- 44,100 samples per second

CD Performance

- The "X" of CD speed claims represents the number of times faster the CD spins than music CD players. 1X = 75 blocks/sec
- CDs are written in a long spiral instead of concentric tracks. This is good for music.
- The average seek time for a CD is 90 ms *(compare to 9 ms for a hard drive)*.
- CDs are efficient reading large files but slow reading small files.

Writing a CD

- Prerecorded CDs have bumps pressed into the aluminum before being embedded in the plastic.
- CD-Recordables burn spots in an organic dye on the aluminum. The spots do not reflect as well.
- CD-Rewritables use two different temperatures to melt or crystallize the metal layer. High heat makes it opaque. Low heat makes it transparent.

Optical Disks

Optical Disk	Wavelength	Capacity
CD	780 nm infrared	750 MB
DVD	650 nm red	4.7 GB
Blu-Ray	405 nm blue-violet	25 GB