Disk Based Storage

Lecture Objectives:

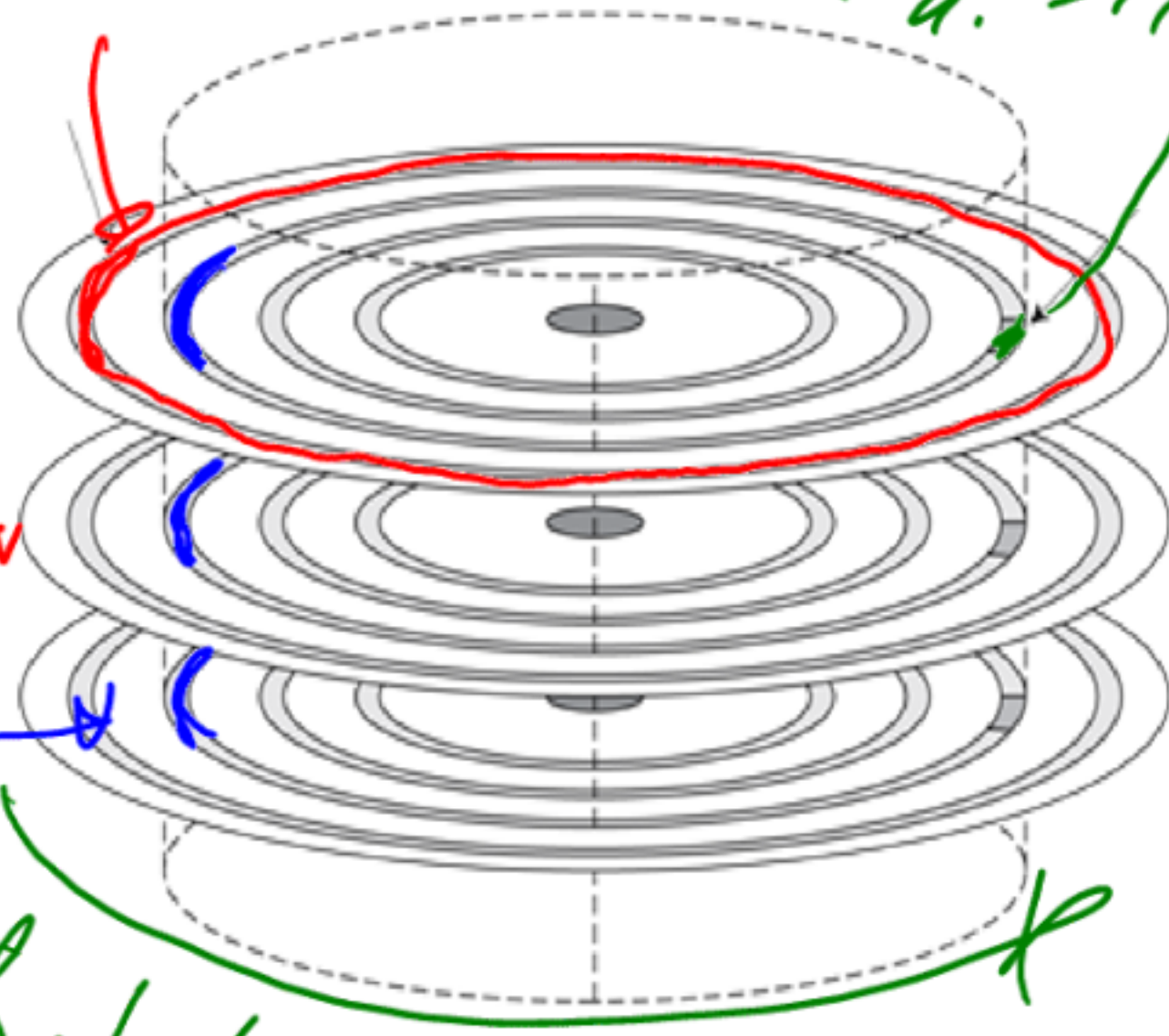
1) Define the terms track, sector, and seek as pertaining to a nonvolatile storage medium.
2) Calculate the average rotational for a disk given disk performance criteria.
3) Calculate the disk read time for a hard drive given performance characteristics for the disk.
4) Based on desired criteria, choose appropriate performance characteristics for a given drive based on need.

Definitions

- Nonvolatile
  - Storage device where data retains its value even when power is removed
- Track
  - A concentric circle of data on the surface of a magnetic disk
- Sector
  - A segment of a track on a magnetic disk
  - The smallest amount of information that is read to or written from a disk
- Seek
  - The process of positioning a read/write head over the proper track on a disk

Disk Storage

- Help me label the following parts



- Rotational latency
  - The time required for the desired sector of a disk to rotate under the read/write head
  - Usually assumed to be half the rotation time

Definition

Rotational Latency Calculation

$$\text{Average Rotational Latency} = \frac{.5 \text{ rotation}}{\text{r Rotations Per Minute}}$$

How long does it take for a sector to rotate under a the head

Problem

- With the partner next to you solve the following problem:
  - A hard drive spins at 10000 RPM. What is the average rotational latency?

$$\overline{RL} = \frac{.5 \text{ rotations}}{10000 \text{ RPM} / 60 \text{s/min}}$$

$$= .003 \Rightarrow 3 \text{ms}$$

- How long does it take to read a sector from the disk?
  - Depends on
    - Seek time
    - Rotational latency
    - Transfer time
    - Overhead of the IO Controller

Disk Read Time

Disk Access Time = seek time + rotational delay + transfer time + controller overhead

How long to move a head to desired track

Calculated

How long for the data to move

Not dependent on the HD itself.

Partner exercise

- With your partner next door, calculate the following
  - A hard drive rotates at 15000 RPM and the average seek time is 5 ms. The transfer rate is 75 MB/second, and the controller overhead is .5ms.

Why do we care about these numbers?

- Desktop PC?

⇒ Gaming ⇒ Good performance ⇒ High speeds

- Laptop PC?

Battery Life ⇒ Lower performance ⇒ slower seek times / slower rotational speeds

- Cloud based server?

Fast access time ⇒

Problem

- On the next slide there will be specifications for multiple hard drives. With your partner discuss the following
  - You are asked to pick a hard drive that would best suite a laptop PC which is to have as long as possible for battery life. Which drive would you choose and why?
  - You have been asked to create a system to serve video out over the internet, starting with an estimate storage need of 10 TB. Which hard drive would be your best choice for long term reliability, cost, and performance? Why?

Drive data sheets

Characteristics	Seagate ST3300655SS	Seagate ST31000340NS	Seagate ST973451SS	Seagate ST9160821AS
Disk diameter (inches)	3.50	3.50	2.50	2.50
Formatted data capacity (GB)	147	1000	73	160
Number of disk surfaces (heads)	2	4	2	2
Rotation speed (RPM)	15,000	7200	15,000	5400
Internal disk cache size (MB)	16	32	16	8
External interface, bandwidth (MB/sec)	SAS, 375	SATA, 375	SAS, 375	SATA, 150
Sustained transfer rate (MB/sec)	73–125	105	79–112	44
Minimum seek (read/write) (ms)	0.2/0.4	0.8/1.0	0.2/0.4	1.5/2.0
Average seek read/write (ms)	3.5/4.0	8.5/9.5	2.9/3.3	12.5/13.0
Mean time to failure (MTTF) (hours)	1,400,000 @ 25°C	1,200,000 @ 25°C	1,600,000 @ 25°C	—
Annual failure rate (AFR) (percent)	0.62%	0.73%	0.55%	—
Contact start-stop cycles	—	50,000	—	>600,000
Warranty (years)	5	5	5	5
Nonrecoverable read errors per bits read	<1 sector per 10^{16}	<1 sector per 10^{15}	<1 sector per 10^{16}	<1 sector per 10^{14}
Temperature, shock (operating)	5°–55°C, 60 G	5°–55°C, 63 G	5°–55°C, 60 G	0°–60°C, 350 G
Size: dimensions (in.), weight (pounds)	1.0" × 4.0" × 5.8", 1.5 lbs	1.0" × 4.0" × 5.8", 1.4 lbs	0.6" × 2.8" × 3.9", 0.5 lbs	0.4" × 2.8" × 3.9", 0.2 lbs
Power: operating/idle/ standby (watts)	15/11/—	11/8/1	8/5.8/—	1.9/0.6/0.2
GB/cu. in., GB/watt	6 GB/cu.in., 10 GB/W	43 GB/cu.in., 91 GB/W	11 GB/cu.in., 9 GB/W	37 GB/cu.in., 84 GB/W
Price in 2008, $/GB	~ $250, ~ $1.70/GB	~ $275, ~ $0.30/GB	~ $350, ~ $5.00/GB	~ $100, ~ $0.60/GB

Server HDD?

Laptop?