Hard Disk Drives

How to store and access data on disk?

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Hard Disk Drives (HDD)

HDD have been main form of persistent data storage for decades

Most of file systems were developed around their behavior

Later we will see what different design decisions are made based on Solid State Drive (SSD)

How to store and access data on disk?

IBM Model 350 RAMAC. [source]

Interface

The interface for a drive is virtualized by the drive's controller

From software perspective the **address space** of the drive is divided into 512-byte blocks called **sectors**

Writing to a block is **atomic**

- Either write to block fully succeeds or it doesn't change anything
- No partial write to block, even if power goes out in the middle

Multi-sector reads and writes are supported, but no guarantee of atomicity

- If power goes out during multi-sector write, **torn write** possible
- Software's responsibility to handle torn writes

Geometry

Platter – circular hard surface were data is stored using magnetic persistence

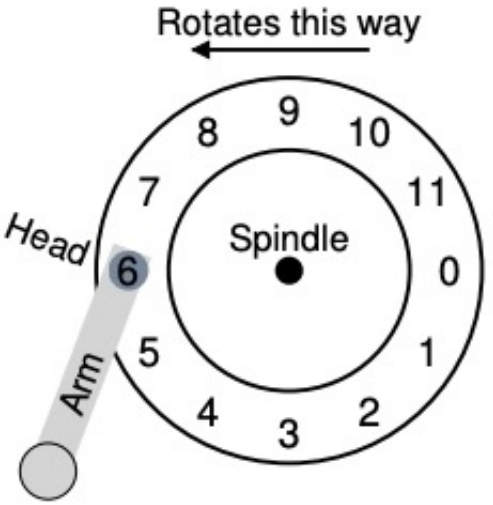
Surface – a platter has a top and bottom surface, both can store data

Track – a single circle around the center, a surface consists of thousands of tracks

Spindle – the center of the platter which connects to a motor

Disk Arm – moves the head across the platter to select a specific track

Disk Head – transforms the magnetic field into electrical current

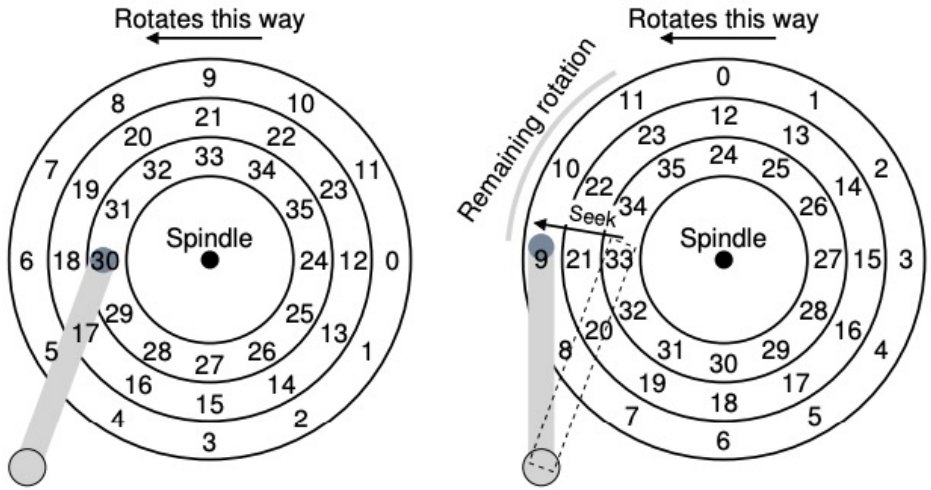


Latencies

Rotational delay – time for sector to rotate under the disk head

Seek time – time for disk arm to change position to the correct track

$$T_{I/O} = T_{seek} + T_{rotation} + T_{transfer}$$



Random vs. Sequential

Random – software requests addresses in any order it choses

1, 20, 5, 6, 25, 10

can result in very high seek time

Sequential – software requests addresses in increasing

1, 2, 3, 4, 5, 6

only need to seek for the first access

Examples

	Cheetah 15K.5	Barracuda
Capacity	300 GB	1 TB
RPM	15,000	7,200
Average Seek	4 ms	9 ms
Max Transfer	125 MB/s	105 MB/s
Platters	4	4
Cache	16 MB	16/32 MB
Connects via	SCSI	SATA

	Cheetah	Barracuda
$R_{I/O}$ Random	0.66 MB/s	0.31 MB/s
$R_{I/O}$ Sequential	125 MB/s	105 MB/s

Scheduling

Multiple processes making concurrent requests can result in frequent seeking

Order of requests by an application can also increase seek time

Solution is to use a scheduling policy

- Maintain an ordered queue of I/O requests by track
- Example policy: **Shortest Seek Time First (SSTF)** – pick requests on the nearest track to complete first