Disk Access and Scheduling

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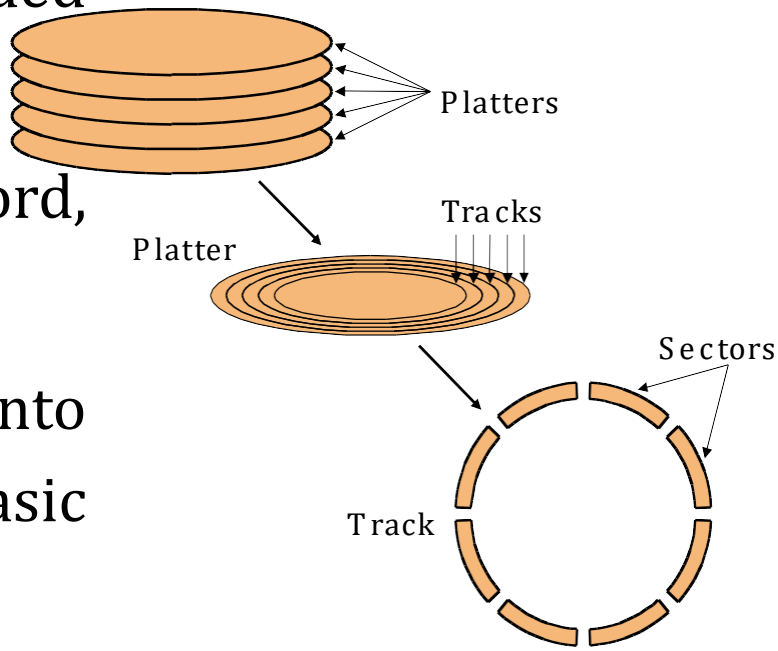
The ugly guts of a hard disk

- Data is stored on double-sided magnetic disks called platters.
- Each platter is arranged like a record, with many concentric tracks.
- Tracks are further divided into individual sectors, which are the basic unit of data transfer.
- Each surface has a read/write head like the arm on a record player, but all the heads are connected and move together.



Accessing data on a hard disk

- Accessing a sector on a track on a hard disk takes a lot of time!
  - Seek time measures the delay for the disk head to reach the track.
  - A rotational delay accounts for the time to get to the right sector.
  - There may be additional overhead for the operating system or the controller hardware on the hard disk drive.
  - The transfer time is how long the actual data read or write takes.
- Rotational speed, measured in revolutions per minute or RPM, partially determines the rotational delay and transfer time.

Average seek time & Average rotational delay

- Manufacturers often report average seek times
  - average the time to seek from any track to any other track.
- Once the head is in place, we need to wait until the right sector is underneath the head.
  - This may require as little as no time (reading consecutive sectors) or
  - as much as a full rotation (just missed it).
  - On average, for random reads/writes, we can assume that the disk spins **halfway on average**.

Average rotational delay

- Rotational delay depends partly on how fast the disk platters spin.
  - Average rotational delay = 0.5 rotations x rotational speed

- For example, a 5400 RPM disk has an average rotational delay of:
  - 0.5 rotations / (5400 rotations/minute) = 5.55ms

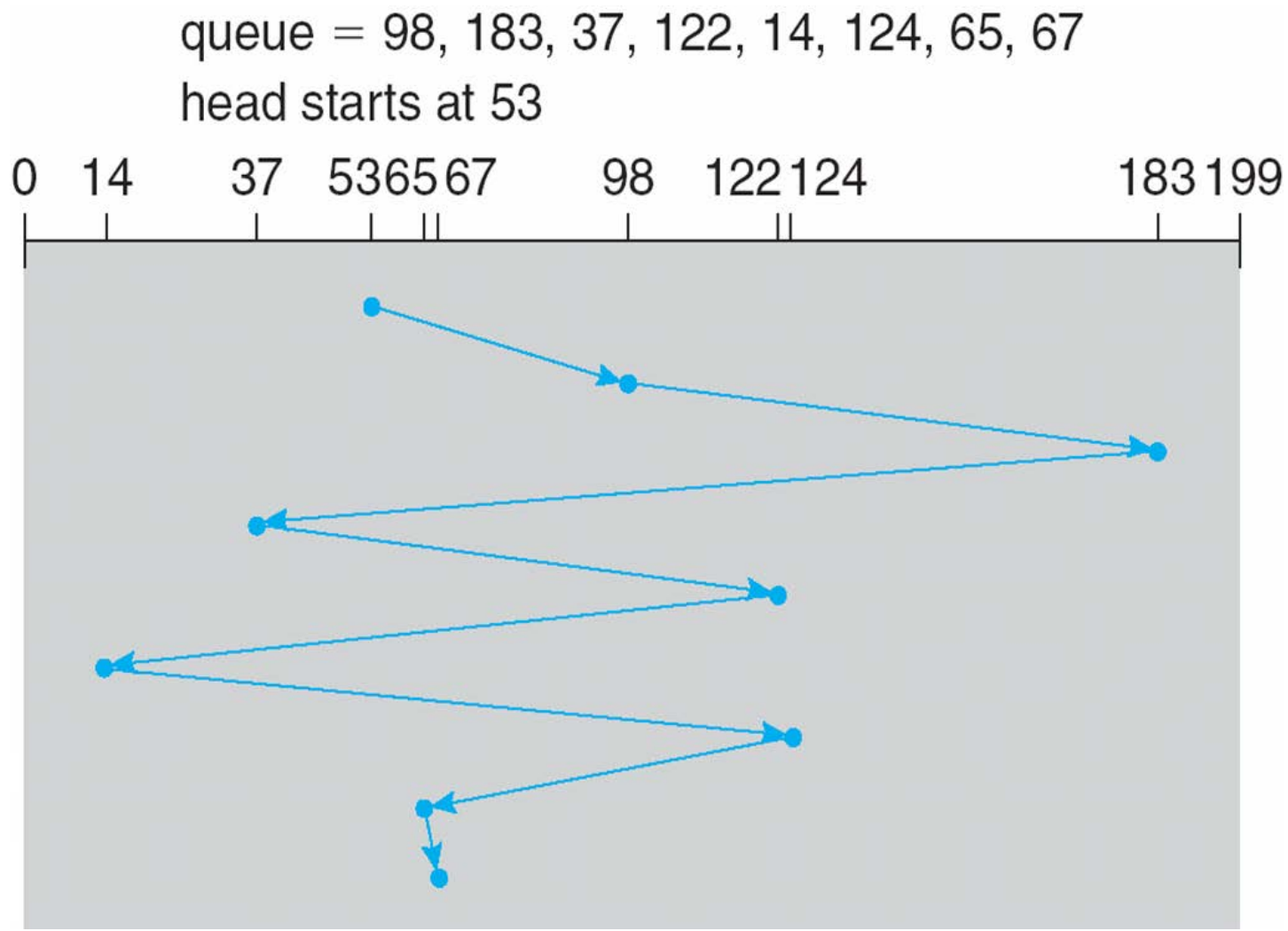
Response Time

- The overall response time is the sum of the seek time, rotational delay, transfer time, and overhead.
- Assume a disk has the following specifications.
  - An average seek time of 9ms
  - A 5400 RPM rotational speed
  - A 10MB/s average transfer rate
  - 2ms of overheads
- How long does it take to read a random 1,024 byte sector?
  - The average rotational delay is 5.55ms.
  - The transfer time will be about (1024 bytes / 10 MB/s) = 0.1ms.
  - The response time is then 9ms + 5.55ms + 0.1ms + 2ms = 16.7ms.
  - That's 16,700,000 cycles for a 1GHz processor!
- One possible measure of throughput would be the number of random sectors that can be read in one second.
  - (1000/ 16.7) = 60 sectors/second.
  - Bandwidth = bytes transferred per unit time = throughput * sector size

Disk Scheduling

- The response time and bandwidth can be improved by proper disk scheduling
  - FCFS
  - SSTF
  - SCAN
  - CSCAN
  - LOOK
  - CLOOK
- Tracks: 0-199
- Request queue: 98, 183, 37, 122, 14, 124, 65, 67
- Head pointer 53

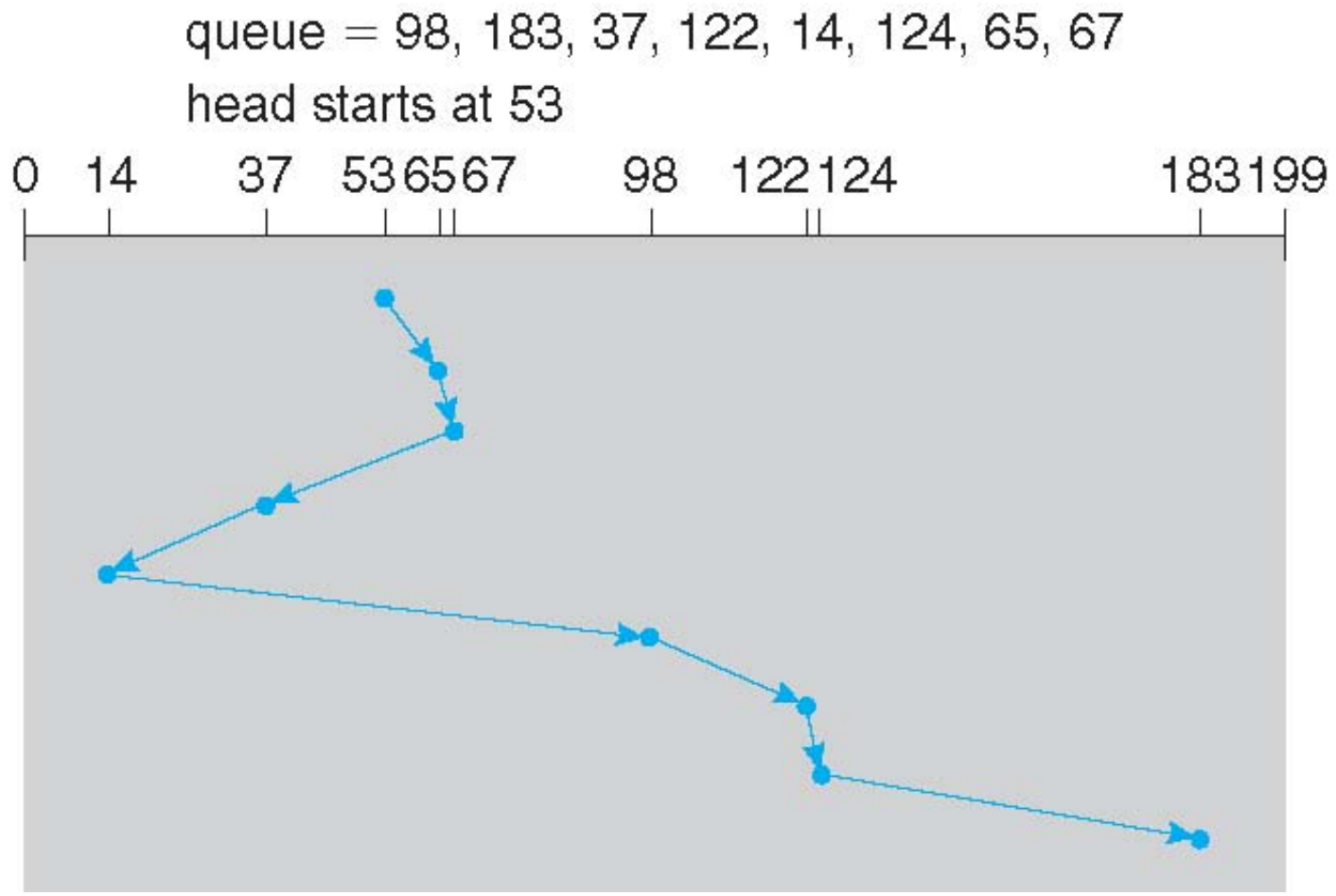
FCFS Scheduling



Total head movement of 640 tracks.

SSTF (Shortest Seek Time First)

- Selects the request with the minimum seek time from the current head position.



Total head movement of 236 tracks.

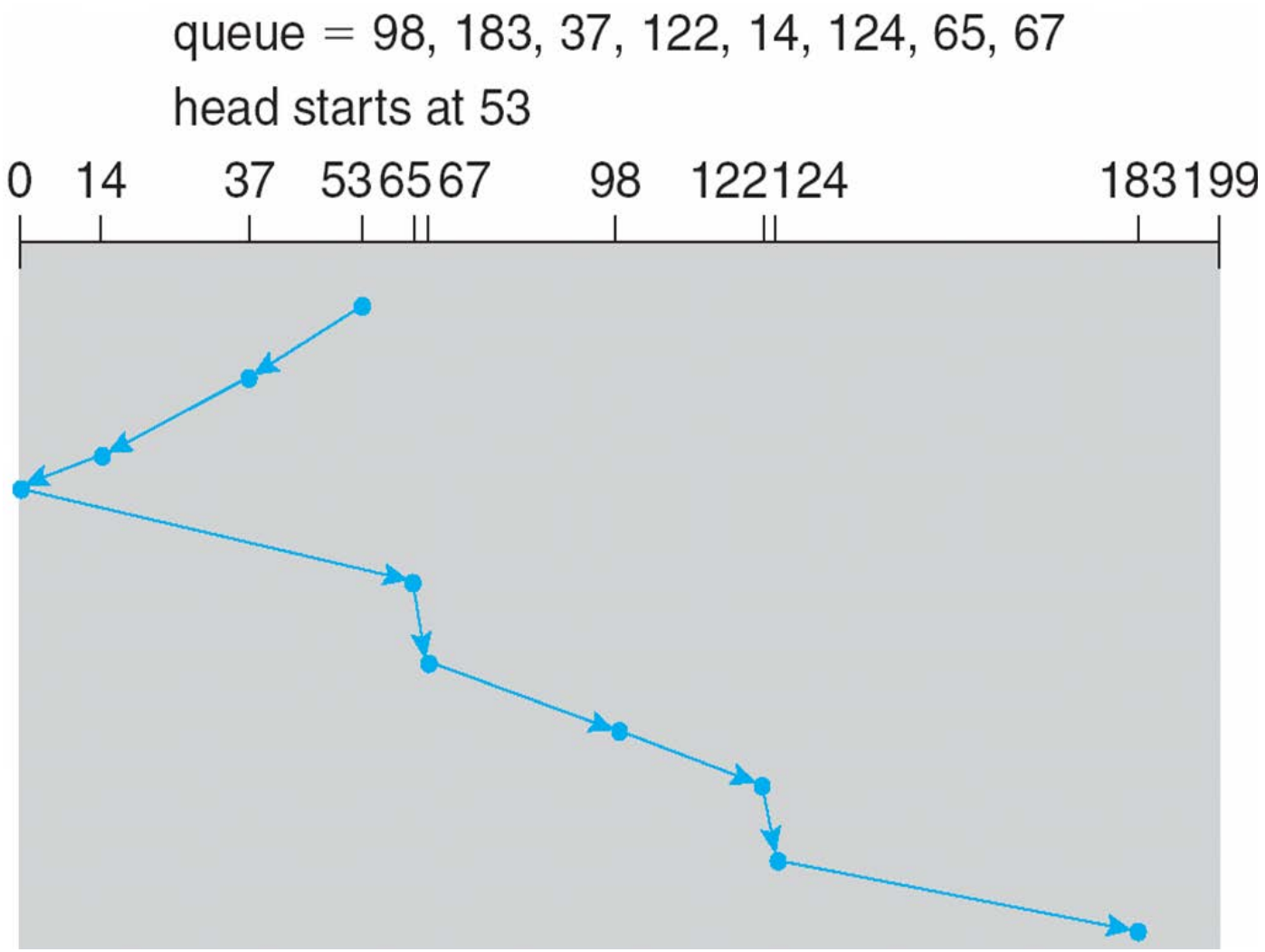
SSTF (Shortest Seek Time First)

- May lead to starvation
- NOT optimal:
  - 53 → 37 → 14 → 65 → 67 → 98 → 122 → 124 → 183
  - Total head movements = 208 tracks

SCAN (Elevator) Scheduling

- The disk arm starts at one end of the disk, and moves toward the other end, servicing requests until it gets to the other end of the disk, where the head movement is reversed and servicing continues.

SCAN (Elevator) Scheduling



Total head movement of 236 tracks.

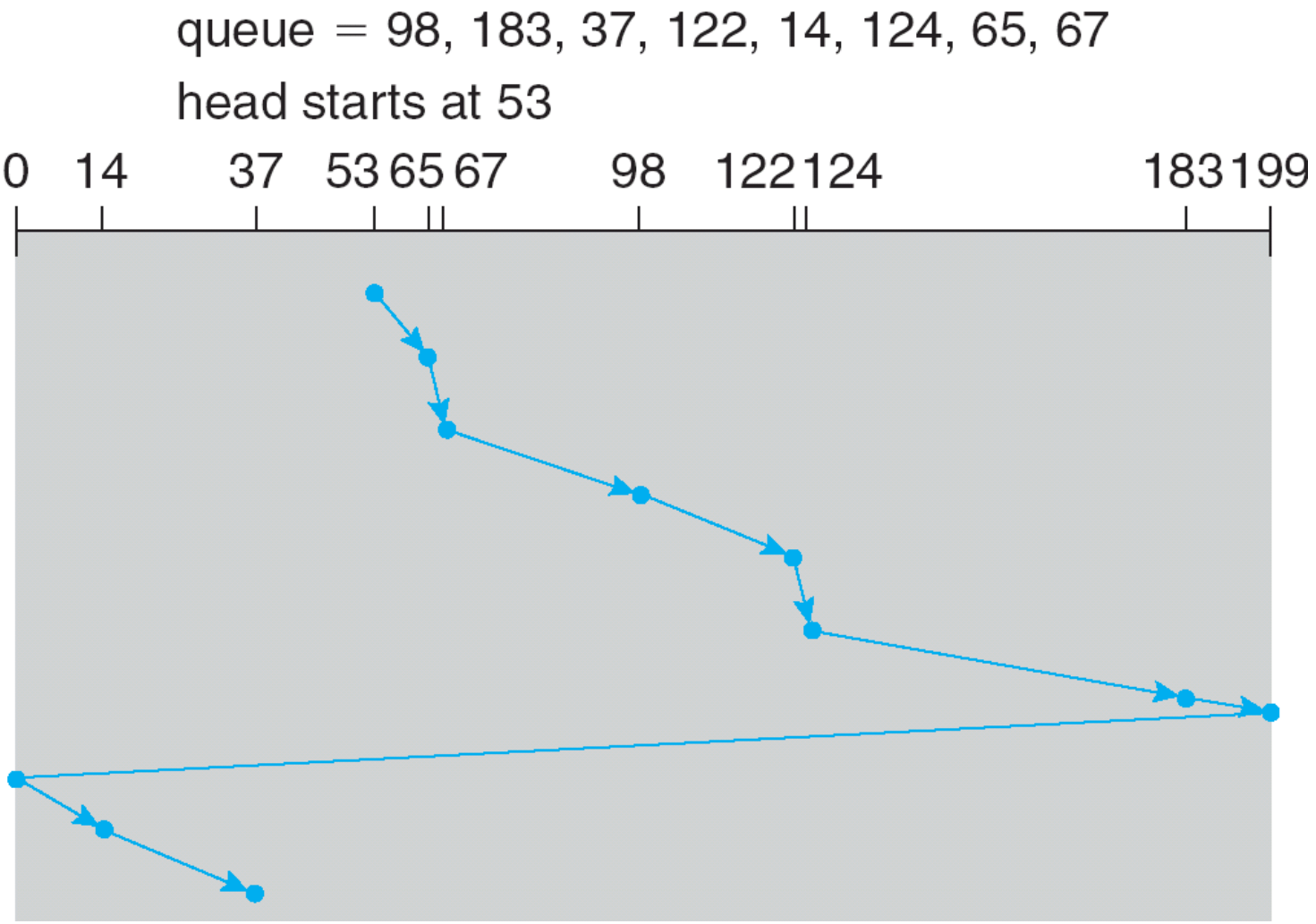
SCAN (Elevator) Scheduling

- Non-uniform wait time
  - Request arrived just in front of the head – no wait time
  - Request arrived just behind the head – more wait time
- When head reverses its direction, more dense region will be farther from the head.

CSCAN (Circular SCAN)

- Provides a more uniform wait time than SCAN
- The head moves from one end of the disk to the other, servicing requests as it goes
  - When it reaches the other end, however, it immediately returns to the beginning of the disk, without servicing any requests on the return trip

CSCAN (Circular SCAN)



LOOK and CLOOK Scheduling

- Variation of SCAN and CSCAN scheduling
- Arm only goes as far as the last request in each direction, then reverses direction immediately, without going all the way to the end of the disk