CS 471 Operating Systems

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Review: Disks

Device I/O Protocol Variants

- Status checks
  - Polling
  - Interrupts
- Data
  - PIO
  - DMA

Disks

- Doing an disk I/O requires:
  - Seek
  - Rotate
  - Transfer

- Which step(s) are **expensive**?

Disks

- Doing an disk I/O requires:
  - Seek
  - Rotate
  - Transfer

- Which step(s) are **expensive**?
  - A: Depends: Seek and rotate cost dominate for small random I/Os, while transfer cost dominates for large sequential I/Os

Q: Given a stream of I/O requests, in what order should they be served?

Disk Scheduling

Disk Scheduling

- OS is responsible for using hardware efficiently — for the disk drives, this means having a fast access time and high disk bandwidth utilization

- Strategy: **reorder** requests to meet some goal
  - Performance (e.g., by making I/O sequential)
  - Fairness
  - Consistent latency

- Usually implemented in both OS and hardware

Disk Scheduling

- Performance objective: minimize seek+rotation time
  - Minimize the distance the head needs to go

- Disk bandwidth:
  - The total number of bytes transferred, divided by the total time between the first request for service and the completion of the last transfer

Disk Scheduling

- There are many sources of disk I/O requests:
  - OS
  - System processes
  - User processes
- I/O request:
  - Read/write mode, disk address, memory address, number of sectors to transfer
- OS maintains queue of requests, per disk or device
- Idle disk can immediately work on I/O request, busy disk means work must queue
  - **Optimization algorithms make sense only when a queue exists**

Disk Scheduling

- Note that drive controllers have small buffers and can manage a queue of I/O requests (of varying "depth")

- Disk scheduling algorithms:
  - Algorithms that schedule the orders of disk I/O requests

Disk Scheduling

- Disk scheduling algorithms:
  - Algorithms that schedule the orders of disk I/O requests
- The analysis is true for one or many platters
- We illustrate scheduling algorithms with an example request queue (0-199)

98, 183, 37, 122, 14, 124, 65, 67

Initially, head pointer pointing to 53

FIFO

- Idea: Serve the I/O request in the order they arrive

FIFO

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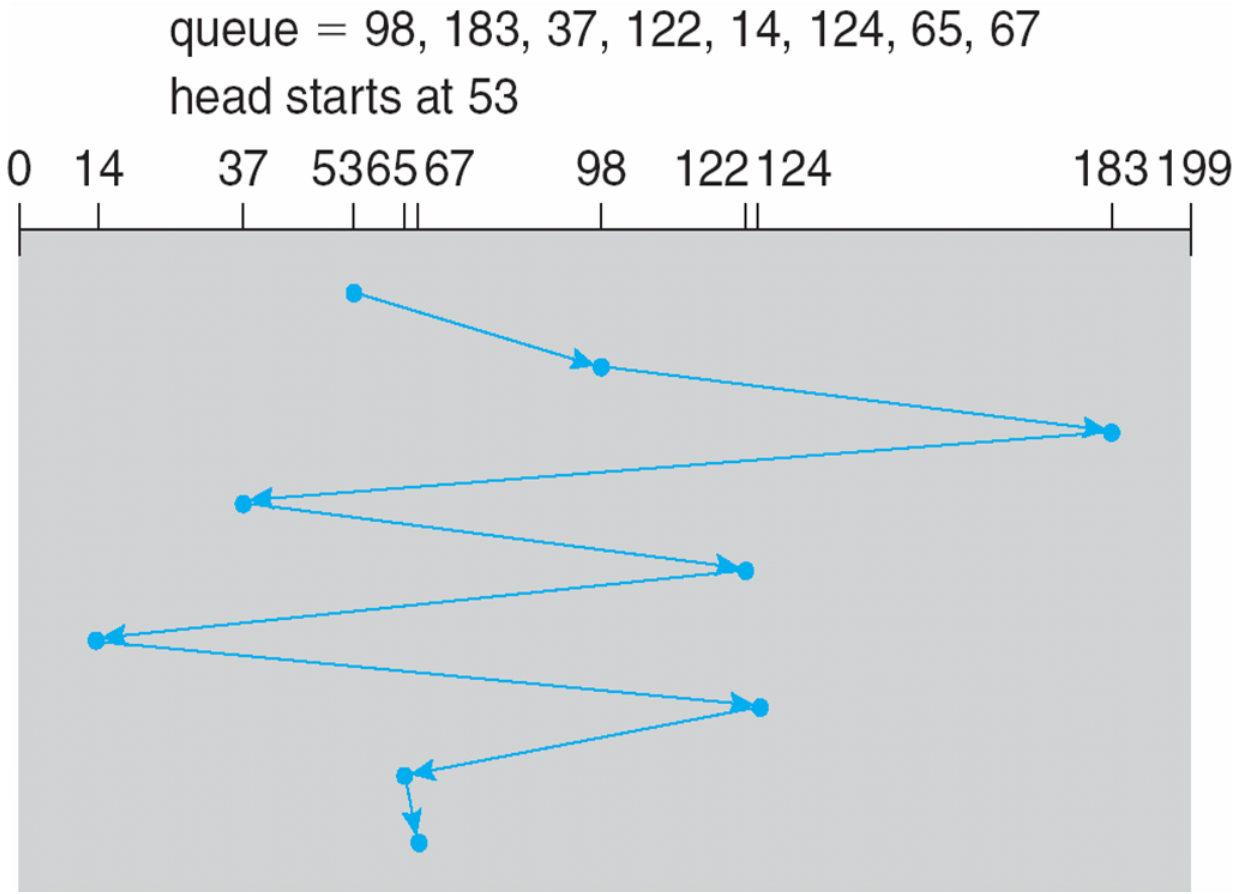

FIFO

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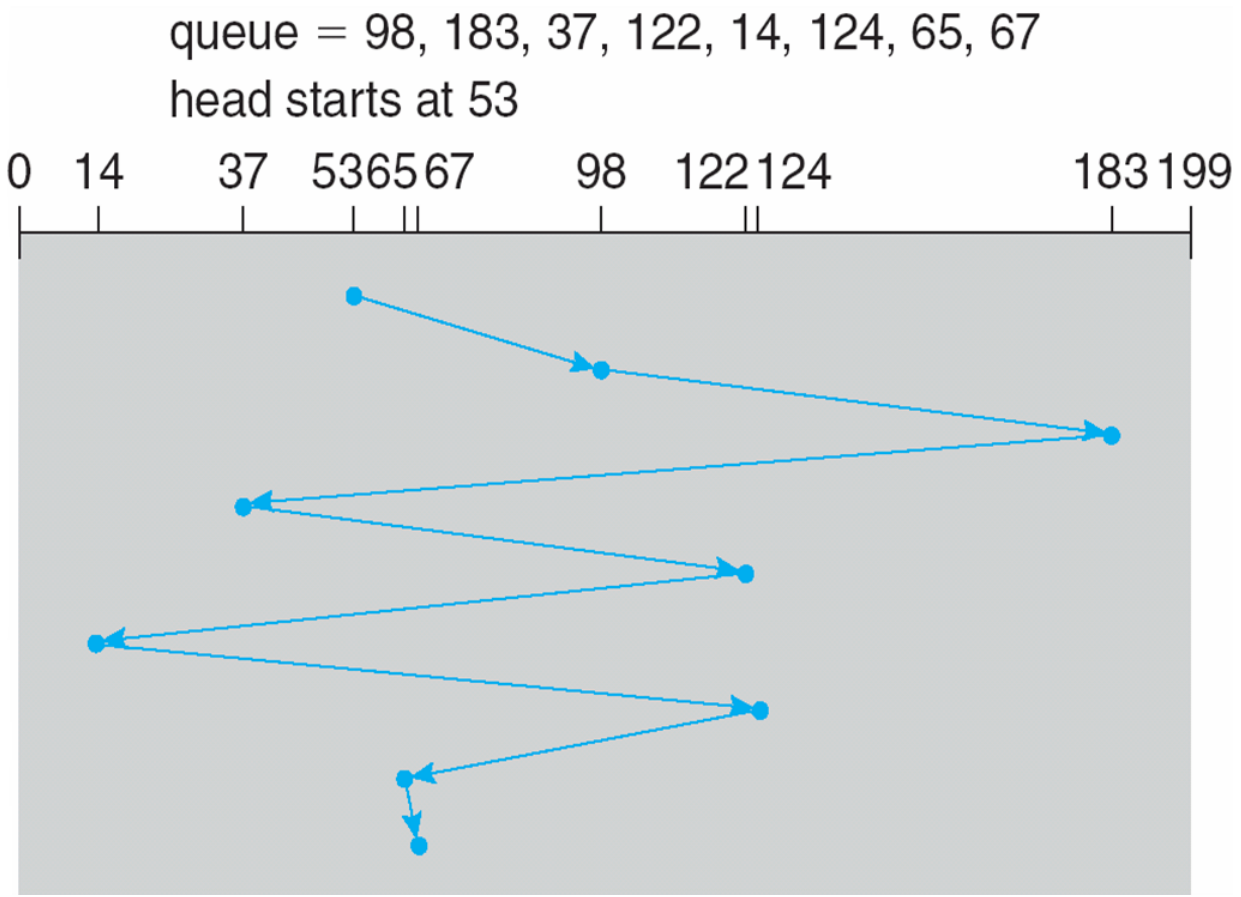

Illustration shows total head movement of **640** cylinders

Shortest Positioning Time First (SPTF)

- Idea: Selects the request that will take the least time for seeking and rotating

- Also called Shortest Seek Time First (SSTF) if rotational positioning is not considered

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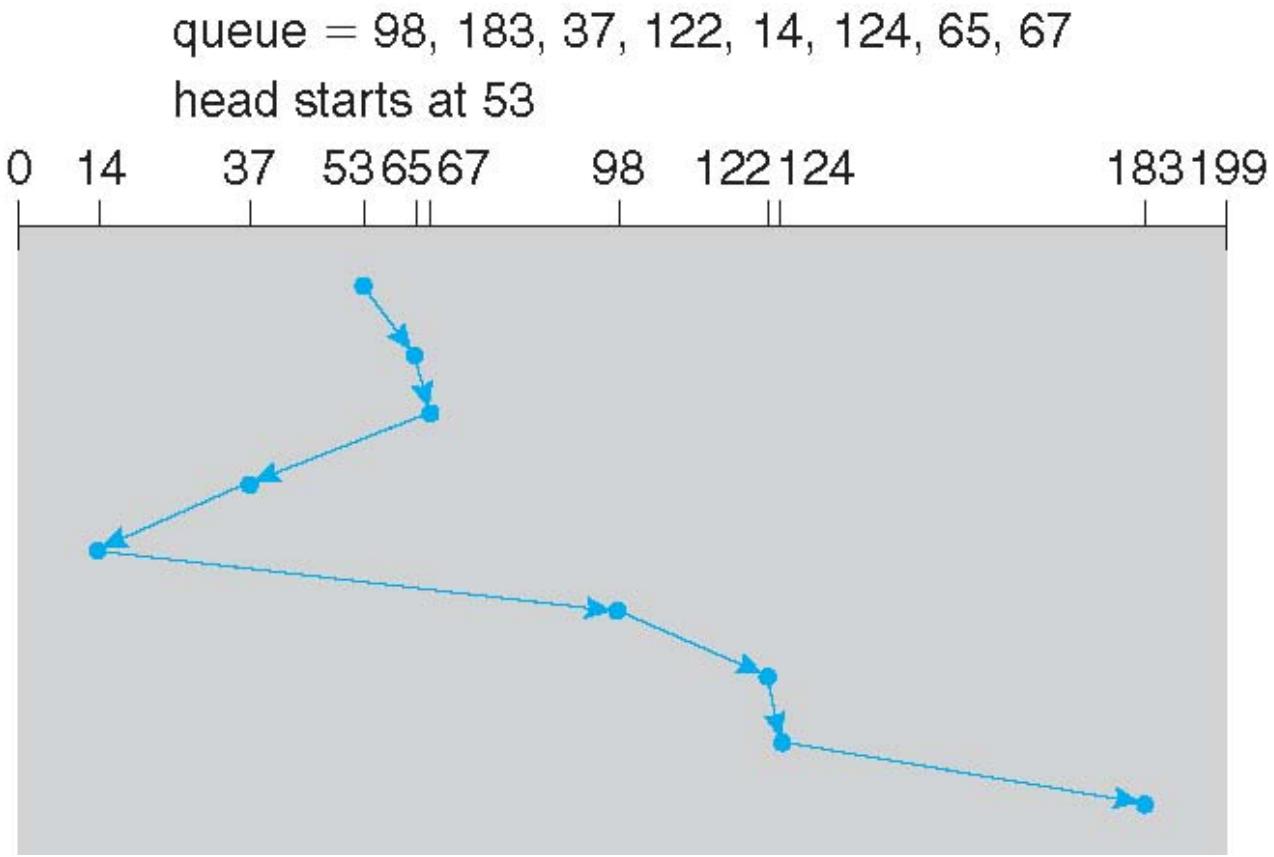


Illustration shows total head movement of **236** cylinders.

Greedy algo: A form of SJF scheduling: may cause starvation of some requests!

SCAN

- Idea: Sweep back and forth, from one end of disk to the other, serving requests as you go
  - 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
  - AKA **Elevator Algorithm**

SCAN

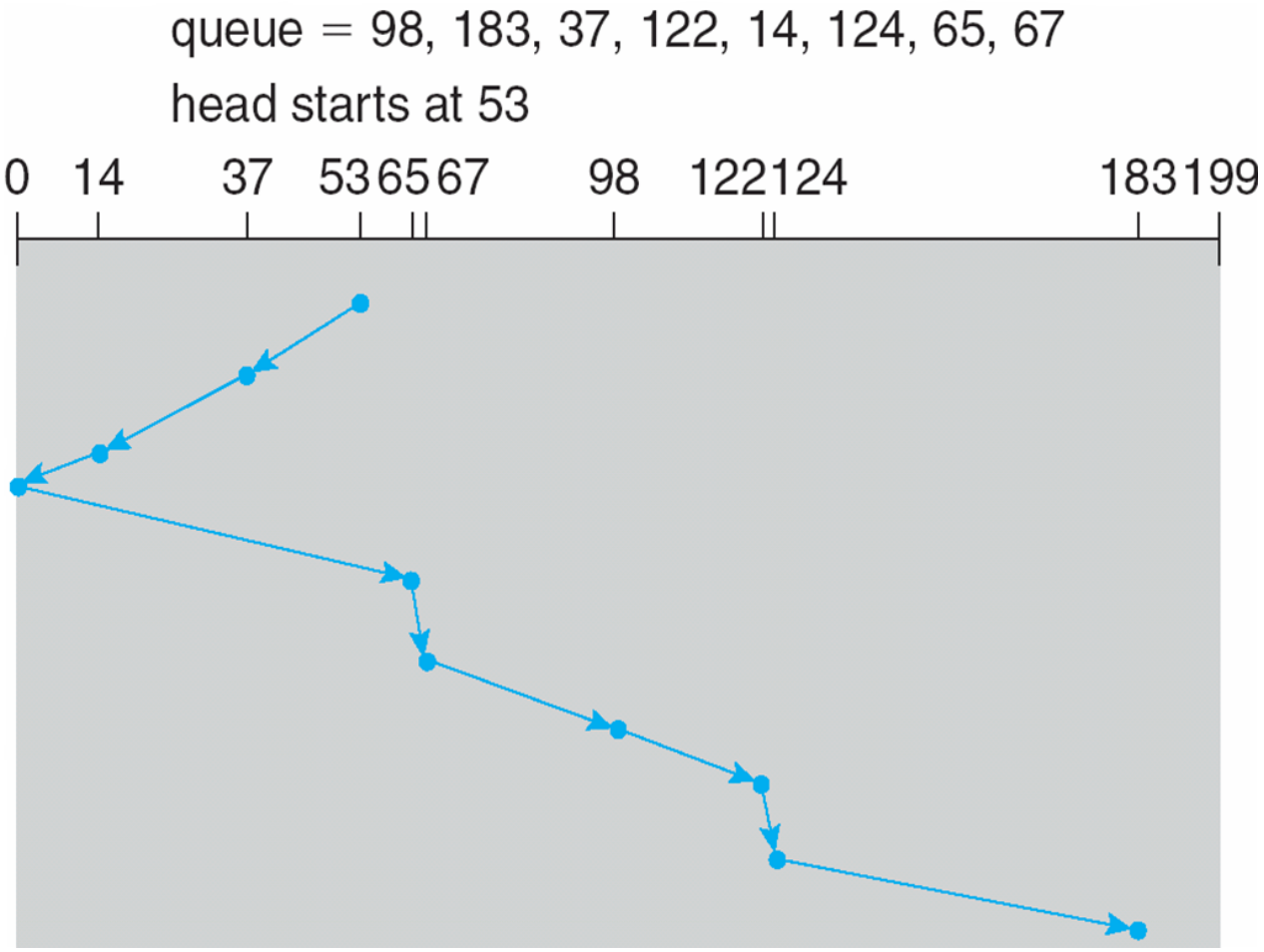


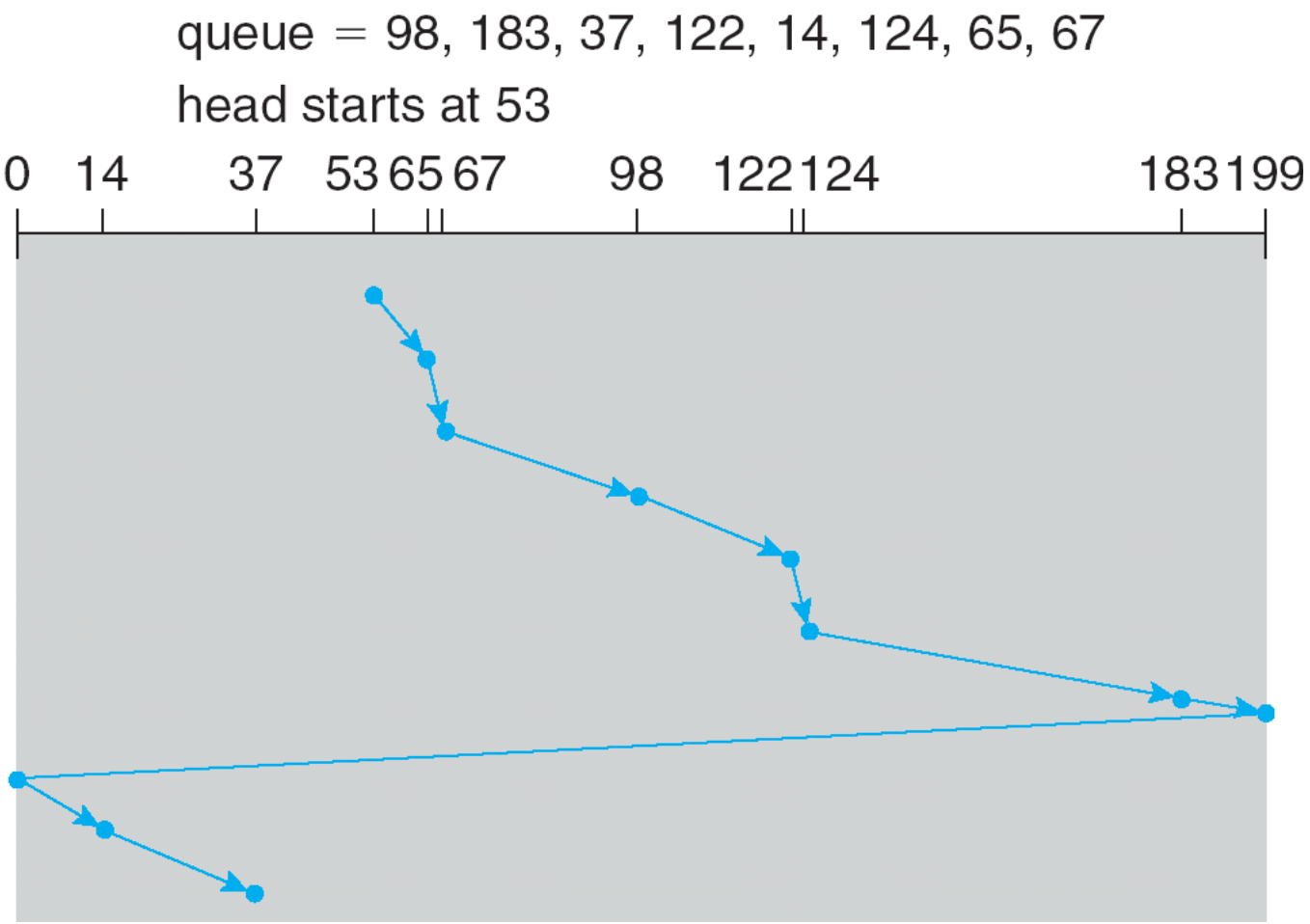
Illustration shows total head movement of **236** cylinders.

Issue: Cylinders in the middle get better service;
Requests at the other end wait the longest!

C-SCAN (Circular-SCAN)

- Idea: Only sweep in **ONE** direction
  - When it reaches the other end, however, it immediately returns to the beginning of the disk, without servicing any requests on the return trip
- Provides a more uniform wait time than SCAN
- Treats the cylinders as a circular list that wraps around from the last cylinder to the first one

C-SCAN

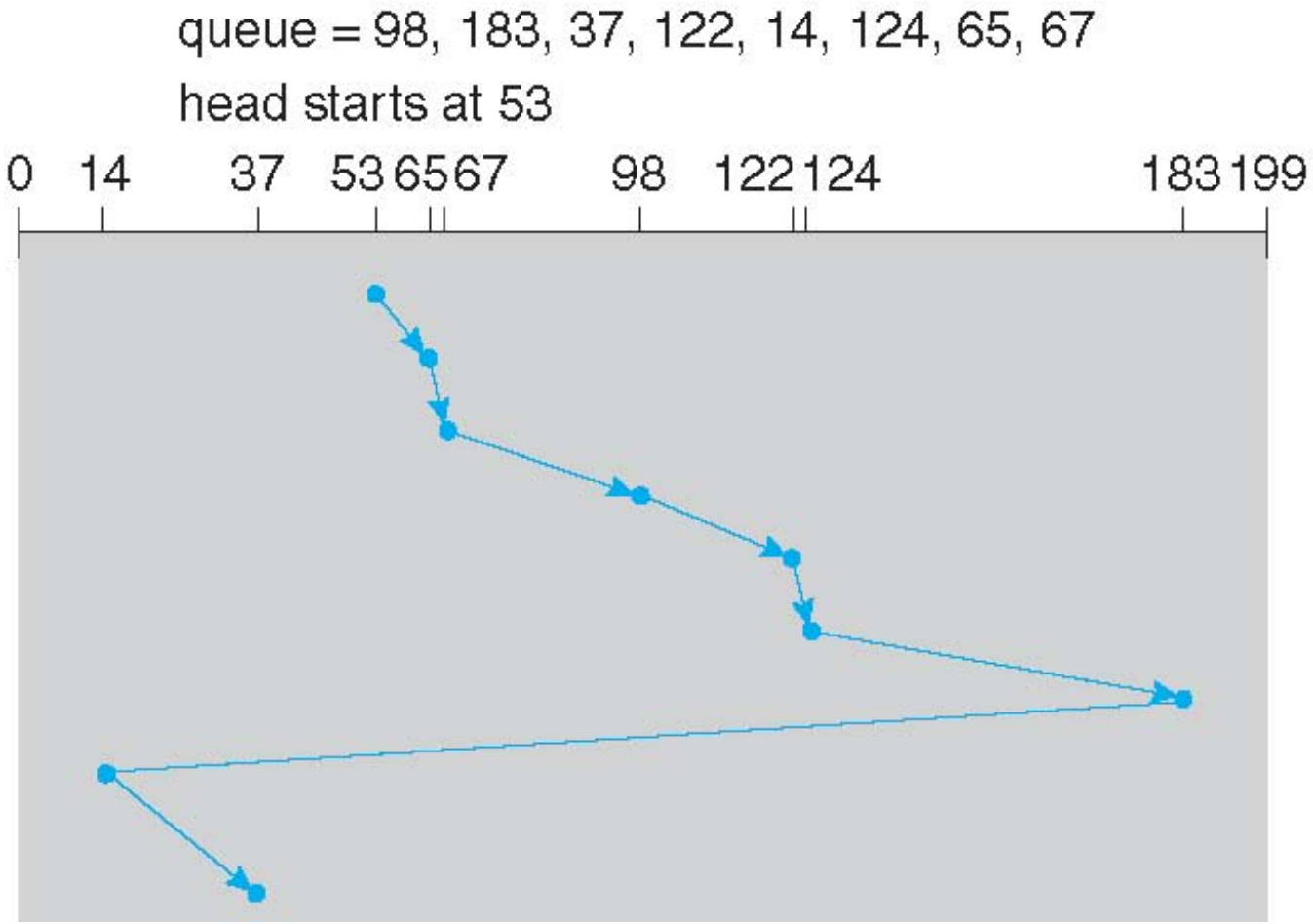


Total number of cylinders?

C-LOOK

- Idea: Arm only goes as far as the last request in each direction, then reverses direction immediately, without first going all the way to the end of the disk
  - LOOK: A version of SCAN
  - C-LOOK: A version of C-SCAN

C-LOOK



Total number of cylinders?

Work Conservation

- Work conserving schedulers always try to do I/O if there's I/O to be done
- Sometimes, it's better to wait (delay) instead if you anticipate another request will appear nearby
- Such non-work-conserving schedulers are called anticipatory schedulers

CFQ (Linux Default)

- Completely Fair Queueing
- Queue for each process
- Do weighted round-robin among queues, with slice time proportional to priority
- Optimize order within queue
- Yield slice only if idle for a given time (anticipation)

Summary:
Selecting A Disk Scheduling Algorithm

- SPTF is common and has a natural appeal
  - Starvation
- SCAN and C-SCAN perform better for systems that place a heavy load on the disk
  - Less starvation
- Performance depends on the workload (i.e., number and types of requests)
- The disk scheduling algorithm should be written as a separate OS module, allowing it to be replaced with a different algorithm if necessary
- Requests for disk service can be impacted by the file-allocation method/pattern
  - And metadata layout – **topic of file systems**