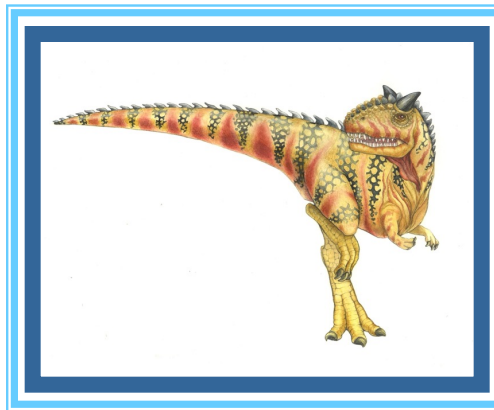
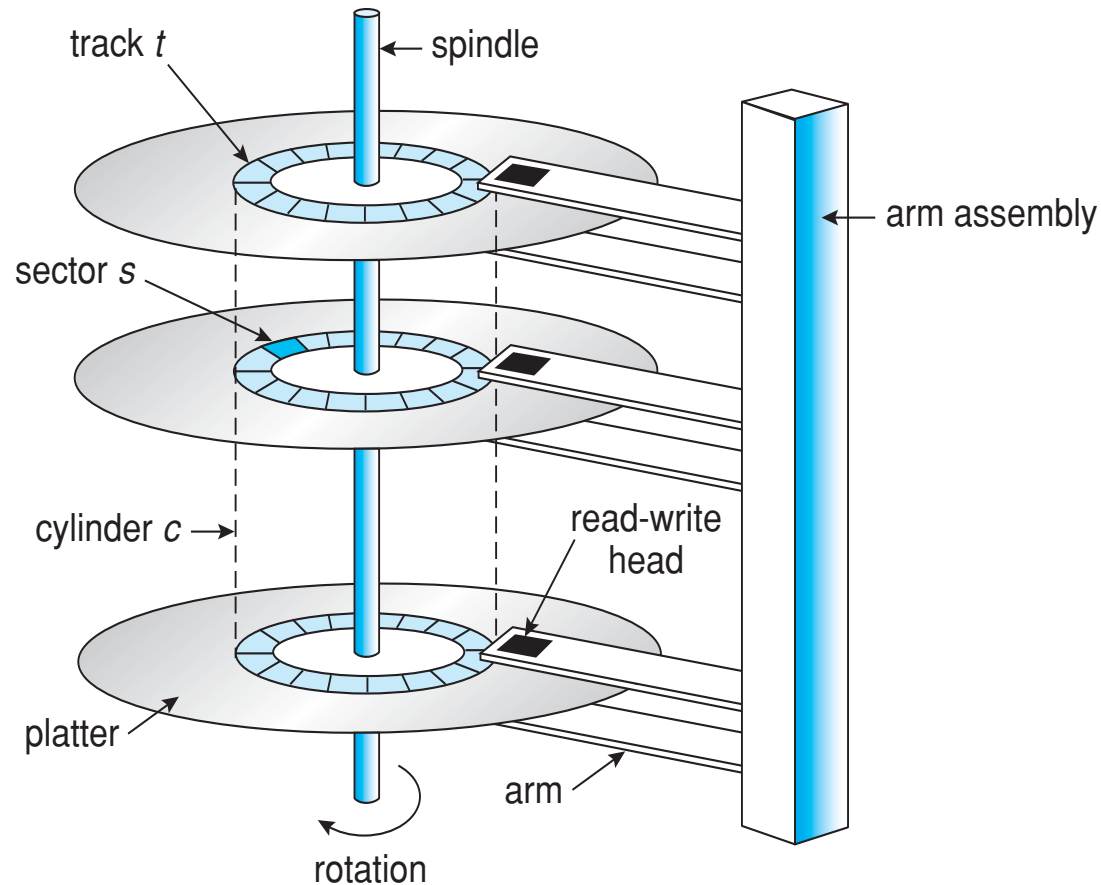


Chapter 9: Mass-Storage Systems





Moving-head Disk Mechanism





Hard Disk Performance

- **Access Latency** = **Average access time** = average seek time + average latency
 - For fastest disk $3\text{ms} + 2\text{ms} = 5\text{ms}$
 - For slow disk $9\text{ms} + 5.56\text{ms} = 14.56\text{ms}$
- Average I/O time = average access time + (amount to transfer / transfer rate) + controller overhead
- For example to transfer a 4KB block on a 7200 RPM disk with a 5ms average seek time, 1Gb/sec transfer rate with a .1ms controller overhead =
 - $5\text{ms} + 4.17\text{ms} + 0.1\text{ms} + \text{transfer time} =$
 - Transfer time = $4\text{KB} / 1\text{Gb/s} * 8\text{Gb} / \text{GB} * 1\text{GB} / 1024^2\text{KB} = 32 / (1024^2) = 0.031 \text{ ms}$
 - Average I/O time for 4KB block = $9.27\text{ms} + .031\text{ms} = 9.301\text{ms}$





Disk Structure

- Disk drives are addressed as large 1-dimensional arrays of **logical blocks**, where the logical block is the smallest unit of transfer
 - Low-level formatting creates **logical blocks** on physical media
- The 1-dimensional array of logical blocks is mapped into the sectors of the disk sequentially
 - Sector 0 is the first sector of the first track on the outermost cylinder
 - Mapping proceeds in order through that track, then the rest of the tracks in that cylinder, and then through the rest of the cylinders from outermost to innermost
 - Logical to physical address should be easy
 - ▶ Except for bad sectors
 - ▶ Non-constant # of sectors per track via constant angular velocity





Disk Scheduling

- The operating system is responsible for using hardware efficiently — for the disk drives, this means having a fast access time and disk bandwidth
- Minimize seek time
- Seek time \approx seek distance
- Disk **bandwidth** is 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 (Cont.)

- There are many sources of disk I/O request
 - OS
 - System processes
 - Users processes
- I/O request includes input or output 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 only make sense when a queue exists





Disk Scheduling (Cont.)

- Note that drive controllers have small buffers and can manage a queue of I/O requests (of varying “depth”)
- Several algorithms exist to schedule the servicing of disk I/O requests
- The analysis is true for one or many platters
- We illustrate scheduling algorithms with a request queue (0-199)

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

Head pointer 53



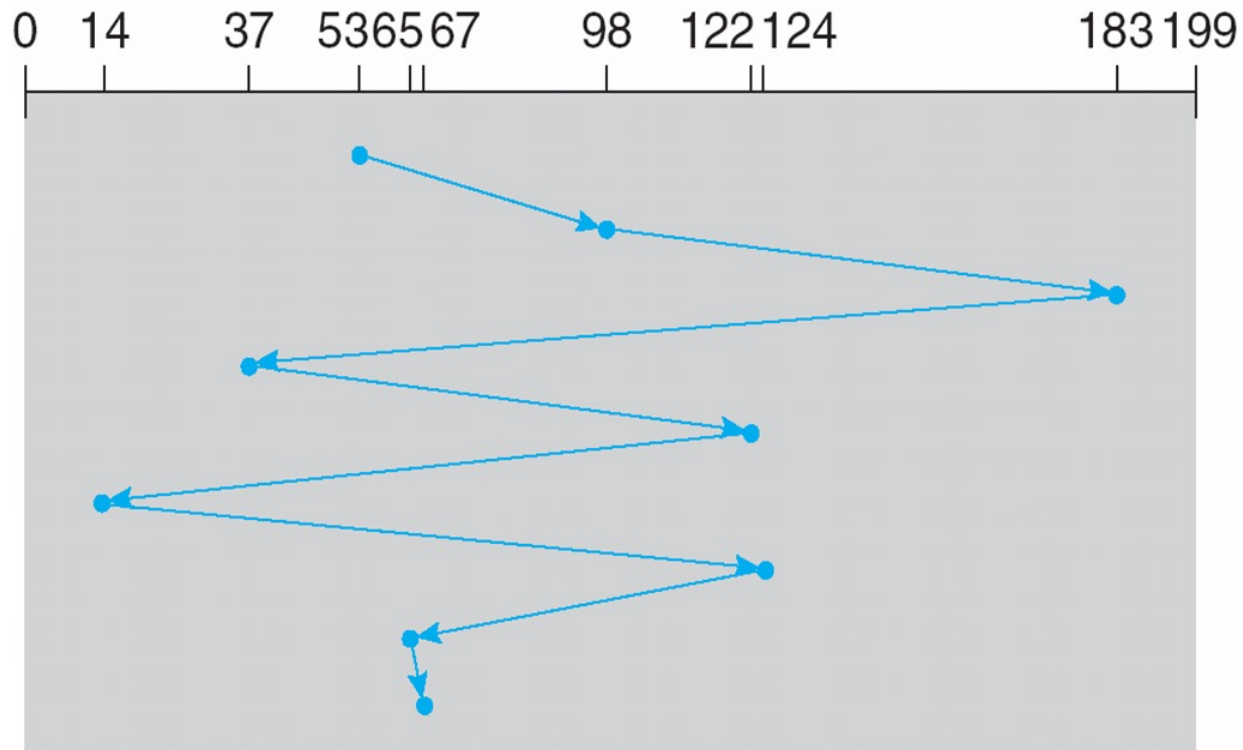


FCFS

Illustration shows total head movement of 640 cylinders

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

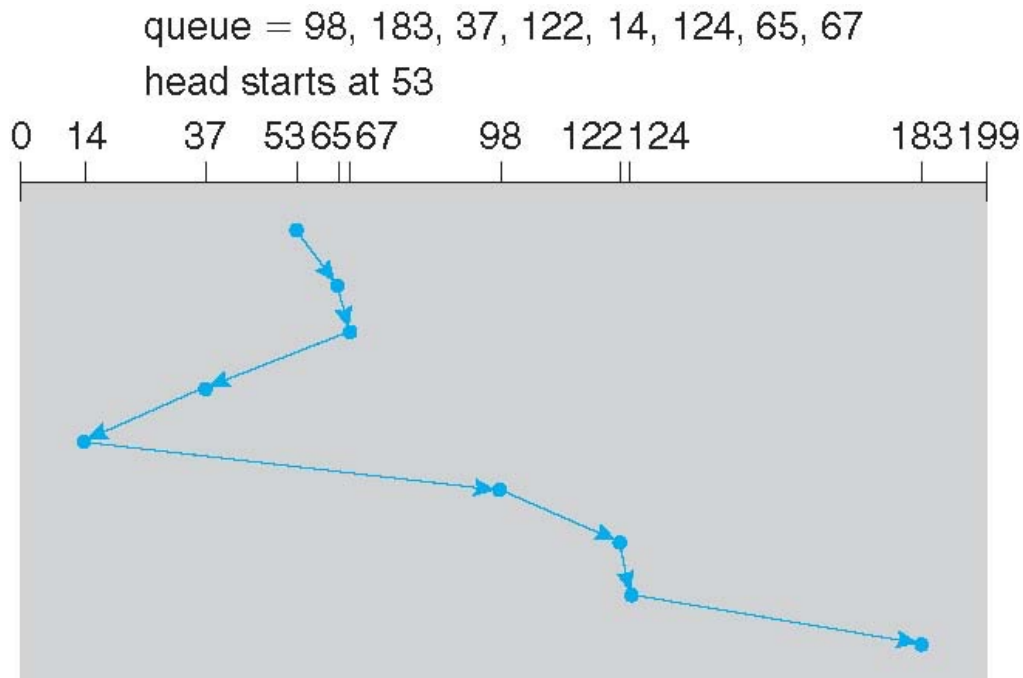
head starts at 53





SSTF

- Shortest Seek Time First selects the request with the minimum seek time from the current head position
- SSTF scheduling is a form of SJF scheduling; may cause starvation of some requests
- Illustration shows total head movement of 236 cylinders





SCAN

- 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 algorithm** Sometimes called the **elevator algorithm**
- Illustration shows total head movement of 236 cylinders
- But note that if requests are uniformly dense, largest density at other end of disk and those wait the longest

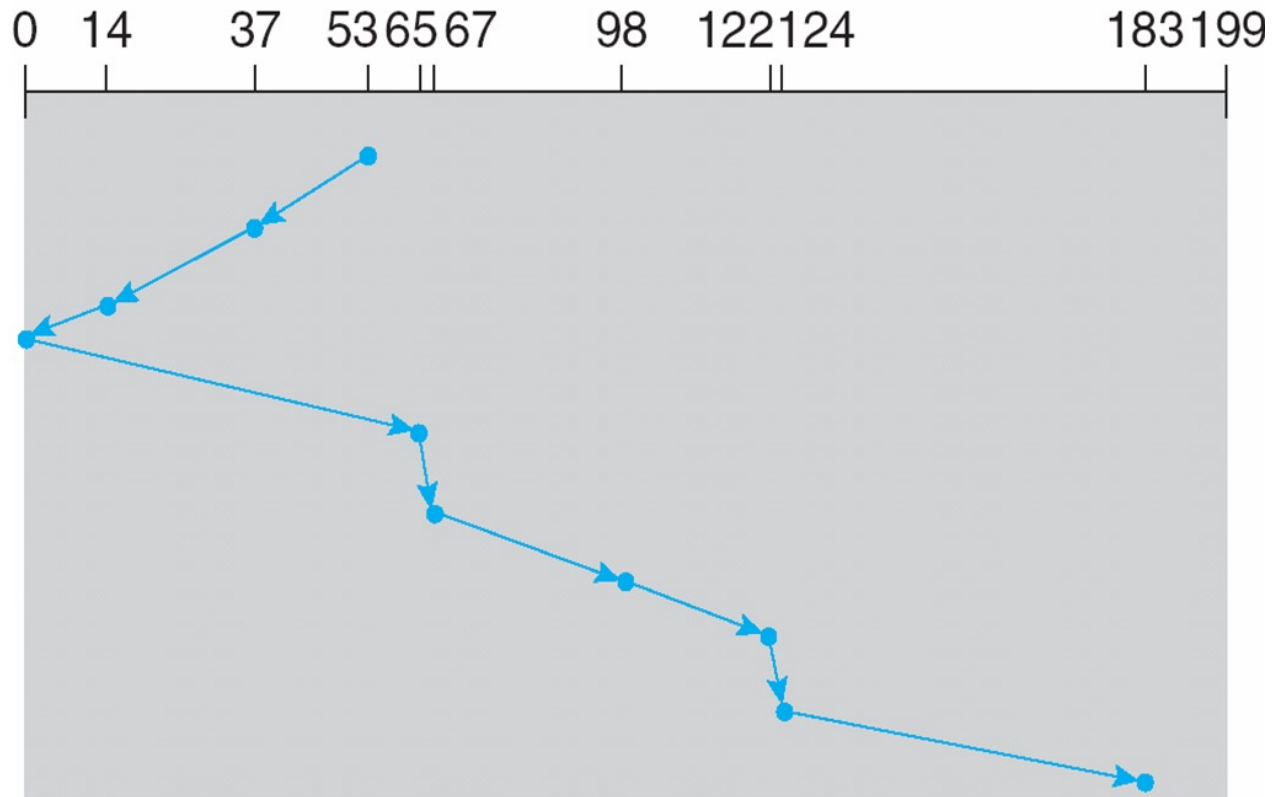




SCAN (Cont.)

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

head starts at 53





C-SCAN

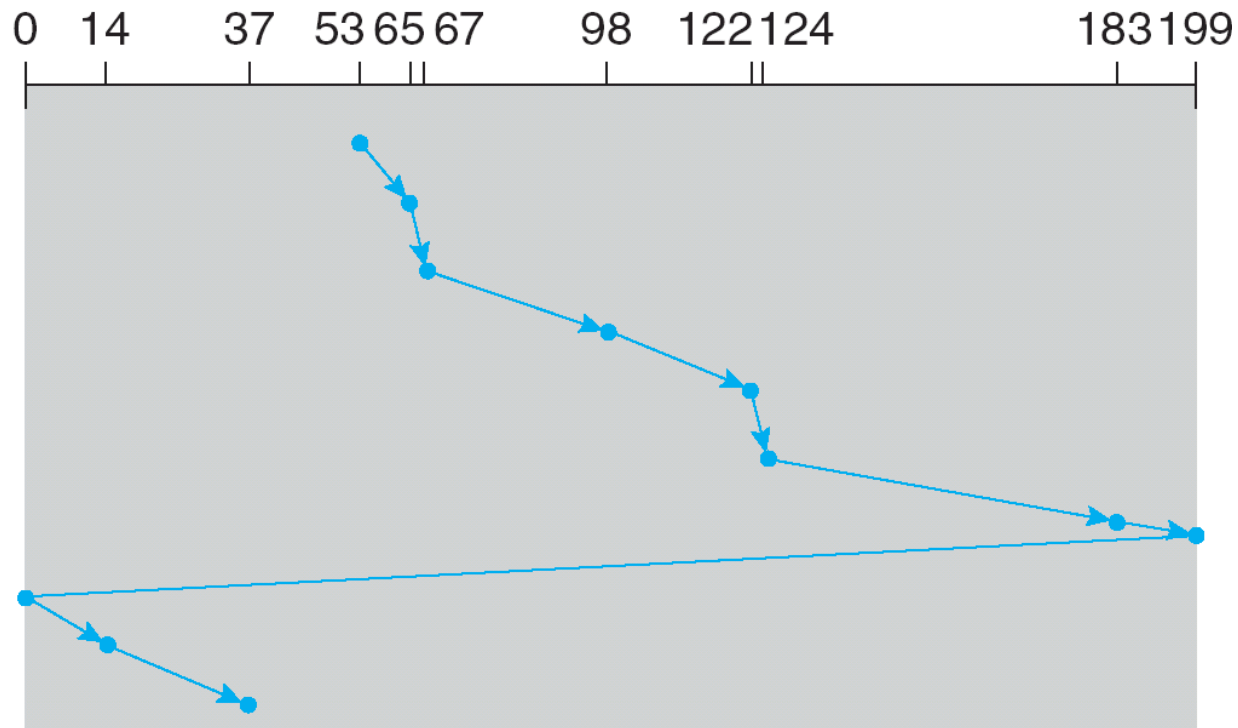
- Provides a more uniform wait time than SCAN
- The head moves from one end of the disk to the other, servicing requests as it goes
 - When it reaches the other end, however, it immediately returns to the beginning of the disk, without servicing any requests on the return trip
- Treats the cylinders as a circular list that wraps around from the last cylinder to the first one





C-SCAN (Cont.)

queue = 98, 183, 37, 122, 14, 124, 65, 67
head starts at 53





C-LOOK

- LOOK a version of SCAN, C-LOOK a version of C-SCAN
- 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
- Total number of cylinders?

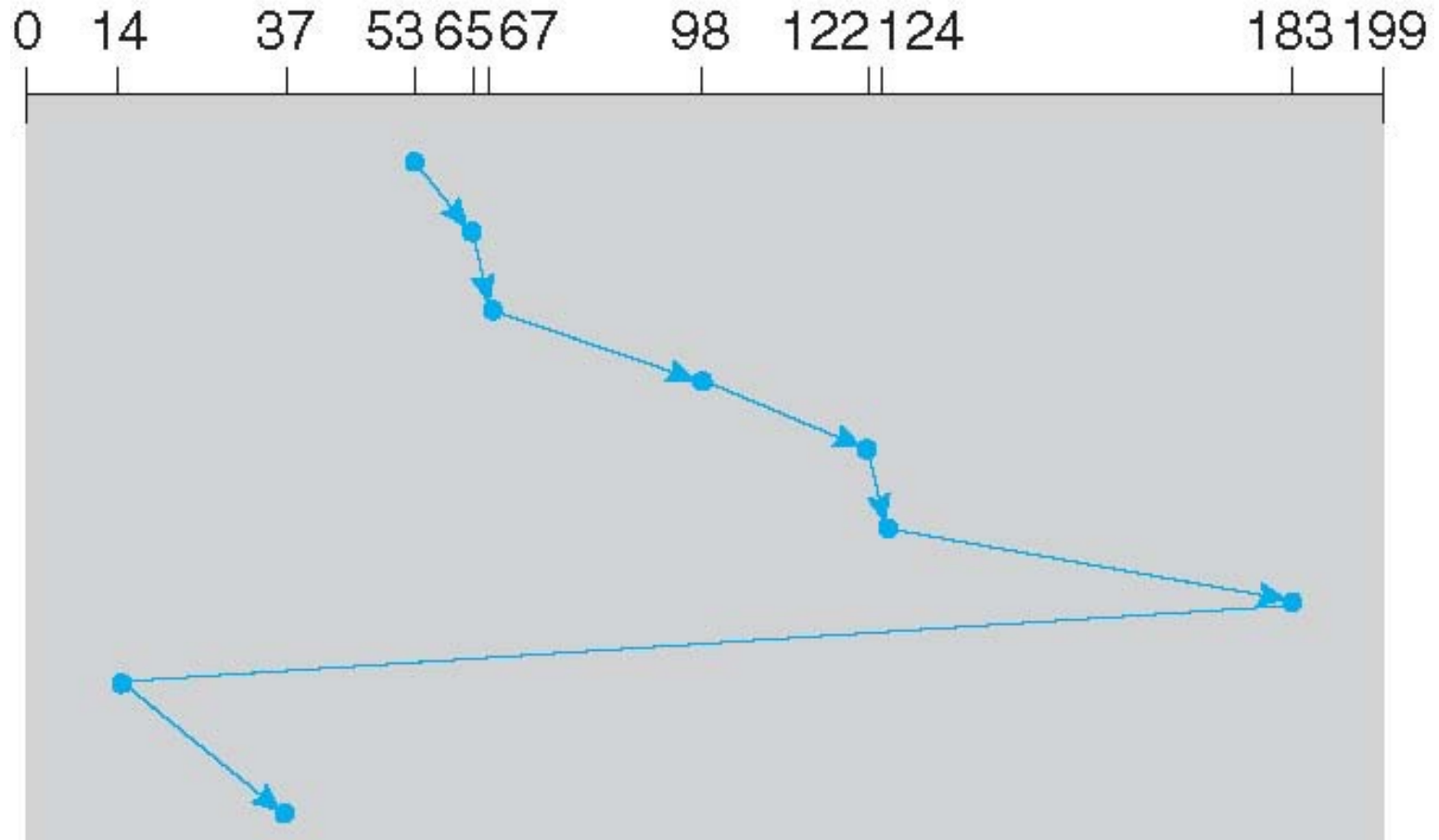




C-LOOK (Cont.)

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

head starts at 53





Selecting a Disk-Scheduling Algorithm

- SSTF is common and has a natural appeal
- SCAN and C-SCAN perform better for systems that place a heavy load on the disk
 - Less starvation
- Performance depends on the number and types of requests
- Requests for disk service can be influenced by the file-allocation method
 - And metadata layout
- The disk-scheduling algorithm should be written as a separate module of the operating system, allowing it to be replaced with a different algorithm if necessary
- Either SSTF or LOOK is a reasonable choice for the default algorithm
- What about rotational latency?
 - Difficult for OS to calculate
- How does disk-based queueing effect OS queue ordering efforts?



End of Chapter 9

