COMP 7500/7506 Advanced Operating Systems
Homework 2: Storage Systems

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Points Possible: **100**
Submission via **Canvas**

This is an individual assignment; no collaboration among students. Students shouldn't share any homework solution with any other student. Collaborations among students in any form will be treated as a serious violation of the University's academic integrity code.

Learning Objectives:

- To study mass storage systems including RAID systems
- To explore I/O scheduling algorithms
- To evaluate the performance of an I/O system

Questions:

1. [20 points] Suppose we apply the SSTF scheduling algorithm (shortest seek time first) to schedule disk requests. Which type of cylinders does SSTF favor? You must justify your answer. **Hint:** There are three types of cylinders, namely, middle cylinders, innermost cylinders, and outermost cylinders.

Answer 1: I think for SSTF will favor middle cylinder because of the following reasons:

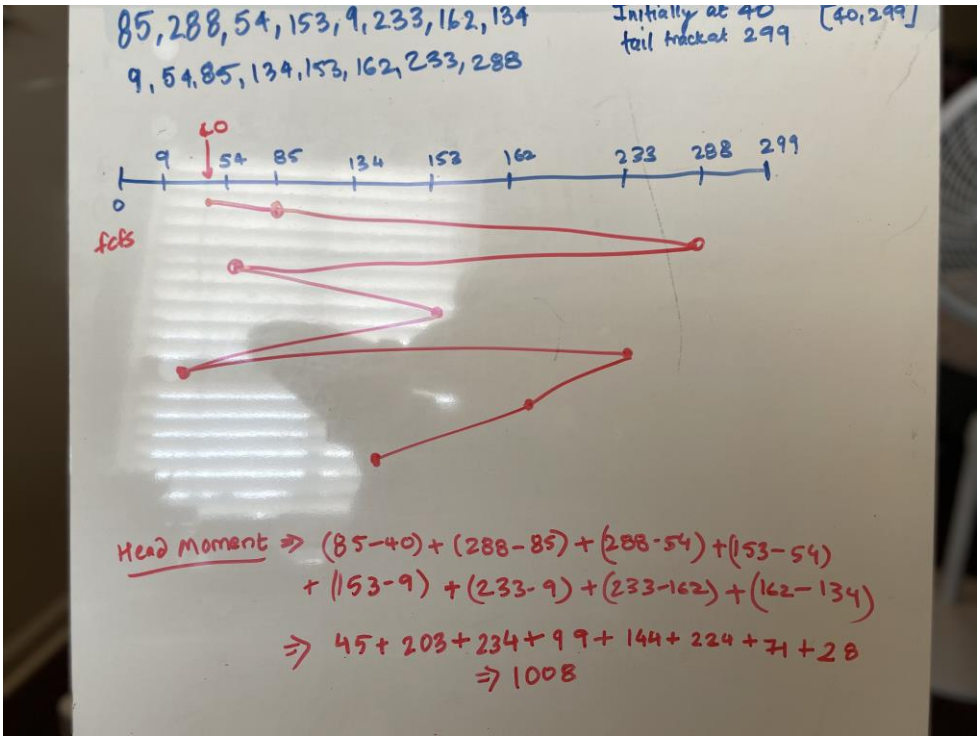
a) The movement of the disk head would be fast and efficient in the middle because center of the disk would be closest to average distance of all other tracks. Therefore, it would be easier for disk head to seek any new request easily.

b) Whenever a new request arrives, it is more likely that the request arrives at the center of the disk so, that SSTF can access quickly and reduce the access time by reducing the seek time.

2. [50 points] Let's consider the following disk request queue: 85, 288, 54, 153, 9, 223, 162, 134 with the disk head initially at the track 40 and the tail track being at 299.

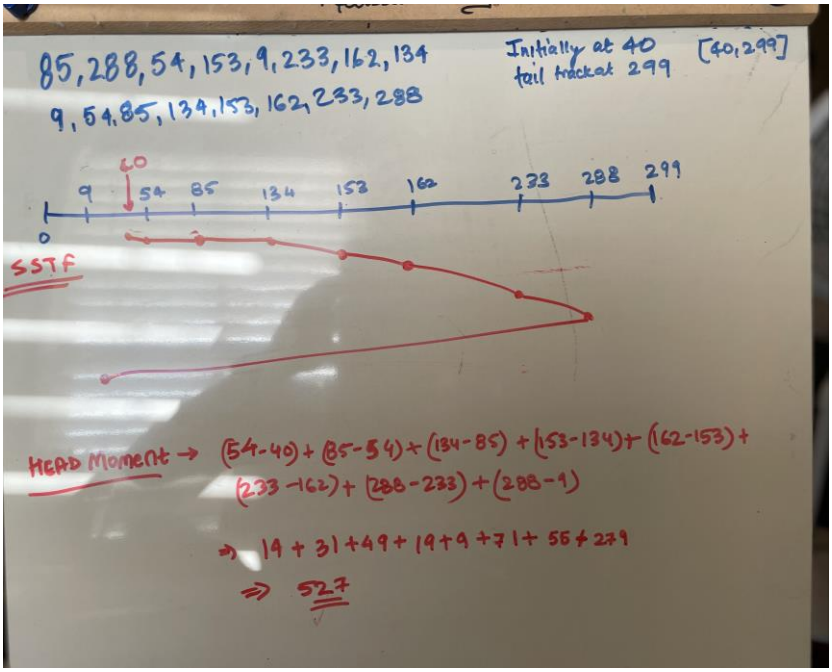
2.1 [10 points] What is the total head movement if the FCFS algorithm (i.e., first-come, first-served) is employed to schedule these disk requests?

Answer 2.1: 1008



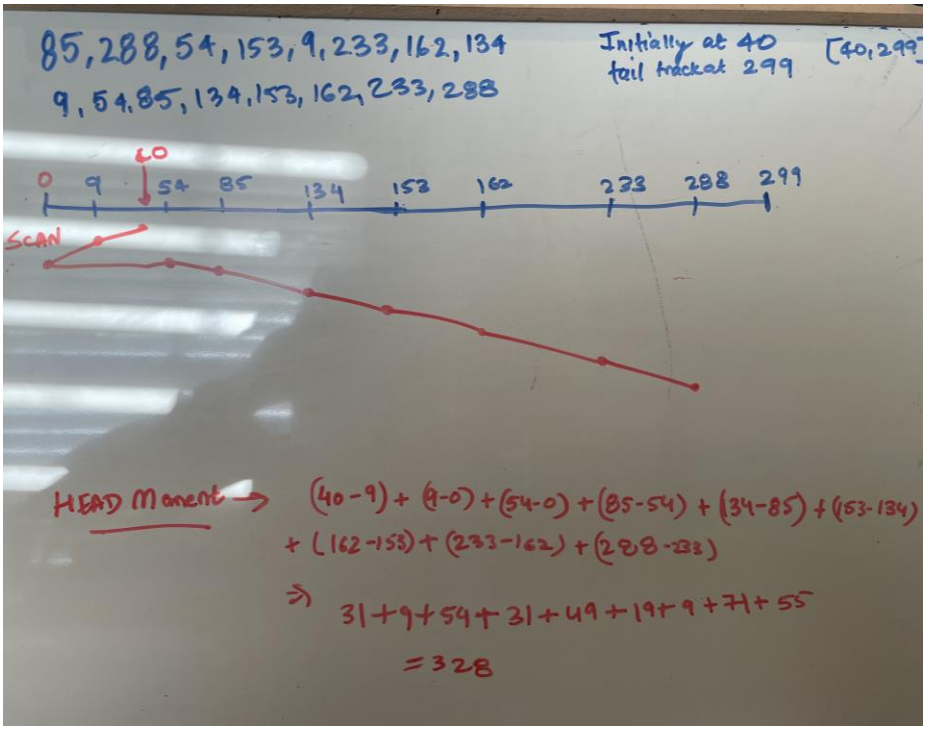
2.2 [10 points] What is the total head movement if the SSTF algorithm (i.e., Shortest Seek Time First) is employed to schedule these disk requests?

Answer: 527



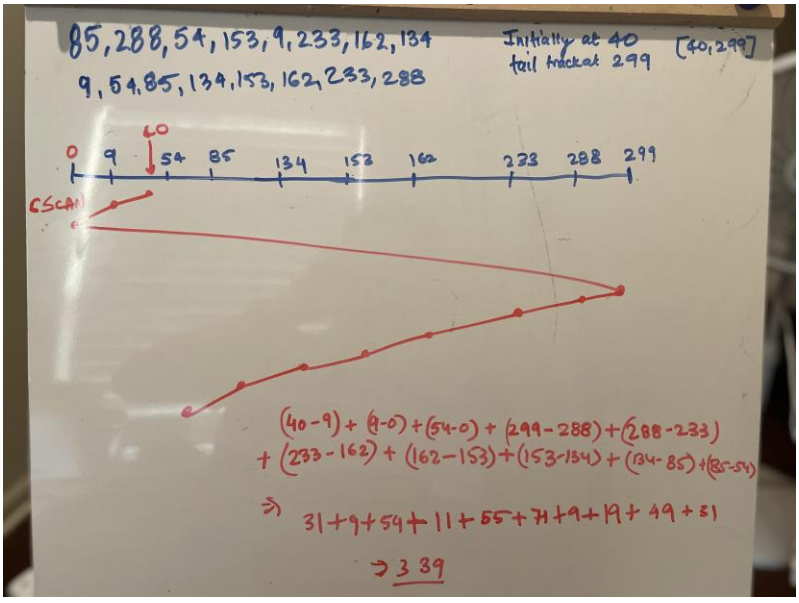
2.3 [10 points] What is the total head movement if the SCAN algorithm (i.e., Elevator) is employed to schedule these disk requests? **Assumption:** We assume that the disk head starts moving toward track 0 first.

Answer: 328



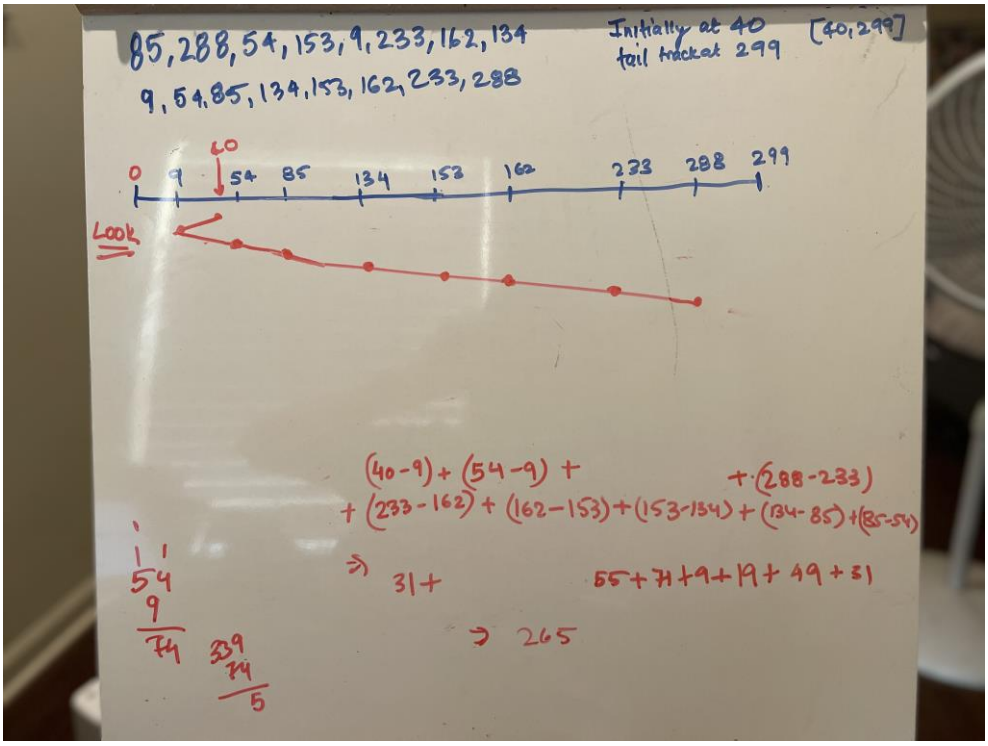
2.4 [10 points] What is the total head movement if the C-SCAN algorithm (i.e., Circular Scanning) is employed to schedule these disk requests? **Assumption:** We assume that the disk head starts moving toward track 0 first. We also assume that the big jump from track 0 to track 299 isn't counted as head movement.

Answer: 339



2.5 [10 points] What is the total head movement if the LOOK algorithm (i.e., Advanced SCAN) is employed to schedule these disk requests? **Assumption:** We assume that the disk head starts moving toward track 0 first.

Answer: 265



3. [15 points] Let's compare two RAID systems (i.e., a RAID-0 system and its RAID-1 counterpart), which share the same number of disks.

Answer: Below are the points that compare the RAID-0 and RAID-1:

a) RAID-0 use data striping or splitting technique whereas RAID-1 uses data mirroring technique or data redundancy techniques.
b) RAID-0 organization achieve better writing performance than RAID-1.
c) It is proven that RAID-0 organization achieve better performance in read requests than RAID-1 organization.
d) Data is more reliable in RAID-1 than RAID-0 due to redundancy storage in RAID-1. Therefore, making RAID-1 fault tolerant.
e) The RAID-0 organization focuses on data accessing speed whereas RAID-1 organization focuses on data availability.
f) RAID-0 require less storage space to store all data whereas RAID-1 require more amount of space to store the same size of data due to redundantly storing the data.

3.1 [5 points] Can you explain why in normal cases the RAID-0 system outperforms the RAID-1 system in terms of read performance?

Answer: In normal cases, RAID-0 outperform the RAID-1 because the speed of reading is measure from disk transfer speed and as we are aware that RAID-0 require lowest amount to disk space compare to other disk due to no redundant data policy. Hence, RAID-0 becomes fast in reading as it has to search the required data in less number of disks.

3.2 [10 points] Please describe a scenario in which RAID-1 may be superior to RAID-0.

Answer: The following points will show how RAID-1 is superior than RAID-0:

a) RAID-1 can bear heavy load or process multiple request simultaneously by channelizing the requests to separate disk. Whereas in RAID-0 can handle light load as it can handle one request at a time.
b) When we want to store critical and sensitive data, RAID-1 is best choice over RAID-0 due to data reliability.
c) In RAID-1, the data availability is high as data is stored in multiple disk and it is available when it is needed without any loss. For example, it more than two users are trying to access the same data, then RAID-1 can provide service to all users as it store same data in multiple disks
d) RAID-1 take the advantage of mirroring the data i.e. storing data redundantly. This redundancy of data make it more reliable than RAID-0. RAID-0 stores data in strips and they are not redundant.
e) The RAID-1 is more fault torrent than RAID-0. For example, if we lose on the disk then, because of data redundancy policy in RAID-1 we can retrieve loose data from other disks. However, in RAID-0, there is not redundancy of data, so if we lose a disk, we lose the data also.
f) RAID-1 has higher performance because data can be read from any disk simultaneously whereas in RAID-0 we need go through all strips until we find one we are looking for.

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4. [15 points] Rebuilding a failed RAID-5 system requires reading data from all surviving disks. Please describe two potential problems during the read-intensive RAID-5 rebuilding process.

Answer: if one disk fails in a RAID-5 then none of the data is loss. But if we require data from the failed disk then the system reads all the data from the remaining good data strips and parity strips. And to get the missing strip each data strip is subtracted from the parity strip. The final result is a missing data strip. But this process consume more performance and therefore, increase system difficulty to keep environment operational.

- Disk sequence within an array
    - During rebuilding, large sequential data transfer is required and these large data transfer prevent effective I/O load balancing.
    - As disk size increases each year, the reading from the disk becomes intensive task. During a rebuilding process, due to large disk sequential array the reading process becomes intensive as the system has to read each disk for parity information for rebuilding. This rebuilding continuously grow over the period of time.
- The strip size used in RAID-5:
    - If data strip size is large then while rebuild the disk the system has to read each large strip to retrieve data and this process may cause system to halt on one disk for longer time which result in overall system delay. Eventually, whole system may loss data because of unavailability of system on new task.
    - The RAID 5 uses disk stripping with parity of data storage and both are stripped across all RAID 5 disk. This stripping of data and parity show performance of RAID-5 equivalent to RAID-0 and protect data loss from disk failure. However, the problem is that the longer rebuilding time in RAID-5 disk goes offline or fail. And if RAID-5 disk goes offline it can't read data which can lead to permanent loss of data.

Submission:

- Submit your solution as a PDF file named as ""hw2.pdf" through Canvas

Late Submission Penalty:

- Ten percent (10%) penalty per day for late submission. For example, an assignment submitted after the deadline but up to 1 day (24 hours) late can achieve a maximum of 90% of points allocated for the assignment. An assignment submitted after the deadline but up to 2 days (48 hours) late can achieve a maximum of 80% of points allocated for the assignment.

- Assignment submitted more than 3 days (72 hours) after the deadline will not be graded.

Rebuttal period:

- You will be given a period of one week (i.e., 7 days) to read and respond to the comments and grades of your homework or project assignment. The TA may use this opportunity to address any concern and question you have. The TA also may ask for additional information from you regarding your homework or project.