Disk Scheduling and Performance Exploration Using the Disk Simulator

Code Submission

https://github.com/baralsamrat/MSCS630_Lab_3

Lab 3

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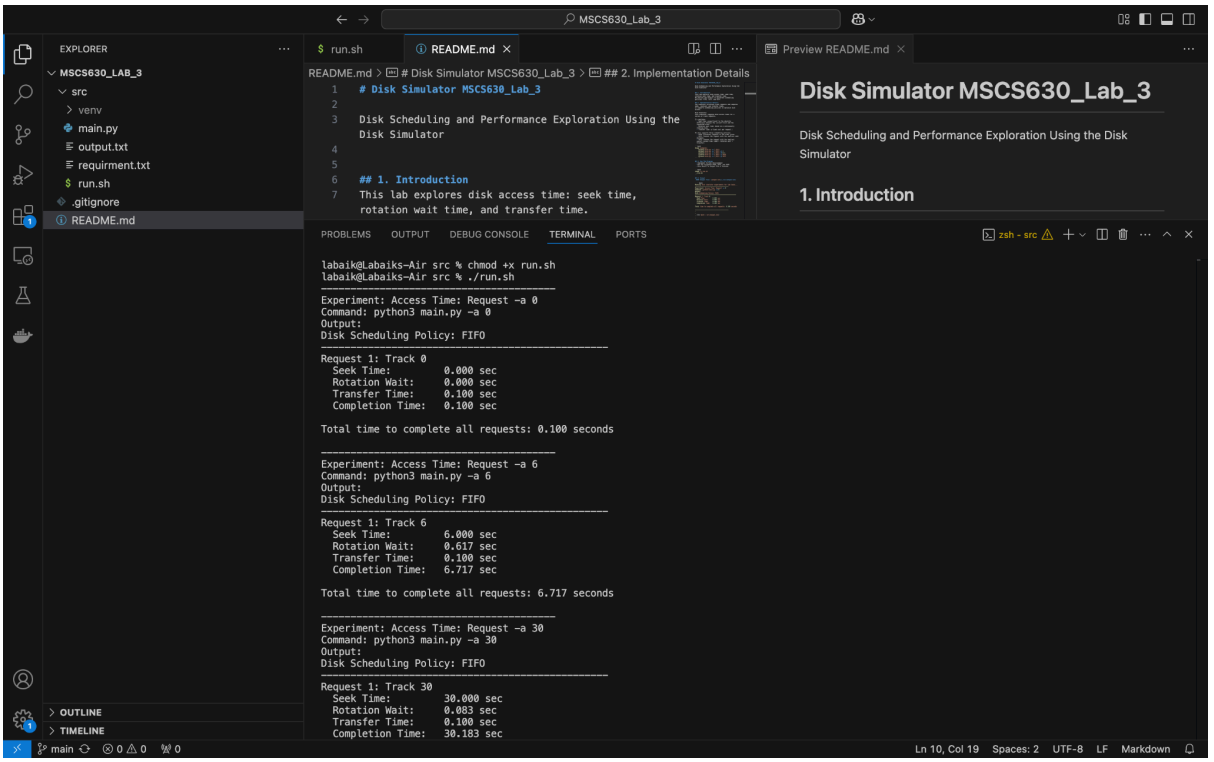
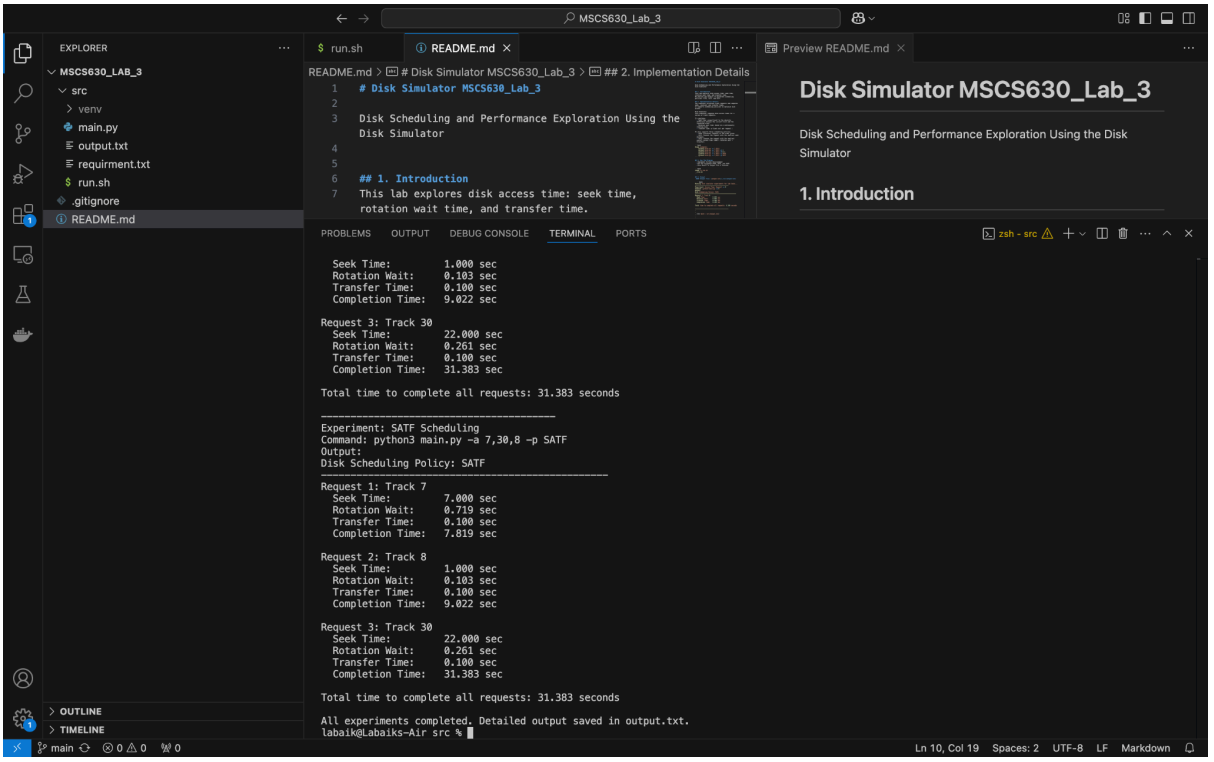
Screenshots:





Introduction

This lab investigates disk access performance by using a disk simulator implemented in main.py. The simulator computes three key components of disk access time:

Disk Access Time Component	Definition	Experiment to Measure
Seek Time	Time required for the disk head to move between tracks	Measure the time to read data from tracks that are far apart and subtract the time to read from tracks that are close together.
Rotation Wait Time	Delay while waiting for the desired disk sector to rotate under the head	Calculate the average time by measuring the time to read multiple sectors and dividing by the number of sectors.
Transfer Time	Fixed duration to read or write data once the head is positioned	Measure the time to read a large amount of data and divide by the amount of data.

The laboratory experiments encompass:

- **Basic Disk Access Time Computation:** Executing the simulator with various disk request sets.
- **Impact of Seek Rate:** Modifying the seek rate to observe its effect on overall access time.
- **Impact of Rotation Rate:** Altering the disk rotation rate and observing its resulting impact.
- **Disk Scheduling Policies Exploration:** Comparing First-In, First-Out (FIFO), Shortest Seek Time First (SSTF), and Shortest Access Time First (SATF) scheduling for the request stream -a 7,30,8.

Basic Disk Access Time Computation

Objectives

- To compute the seek, rotation, and transfer times for various disk request sets.
- To observe how these components vary with different inputs.

Request	Seek Time (sec)	Rotation Wait (sec)	Transfer Time (sec)	Completion Time (sec)	Total Time (sec)
-a 0	0	0	0.100	0.100	0.100
-a 6	6.000	0.617	0.100	6.717	6.717
-a 30	30.000	0.083	0.100	30.183	30.183
-a 7,30,8	-	-	-	-	54.122
-a 10,…	-	-	-	-	13.736
-a 7	7.000	0.719	0.100	7.819	-
-a 30	23.000	0.364	0.100	31.283	-
-a 8	22.000	0.739	0.100	54.122	-
-a 10	10.000	0.028	0.100	10.128	-
-a 11	1.000	0.103	0.100	11.331	-
-a 12	1.000	0.103	0.100	12.533	-
-a 13	1.000	0.103	0.100	13.736	-

Observations and Analysis

- **Seek Time:** Increases with the track number (or distance between tracks). For instance, a request for track 30 results in a higher seek time compared to track 6.
- **Rotation Wait Time:** Varies with the disk's rotational position. For some tracks, the wait time is minimal (e.g., track 30 with 0.083 sec), while for others it is higher.
- **Transfer Time:** Remains constant at 0.100 sec per request.
- **Total Time:** The cumulative time reflects the combination of seek, rotation, and transfer times.

Impact of Seek Rate

Objectives

- To analyze how different seek rate parameters affect the total access time.

Seek Rate (-S)	Seek Time (Request 1)	Seek Time (Request 2)	Seek Time (Request 3)	Total Time
2	14.000 sec	46.000 sec	44.000 sec	106.122 sec
8	56.000 sec	184.000 sec	176.000 sec	418.122 sec
40	280.000 sec	920.000 sec	880.000 sec	2082.122 sec
0.1	0.700 sec	2.300 sec	2.200 sec	6.122 sec

Observations and Analysis

- **Higher Seek Rates:** (e.g., 40 and 8) lead to a substantial increase in seek time and therefore a dramatic increase in overall access time.
- **Lower Seek Rate:** (e.g., 0.1) results in very low seek times and overall faster access.
- **Trade-offs:**
  A high seek rate may be used to simulate hardware with slow head movement, but it negatively impacts performance. Conversely, a low seek rate reduces the delay due to head movement.

Impact of Rotation Rate

Objectives

- To observe how varying the rotation rate affects the rotation wait time and total access time.

Rotation Rate	Seek Time	Rotation Wait	Transfer Time	Completion Time	Total Time

0.1	52	6.122	0.3	58.522	58.522
0.5	52	3.635	0.3	55.944	55.944
0.01	52	129.222	0.3	182.522	182.522

Observations and Analysis

- **Low Rotation Rate (0.01):** Leads to very high rotation wait times, significantly increasing the total access time.
- **High Rotation Rate (0.5):** Reduces rotation wait times and overall access time.
- **Overall Impact:** The rotation rate is critical for performance; a slower disk rotation means the head waits longer for the correct sector.

Disk Scheduling Policies Exploration

Objectives

- To analyze and compare the performance of FIFO, SSTF, and SATF scheduling policies using the request stream -a 7,30,8.

Scheduling Policy	Request	Seek Time (sec)	Rotation Wait (sec)	Transfer Time (sec)	Completion Time (sec)	Total Time (sec)
FIFO	1	7	0.719	0.1	7.819	54.122
FIFO	2	23	0.364	0.1	31.283	54.122
FIFO	3	22	0.739	0.1	54.122	54.122
SSTF	1	7	0.719	0.1	7.819	31.383
SSTF	2	1	0.103	0.1	9.022	31.383
SSTF	3	22	0.261	0.1	31.383	31.383
SATF	1	7	0.719	0.1	7.819	31.383
SATF	2	1	0.103	0.1	9.022	31.383

SATF	3	22	0.261	0.1	31.383	31.383

Observations and Analysis

- **FIFO:** Processes requests in the order received, resulting in non-optimal head movements and the longest total time (54.122 sec).
- **SSTF:** Chooses the next request based on the shortest seek time, reducing head movement and achieving a total time of 31.383 sec.
- **SATF:** Also achieves a total time of 31.383 sec in this simulation. Although it considers both seek and rotation wait times, for this particular workload the benefits over SSTF were negligible because the rotational delays were relatively low compared to the seek times.

Scheduling Policy	Advantages	Disadvantages	When to Use
FIFO	Simple to implement	Does not optimize request order, leading to longer total access times	When simplicity is more important than performance
SSTF	Optimizes request order to minimize head movement, leading to improved performance	More complex than FIFO	When performance is important and rotation wait times are small relative to seek times
SATF	Optimizes request order to minimize head movement AND rotation wait, leading to improved performance (especially when rotation wait times are large relative to seek times)	More complex than FIFO and SSTF	When performance is critical and rotation wait times are large relative to seek times

Conclusions

In conclusion, disk access time is heavily influenced by seek time, rotation wait time, and transfer time. Seek rate and rotation rate are critical parameters: higher seek rates and lower rotation rates (slower disks) significantly increase overall access time.

Different scheduling policies also impact performance. FIFO, while simple, often results in longer access times. SSTF minimizes head movement and overall time, while SATF further optimizes by considering rotation delay, particularly when rotational delays are substantial compared to seek times. Understanding these factors and choosing appropriate scheduling policies are crucial for optimizing disk access and system performance.

In our simulated workload (-a 7,30,8), SSTF and SATF yielded similar performance. SATF has the potential to outperform SSTF in systems with greater rotational delays, such as when disks have slower rotation speeds or when the target sectors are widely distributed in terms of angular position.

References

- **Operating Systems: Three Easy Pieces (OSTEP)**
- Course lecture notes and lab instructions