Sample Exercises: Storage

Exercise 1
Consider a disk with a sector size of 512 bytes, 2000 tracks per surface, 50 sectors per track, five double-sided platters, and average seek time of 10 msec.

1. What is the capacity of a track in bytes? What is the capacity of each surface? What is the capacity of the disk?
2. How many cylinders does the disk have?
3. Give examples of valid block sizes. Is 256 bytes a valid block size? 2048? 51200?
4. If the disk platters rotate at 5400 rpm (revolutions per minute), what is the maximum rotational delay?
    a. What is the average rotational delay?
5. If one track of data can be transferred per revolution, what is the transfer rate?

Exercise 2
Consider a hard disk that uses Advanced Format with sector size of 4096 bytes (4KB), 1000 tracks per surface, 50 sectors per track, five (5) double-sided platters, and average seek time of 8 msec. Suppose that the disk platters rotate at 7200 rpm (revolutions per minute).

Suppose also that a block (page) of 4096 bytes is chosen. Now, consider a file with 150,000 records of 100 bytes each that is to be stored on such a disk and that no record is allowed to span two blocks. Also, no block can span two tracks.

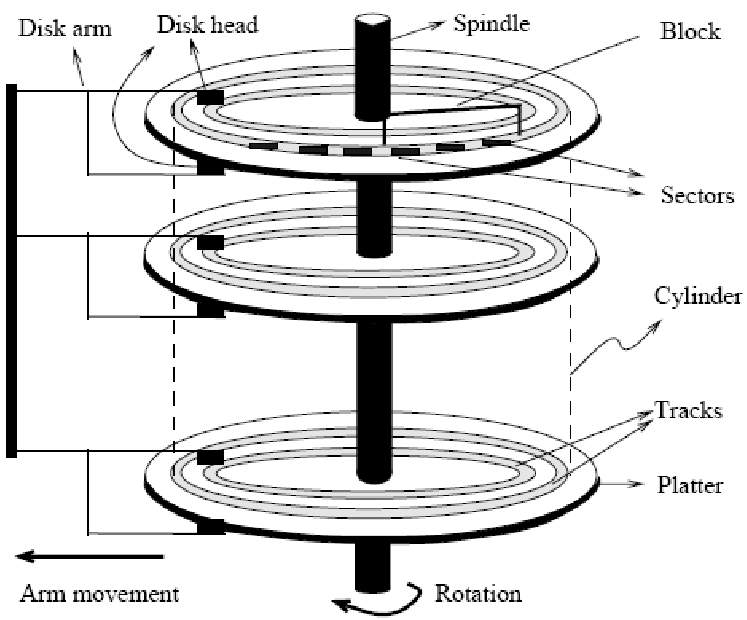
1. How many records fit onto a block?
2. How many blocks are required to store the entire file? If the file is arranged "sequentially on the disk, how many cylinders are needed?
3. How many records of 100 bytes each can be stored using this disk?
4. What time is required to read a file containing 100,000 records of 100 bytes each sequentially? You can make an assumption about how long it takes moving the heads from one cylinder to the next here.
5. What is the time required to read a file containing 100,000 records of 100 bytes each in a random order? To read a record, the block containing the record has to be fetched from the disk. Assume that each block request incurs the average seek time and rotational delay. You need also to include the transfer time for each block.

Exercise 3 What is *sequential flooding* of the buffer pool?

Exercise 4 Explain the term prefetching. Why is it important?

Solutions

Answer 1



1. bytes/track = bytes/sector * sectors/track = 512 * 50 = 25K
   bytes/surface = bytes/track * tracks/surface = 25K * 2000 = 50, 000K
   bytes/disk = bytes/surface * surfaces/disk = 50, 000K * 5 * 2 = 500, 000K
2. The number of cylinders is the same as the number of tracks on each platter, which is 2000.
3. The block size should be a multiple of the sector size. We can see that 256 is not a valid block size while 2048 is. 51200 is not a valid block size in this case because block size cannot exceed the size of a track, which is 25600 bytes.
4. If the disk platters rotate at 5400rpm, the time required for one complete rotation, which is the maximum rotational delay, is:
   (1/5400) * 60 = 0.011 seconds.
   a. The average rotational delay is half of the rotation time, 0.0055 seconds.
5. The capacity of a track is 25K bytes. Since one track of data can be transferred per revolution, the data transfer rate is:
   25K/0.011 = 2, 250Kbytes/second

Answer 2

1. 4096 / 100 = 40.96. Which means that 40 records can fit in a block.

2. The file requires 150,000 records / 40 records per block = 3750 blocks to be saved. In our case one block is equal to one sector(4KB)
1 track holds 50 blocks
10 tracks (two for each platter), which is one cylinder holds 500 blocks.

The file is 3750 blocks. Thus 3750/500 = 7,5 cylinders. So 8.

3. 1 block can hold 40 records.

The disk has 50*1000*5 number of blocks (blocks per track * tracks * cylinders)

Thus, this disk can store 40*50*1000*10 = 20M records.

4. A file containing 100,000 records of 100 bytes is stored in 100,000/40 = 2500 blocks.

From answer 1, we have that 1 cylinder holds 500 blocks. Our file will be saved in 2500/500 = 5 cylinders.

In order to read one track, we need 60s/7200(rpm) = 0,0083 seconds. In order to read one cylinder, we need 10 * 0,0083 = 0,083 seconds. We need to read 5 cylinders, so the total time will be 5 * 0,083 = **0.415 seconds**. We assume that the time for moving from one cylinder to another is very small. The average seek time is 8msec = 0,008 seconds and the average rotational delay is 0.00415 seconds. Therefore, the total time is 0,415 + 0,00415 + 0,008 = 0,42715 seconds.

5. A file containing 100,000 records of 100 bytes is stored in 100,000/40 = 2500 blocks

For any block of data, average access time =avg seek time +avg rotational delay + transfer time Average seek time = 0,008s and average rotational-delay = 0,00415s .
To find transfer time:

Each track has 50 blocks. To read all 50 blocks it takes 0,0083 seconds. To read just one takes 0,0083/50 = 0,000166 seconds

As a result, the total time is (0,008 + 0,00415 + 0,000166) * 2500 = 30.79 seconds.

Answer 3 Some database operations (e.g., certain implementations of the join relational algebra operator) require repeated sequential scans of a relation. Suppose that there are 10 frames available in the buffer pool, and the file to be scanned has 11 or more pages (i.e., at least one more than the number of available pages in the buffer pool). Using LRU, every scan of the file will result in reading in every page of the file! In this situation, called *"sequential flooding"*, LRU is the worst possible replacement strategy.

Answer 4 Because most page references in a DBMS environment are with a known reference pattern, the buffer manager can anticipate the next several page requests and fetch the corresponding pages into memory before the pages are requested. This is prefetching.

Benefits include the following:

1. The pages are available in the buffer pool when they are requested.
2. Reading in a contiguous block of pages is much faster than reading the same pages at different times in response to distinct requests.