Computer Architecture–Homework V

107 Fall semester, Chapter 6 & 7

6.3 Consider a magnetic disk drive with 8 surfaces, 256 tracks per surface, and 32 sectors per track. Sector size is 1KB. The average seek time is 8ms, the track-to-track access time is 1.5ms, and the drive rotates at 3,000rpm. Successive tracks in a cylinder can be read without head movement.

(a) What is the disk capacity?

(b) What is the average access time?

(c) Assume this file is stored in successive sectors and tracks of successive cylinders, starting at sector 0, track 0, of cylinder i. Estimate the time required to transfer a 2.5MB file.

(d) What is the burst transfer time?

Sol:

(a) $8 \times 256 \times 32 \times 1\text{KB} = 64\text{MB}$

(b) Average access time = average seek time + rotational delay

- Average seek time = 8ms
- 3000rpm = 50rps $\Rightarrow$ 1 revolution requires $\frac{1}{50}$s = 20ms $\Rightarrow$ rotational delay = $\frac{20}{2}$ = 10ms
- Average access time = 8+10 =18ms

(c) Each cylinder consists of 8 tracks $\times$ 32 sectors/track $\times$ 1KB/sector = 256KB.
2.5MB = 2.5 $\times$ 1024KB requires exactly 10 cylinders.

- The 1st cylinder requires 8ms seek time, 10ms rotational delay, followed by 8 revolutions. $\Rightarrow 8 + 10 + 8 \times 20$
- For the 2nd to the 10th cylinder, each cylinder requires 1.5ms seek time, 10ms rotational delay, followed by 8 revolutions. $\Rightarrow (1.5 + 10 + 8 \times 20) \times 9$
- $(8 + 10 + 8 \times 20) + (1.5 + 10 + 8 \times 20) \times 9 = 1721.5\text{ms}$

(d) Burst transfer rate = (revolutions/sec) $\times$ (sectors/revolution) $\times$ (bytes/sector)
$= \frac{3000}{60} \times 32 \times 1\text{KB} \approx 1.6\text{MB/s}$

6.4 Consider a single-platter disk with the following parameters:

- rotation speed: 3,600rpm;
- number of tracks on one side of platter: 3,000;
- number of sectors per track: 300;
- seek time: 1ms for every hundred tracks traversed.

Let the disk receive a request to access a random sector on a random track and assume the disk head starts at track 0.

(a) What is the average seek time?

(b) What is the average rotational latency?

(c) What is the transfer time for a sector?

(d) What is the total average time to satisfy a request?

Sol:

(a) If the request track is track 0, then the seek time is 0; if the requested track is track 2999, then the seek time is the time to traverse 2999 tracks. For a random request, on average the number of tracks traversed is $\frac{2999}{2}$ = 1499.5tracks. At one ms per 100 tracks, the average seek time is therefore $\frac{1499.5}{100}$ = 14.995ms.

(b) 3600rpm = 60rps $\Rightarrow$ 1 revolution = $\frac{1}{60}$s = 16.67ms $\Rightarrow$ average rotational delay = $\frac{16.67}{2}$ = 8.335ms.

(c) 300sectors/track $\Rightarrow$ 1 sector = $\frac{1}{300}$revolution = $\frac{16.67}{300}$ = 0.056ms

(d) seek time + rotational delay + transfer time = $14.995 + 8.335 + 0.056 = 23.386$ms

6.6 Consider a disk that rotates at 3,600rpm. The seek time to move the head between adjacent tracks is 2ms. There are 64 sectors per track, which are stored in linear order from sector 0 through sector 63. The head sees the sectors in ascending order. Assume the read/write head is positioned at the start of sector 1 on track 8. There is a main memory buffer large enough to hold an entire track. Data is transferred between disk locations by reading from the source track into the main memory buffer and then writing the data from the buffer to the target track.

(a) How long will it take to transfer sector 1 on track 8 to sector 1 on track 9?

(b) How long will it take to transfer all the sectors of track 8 to the corresponding sectors of track 9?

Sol:

(a) The transfer time consists of the following components:

- Read sector 1 (of track 8): A single revolution to read or write an entire track takes $\frac{60\times10^3}{3600} =$ 16.67ms. Time to read a single sector is $\frac{1}{64}$revolution $= \frac{1}{64} \times 16.67 = 0.26$ms.
- Head movement to access track 9: Head moves from track 8 to track 9. Head takes 2ms to move between adjacent tracks.
- Rotation to line up with sector 1 (of track 9): A rotational delay of $\frac{63}{64}$revolution is required for the head to line up with sector 1 again. This is $\frac{63}{64} \times 16.67 = 16.41$ms.
- Write sector 1 (of track 9): Time to write a single sector is $\frac{1}{64}$revolution $= \frac{1}{64} \times 16.67 = 0.26$ms.

The head movement time of 2 ms "overlaps" with the 16.2 ms of rotational delay, so only the rotational delay time is counted. Total transfer time is $0.26+16.41+0.26 = 16.93$ms, $\frac{1}{64}+\frac{63}{64}+\frac{1}{64} = \frac{65}{64}$revolution.

(b) First of all, because the entire track is buffered, sectors can be written back in a different sequence from the read sequence. The transfer time consists of the following components:

- Read track 8: The time to read or write an entire track is simply the time for a single revolution, which is 16.67ms.
- Head movement to access track 9: Head moves from track 8 to track 9. Head takes 2ms to move between adjacent tracks.
- Write track 9: The time to write an entire track is simply the time for a single revolution, which is 16.67ms.

During head movement, the head moves past 7 sectors and most of a 8th sector. Thus, the write can start with sector 9 of track 9. This sector is reached $0.26 \times 8 = 2.08$ms after the completion of the read track operation. Thus the total transfer time is $16.67 + 2.08 + 16.67 = 35.42$ms, $1 + \frac{8}{64} + 1 = 2\frac{1}{8}$revolution.

7.12 DMA module is transferring data to memory using cycle stealing, from a device that transmits data at a rate of 19,200 bps. The speed of the CPU is 1MIPS. By how much would the DMA module affect the performance of the CPU? (*Hint:* Ignore data read/write operations and assume the processor only fetches instructions.)

Sol:
The processor is fetching 10^6 instructions per second.
The DMA module is transferring characters at a rate of $\frac{19200}{8} = 2400$ characters per second.
This slows down the processor $\frac{2400}{10^6} = 0.24\%$.