CS & IT ENGINEERING

COMPUTER ORGANIZATION AND ARCHITECTURE

Disk

Lecture No.- 1

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Recap of Previous Lecture

Topic Array Access with Cache

Topic Multilevel Cache

Topics to be Covered

Topic Magnetic Disk

[NAT]

#Q. In the three-level memory hierarchy shown in the following table, p_i denotes the probability that an access request will refer to M_i.

Hierarchy Level (M_i)	Access Time (t_i)	Probability of Access (p_i)	Page Transfer Time (T_i)
M_1	10^{-6}	0.99000	0.001 sec
M_2	10^{-5}	0.00998	0.1 sec
M_3	10^{-4}	0.00002	---

If a miss occurs at level M_i, a page transfer occurs from M_{i+1} to M_i and the average time required for such a page swap is T_i.

Calculate the average time t_A required for a processor to read one word from this memory system.

$$= 0.99 * 10^{-6} +$$

$$0.00988 * (10^{-6} + 10^{-5} + 0.001) +$$

$$0.00002 * (10^{-6} + 10^{-5} + 10^{-4} + 0.1 + 0.001)$$

$$= 10^{-6} \Big[0.99 + 0.00988 * (1 + 10 + 1000)$$

$$+ 0.00002 * (1 + 10 + 100 + 10^5 + 10^3) \Big] \text{ sec}$$

$$= 10^{-6} * (13.0009) \text{ sec}$$

$$= \underline{\underline{13.0009 \ \mu\text{sec}}}$$

[NAT]

4.72 Ans.

#Q. The read access times and the hit ratios for different caches in a memory hierarchy are as given below:

Cache	Read access time (in nanoseconds)	Hit Ratio
I-cache	2	0.8
D=cache	2	0.9
L2-cache	8	0.9

The read access time of main memory in 90nanoseconds. Assume that the caches use the referred-word-first read policy and the write-back policy. Assume that all the caches are direct mapped caches. Assume that the dirty bit is always 0 for all the blocks in the caches. In execution of a program, 60% of memory reads are for instruction fetch and 40% are for memory operand fetch. The average read access time in nanoseconds (up to 2 decimal places) is _______?

[MCQ GATE-2021]

#Q. Assume a two-level inclusive cache hierarchy, L1 and L2, where L2 is the larger of the two. Consider the following statements.

S1: Read misses in a write through L1 cache do not result in writebacks of dirty lines to the L2 ⇒ True

S2: Write allocate policy must be used in conjunction with write through caches and no-write allocate policy is used with writeback caches. ⇒ false

Which of the following statements is correct?

(A) ✓ S1 is true and S2 is false

(B) S1 is false and S2 is true

(C) S1 is true and S2 is true

(D) S1 is false and S2 is false

[MCQ]

GATE-10

#Q. A computer system has an L1 cache, an L2 cache, and a main memory unit connected as shown below. The block size in L1 cache is 4 words. The block size in L2 cache is 16 words. The memory access times are 2 nanoseconds, 20 nanoseconds and 200 nanoseconds for L1 cache, L2 cache and the main memory unit respectively.

When there is a miss in L1 cache and a hit in L2 cache, a block is transferred from L2 cache to L1 cache. What is the time taken for this transfer?

A 2 nanoseconds

B 20 nanoseconds

C 22 nanoseconds

D 88 nanoseconds

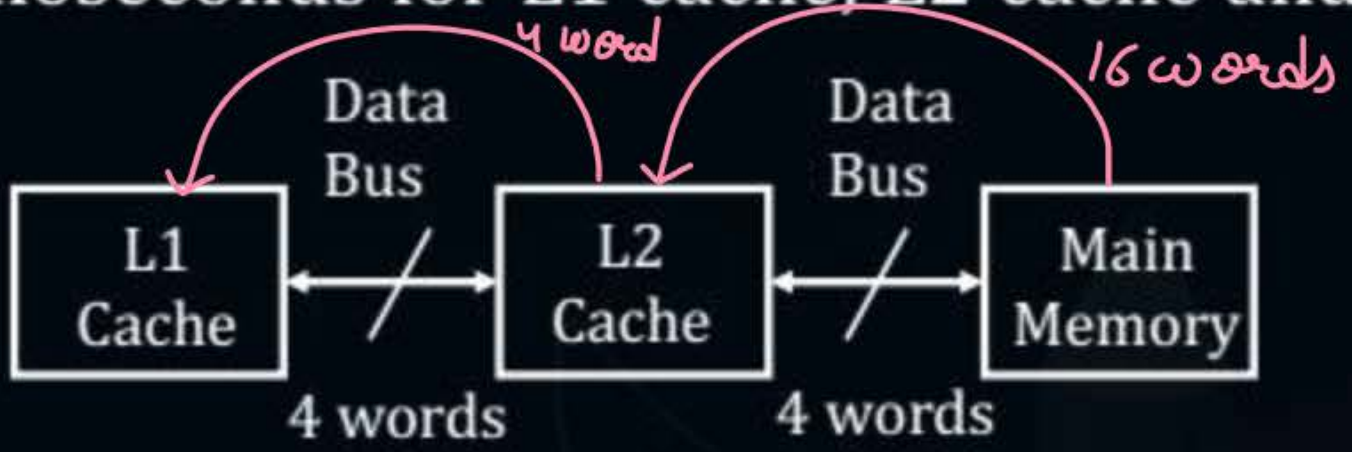
read block from L2 $\Rightarrow$ 20ns

write —"— in L1 $\Rightarrow$ 2

22 ns

[MCQ] GATE-2010

#Q. A computer system has an L1 cache, an L2 cache, and a main memory unit connected as shown below. The block size in L1 cache is 4 words. The block size in L2 cache is 16 words. The memory access times are 2 nanoseconds, 20 nanoseconds and 200 nanoseconds for L1 cache, L2 cache and the main memory unit respectively.



When there is a miss in both L1 cache and L2 cache, first a block is transferred from main memory to L2 cache, and then a block is transferred from L2 cache to L1 cache. What is the total time taken for these transfers?

A. 222 nanoseconds

B. 888 nanoseconds

C. 902 nanoseconds

D. 968 nanoseconds

$$
\begin{array}{r}
4 * \left[200 + 20 \right] \\
+ \quad 22 \\
\hline
902 \ \underline{\underline{ns}}
\end{array}
$$

[Question]

#Q. Consider a computer with the following features:

- 90% of all memory accesses are found in the cache (hit ratio = 0.9)
- The block size is 2 words and the whole block is read on any miss
- The CPU sends references to the cache at the rate of 10^7 words per second
- 25% of the above references are writes (writes = 25%, reads = 75%)
- The bus can support 10^7 words per second, read or writes (total bus bandwidth $=10^7$)
- The bus reads or writes a single word at a time
- Assume at any one time, 30% of the block frames in the cache have been modified

Calculate the percentage of the bus bandwidth used on the average when:

1. Cache is write through with no write allocate $= \frac{0.4 * 10^7}{10^7} = 0.4 = 40\%$
2. Cache is write back with write allocate

$\hookrightarrow \frac{0.26 * 10^7}{10^7} = 0.26 = 26\%$

for write through cache

Case	Bus used
Read hit	0
Read miss	$10^7 * 0.75 * 0.1 * \underline{2}$
write hit	$10^7 * 0.25 * 0.9 * \underline{1}$
write miss	$10^7 * 0.25 * 0.1 * \underline{1}$
Total	$10^7 * (0.15 + 0.225 + 0.25)$

block from mm to cm

write word in mm

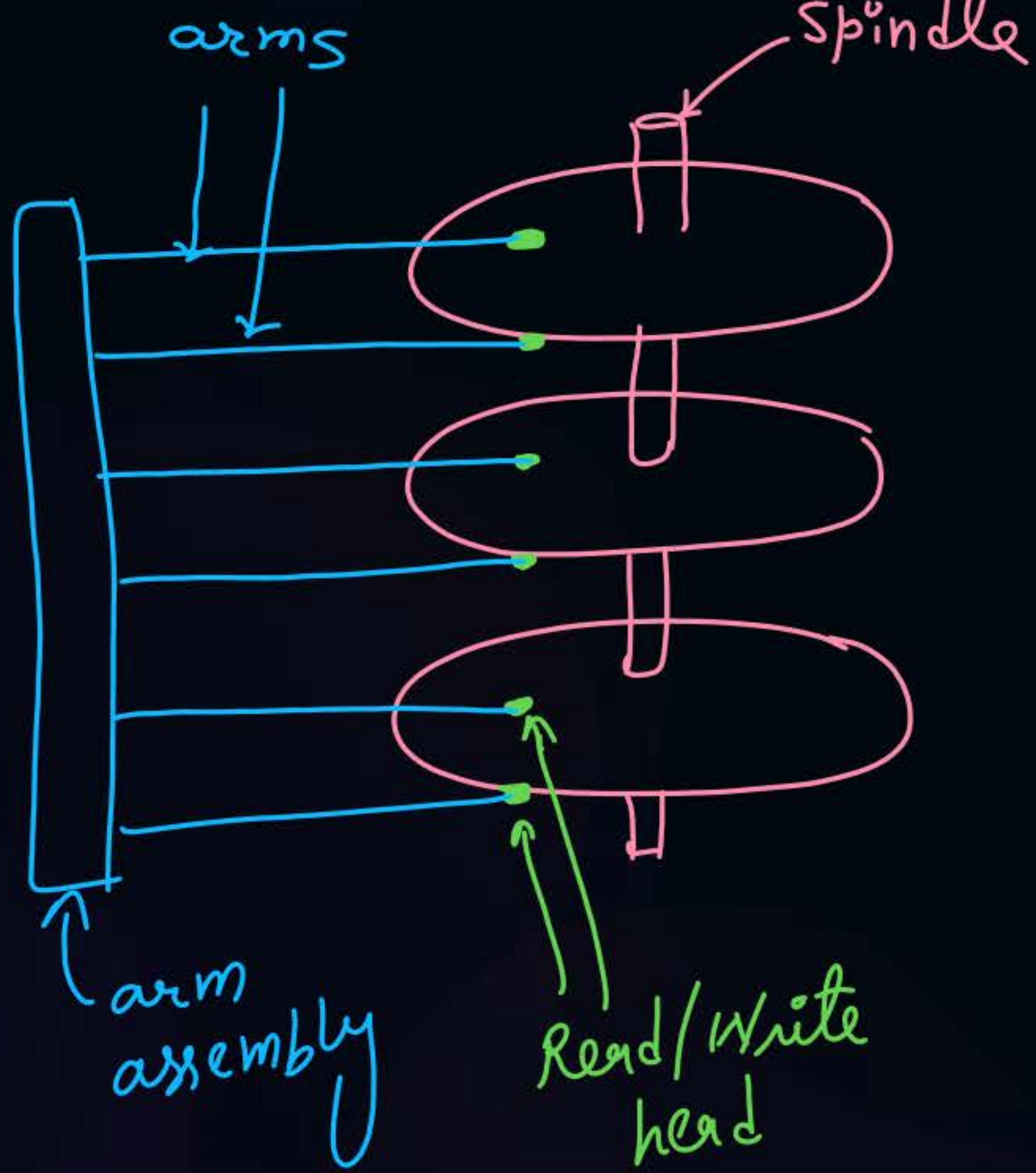
$= \underline{10^7 * 0.4}$

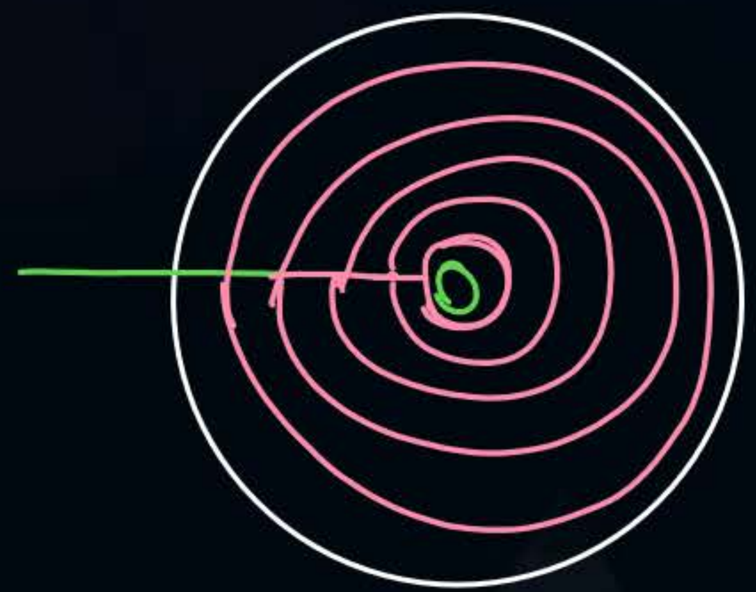
no. of words transfers through bus per sec.

for write back cache

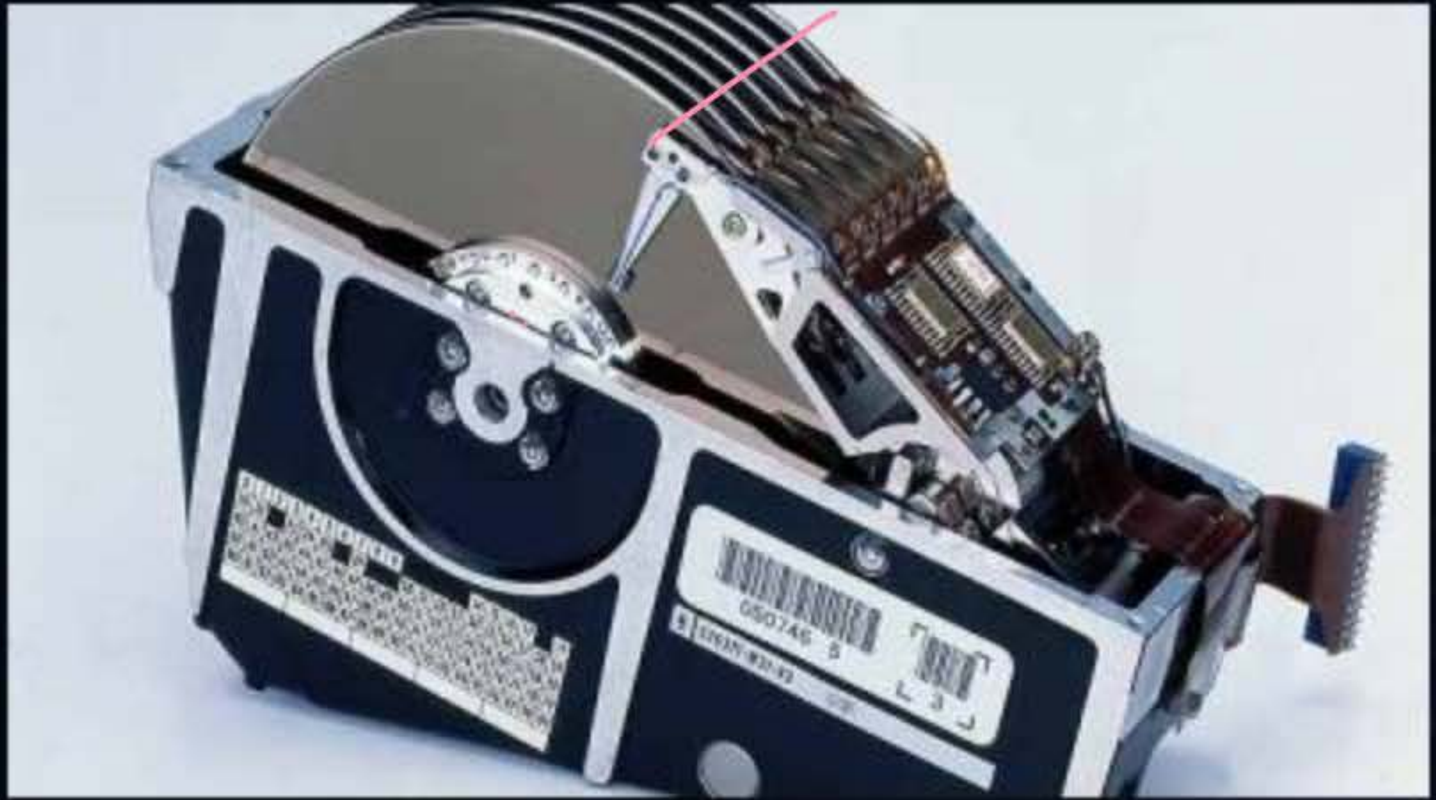
Case	Bus used
Read hit	0
Read miss	$10^7 * 0.75 * 0.1 * [\underbrace{2}_{\text{block from mm to cache}} + 0.3 \underbrace{* 2}_{\text{write back}}]$
write hit	0
write miss	$10^7 * 0.25 * 0.1 * [2 + 0.3 * 2]$
Total	$10^7 * (0.195 + 0.065)$ $= 0.26 * 10^7$

Topic : Magnetic Disk

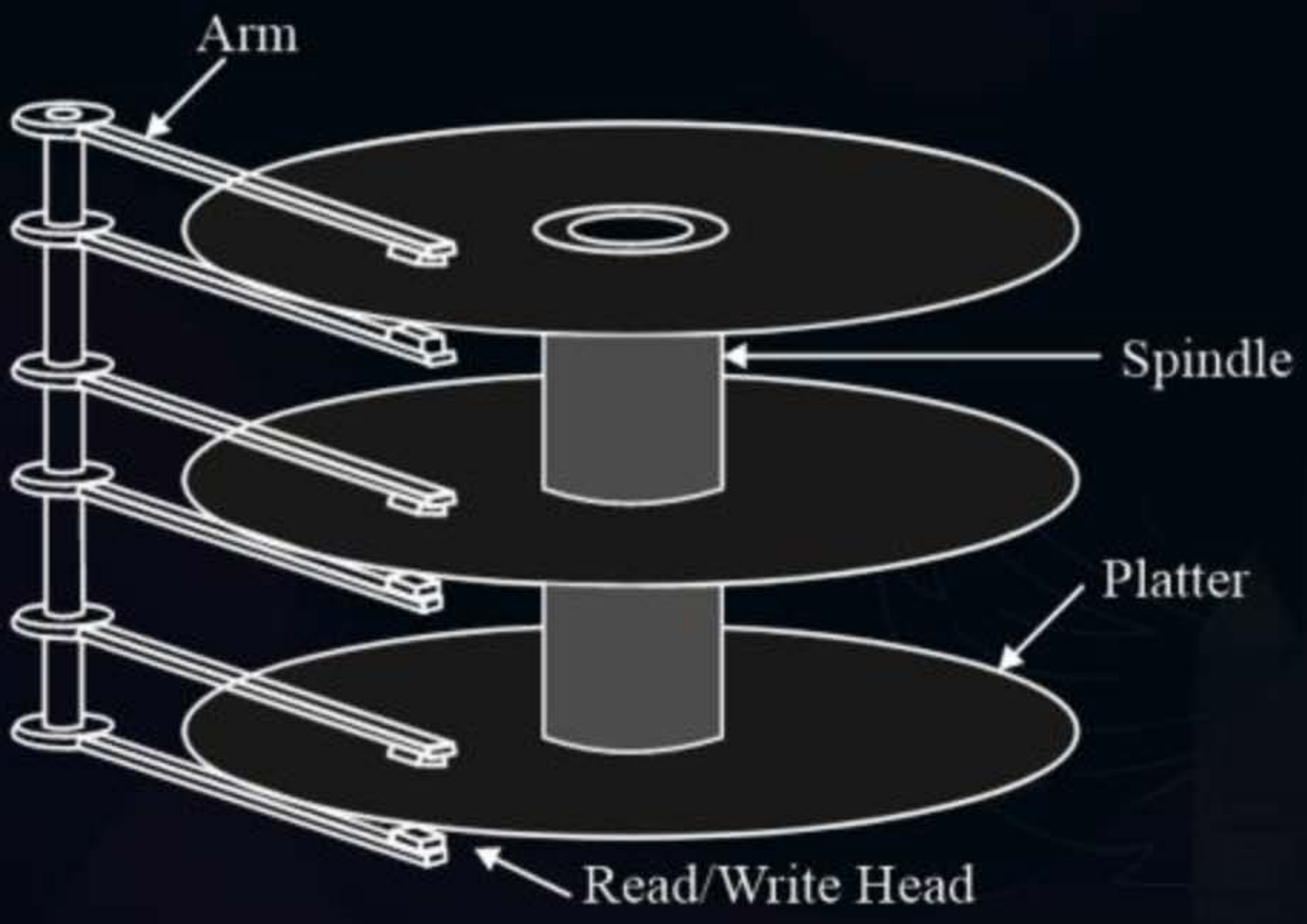


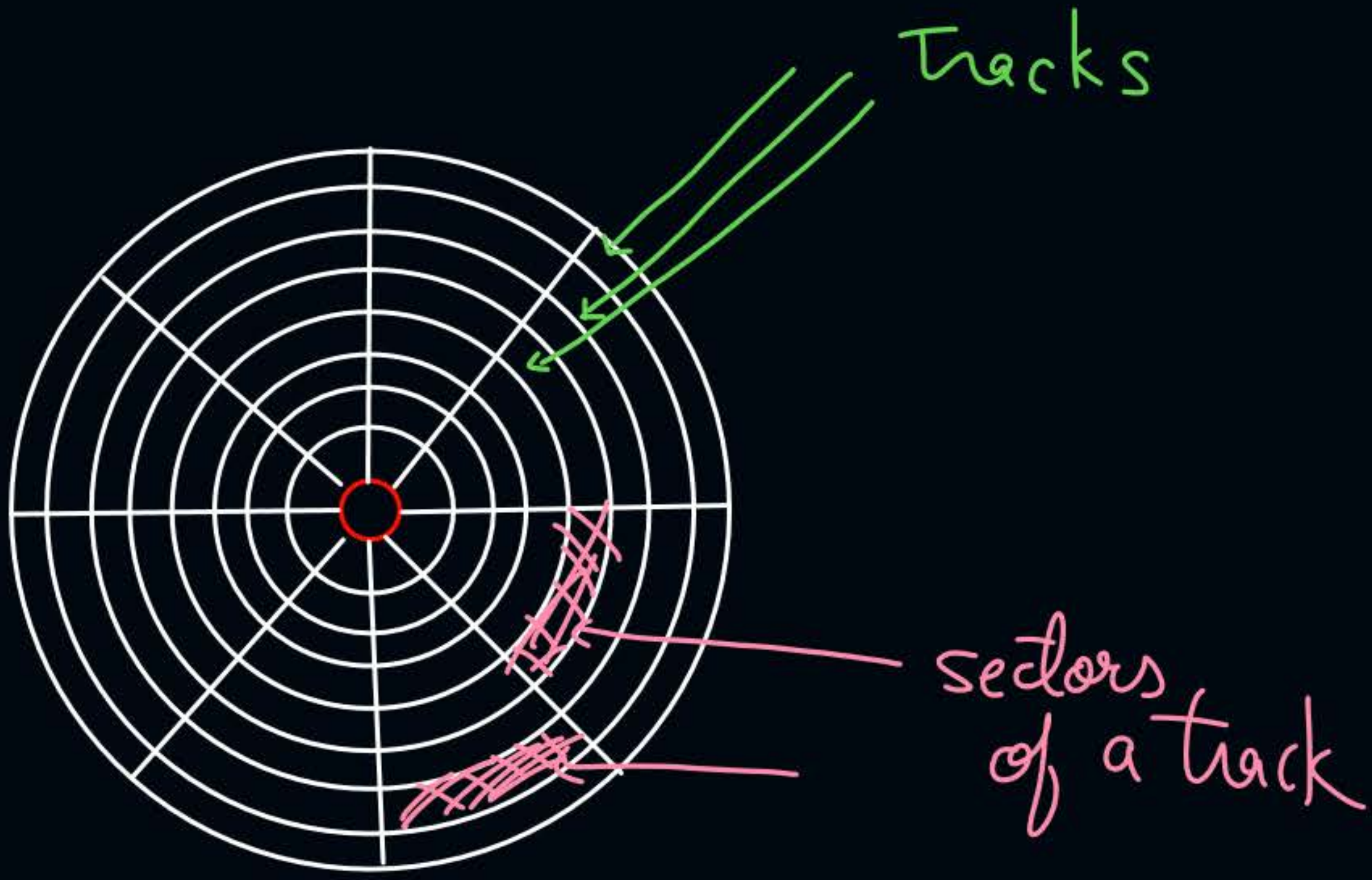


Topic : Magnetic Disk



Topic : Magnetic Disk





sector is the smallest unit of the disk which can be read or written at once.

Each sector gets an address in disk

Topic : Magnetic Disk

Number of ~~surfaces~~ sectors in disk:

= 2 * no. of platters * no. of tracks per surface * no. of sectors per track

$= 2 * 3 * 8 * 8$

$= 384$

Topic : Sector Capacity

Disk

Constant sector capacity
or
variable storage density
or
constant angular velocity

variable sector capacity
or
Constant storage density
or
constant linear velocity

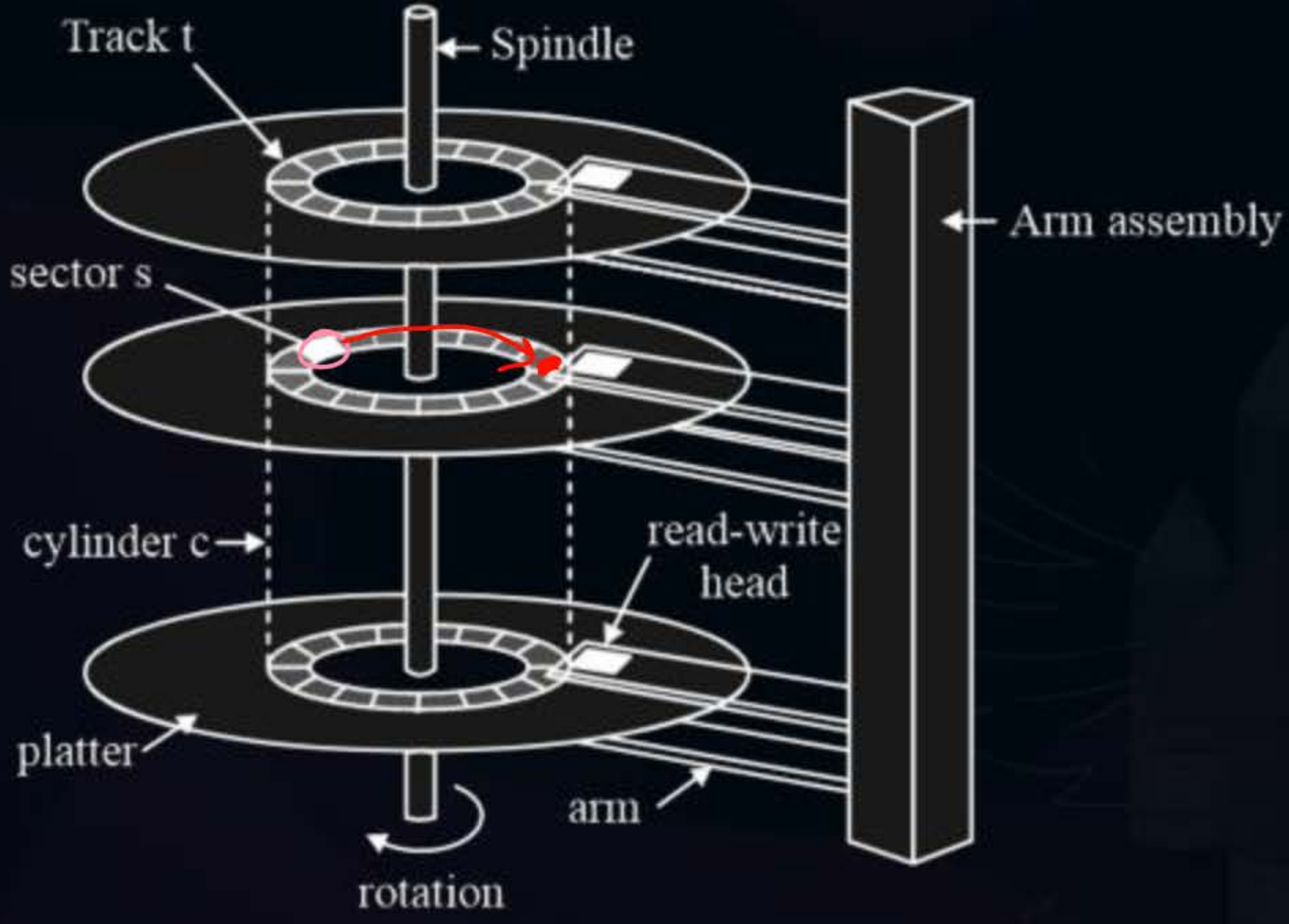
[NAT]

#Q. Consider a disk with 32 platters each with 2 recording surfaces. There are 128 tracks per surface and 32 sectors per track. Each sector has equal capacity of 1KBytes.

Calculate:

1. Number of surfaces in disk: $2 * 32 = 64$
2. Number of tracks on disk: $64 * 128 = 2^{13}$
3. Number of sectors in disk: $2^{13} * 32 = 2^{18}$
4. Number of bytes on disk: $2^{18} * 1KB = 256MB$
5. Number of bits for disk addressing: 18 bits

Topic : Magnetic Disk



Disk access time :-

= seek time + rotational delay or latency + 1 sector transfer time + additional delay

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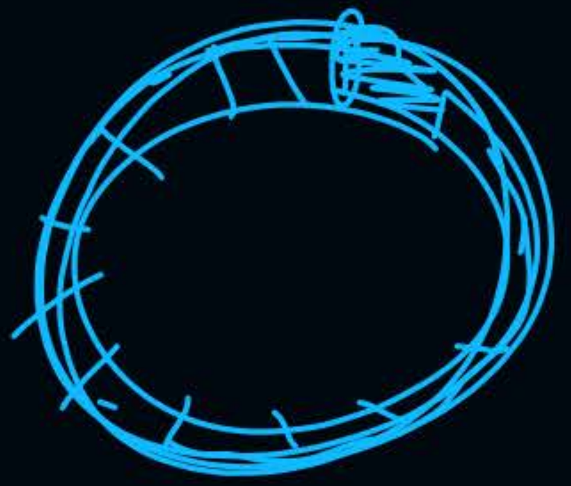
Note :-

In one rotation of disk, one track can be transferred



Topic : Disk Access Time

Seek Time: Time required to position the arm over the desired track

Rotational Latency: time required to rotate desired sector under R/W head

Transfer Time: Time required to read or write 1 sector

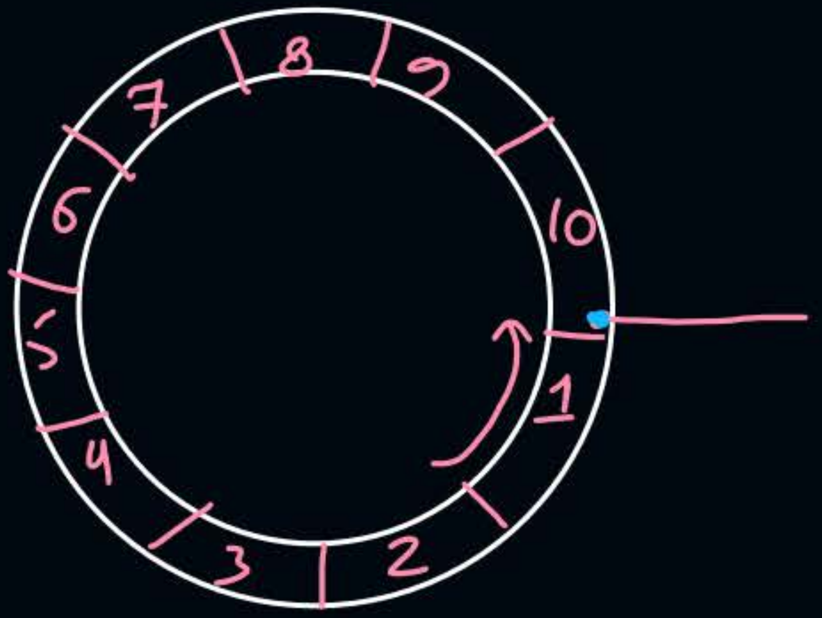
$$\text{avg. rotational latency} = \frac{\text{1 rotation time}}{2}$$

$$\text{1 sector transfer time} = \frac{\text{1 rotation time}}{\text{no. of sectors per track}}$$

ex:-

1 rotation time = 20 msec
no. of sectors per track = 10

1 sector rotation time = $\frac{20\,ms}{10}$ = 2 ms



Target sector ⇒ 4th sector
⇓
no. of sectors to be rotated = 3
⇓
rotational latency = 3 * 2 ns
= 6 ns

Ques)
current position = 6
Target sector = 3

rotational latency = 7*2 = 14 ms
⇓
sectors to rotate

Avg. seek time :-

50 tracks

time needed to move arm to next adjacent track = 1 ms

avg. seek time = ______ ?

Time needed to move arm from track 1 to 1 = 0

—— || —— to 2 = 1 ms

—— || —— to 3 = 2 ms

⋮

—— || —— to 50 = 49 ms

$$\text{avg} = \frac{1 + \cdots + 49}{50}$$

$$= 24.5 \text{ ms}$$

Speed to time :-

10000 rotations per minute (RPM)

for 10000 rotations, time = 1 min = 60 sec = 60 * 1000 ms

for 1 —— " —— = $\frac{60000 \text{ ms}}{10000}$

= 6 ms

[NAT]

#Q. Consider a disk with 16 platters, 2 surfaces per platter, 2K tracks per surface, 4K sectors per track and 4096 Bytes per sector. Disk rotates with 6000 rpm. Seek time is 5ms. Find disk access time?

1 rotation time = 10ms

$$\text{Disk access time} = 5\text{ms} + \frac{10\text{ ms}}{2} + \frac{10\text{ ms}}{4\text{k}}$$

$$= 10.0025\text{ ms}$$

2 mins Summary

Topic Magnetic Disk

Happy Learning

THANK - YOU