Database storage & File structure

* **Data storage media :**

(i) Cache memory: It is fastest seach memory that stores the fraction of main memory.

cache ⊆ main memory.

Due to the size of cache, it is fastest.

(ii) Main memory: CPU directly communicates with the main memory.

There are two types of main memory RAM & ROM.

(iii) flash memory: Flash memory is non volatile storage media. It is constructed with the help of NAND or NOR gates.

NAND flash memory has higher storage capacity than NOR flash memory.

The cost of flash memory is higher than the cost of hard disk.

e.g. Registers, Pendrive, memory cards & Solid state drive (SSD).

(iv) magnetic disk (Hard disk) is magnetic data storage media that is constructed with the help of dual coated magnetic disks.

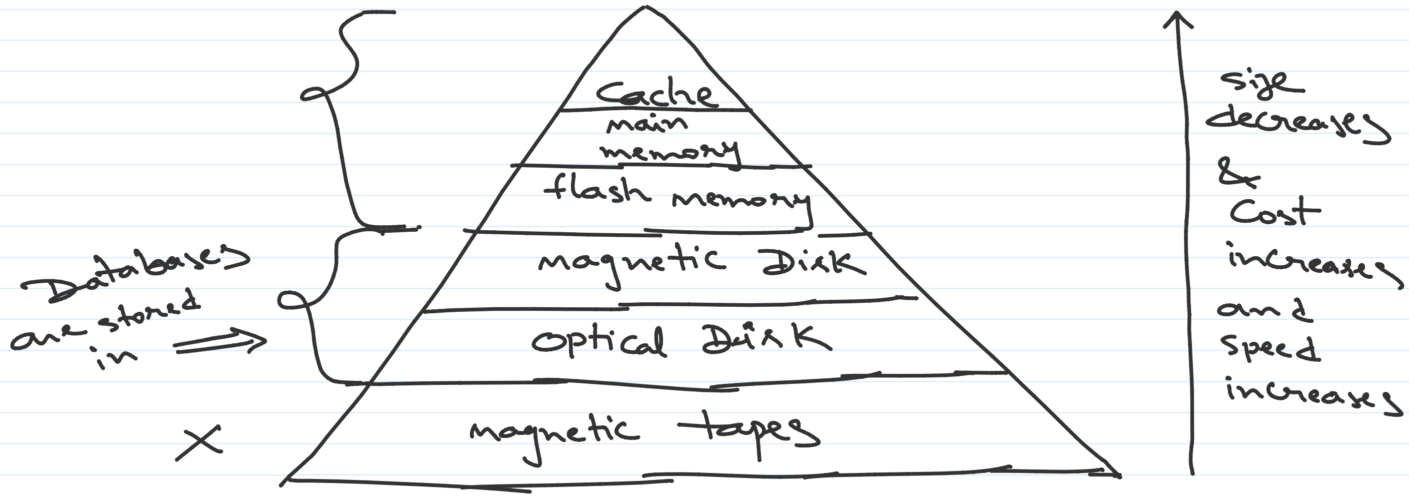
(v) optical storage: It is optical storage media that stores data on optical media

e.g. CD, DVD & Blu-ray disk.

size (CD) < size(DVD) < size(Blu-ray disk)

(vi) magnetic tape: It is a storage media that stores data on magnetic tape.

tape.

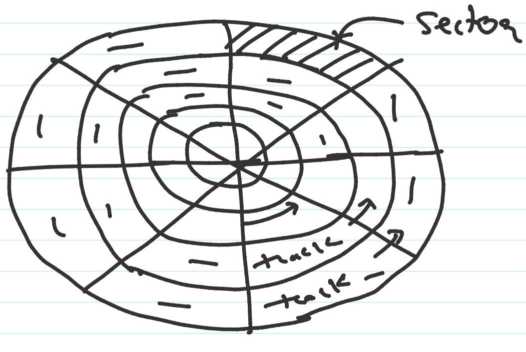
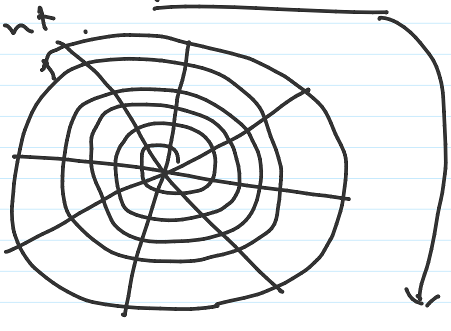


* Disk storage media :

There two types of storage based on the speed of disk. Based on.

(i) constant angular velocity

(ii) constant linear velocity

Constant angular velocity	Constantant linear velocity
(i) logically disk is divided into tracks & sectors.	(i) Logical disk is divided into track & sectors only one spiral track is present.
	
(ii) size of all the tracks are same.	(ii) Size of all the tracks are different. (logically)
(iii) Inner track is dense but outer track is sparse	(iii) Inner track has lower size and outer track has highest size.
(iv) size of inner track is applicable to all the outer tracks $T_1 = T_2 = \cdots = T_n$	$T_1 < T_2 < \cdots < T_n$ Inner most ... outer most

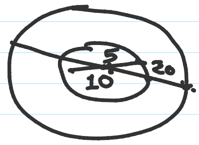
tracks $T_1 = T_2 = \cdots = T_n$ Inner most ... outer most	inner most ... outer most
e.g. magnetic disk	e.g. optical disk

e.g. A disk has 8 tracks. Size of inner most track is 1 MB. All the tracks are equi-distanced with parameter inner most track diameter 10 cm & outer most track diameter 20 c.m..
Find the size of disk, If disk rotates with
(i) Constant angular velocity.
(ii) constant linear velocity.

(i) Constant angular velocity:
All the track will have same size

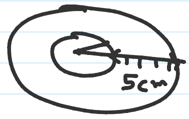
$T_1 = T_2 = \cdots = T_8$

Size of disk = 8 MB



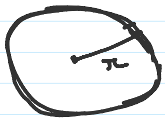
(ii) Constant linear velocity:

$T_1 < T_2 < \cdots < T_8$



Size of inner most track = 1 MB

Size of inner most track = parimeter(T_1) * storage density



storage density = data storage per unit of length

$$2\pi * 5 * D = 1\text{ MB}$$

$$\underset{\text{(storage density)}}{D} = \frac{1}{10\pi}\text{ MB}$$

$$\left\{ \text{Gap} = \frac{\text{outer track radius} - \text{inner track radius}}{\text{No. of tracks} - 1} \right.$$

No. of tracks − 1

Gap $= \dfrac{10-5}{7} = \dfrac{5}{7}$

Size of disk $= 2\pi r_1 D + 2\pi r_2 D + \cdots + 2\pi r_8 D$

$= 2\pi D(\underbrace{r_1 + r_2 + \cdots + r_8}_{A.P.})$

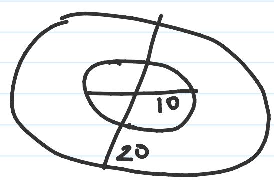
$= \cancel{2}\cancel{\pi} * \dfrac{1MB}{\cancel{10}\cancel{\pi}_{5}} * \left(\dfrac{8}{2}(r_1 + r_8)\right)$

$= \dfrac{1MB}{5} * (4 * (5 + 10))$

$= \dfrac{1MB * 4 * \cancel{15}^{3}}{\cancel{5}} = \underline{\underline{12MB}}$

* A disk has inner track & outer track diameter of 10 & 20 cm. The storage density is 1400 bits/cm. All the tracks are equidistanced tracks with inter track gap of 5 mm. Find the size of disk when disk rotates with (i) constant angular velocity
(ii) constant linear velocity

(i) Constant angular velocity:



Size of innermost track

Size of Inner track $= 2\pi * \text{inner radius} * D$

$= 2\pi * 5 * 1400$

$= \dfrac{22}{\cancel{7}} * \cancel{14000}^{2000} = 44000 \text{ bits}$

$= 5500$ bytes.

No. of tracks $= \dfrac{\text{outer radius} - \text{inner radius}}{\text{gap}} + 1$

$= \dfrac{10-5}{1/2} + 1 = 11$ tracks

Size of the disk = No. of tracks * size of inner track

$= 11 * 5500$ bytes $= \underline{60500}$ bytes

(ii) Constant linear velocity:

$= 11 * 5500$ bytes $=$ 60500 bytes

(ii) Constant linear velocity:

Size of disk $= 2 * \pi * D * (r_1 + r_2 \cdots r_{11})$

$= \cancel{2} * \frac{22}{\cancel{7}} * \overset{200}{\cancel{1400}} * \frac{11}{\cancel{2}} * (5 + 10)$

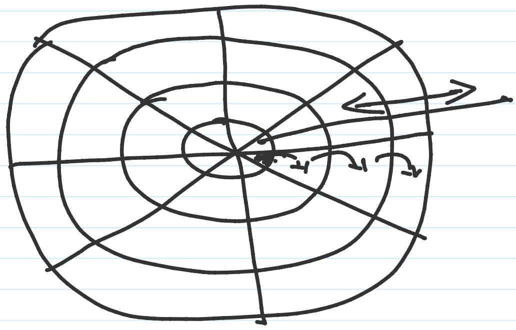
$= 4400 * 165 = 726000$ bits

$=$ 90750 bytes.

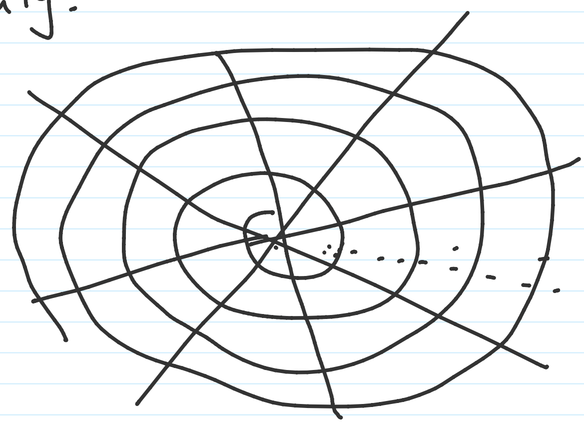
* Avg. Access time :

size of constant linear velocity disk > size of constant angular velocity

* why we have hard disk worked principle of Constant angular velocity?



Constant angular velocity disk



Constant linear velocity disk.

Avg. access time of constant angular velocity disk

Avg. access time = seek time + Rotational latency + Time required to read B bytes.

Seek time : Time required to move disk head on desired track.

Rotational latency : Time required to rotate disk to set disk head on desired sector of desired track.

latency — to set disk head on desired sector of desired track.

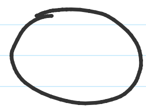
✓ Time required to read B bytes

Transfer rate of disk = Size of inner track * Angular velocity

No. of bits or bytes read by head per unit of time.

Angular velocity = No. of rotations per unit of time ✓

Angular velocity = $\frac{\theta}{T}$



one rotation = 360°

Time required to read B bytes = $\frac{B}{\text{Transfer rate}}$ time unit

* when position of head, track & sector are not given then we always find avg seek time & Avg. rotational latency.

* Consider a disk with inner most & outmost track diameter of 10 c.m. & 20 c.m.. The head of the disk rotates with linear velocity of 10 meters/sec. The angular velocity of disk is 6000 RPM. The storage density of inner most track is 2100 bits/sec.

Find the avg. time required to read

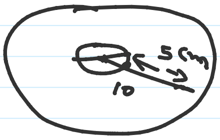
Find the avg. time required to read 200 bytes from the disk.

Avg. access time = avg. seek time + avg. rotational latency + time required to read B bytes

Avg. Seek time = $(0+5)/2 = 2.5$ ms.

Best: Data is present at inner most track and head is also present at inner most track = 0

Worst: Data is present at outer most track and head is present at innermost track = ?

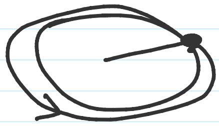


time required to move head by 5c.m. $= \frac{5}{1000}$ sec

$= 5$ ms

Avg. rotational latency $= \frac{\text{best} + \text{worst}}{2}$

$= \frac{0 + 10\text{ms}}{2} = 5$ ms.



Angular velocity = 6000 revolution per minute.

1 minute = 6000 rotations

1 rotation $= \frac{1}{6000}$ minute $= \frac{\cancel{60}}{\cancel{6000}_{100}}$ sec

1 rotation = 10 ms

Trasfer rate of disk = Size of inner track * Angular velocity

$= 2\pi * 5 * 2100 * \frac{\cancel{6000}^{100}}{\cancel{60}}$

$= 22 * 300 * 1000$ bits/sec

$= 6600 * 125$ bytes/sec

$= 165000$ bytes/sec

Time required to read 200 bytes $= \frac{2\cancel{00}}{\ }$ sec

Time required to read 200 bytes $= \frac{2\cancel{0}\cancel{0}}{165\cancel{0}\cancel{0}\cancel{0}}$ sec

$= \frac{1}{825}$ sec

$= 1.21$ ms

Avg. Access time $= 2.5 + 5 + 1.21 = 8.71$ ms.

* A disk has 128 tracks, 256 sectors/track & each sector stores 1024 bytes. The rotates with 3600 rpm. The head is initially positioned at outermost track. The time required to move head b/w adjacent track is 2ms.
Find the time required to read 100 bytes from inner most track.

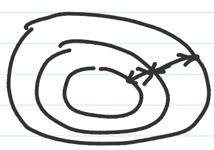
Size of disk = No. of surfaces * No. of tracks per surface * no. of sectors per track * size of a sector.

$= 128 * 256 * 1024$ bytes
$= 2^{15}$ K bytes.

Avg. access time = seek time + rotational latency + Time required to read B bytes.

Seek time = head will move 127 sectors

128



$= 127 * 2$ ms $=$
$= 254$ ms.

Rotational latency $= \frac{\text{~~Best~~} + \text{worst}}{2}$

$= \frac{1 \cdot \cancel{60}^{3\cancel{0}}}{\cancel{2} * 360\cancel{0}}$ sec

$$= \frac{1 \cancel{60}}{\cancel{2 \times 3600}_{120}} \text{ sec}$$

$$= 8.33 \text{ ms.}$$

Transfer rate = Size of track * angular velocity

Size of a track = 256 * 1024 bytes

$$= 256 * 1024 * \frac{\cancel{3600}^{60}}{\cancel{60}} \text{ bytes/sec}$$

$$= 2^{18} * 60 \text{ bytes/sec}$$

Time required to read 100 bytes $= \frac{10\cancel{0}}{2^{18} * 6\cancel{0}}$ sec

$= 6.35$ μsec

$= 0.00635$ ms

Avg. access time = seek + rotational + 100 byte time

$= (254 + 8.33 + 0.00635)$ ms.

$= \underline{262.33635 \text{ ms}}$

RAID

RAID refers to Redundant Array of Independent disk. It connects multiple secondary storage units. It has capability to recover loss of information when there is one or more failure.

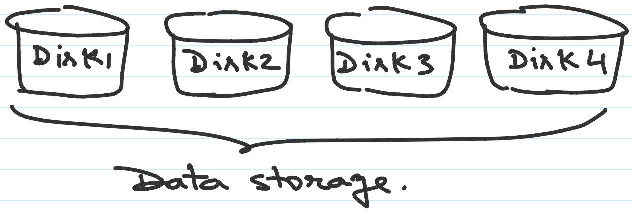
From the OS point of view, RAID is treated as a single logical disk instead of multiple physical disks.

There are 7 RAID models.

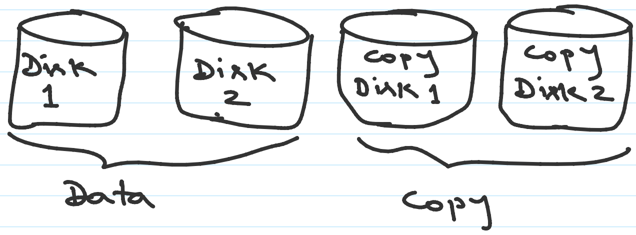
(i) RAID 'O': In RAID 'O' model, data is stripped across multiple disks. No redundant information are stored for data recovery.

It increases system throughput and disk space

It increases system throughput and disk space utilization.

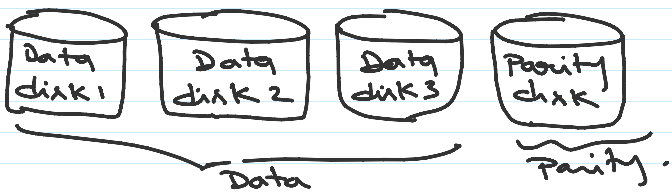


(ii) RAID '1' : In RAID1 model, copy of same disk where data is stored are created. It means mirroring of disk. e.g. let there are disks in RAID then it stores data into first two disks and replicate data into another two disks.



It can recover any loss of information but disk ultilization & throughput is 50% only.

(iii) RAID '2' : RAID 2 consists of bit-level stripping using hamming code parity. Each data bit in a word is recorded on a separate disk while Error correcting code of data words is stored on different disk.



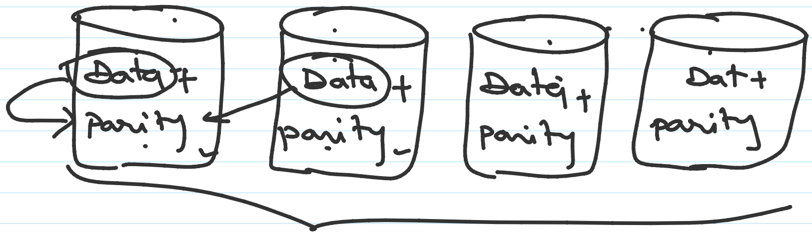
It can recover 1-bit loss of information.
Parallel data access is possible.

(iv) RAID '3' : It is similar to RAID 2 but data stripping is done at byte level.
It consists of byte level stripping with dedicated parity.
parallel data access is also possible.

parallel data access is also possible.

(v) RAID '4': It is similar to RAID 2 & RAID 3 but data stripping is done at block level. It consists of block level stripping with dedicated parity.
Throught of RAID '4' is more than the RAID '2' & '3'. parallel data access is also possible.

(vii) RAID '5': Data stripping is done at block level. It differs with RAID '4' in storing the parity information at every disk instead of a separate parity disk.



Throughput & performance both increases.
Disk failure recovery takes longer time because parity has to be calculated from all remaining disks.
It can not survive in multiple disk failures

RAID '6': It is an extended form of RAID 5.
It contains block level stripping with 2 parity bits.
It can handle 2 concurrent disk failures

File organization

A database is mapped into a number of different files that are maintained by O.S.
These files are stored on non-volatile disk storage model (RAID).
Each file is logically partitioned into fixed length

storage model (RAID).

Each file is logically partitioned into fixed length storage units called blocks. Blocks are common unit of data transfer and data storage both. The default size of a block is 4KB - 8KB.

Records that are stored in files can be fixed length or variable length records.