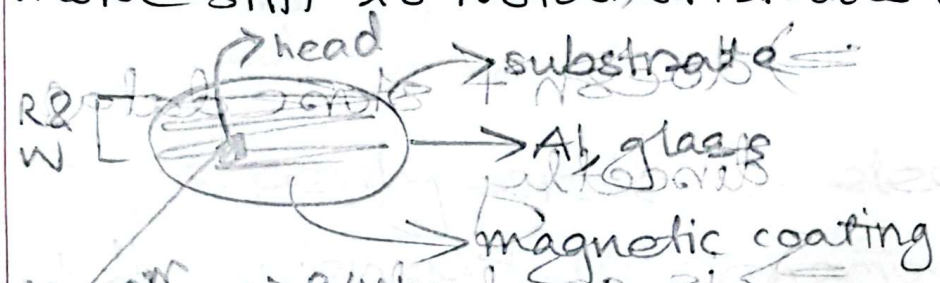
19-10-2024
SATURDAY

COA 4305
Hamjajul Ashmatee sir

Chapter-6

* Magnetic disks are created of Al and glass (more suitable). Its perimeters are called substrate which can't be read or written upon. Often multiple plates are used to make a disk and both the surfaces can be magnetized. Glass is more stiff to rotation & aids magnetic coating.



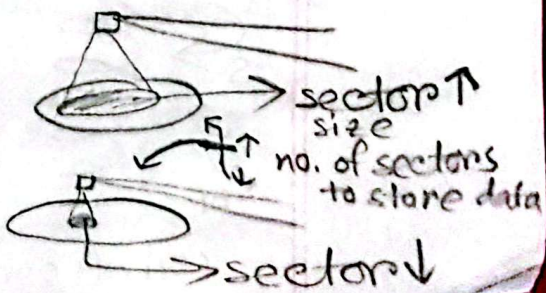
arm → R/W same
→ can have different arms for R & W

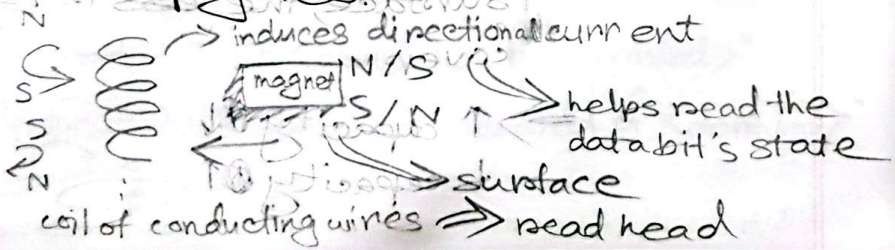
* Due to dynamic inertia, arm may not be aligned with the aimed cell if the substrate isn't stiff enough.

* Fly Height ⇒ the closer the head to the surface, the less range it'll cover

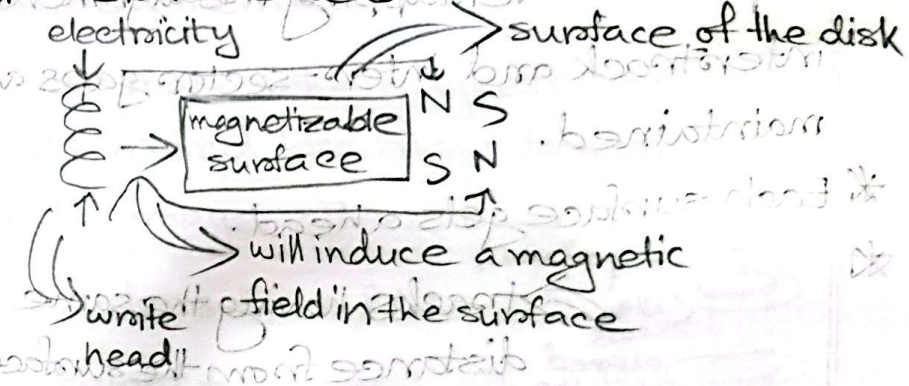
⇒ ↑ capacity ↓

↓ capacity ↑



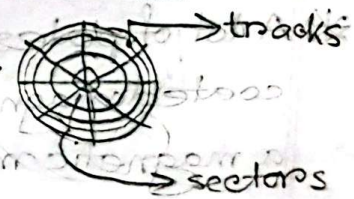
* A R/W operation can be run on a sector which is a packet of data.
* Substrate's ~~suf~~ surfaces are magnetized. They can be made of different materials.
* Substrate ⇒ primary material of the disk
  ⇒ doesn't store data directly
  ⇒ is coated magnetically to be used as memory devices
* Head can be separated into R & W or can be merged. They operate on a single bit at a time. They function based on 2 laws of physics:
* 

So, based on the direction of the current, the bit's state is read.

* 

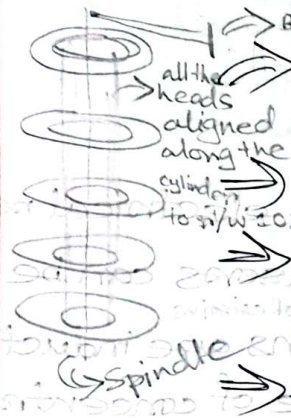
To properly sense the electrical resistance of the signals, MR sensors can be used.
↳ MagnetoResistive

* Magnetic R/W operations are inductive.
* Magnetic disks are made of concentric circles/rings. That's how data is organized on a surface. These circles are called Tracks. Each track is divided into Sectors.



* The closer to the center, the smaller in size the tracks & the sectors get. Each track has the

same no. of sectors.

* To prevent overlapping misalignments, interstrack and inter-sector gaps are maintained.
* Each surface gets a head.
* 

  ⇒ tracks having the same distance from the surface

  ⇒ 5 disks X 2 surfaces = 10 tracks

  ⇒ can work as a cylindrical stack to store a 10-bit data.

  ⇒ this method allows the R/W operations to be carried out simultaneously on multiple platters

* A lot of plates with both the surfaces ~~ma~~ coated magnetically, are adjusted into a magnetic memory disk.

5-11-2024
TUESDAY

COA04305
~~[illegible]~~
Hamjajul Ashmafee sir

* Magnetic disks are a common example of external memory.
* Glass makes the magnetic coating more uniform and less prone to momentum, shock and damage, allows lower fly height.
* Head does the R & W.
* fly height ↓ ⇒ cell size ↓ (unit area for being R&W operable)
* Heads are made up of coils of wires which utilize electromagnetic field.
* MR sensor increases (or decreases) the resistance in the read head for proper reading. Sheild prevents side-reading.
* Head size = Track width
* To prevent magnetic influence of adjacent cells, a gap is maintained.
* For each head, one coil is set up.

* Magnetic disks are separated into tracks & sectors to locate a cell.
  (tracks: concentric rings across the surface)

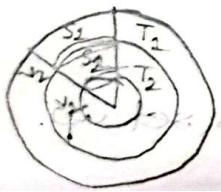
* The closer to the centre, the less circumference will be for a track.

* Gaps between track (Intertrack Gaps) & sectors (Intersector Gaps) are installed to prevent misalignment.

* The size of a sector decreases as the tracks trickle towards the center.

* Cylinder shape ~~operations for~~ allows R-W operations over several surfaces simultaneously.

* The arm is connected to the Boom while the disk spins ~~around~~ around the spindle.

* 

  At time t, $v_1 = \frac{d_1}{t}$ and $v_2 = \frac{d_2}{t}$ (d_1, d_2 → distance from centre to S_1, S_2)

  $v_2 > v_1 \Rightarrow T_1$ must be passed faster

Angular velocity $= \omega$

$\omega_1 = \frac{\theta_1}{t}$, $\omega_2 = \theta_2/t \Rightarrow \omega_1 = \omega_2$

For the constant angular velocity approach, which is easier to implement but spacially wasteful, all sectors in all tracks will have the same amount of data (limited by the size of the sector in the 1st track), so the head can operate on same size of data on all tracks of a sector.

* Zone division method maintains bit density (bits/sector length). It's more complicated to implement but ensures spacial efficiency. However, the head must be smart enough to calculate the zone & operate accordingly. Each zone's bit density is fixed.

* If a sector is permanently damaged, it's a Bad sector. A non-smart OS will throw

an error in this case. A smart one, however, will allocate some of the OS (driver's) reserved memory to run the operation on the redirected location.

* A sector's identity is held at ID Field. Head no. is necessary if there are multiple heads for each surfaces.
* Sync bytes can be 0000 or 1111 signify the start of a R or W operation.
* no. of sectors × bytes/sectors = track size
* Average time to access a track isn't much helpful as the time requirement is much different for track on opposite ends of the disk.
* Fixed head ⇒ no. of heads = no. of tracks
  Movable head ⇒ 1 head for a surface
* Floppy disk is dynamic, HDD is fixed.

* Head mechanisms:
  1. Fixed gap head (physical ~~gap~~ disconnection)
  2. Contact head
* Head gets to the lowest fly height (≈ 0) when a R-W operation is ongoing, but during rotation, an air pressure uplifts the head to shield it from damage due to aerodynamic friction.
* Access Time ⇒ time needed for a R/W operation

Seek Time ⇒ time needed to spot the desired ~~track~~ location (track ~~sector~~) ⇒ T_s

Rotational Delay ⇒ time needed to get the desired sector of the chosen track

Wait for Device ⇒ T_w EM may be serving a prior request

Wait for Channel ⇒ System bus may be busy

serving a prior request

$$T = T_s + T_r + T_t$$

$$= T_s + \frac{1}{2r} + T_t$$

r → rotational speed

r → rotation can occur in both directions

$$= T_s + \frac{1}{2r} + \frac{1}{r} \cdot \frac{b}{N}$$

b → portion of the track to be transferred

b → no. of bytes to be transferred

N → no. of bytes in a track

$\frac{1}{r}$ → unit rotational speed

$\frac{1}{r}$ is the speed needed to transfer one byte from that track

r is calculated for the entire track.

10-11-2024
SUNDAY

COA 4305
Md. Hamjajul Ashmafee sir

* RAID: This mechanism is applied on magnetic disks.

⇒ Redundant Arrays of Independent/ Inexpensive Disks (theoretical; practical)

⇒ counter-mechanism of SLED

Single Large Expensive Disk

* RAID distributes data into small portions while SLED stores them all at a one, large list. Each disk can only process one operation at a time (RAID allows parallelism as multiple portions can process distinct commands).

* Redundancy is used for crucial/critical/vulnerable data, so that if one copy is damaged or pre-occupied, the machine can access another copy instead of freezing. OS manages which data to be made redundant copies. Although the data are physically redundant and distributed, the machine interprets it as a single logical storage. AMS (Array Management Software) takes care of this mapping.

* Logical data should be stored sequentially. Physically, they can be mapped to a strip/stripe (unit block of physical data) of a physical disk.

a set of strip distributed evenly & equally (in terms of position) among physical disk ⇐ similar to the cylinder concept

distribution of physical data

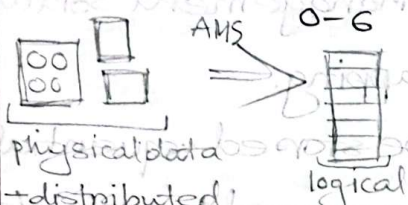
* Mirroring & Stripping are mechanisms used to perform RAID operations.

strips: A B C D

copied to multiple place: ~~A B C D~~ ⇒ mirroring (similar to redundancy)

A A
B B
C C
D D

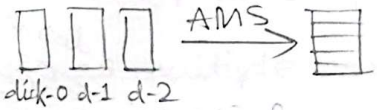
* Redundancy allows speedy recovery.
* AMS handles striping
* RAIDs have 7 levels (not hierarchial): 0–6



- SW doesn't recognize distribution
- sequential.

* Mirroring happens on strip-level, not disk-level.
* RAID-0 has no to absolutely rudimentary features of RAID. Here, it's not standard, rather partially RAID-compatible.

- no redundancy

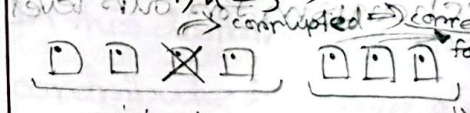


- data is physically distributed and logically sequential
- disks can independently serve I/O requests (benefit of distribution). This parallelism enhances the speed-up.
- data channel must be wide enough to carry multiple requests simultaneously (bandwidth should be sufficiently increased)
- non-redundant, but distributed (# of pd = # of ld)
* RAID-1 introduces redundancy via mirroring
- no. of physical disks = 2x no. of logical disks
- strip-level accessible
* RAID-2 reduces the space requirement (by reducing the redundancy)
- Hamming Code or other ECCs can be used on the original data

* Blocks are larger than stripes.

- data regeneration is still possible through ECC
- $m+k \leq 2^k+1$

let $m=4, k=3$ → not fixed, rather dynamic (based on m)



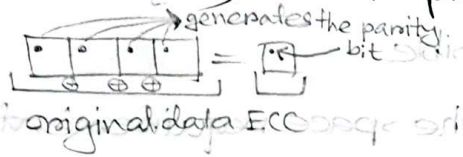
corrupted ⇒ corresponding ECC will help for the 's in the original disks

⇒ help figure out the disk (HC should be produced bit-wise)

After the disk has been identified, the bit is toggled. This method can handle 2 damaged disks at a moment (for the scope of our knowledge).

* RAID-3 involves complex mathematical calculation & mechanisms.

- redundancy further reduced.
- single disk (fixed) to recover data if any of 4 disks (fixed) is corrupted.



- somehow, it must be known which disk is corrupted (then parity bit will help in the recovery), otherwise we must revert to RAID-2.
- parity bit signals if a suspicious disk's data is intact or not (assumed to enough effective of a mechanism for our level of study).

* Multiple approach and algorithms can be combined as ECC & ~~ECD~~ EDC.

* Write Penalty is an issue in RAID-2 & -3. ~~Determining the strip~~ All the disks must be updated for which the strip is involved (redundant disks & code disks)

WP = # of disks affected for a single write operation (on a strip) (includes the # of disks to be read & written upon for the operation to run smoothly)

WP $\xrightarrow{\text{RAID-1}}$ 2

$\xrightarrow{\text{RAID-2}}$ 7 (for one strip to be updated, all the codes must be modified)

$\xrightarrow{\text{RAID-3}}$ 2 $\quad \boxed{x_1} \oplus \boxed{x_2} \oplus \boxed{x_3} \oplus \boxed{x_4} = \boxed{p}$

$\Rightarrow x_1' \oplus x_2 \oplus x_3 \oplus x_4 = p'$

$\Rightarrow \underbrace{x_1 \oplus x_1}_{0} \oplus x_1' \oplus x_2 \oplus x_3 \oplus x_4 = p'$

$\Rightarrow x_1 \oplus x_1' \oplus \underbrace{x_1 \oplus x_2 \oplus x_3 \oplus x_4}_{p} = p'$

$\Rightarrow \underbrace{x_1 \oplus x_1' \oplus p}_{\text{2 disks}} = p'$

* Upto now, RAIDs worked on small-sized strips. In this distributed arrangement, all disks contribute to serve a single I/O request. This increases the bandwidth, but can be wasteful in terms of energy. Hence, later RAIDs introduce larger strips (blocks) so that multiple requests can

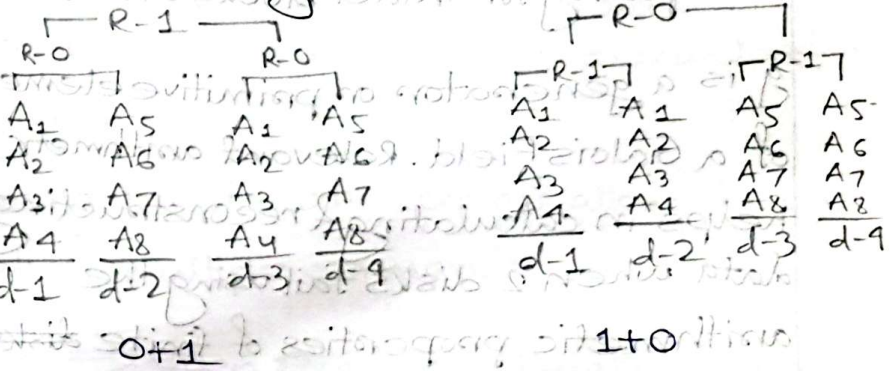
be served simultaneously.

* RAID-4 operates on blocks instead of strips.
  - all disks can serve different requests & channels.
  - all data disks are linked to the same parity disk. This bottleneck disallows multiple write operations at a moment.
  - parity disk's access is allowed to one disk at a moment.
* RAID-5 distributes the parity blocks among different data disks.
  - multiple fetching is (often) possible.
  - no separate parity disks.
  - which disk has the corresponding parity block, it must be calculated.
* RAID-6 introduced dual redundancy.
  - 2 corrupted disks can be detected.
  - 2 different parity generation codes are stored for each block.

* RAID levels can be nested.

example: 0+1 ⟹ distribution, then mirroring

1+0 ⟹ mirroring then distribution



0+1 (Mirror of stripes) 1+0 (Strip of mirrors)

* RAID-6 utilizes multiple ECC codes at once to ensure integrity.

example- $P = \bigoplus_i D_i = D_0 \oplus D_1 \oplus D_2 \oplus \dots \oplus D_{n-1}$

$Q = \bigoplus_i g^i D_i = g^0 D_0 \oplus g^1 D_1 \oplus \dots \oplus g^{n-1} D_{n-1}$

If disks D_i & D_j are affected ⟹

$A = P \oplus \left(\bigoplus_{l: l \neq i, l \neq j} D_l \right) = D_i \oplus D_j$

$B = Q \oplus \left(\bigoplus_{l: l \neq i, l \neq j} g^l D_l \right) = g^i D_i \oplus g^j D_j$

$D_j = (g^{m-i+j} \oplus 1)^{-1} (g^{m-i} B \oplus A)$

$D_i = A \oplus D_j$

m: no. of disks/blocks

A: P parity for intact blocks/disks

B: Q parity for intact blocks/disks.

g is a generator or primitive element of a Galois Field. Relevant arithmetic helps in calculating & reconstructing data when 2 disks fail using the arithmetic properties of finite ~~disks~~ fields. RAID-6 applies these for redundancy and recovery.

CamScanner

13-11-2024
WEDNESDAY

COA 4305
Md. Hamjajul Ashmafee sir

* SSDs are made of Flash NANDs.
  - → internal: (fixed) PCIe
  - → external: (portable) USB
    - → can be shared

SSD compared to HDD:

I/O rate: ↑

Cost: ↑

Size: ↓

Robustness: ↑ ⇒ mecha. error %

Power: ↑

Heat: ↓

* SSD is an external memory and the CPU can't access it directly. Windows will let

CPU → File Explorer → I/O driver / I/O module (Hardware) → SSD (I/O device)

File System SW

* SSD and the host system (OS) are connected through interfaces.

* SSD's controllers manage the interface,

handle its underlying mechanisms and perform BIOS operation.

* The hardwired BIOS commands in SSD are known as Firmware.
* SSD combines multiple components to distribute the data.
* ECC is managed by the controller.
* SSD's data buffer/cache tries to address the speed mismatch between CPU and SSD as it acts as the medium of data transmission.
* Write operation (block-level) can't be performed directly on the components. Rather data from the desired location is copied to the cache (optional), it'll be replaced by the updated data, the previous data on the memory will be completely erased and then the update data will be inserted.

* SSD's problems:

1. Slower than CPU (specially write operation)
2. If no component has enough space left to store a data, a single data may be partioned to multiple components (read cost ↑)

   Overprovisioning: When a data comes in, enough space is allocated so that future W operations can be performed there.

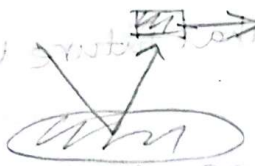
   Streaming: When the CPU is idle, the driver defragments the mem. so that data is pushed from one side & vacant space is formed on the other side.
3. Write count is fixed, crossing it will damage the mem's tolerance, tamper & ICs. Can be 100000+. This count should be balanced and distributed to all components.

* Flash memory is of the same tech. as SSD.

* CD ⇒ Compact Disk
  - ⇒ works based on optical properties
  - ⇒ lights and rays are used (can be in form of laser)

* Although all operations have a count due to physical limitations, WC is the main bottleneck of SSD.

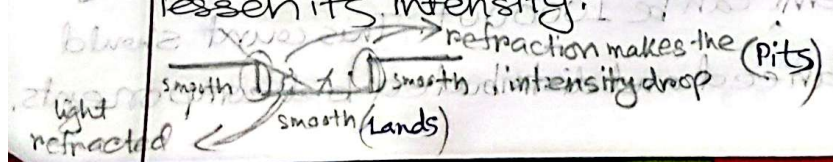
* Laser reads the CD.



CD's surface is scratched and roughened to differentiate 1 to 0 (smoother surface).

* DVD, advanced form of CD, uses UV Ray to make scratches.

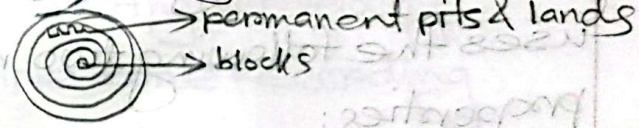
* CD's surface is made rugged to lessen its intensity.



* Reflection high ⇒ 0
  less ⇒ 1

* CD's photoreflective surface is coated with Al or Au to make it shiny.

* HDD is a magnetic disk. Similarly, CD is also a disk made up of 1 single spiral track (centre → periphery).



The track is divided into blocks (similar to sectors).

* CD can be read-only, non-volatile.

* CD-R ⇒ CD-Recordable
  - ⇒ can be written once (permanent write)
  - ⇒ empty CD that can be burned
  - ⇒ WORM = Write Once Read Many

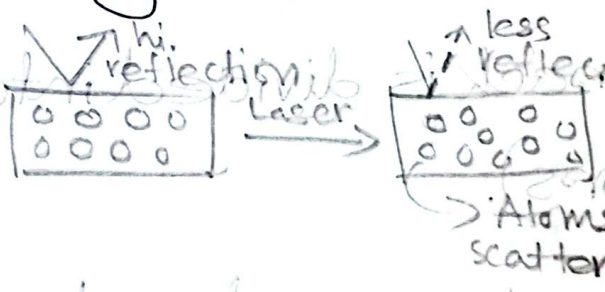
* CD-RW ⇒ CD-ReWritable
  - ⇒ data can be erased

⇒ same physical tech.

⇒ non-permanent W op.

* Special laser generates heat to imprint lands & pits on CD's surface. But CD-RW changes the property of the surface's layer (Dye Layer). It uses the following two molecular properties:

1. Crystalline



2. Amorphous

* CD's SYNC bytes signify the start of a block.

* CD can store data in 3 modes:

0 → remaining space is vacant

1 → remaining space stores ECC

2 → " " holds regular data (enlarging the data capacity)

* CD used to have max. 720 MB size and was gen. used to store audio files, MIN & SEC signify their lengths.

* CD's biggest advantage is portability and mass-production, ~~& its a~~ but its access time is increased as it uses the sequential method

* CAV => Constant Angular Velocity
MZR => Multiple Zone Recording
HDD maintains these.

* CD follows CLV (Constant Linear Velocity).

CamScanner