

* Memory :-

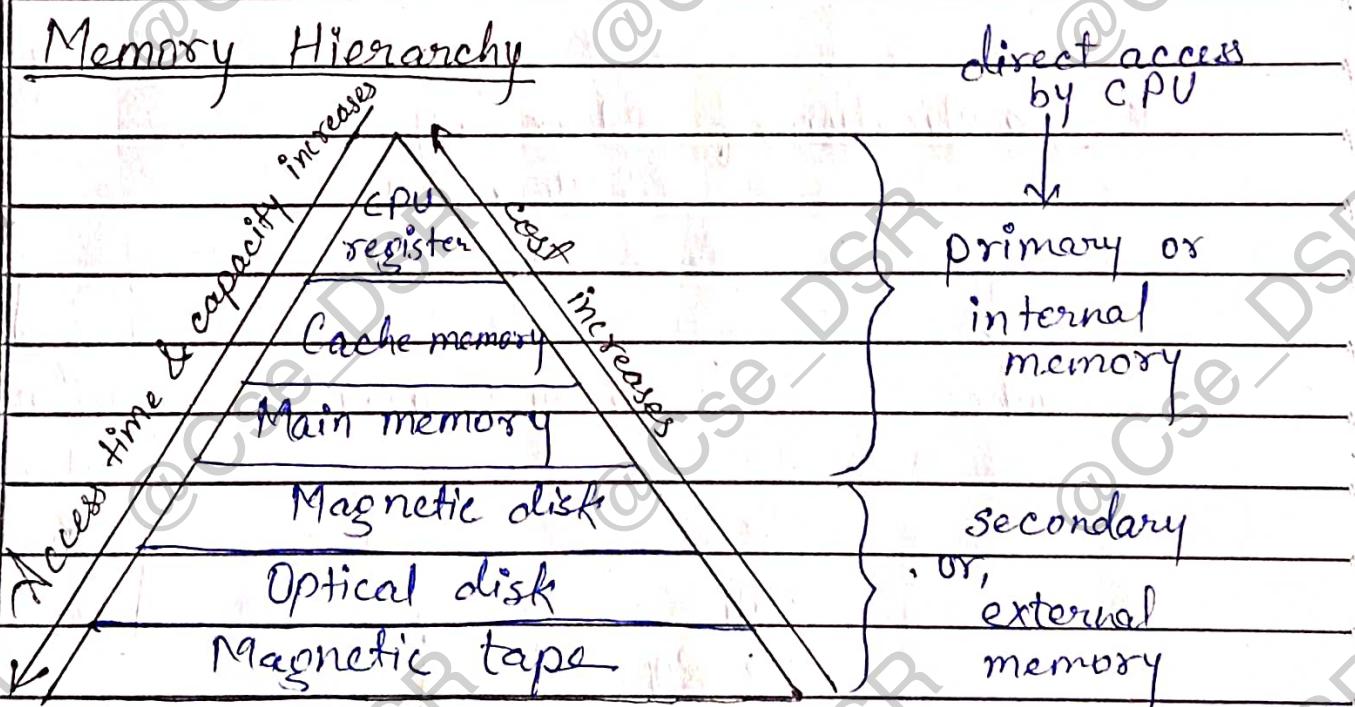
- Memory is storage space in the computer where data and instⁿs are stored. Memory stores the data to be processed & instⁿs required for processing.
- Memory stores both i/p and o/p data.
- Computer memory is any physical device which is used to store data, infoⁿ, instⁿ temporarily or permanently.
- It is a collection of storage units that stores binary infoⁿ in the form of bits.
- The memory block is split into a small number of components called cells. Each cell has unique address to store data in memory.
- We need computer memory to store various types of data like text, images, video, audio, documents etc.

* Key characteristics of memory:-

- i) Capacity:- It is the volume of info^m (in bits) the memory can store.
- ii) Access of time:- It is time interval b/w the read write request & the availability of

- iii) Unit of transfer:— It is the max^m number of bits that can be read or written into the memory.
- iv) Access method:— It is fundamental characteristics of memory. It is the sequence or order in which memory can be access. It can be serial access or sequential access & random direct access.
- v) Throughput:— It is volume of info^m exchanged per unit of time.
- vi) Non-volatile:— It is the ability of memory to store data when it is not being supplied with electricity.

* Memory Hierarchy

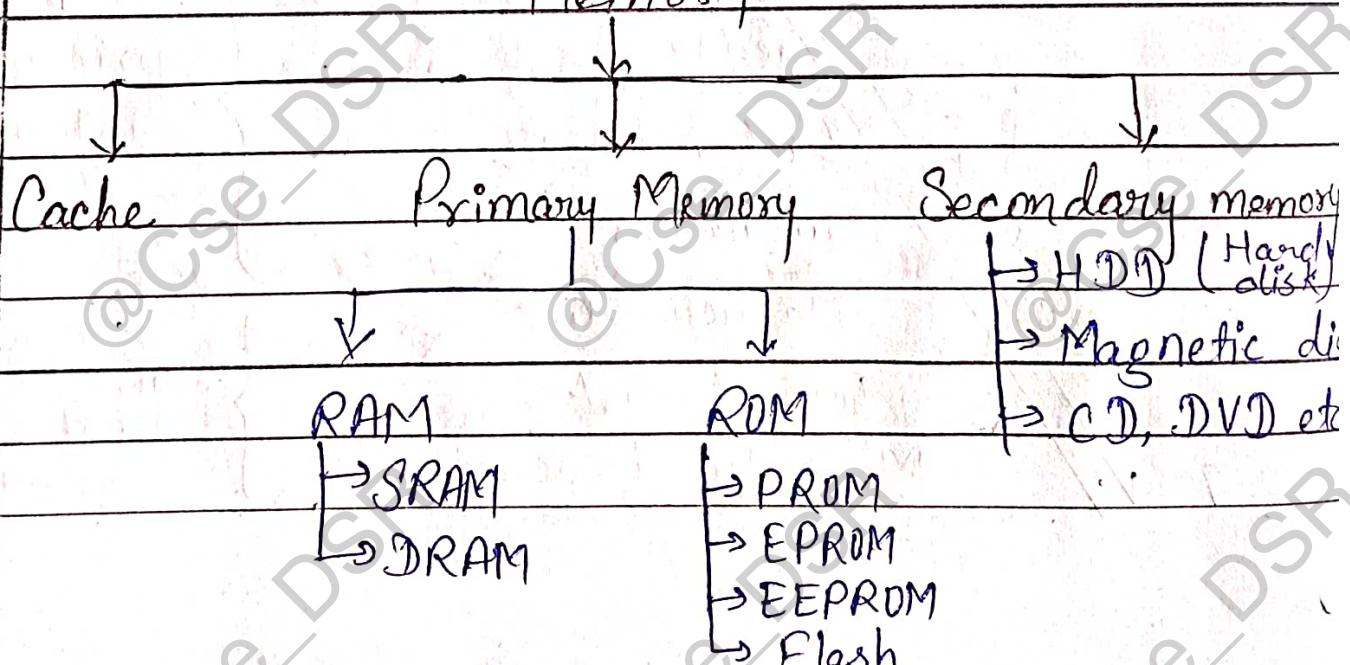


In computer system, memory hierarchy is an enhancement to organise the memory such that it can minimize the access time.

* Characteristics of Memory Hierarchy:-

- a) Capacity:- As we move from top to bottom in hierarchy, the capacity increases.
- b) Access time:- It is the time interval to access the data or read/write time of data. As we move from top to bottom, it increases.
- c) Cost! - As we move from bottom to top, it increases.

* Classification of Memory



* Primary Memory:-

- ↳ Primary memory is also known as main memory.
- ↳ That communicates directly with the CPU and cache memory.
- ↳ Main memory is used to keep programs or data when the processor is active to use them.
- ↳ When program or data is activated to execute the processor first loads inst' from secondary memory to main memory and then execution is performed.
- ↳ It is volatile memory which means the data in memory can be lost when power failure occurs.
- ↳ It is costlier than secondary memory and main memory capacity is limited as compared to secondary memory.
- ↳ The primary memory is further divided into two types :-
- i) RAM ii) ROM

i) RAM :-

RAM is one of the faster types of main memory accessed directly by the CPU. It is the h/w in the computer device.

- to temporarily store data, programs.
- It is volatile.

* Advantages! —

- It is faster type of memory.
- It requires less power to operate.
- Program loads much faster.
- More RAM increases the performance of a system & can multi-task.
- Perform read & write operations.
- The processor can read info^m faster than a hard disk etc.

* Disadvantages! —

- Less RAM reduces the speed & performance of computer.
- Due to volatile, it requires electricity to preserve the data.
- It is expensive.
- It is unreliable.
- Its size is limited.

There are two types of RAM: —

- i) SRAM (Static Random Access Memory)
- ii) DRAM (Dynamic Random Access Memory)

a) SRAM :- SRAM is a type of RAM used to store static data in memory. It means stored data is SRAM remains active as long as the system has power supply.

* Characteristics :-

- It is faster than DRAM.
- It is expensive.
- Less power consumption.
- Longer life
- Larger size
- It does not require to refresh.

b) DRAM :- DRAM is a type of RAM that is used for dynamic storage of data in RAM.

- Here, the cell is made up of two parts : a capacitor & a transistor.
- It is volatile also.

* Characteristics ! -

- It requires continuously refreshed to retain the data.
- It is slower than SRAM.
- It holds large amount of data.
- It is less expensive compared to SRAM.
- More power consumption.



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SRAM

DRAM

- i) It is a static random access memory.
- ii) It is faster.
- iii) It uses flip-flops to store each bits.
- iv) It does not require periodic refresh.
- v) It is used in cache.
- vi) It is expensive.
- vii) It has complex structure.
- viii) It requires low power consumption.
- i) It is a dynamic random access memory.
- ii) It is slower.
- iii) It uses capacitors to store each bits.
- iv) It requires periodically refreshment.
- v) It is used in main memory.
- vi) It is less expensive.
- vii) It has simple structure.
- viii) It requires more power consumption.

* ROM (Read Only Memory):-

ROM is a memory device used to store permanently information inside the chip. It is a read only memory that we can only read the stored info^m, data, or programs, but we can not write or modify anything.

→ A ROM contains some important instructions or program that are required to start or boot a computer.

→ It is non-volatile memory, that means data cannot be lost when power is turned off.

* Types of ROM :-

i) MROM (Masked ROM) :-

If it is the oldest type of ROM whose program or data is pre-configured by the manufacturer. So, the data & info^m stored cannot be changed by the user. It is non-volatile.

ii) PROM (Programmable ROM) :-

In this, the user can write any types of info^m or program only once.

→ It is non-volatile.

Initially, it is empty PROM chip in which user can write desired content only once using the special PROM programmer or PROM burner device, after that the data cannot be changed or erased.

iii) EEPROM (Erasable & Programmable ROM) :-

In this, the stored data can be erased & reprogrammed only once.

→ It is non-volatile & can hold data minimum of 10 to 20 years.

To erase the data, we need to pass ultraviolet light for 40 minutes; after that, data can be re-written.



iv)

EEPROM (Electrically EPROM) :-

The EEPROM is an electrically erasable & programmable ROM uses high voltage electrical charge to erase the stored data.

↳

It is non-volatile & the stored data can be erased & reprogrammed upto 10 thousand times.

v)

Flash ROM:-

Flash ROM is an EEPROM form of computer memory which is also non-volatile.

↳

It can be written or programmed in small units called block or sector.

*

Advantages of ROM:-

- It is non-volatile memory in which stored info cannot be lost even power is turned off.
- It is static, so it does not require refreshing the content.
- Data is permanently stored.
- It is cheaper than RAM.
- It is simple & reliable as compared to RAM.
- It helps to start the computer & loads the O.S. (Operating System).

* Disadvantages of ROM :-

- It is read only memory, so stored data cannot be modified, or very difficult to modify.
- It is slower than RAM to access store data.

RAM

ROM

- | | |
|-------------------------------------|---|
| i) It is Random Access | i) It is Read Only Memory. |
| ii) Read & write operations | ii) Only read op ⁿ can be performed. |
| iii) It is volatile. | iii) It is non-volatile. |
| iv) It is temporary storage device. | iv) It is permanent storage device. |
| v) It is faster than ROM. | v) It is slower than RAM. |
| vi) It is expensive. | vi) It is less expensive. |
| vii) Chip size is bigger. | vii) Chip size is smaller. |
| viii) It is not reliable. | viii) It is reliable. |

* Secondary Memory :-

- It is a permanent storage space to hold a large amount of data. It is also known as external memory that representing the various storage media (H.D.D, C.D, D.V.D etc.).

- Here, data can be saved on a long term basis.
- It is cheaper & slower than main memory.
- It can not accessed directly by the CPU.
- The data of secondary memory first loaded into the RAM & then processor use it.

* Features :-

- i) It is non-volatile . Stored data can not be lost if power failure occur.
- ii) It can store large collection of data of different types, such as audio, video, images, text, s/w etc.

* Types of Secondary Memory :-

j) Hard disk :-

A hard disk is a computer's permanent storage device . It is non-volatile disk that permanently stores data, programs and files, and cannot lose stored data when power is switched off.

- It is located internally on the motherboard that stores & retrieves data using one or more rigid, fast, rotating disk platters inside the casing.

→ It is large storage device which is found on every computer or laptop.

ii) Floppy disk :-

A floppy disk is a secondary storage system that consisting of thin, flexible magnetic coating disks for storing computer files.

→ It is also known as Floppy Diskette that comes in 3 sizes like 8 inches, 5.5 & 3.5 inches.

→ The stored data of floppy disk can be accessed through the floppy disk drive.

→ It is the oldest type of storage device, which can store data upto 1.44 MB. It is not used due to low memory storage.

iii) C.D (Compact Disk) :-

It is an optical disk storage device, used to store various data types like audio, video, files, O.S, backup files etc. The C.D has a width of 1.2 mm & 12 cm in height.

→ It can store approximately 783 MB of data files size. It uses laser light to read & write data.

* Types of C.Ds :

- i) CD-ROM :- In this user can only read the data, text, audio, video, etc. It cannot be modify or burn.
- ii) CD-R (CD Recordable) :- This type of CD is used to write once by the user after that it cannot be modified or erased.
- iii) CD-RW (CD Rewritable) :- It is re-writable CD after used to write or delete stored data.
- iv) DVD (Digital Video display or digital versatile disc) :-
 - It is an optical disc storage device, same size as CD but stores larger amount of data than C.D.
 - The storing capacity of data is 4.7GB to 17G.
 - Types :- DVD ROM, DVD-R, DVD-RW.
 - It was developed in 1995 by Sony, Panasonic, Toshiba & Philips four electronics company.



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- v) Pen drive :- Pen drive is a portable device used to store data permanently. It is also known as USB flash device. It is used to store & transfer data connected to computer using USB port. It uses integrated circuit chip. The storing capacity of pendrive is from 64 MB to 128 GB or more.

(3) Cache Memory :-

It is a small sized chip based computer memory that lies b/w the CPU and main memory. It is a faster high performance and temporary memory to enhance the performance of CPU.

- It stores all the data & instructions used by CPU. It reduces access time. It is faster than main memory and sometimes, it is also called CPU memory because it is very close to the CPU chip.

There are following levels of cache :-

- i) L1 cache :- It is also known as onboard, internal, and primary cache. It is built with the help of CPU. Its speed is very high and size varies from 8 KB to 128 KB.

- ii) L2 cache: → It is also known as external or secondary cache. It is built into a separate chip in motherboard, not built into CPU like L1 level.
- The size varies from 188KB to 1MB.

- iii) L3 cache: → It is also external cache built into motherboard separately. It is slower than other levels. The maximum size of this is upto 8MB.

* Advantages :-

- i) It is faster memory than main memory.
- ii) It stores all data & instⁿ that are repeatedly used by CPU for improving performance of computer.
- iii) The access time is less than main memory.

* Disadvantage:-

- i) It is very costly as compared to main memory & secondary memory.
- ii) It has very limited storage capacity.

* Cache Memory Mapping:-

Cache mapping is a technique by which the content of main memory are brought into cache memory.

→ It tells that which content of main memory will be placed at which location of cache memory.

Types of Mapping

- i) Direct Mapping
- ii) Associative Mapping
- iii) Set associative mapping.

i) Direct Mapping:— It is the simplest technique of cache mapping.

→ In this, assign each memory block to a specific line in the cache. If a line is previously taken up by memory block, when a new block needs to be loaded, the old block is trashed.

ii) Associative Mapping:— In this, any block can go into any line of the cache.

→ It is considered to be faster & most flexible mapping form.

iii) Set associative:— This form of mapping is an enhancement form of direct & associative mapping.

→ In this, we will group a few lines together creating a set. Then a block can map to any of the line of specific set.

* Virtual Memory →

Virtual Memory is a storage scheme that provides user an illusion of having a very big main memory. This is done by treating a part of secondary memory as the main memory.

→ In this, user can load the bigger size processes than the available main memory by having the illusion that the memory is available to load the processes.

By doing this, the degree of multiprogramming will be increased and therefore CPU utilization will also be increased.

* Advantages :—

- i) The degree of multiprogramming will be increased.
- ii) User can run large application with less RAM.
- iii) There is no need to buy more memory RAM.

* Disadvantages :—

- i) The system becomes slower.



* Page Replacement:-

Page replacement is an algorithm which helps to determine which page should be removed from main memory to load a new page.

→ There are four types of page replacement algorithm.

- i) FIFO ii) LRU iii) Optimal iv) Random

i) FIFO :— In this, we replace the oldest page that has been present in the main memory for the longest time.

ii) LRU :— It stands for Least Recently Used. It replaces the page that has not been referred by the CPU for the longest time.

iii) OPTimal :— It replaces the page that will not be referred by the CPU in future for the longest time.

→ It is practically impossible to implement this algorithm.

iv) Random :— As the name suggests, this algorithm randomly replaces any page from the main memory.

* RAID:— (Redundant Array of Independent Inexpensive disk.)

- It is a technique which makes use of a combination of multiple disk instead of using a single disk to increase performance, data redundancy or both.
- It was made by Randy Katz in the university of California berkeley, in 1987.
- RAID combined several independent & relatively small disk into single storage of a larger size.

* Characteristic of RAID

- Reliability:— RAID makes a reliable environment because it is fault tolerance. Fault tolerance is ability to survive one or more disk failure.
- Availability:— RAID makes data available in the system for the execution.
- Performance:— It shows the change into read & write speed of the entire array compare to single disk.



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Capacity:— The capacity is determined by the amount of user data written in RAID. The capacity depends on the levels.

* LEVELS O.F. RAID

RAID 0

RAID 1

RAID 2

RAID 3

RAID 5

RAID 6

Nested

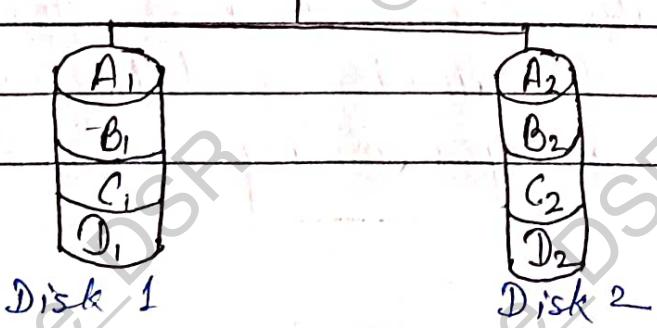
- RAID 01 ($n+1$)
- RAID 03
- RAID 05 etc.

① RAID 0 (Stripped disk):—

In this, we break the data in small modules and store more than one different disk. It will increase the performance of system because ^{we can} access those modules parallelly read and write.

RAID 0

$$A = A_1 + A_2$$



→ It gives the higher throughput.

→ In this the loss of any individual disk will cause complete data loss.

→ This is very less reliable type of RAID because there is no redundant data.

→ This is rarely used in the server environment.

→ It can be used for cache or other purpose where speed is essential and reliability or data loss does not matter.

② RAID - 1 (Mirrored disk) :-

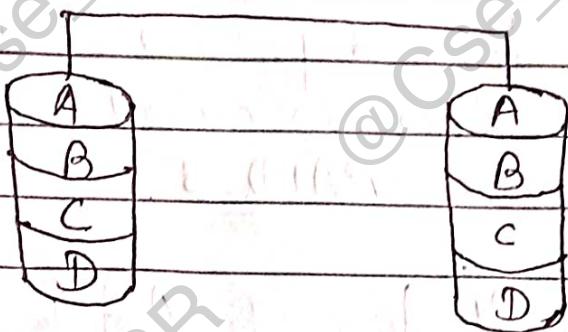
→ RAID 1 is primarily used for redundancy. In this, same data is stored in both disk. It duplicates data across two disks in the array providing full redundancy.

Data is not lost here. If one disk fails, we can replace the disk from another.

It provides better data availability and also increases the performance.

It provides security to the stored data.

RAID 1



③ RAID 3 :

In this, we divides data into bytes and store it on different disks. And in one disk we store the parity of data.

This configuration requires atleast three separate hard disks - two for striping data and one for storing parity bits.

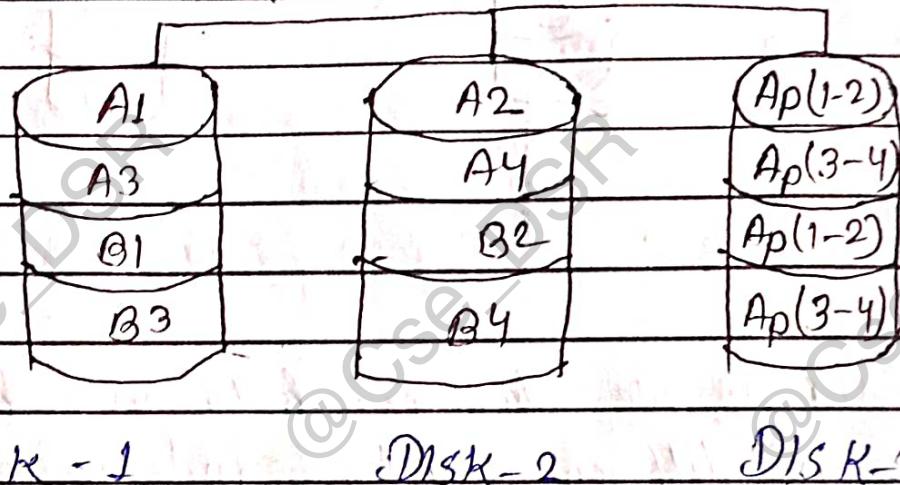
If one of the stripped data disk fail, then with the help of parity bit disk, we can easily

recover the data.

→ But if parity bit disk fails then loss of data occurs and cannot be recovered.

→ During write of data there will be need of modifying parity bit. This parity disk bit will be frequently used, this may create trouble in access. This is called bottleneck problem.

RAID 3



(4)

RAID - 4:

→ It is similar to RAID-3. The only difference is there data is divided into blocks (16, 32, 64 or 128 etc).

→ It has also problem of bottleneck.

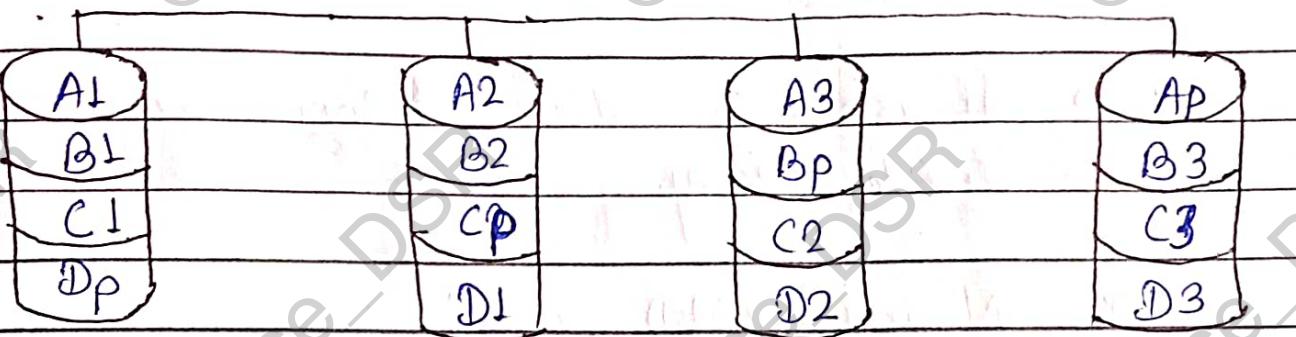
⑤ RAID - 5 :-

→ It solves the problem of bottleneck.

→ It is similar to RAID 4 but here parity is distributed among all the disks, so if one disk fails, recovery is possible.

→ Here all disk are utilized & none of the disk is over utilized.

RAID 5



→ It will increase the performance.

→ But if two disk fails here, then recovery not possible.

⑥ RAID 6 :-

→ It will use two parities to overcome the problem of RAID 5.



→ It is same as RAID 5, only difference is here we use two parity bit which are failed then recovery is also possible.

→ It is also called striped disk with double parity.

* Nested RAID levels :-
(hybrid raid)

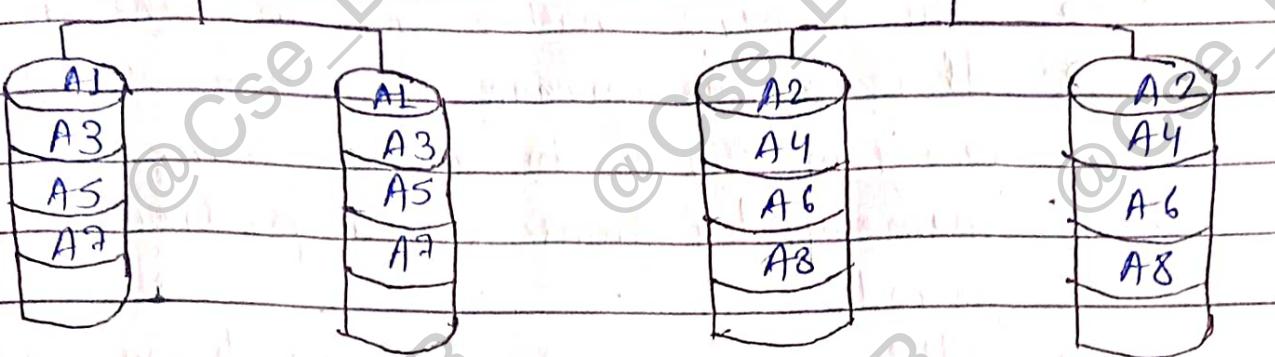
These are combination of RAID levels.

① RAID (10) (1+0) :-

This level combines RAID 1 & 0 in single system. It provides higher performance but at higher cost.

→ In this first mirror is created then striping is done.

RAID 1+0 (mirroring + striping)



② RAID (0+1) :-

If creates a strip set and then mirrors the strip set.

③ RAID (03)

RAID (50) etc.

Benefits of RAID:-

- ① An improvement in cost-effectiveness because lower priced disks are used in large numbers.
- ② Use of multiple drives to improve the performance.
- ③ Increases speed of computer & reliability.
- ④ Increases the availability of data & provides backups.

Drawback:-

- Nested RAID levels are more expensive to implement.

* Locality of Reference

- This concept mostly comes in cache memory.
- It is a phenomenon in which computer program tends to access same set of memory locations for a particular time period.
- This property is mainly shown by loops and subroutine (function) calls in a program.
- It is of two types :—

- ① Spatial locality
- ② Temporal locality

① Spatial locality :— If a word is accessed now then the word adjacent to it will be accessed next.

→ This means the instⁿ or data near to the current memory location that is being fetched, may be needed soon in future.

② Temporal locality :— If a word is referenced now then the same word will be referenced again in future.

→ LRU is used in this.

→ This means current data or instⁿ that is being fetched may be needed soon.