SAN Problems

Application IOPS and RAID Configurations

- When deciding the number of disks required for an application, it is important to consider the impact of RAID based on **IOPS (Input / Output Per Second)** generated by the application.
- The total disk load should be computed by considering the **type of RAID** configuration and the **ratio of read compared to write** from the host.

- ***Write penalty in RAID 1 is 2***
- ***Write penalty in RAID 1/0 is 2***
- ***Write penalty in RAID 5 is 4***
- ***Write penalty in RAID 6 is 6***

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Example Problem 01:

Consider an application that generates 5,200 IOPS, with 60 percent of them being reads.

a. Calculate the disk load in RAID 5, RAID 1 and RAID 6.

b. Calculate the number of disks required for the application. HDD (hard Disk Drive) with a specification of a maximum 180 IOPS is used.

Solution:

According to the given problem statement among 5200 IOPS 60% is read. Than 40% is write.

i.e 60% of 5200 = 0.6 * 5200 = 3120 reads

40% of 5200 = 0.4 * 5200 = 2080 writes

Disk Load in RAID 5:

With respect to write:

In RAID 5 the write penalty is 4. i.e every 1 write instruction results in 4 write operations.

With respect to read:

In RAID 5 1 read instruction results in 1 read operation.

So, disk load in RAID 5 is = read load on disk + write load on disk

read load on disk = 0.6 * 5200 = 3120

write load on disk = 4 * (0.4 * 5200) = 8320

Disk load in RAID 5 is 3120 + 8320 = 11400 IOPS.

The computed disk load determines the number of disks required for the application. The number of disks required to meet the workload for the RAID configuration would be as follows:

RAID 5: 11,440 / 180 = 64 disks

Disk Load in RAID 1:

With respect to write:

In RAID 1 the write penalty is 2. i.e every 1 write instruction results in 2 write operations.

With respect to read:

In RAID 1, 1 read instruction results in 1 read operation.

So, disk load in RAID 1 is = read load on disk + write load on disk

read load on disk = 0.6 * 5200 = 3120

write load on disk = 2 * (0.4 * 5200) = 4160

Disk load in RAID 5 is 3120 + 4160 = 7280 IOPS.

The computed disk load determines the number of disks required for the application. The number of disks required to meet the workload for the RAID configuration would be as follows:

RAID 1: 7280 / 180 = 40.444 disks, rounded off to 42 disks (approximated to the nearest even number)

Disk Load in RAID 6:

With respect to write:

In RAID 6 the write penalty is 6. i.e every 1 write instruction results in 6 write operations.

With respect to read:

In RAID 6 1 read instruction results in 1 read operation.

So, disk load in RAID 6 is = read load on disk + write load on disk

read load on disk = 0.6 * 5200 = 3120

write load on disk = 6 * (0.4 * 5200) = 12480

Disk load in RAID 6 is 3120 + 12480 = 15600 IOPS.

The computed disk load determines the number of disks required for the application. The number of disks required to meet the workload for the RAID configuration would be as follows:

RAID 6: 15600 / 180 = 86.666 disks, rounded off to 88 disks (approximated to the nearest even number)

Example Problem 02

An application has 1,000 heavy users at a peak of 2 IOPS each and 2,000 typical users at a peak of 1 IOPS each, with a read/write ratio of 2:1. It is estimated that the application also experiences an overhead of 10 percent for other workloads. Calculate the IOPS requirement for RAID 1, RAID 5 and RAID 6. compute the number of drives required to support the application in different RAID environments if HDD with specification of 130 IOPS is used.

Solution:

The application has 1000 heavy users with 2 IOPS each. i.e 1000*2=2000 IOPS and

the application has 2000 typical users with 1 IOPS each i.e 2000*1 = 2000 IOPS.

So totally 2000 + 2000 = 4000 IOPS. Also the given problem states that application experiences an overhead of 10%. i.e 10% overhead above 4000 IOPS.

So 10% of 4000 IOPS is over head.

0.1*4000 = 400. So overall 4000 + 400 = 4400 IOPS the application generates.

Now among 4400 IOPS how many are write and how many are read?

According to problem statement read/write ratio is 2:1. So Ratio 2:1 implies that approximately 66.6% are reads and 33.3% are writes.

read load on disk is 66.6% of 4400 = 0.66 * 4400 = 2904

write load on disk is 33.3% of 4400 = 1452

RAID 1:

In RAID 1 the write penalty is 2. i.e every 1 write instruction results in 2 write operations.

So, disk load in RAID 1 is = read load on disk + write load on disk

read load on disk = 0.66 * 4400 = 2904

write load on disk = 2 * (0.33 * 4400) = 2904

Disk load in RAID 1 is 2904 + 2904 = 5808 IOPS.

The number of HDD required is 5808 / 130 = 44.67 round off to 46 disks.

RAID 5:

In RAID 5 the write penalty is 4. i.e every 1 write instruction results in 4 write operations.

So, disk load in RAID 5 is = read load on disk + write load on disk

read load on disk = 0.66* 4400 = 2904

write load on disk = 4 * (0.33 * 4400) = 5808

Disk load in RAID 5 is 2904 + 5808 = 8712 IOPS

The number of HDD required is 8712 / 130 = 67.05 round off to 68 disks

RAID 6:

In RAID 6 the write penalty is 6. i.e every 1 write instruction results in 6 write operations.

So, disk load in RAID 5 is = read load on disk + write load on disk read load on disk = 0.66* 4400 = 2904

write load on disk = 6 * (0.33 * 4400) = 8712

Disk load in RAID 6 is 2904 + 8712 = 11616 IOPS

The number of HDD required is 11616 / 130 = 89.38 round off to 90 disks.

PTO

Application Requirements and Disk Performance

Little's Law is a fundamental law describing the relationship between the number of requests in a queue and the response time. The law states the following relation

$$\mathbf{N = a \times R}$$

where

"N" is the total number of requests in the queuing system (requests in the queue + requests in the I/O controller)

"a" is the arrival rate, or the number of I/O requests that arrive to the system per unit of time

"R" is the average response time or the turnaround time for an I/O request — the total time from arrival to departure from the system

Utilization law is another important law that defines the I/O controller utilization. This law states the relation:

$$\mathbf{U = a \times RS}$$

where

"U" is the I/O controller utilization

"R_s" is the *service time,* or the average time spent by a request on the controller**.** $1/R_s$ is the *service rate.*

From the arrival rate "a", the average inter-arrival time, R_a, can be computed as:

$$\mathbf{R_a = 1/a}$$

Consequently, *utilization* can be defined as the ratio of the service time to the average inter-arrival time, and is expressed as:

$$\mathbf{U = R_s / R_a}$$

<u>Example Problem 03</u>

Consider a disk I/O system in which an I/O request arrives at the rate of 80 IOPS. The disk service time is 6 ms. Compute the following:

i. Utilization of I/O controller ii. Total response time

iii. Average queue size iv. Total time spent by a request in a queue

Solution:

i. Arrival rate ***a*** *= 80* ***IOPS*** **(Input / Output Per Second).**

Service time (R_s) = 6ms

Utilization of I/O controller ***U*** *=?*

$$\boldsymbol{U = a \times R_s}$$

R_s *service time is given in milliseconds and arrival rate* ***'a'*** *is given in seconds so convert* ***a*** *to milliseconds.*

a = 80 IOPS => 0.08 I/O per millisecond

*U = 6 * 0.08*

=0.48 or 48% utilization of I/O Controller.

ii. Total response time

Total Response Time (R) is given by:

$R = R_s / (1-U)$

$= 6 / (1-0.48)$

$= 11.5$ ms.

iii. Average queue size

Average Queue Size = (U*U) / (1-U)

=> (.48*.48) / (1-0.48)

=> (.2304) / (.52)

=> 0.44

iv. Total time spent by a request in a queue

Total Time Spent by a request in a Queue = U * R

=> 0.48 * 11.5

=> 5.52 milliseconds.