POLITECNICO
DI MILANO

# Storage systems: Exercises and solutions

# Exercise 1

A HDD has a rotation speed of 6000 RPM,
an average seek time of 3 ms,
a negligible controller overhead and
transfer time of 128 MB/s.
Files are stored into blocks whose size is 4 KB

Compute:

a) The rotational latency of the disk (ms)
b) The average time required to read a 4 KB block
c) The time required to read a 128 KB file with a locality of 96.875%

# Exercise 1: Solution

a)
The rotational latency is half of the time required to perform one rotation:
$T_{lat}$ = 60000/(2* 6000) = 5 ms.

b) The total average transfer time is:
$T_{tt} = T_{lat} + T_{seek} + T_{transf}$= 5 + 3 + 4 / (128 * 1024) * 1000 = 8.0305 ms

c)
The file is composed by 128/4=32 blocks. Then we have:
$T_{tt} = 32*[(1 – l)*(T_{lat}+ T_{seek}) +T_{transf}]$
32 *[(1-0.96875)*(5 + 3) + 4 / (256 * 1024) * 1000] = 8.9766 ms

# Exercise 2

A HDD has a rotation speed of 10000 RPM,
an average seek time of 4 ms,
a negligible controller overhead and transfer rate of 256 MB/s.
Files are stored into blocks whose size is 4 KB.

Compute

a. The rotational latency of the disk
b. The time required to read a 400 KB file divided into 5 sets of contiguous blocks
c. The time required to read a 400 KB file with a locality of 95%

# Exercise 2: solution

a)
The rotational latency is half of the time required to perform one rotation:
$T_{lat}$ = 60000/(2* 10000) = 3 ms.

b) Since the file is divided into 5 sets of contiguous blocks,
latency and seek times are spent 5 times. The total average transfer time is:
$T_{tt} = 5*( T_{lat} + T_{seek} )+ T_{transf} = 5*(3 + 4) + 400 / (256 * 1024) * 1000 = 36.526$ ms

c)
The file is composed by 400/4=100 blocks. Then we have:
$T_{tt} = 100*((1 – l)*(T_{lat}+ T_{seek}) +T_{transf})$
100 *[(1-0.95)*(5 + 3) + 4 / (256 * 1024) * 1000] = 36.526 ms

# Exercise 2 (continue)

The answers to questions b and c before are:
1. Identical, because the average transfer time for a file depends only on its length
2. Different, because the number of blocks equal to 5 does not corresponds to a 95% locality for a 400 KB file.
3.Due to the write amplification factor, they could either be identical or different.
4. Identical, because the number of contiguous set of blocks equal to 5 corresponds to a 95% locality for a 400 KB file

**Answer:**
Identical, because the number of contiguous set of blocks equal to 5 corresponds to a 95% locality for a 400 KB file and 4 KB blocks.
The Write Amplification Factor is a characteristic of SSD, not of HDD, so this answer was misleading.

# Exercise 3

A cylinder is:

1 The set of tracks with the same radius
2. The smallest unit that can be read or written by a disk
3. The set of platters in a disk
4. The spindle around which disks rotates

The correct answer is 1

POLITECNICO DI MILANO

# RAID: First Exercises and solutions

# Exercise 2

Consider the following set of disks connected in RAID 6, with generator g=2, rotating at 8400 RPM, with an average seek of

3 milliseconds, transfer time of 128 MB/second, and a controller overhead of 150 microseconds:

# Exercise 2

The rotational latency of each disk is:

1. 7.143 ms
2. 14.286 ms
3. 3.571 ms
4. 3 ms

**Solution**

The rotational latency is half of the time required to perform one rotation:

$T_{lat}$ = 60000/2* 8400 = 3.571 ms.

# Exercise 2

The average time required to read a 512 B block on one of the disk of the array:

1. 6.725 ms
2. 6.575 ms
3. 10.147 ms
4. 10.296 ms

**Solution**

$T_{tt} = T_{contr} + T_{lat} + T_{seek} + T_{trans} =$

$0.15 + 3 + 3.571 + 512 / (128 * 1024 * 1024) * 1000 = 6.725$ ms

POLITECNICO DI MILANO

# RAID: Second set of Exercises solution

# Exercise 1

Consider the following set of six disks connected in RAID 6, with generator g=2, MTTF = 1485 days, MTTR = 15 days, rotating at 12000 RPM, with an average seek of 2 milliseconds, transfer time of 0.5 GB/ second:

# Exercise 1

The rotational latency of each disk is:

1. 2.5 ms
2. 5 ms
3. 6 ms
4. 3 ms

**Solution**

The rotational latency is half of the time required to perform one rotation:

$T_{lat}$ = 60000/2* 12000 = 2.5 ms.

# Exercise 1

The average time required to read a 4 KB block on one of the disk of the array read independently:

1. 4.5076 ms
2. 12.3125 ms
3. 7.008 ms
4. 10.296 ms

**Solution**

The total average transfer time is:

$T_{tt} = T_{lat} + T_{seek} + T_{trans} = 2.5 + 2 + 4096 / (512 * 1024 * 1024) * 1000 = 4.5076$ ms

# Exercise 1

The mean time to repair of the system is:

1. 242574.75 days
2. 485149.5 days
3. 15 days
4. 121287.375 days

**Solution**

MTTR = 15 days, as written in the text.

# Exercise 2

A system administrator has decided to use a stock of disks characterized by: MTTF = 800 days and MTTR = 20 days.

The target lifetime of the system is 3 years.

# Exercise 2

The maximum number of disks that could be used in RAID 0 to have a MTTDL larger the the system lifetime is:

1. 1 disk
2. None
3. 2 disks - since RAID 0 requires at least two disks
4. 800/20 = 40 disks

**Solution**

None, since the MTTF (2.2) of one disks is already less than 3 years, and RAID 0 can only reduce the system's lifetime

# Exercise 2

The maximum number of disks that could be used in RAID 01 to have a MTTDL larger the the system lifetime is:

1. No more than 58 disks
2. No more than 7 disks
3. At least 8 disks
4. No more than 6 disks

**Solution**

$2MTTF^2/N^2\ MTTR\} > MTTDL$

$N<SQRT(2MTTF^2/MTTDL* MTTR)$, $N < SQRT(2* 800^2/(3 *365 * 20)) = 7.6451$.

Since the number of disks in a RAID 01 must be even, the answer is no more than 6 disks.

# Exercise 3

In a RAID 6 configuration of 6 disks, if each disk has a capacity of 1 TB the total storage capacity of the system will be:

1. 3TB
2. 4TB
3. 6TB
4. 5TB

Solution
Since there are 6 disks, and two are used for parity, the total capacity will be 4 * 1TB, that is 4TB.

# Exercise 3

If the same set of disks as in the previous question would be used as RAID 10, the total capacity would be:

1. RAID 10 does not exists
2. 4 TB
3. 6 TB
4. 3 TB

**Solution**

Since there are 6 disks, and three are used for data and three for mirroring, the total capacity will be 3 * 1TB, that is 3TB