



## Computing Infrastructures

September 5, 2024

Course Section:       Prof. Ardagna       Prof. Palermo       Prof. Roveri

Student ID (Codice Persona): .....

Last Name: .....  
(LAST NAME IN CAPITAL LETTERS)

First Name: .....  
(FIRST NAME IN CAPITAL LETTERS)

### Exam Duration: 1hour and 30min

Students are not permitted to use mobile phones and similar connected devices. Course materials and programmable devices (e.g. programmable calculators) cannot be used as well. **Any violation of the rules is considered a cheating action.**

**Answers must be given on the Answer Sheets and in English.** Any box filled or answer provided on the other sheets will be ignored. Students must use a pen (black or blue) to mark the answers (no pencil).

Write the LAST and FIRST name in CAPITAL LETTER, and in this order, in all places where requested. **Where it is requested only the STUDENT ID (Codice Persona), do not write your name.**

**Check that the first number of the code for the Answer Sheet** is the same as for the other sheets. The code can be found in the top-right corner of each page in the form +NN/KK/XX+. The parts that should correspond is ONLY the first digit NN.

Mark clearly the box corresponding to your answers, without overlapping on other boxes. If you make a mistake on them, circle the word *Question* together with the related number, and write the correct letter to its side.

**Numerical exercises require writing the formulas and procedure used to solve the problem just after the question in the left space.** Exercises without the procedure used to reach the result will not be considered for the evaluation. Only the numeric answer and its unit should be reported on the corresponding dotted line in the Answer Sheet.

**The answers to the *Open Questions* should be written using ONLY the space available on in the boxes within the Answer Sheets.** The answers should be readable by the professor. Unreadable answers will not be considered for the evaluation.

Scores: correct answers take positive points, unanswered questions take 0 points, **wrong answers can have negative points.** An indication of the points is available at the beginning of each section. The final score can be re-modulated at the end of the evaluation.

**True false questions**

Correct answer: +1, No answer: 0, Wrong Answer -0.5

*Answers must be given on the ANSWER SHEETS. Any box filled here will be ignored. Pay attention to the position (A or B) of the True/False answers, since they are not always in the same position.*

**Question 1** Warehouse-scale computers are primarily used in small businesses with limited computing needs.

A False

B True

**Question 2** Given their efficiency, accelerators like GPUs and TPUs have no impact on the cooling requirements of datacenters.

A True

B False

**Question 3** Hypervisors can only be used to run virtual machines with the same amount of memory as the physical machine on which they are hosted.

A True

B False

**Question 4** Leaf-spine topologies are not suitable for highly virtualized environments with a large number of virtual machines.

A True

B False

**Question 5** GPUs in datacenters are primarily used for accelerating graphics rendering and video processing tasks.

A True

B False

**Question 6** RAID 10 provides better random write performance than RAID 6.

A True

B False

**Question 7** Virtualization can reduce costs by enabling the sharing of hardware resources between virtual machines.

A True

B False

**Question 8** RAID architectures are used to substitute regular backups

A False

B True

**Question 9** A UPS provides backup power to equipment during a power outage.

A True

B False

**Question 10** Cooling towers are not suitable for high-density datacenters.

A True

B False



## Exercises

Correct answer: +2, No answer: 0.

The formulas and procedures used to solve the exercises should be included here close to the question. The numeric answer, and only that, must be given on the ANSWER SHEETS. Any number written only here will be ignored. The correct number is ONLY a necessary condition for a correct answer. If the formulas are not available after each exercise, they will be considered as not answered.

### Question 11

A monitoring system for a rack inside a data center is designed to be composed of 2 hardware sensors ( $M_{HW}$ ), all necessary to extract information on the use of each blade. Each of the sensors is characterized by a MTTF of 27 days and a MTTR of 1 day. If the monitoring system were to be updated to include a purely software system ( $M_{SW}$ ), from which it would be possible to extract the same usage information obtained with the HW sensors, what would be the availability of the entire blade-usage monitoring system ( $M_{HW} + M_{SW}$ ) if the availability of the software system ( $M_{SW}$ ) was 96%? Use always at least 5 decimal digits for each calculation.

$$A_{HW} = \frac{MTTF}{MTTF + MTTR} = \frac{27}{27+1} = 0.96429$$
$$A_{SW} = 96\%$$
$$A_{sys} = 1 - (1 - 0.96429)^2 = 0.9971$$

### Question 12

A company uses a temperature sensor to monitor a critical environment within an industrial plant. The sensor has a MTTF (Mean Time To Failure) of 4000 hours. If the company decides to replace the original sensor with a redundant version consisting of two sensors like the previous one, what is the overall reliability of the monitoring system after 2000 hours? Use always at least 4 decimal digits for each calculation.

$$R(2000) = e^{-\frac{2000}{4000}} = 0.6065$$
$$R_{sys} = 1 - (1 - 0.6065)^2 = 0.8452$$

**Question 13**

Consider the following RAID 1+0 setup composed of 6 disks, each one with an MTTF equal to 410 days and an MTTR equal to 2 days, and a single mirror case for the RAID 1 part. What is the MTTF of the storage infrastructure?

$$\text{MTTF}_{\text{RAID}10} = \frac{(\text{MTTF}_{\text{single}})^2}{N \times \text{MTTR}} = \frac{410^2}{6 \times 2} = 14.008$$

**Question 14**

You are tasked with performing capacity planning for an application cluster. Your system can be modeled using a closed model. On average, there are  $N = 30$  users logged into the system, with a think time of  $Z = 10$  seconds. Your objective is to determine whether it is more efficient to introduce:

- 10 servers, **each** with a service demand of  $D_{10} = 10$  seconds, or
- A single server that is 10 times faster than each server in the previous case, with a service demand of  $D_1 = 0.1$  seconds.

Calculate the lower bound on response time for both scenarios.

$$R_A = \frac{N \cdot D}{m} - Z = \frac{30 \times 10}{10} - 10 = 20$$
$$R_B = D = 0.1$$

**Question 15**

Based on the system described in question 14, calculate the upper bound on throughput for both scenarios.

Case A:

Due to think time

$$X \leq \frac{N}{D+z} = \frac{30}{10+10+10} = 2.7272$$

Due to hardware bottleneck

$$X \leq \frac{1}{D_{max}} = \frac{1}{1} = 1$$

Case B:

Due to think time:

$$X \leq \frac{h}{D+z} = \frac{30}{0.1+10} = 2.970$$

Due to hardware bottleneck

$$X \leq \frac{1}{D_{max}} = \frac{1}{0.1} = 10$$

**Question 16**

Considering the system in question 14, compute the number of users  $N^*$  that determines whether the system should be analyzed using the light load or heavy load optimistic bounds.



## Open Questions

Correct answer: +5, No answer: 0. Points are modulated considering the written text

*Write the answer using ONLY the space available in the boxes on the ANSWER SHEETS. The answers should be readable by the professor. Unreadable answers will be considered wrong.*

### Question 17

⇒ Describe characteristics, advantages, and disadvantages of Direct Attached Storage (DAS), Network Attached Storage (NAS) and Storage Area Networks (SAN).

### Question 18

⇒ Describe, comment, and contextualize the four main types of Clouds

**!!!ANY ANSWER PROVIDED ON THIS PAGE WILL BE IGNORED!!!**

If needed, you can use the space hereafter to organize your answer.



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## Answer Sheets (Page 1)

First Name (CAPITAL LETTERS): .....

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## Question 17

- ⇒ Describe characteristics, advantages, and disadvantages of Direct Attached Storage (DAS), Network Attached Storage (NAS) and Storage Area Networks (SAN).



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## Answer Sheets (Page 2)

## Question 18

⇒ Describe, comment, and contextualize the four main types of Clouds



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## Answer Sheets (Page 3)

Student ID (Codice Persona): .....

## True/False Questions

Question 01 :  A  BQuestion 02 :  A  BQuestion 03 :  A  BQuestion 04 :  A  BQuestion 05 :  A  BQuestion 06 :  A  BQuestion 07 :  A  BQuestion 08 :  A  BQuestion 09 :  A  BQuestion 10 :  A  B

## Exercises

0.8871

Question 11 : .....

0.8952

Question 12 : .....

16008 days

Question 13 : .....

Question 14 : ..... | ..... 0.1 SEC

20 SEC

1 REC SEC

2.87 REC

 $\frac{1}{sec}$ 

Question 15 : ..... | ..... = 101

N\* = 20

Question 16 : ..... | ..... = 101