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Computing Infrastructures  
September 2, 2022

Course Section:	<input type="checkbox"/> Prof. Ardagna	<input type="checkbox"/> Prof. Palermo	<input type="checkbox"/> Prof. Roveri
Student id (codice persona):	.....		
Last Name:	..... (LAST NAME IN CAPITAL LETTERS)		
First Name:	..... (FIRST NAME IN CAPITAL LETTERS)		

**Exam Duration: 1hour and 15min**

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 Sheet.** 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, on the first and last page of the exam. **Do not write your name on the first page of the Answer Sheet.** It is requested only the personal code.

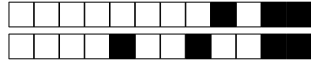
**Check that the first number of the code for the Answer Sheet** is the same as for the other sheets. The code can be found in the top-right corner of each page in the form +NN/KK/XX+. The parts that should correspond is ONLY the first digit NN

Do not use crosses to mark the answers, **fill clearly the box you selected** 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 to write the formulas and procedure used to solve the problem just after the question in the left space.** Only the numeric answer and its unit should be reported on the corresponding dotted line in the Answer Sheet.

**The answer to Question 17 should be written using ONLY the space available on Page 2 of the Answer Sheet.** The answer should be readable by the professor. Unreadable answers will be considered wrong.

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.



### Multiple choice questions

Correct answer: +2, No answer: 0, Wrong Answer -0.5

*Answers must be given on the ANSWER SHEET. Any box filled here will be ignored.*

#### Question 1

Consider an array of N disks. Select the right order of the RAID levels in terms of effective data storage in ascending order, i.e. for the lower to the higher data storage availability.

- ☐ A RAID 1+0, RAID 5, RAID 6
- ☐ B None of the others
- ☐ C RAID 1+0, RAID 6, RAID 5
- ☐ D RAID 6, RAID 5, RAID 1+0

#### Question 2

Which is the main characteristic of the D-Cell topology for data center network architectures?

- ☐ A the network is organized in a recursive way
- ☐ B The network is organized in a distributed way
- ☐ C The network comprises edge, aggregation and core layers
- ☐ D the network is organized in a hierarchical way

#### Question 3

In the context of SSDs, one of the following activities is NOT managed by the Flash Translation Layer:

- ☐ A Data Allocation
- ☐ B Address Translation
- ☒ C Defragmentation
- ☐ D Garbage Collection

#### Question 4

Which of the following is not a feature of a fat tree topology in a data center network architecture?

- ☐ A It has multiple connections to the core
- ☐ B It has a three-tier model
- ☐ C None of the others
- ☐ D It has a recursive organization



### True false questions

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

*Answers must be given on the ANSWER SHEET. 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 5

In-rack cooling refers to cooling equipment where the cooling coils are adjacent to the rack.

☐ True

☐ False

#### Question 6

Warehouse-scale computers belong to a single organization, use a relatively homogeneous hardware and system software platform, and share a common systems management layer

☐ False

☒ True

#### Question 7

In datacenter storage context, DAS means Distributed Application Storage:

☒ False

☐ True

#### Question 8

Data centers are buildings where multiple servers and communication units are co-located

☐ False

☒ True

#### Question 9

Graphical Processing Units support data-parallel computation

☐ False

☒ True



## 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 SHEET. 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 10

You have in charge to design a computer system to do a long and extremely critical computation that takes 4 days to run. The system is composed by 500 servers and the computation is executed in parallel on all of them. All the servers should be up and running otherwise the computation fails. Considering that we want to achieve a reliability of 0.9 at  $T=4$ days, what should be the MTTF for a server that I have to consider during the system procurement/acquisition phase?

### Question 11

The analysis of the failure behavior of a three-component system (A, B and C) reveals that the system is down when both A and B are down, or C is down. The three components have the following characteristics:  $MTTF_A = 80days$ ,  $MTTR_A = 1day$ ,  $MTTF_B = 12days$  and  $MTTR_B = 12hour$ ,  $MTTF_C = 120days$ ,  $MTTR_C = 2days$ . What is the average availability of the system?



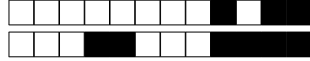
+11/5/16+

### Question 12

Consider an HDD with, 4KB as block size, a rotation speed of 12000 RPM, 0.5 ms as transfer time of 1 block, and a negligible overhead of the controller. Knowing that the average transfer time for a file of 200KB is 320 ms, and the average locality is 70%, what is the average seek time of the disk?

### Question 13

A RAID 5 system uses eight 2TB disks to store data and the required parity bits. Considering that each disk has a Sequential Access Speed (Throughput) of 75MB/s and a Random Access Speed (Throughput) of 7.5MB/s, what is the expected throughput of the RAID 5 considering a random read pattern?



#### Question 14

A company wants to evaluate the performance of the services provided to its users. The computer system comprises two servers S1 and S2. The system is initially considered as an open queue network model and the following measurements were obtained during 30-minute monitoring:

- System Throughput:  $X_{Sys} = 1.2$  req/sec
- Busy time S1:  $B_{S1} = 1080$ sec
- Throughput S1:  $X_{S1} = 6$ req/sec
- Busy time S2:  $B_{S2} = 900$ sec
- Throughput S2:  $X_{S2} = 2.4$ req/sec

What is the service demand for S1 and S2 ( $D_{S1}$  and  $D_{S2}$ )?

#### Question 15

Considering the system described in the previous question, what is the number of visits for S1 and S2 ( $V_{S1}$  and  $V_{S2}$ )?

#### Question 16

Considering now the same system as a closed model with a think time  $Z = 1.5$  sec, and the same values for the demand  $D_{S1}$  and  $D_{S2}$  calculated for the open model. In the context of the asymptotic bounds, what is the value of  $N^*$  after which the bound saturates (remains constant)?



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### Open Question

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

*Write the answer using ONLY the space available on Page 2 of the Answer Sheet. The answer should be readable by the professor. Unreadable answers will be considered wrong.*

### Question 17

⇒ Could you briefly explain the reason why in recent years we also saw a growing interest in the concept of fog/edge computing?

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

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



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⇒ **This page intentionally left blank** ⇐

If needed, you can use this page for notes. Any answer written here will be ignored.





## Computing Infrastructures - Answer Sheet (Page 1)

### September 2, 2022

Student id (codice persona): .....

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

#### Multiple Choice Questions

Question 01 :    ☐ A    ☐ B    ☐ C    ☐ D

Question 02 :    ☐ A    ☐ B    ☐ C    ☐ D

Question 03 :    ☐ A    ☐ B    ☐ C    ☐ D

Question 04 :    ☐ A    ☐ B    ☐ C    ☐ D

#### True/False Questions

Question 05 :    ☐ A    ☐ B

Question 06 :    ☐ A    ☐ B

Question 07 :    ☐ A    ☐ B

Question 08 :    ☐ A    ☐ B

Question 09 :    ☐ A    ☐ B

#### Exercises

Question 10 : .....

Question 11 : .....

Question 12 : .....

Question 13 : .....

Question 14 : .....

Question 15 : .....

Question 16 : .....

Computing Infrastructure - Answer Sheet (Page 2)  
September 2, 2022

FIRST NAME and LAST NAME in CAPITAL LETTERS

.....

(LAST NAME) (FIRST NAME)

### Question 17

⇒ Could you briefly explain the reason why in recent years we also saw a growing interest in the concept of fog/edge computing?

[illegible]

	<b>11</b>
1	C
2	A
3	C
4	D
5	B
6	B
7	A
8	B
9	B
10	>18982days or >52years
11	0,9831
12	17,1667ms
13	60MB/s
14	Ds1=0,5sec - Ds2=0,417sec
15	Vs1=5 - Vs2=2
16	N*=4,833