Computing Infrastructures
September 6, 2023

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   The computing continuum refers to the idea that computing devices exist on a spectrum, from small, low-power devices to large, high-performance machines.

A False   B True

Question 2   Virtualization can improve disaster recovery by enabling quick and easy backup and restoration of virtual machines.

A False   B True

Question 3   In-row cooling systems are less efficient at removing heat compared to traditional perimeter cooling systems.

A True   B False

Question 4   Oversubscription is not used in TOR switches

A False   B True

Question 5   Liquid cooling is a new technology that is not yet suitable for use in production datacenters.

A False   B True

Question 6   NAS devices can be used to share files across multiple clients, providing a centralized storage location for an organization.

A True   B False

Question 7   RAID 10 can achieve better sequential read performance than RAID 0.

A True   B False

Question 8   Multiple Compute Regions permit not only disaster recovery but also a very efficient application-level synchronous replication

A False   B True

Question 9   Cloud architectures can help organizations to reduce their carbon footprint by enabling resource sharing and consolidation.

A True   B False

Question 10   FPGAs are more power-efficient and offer higher performance compared to CPUs for certain types of workloads.

A False   B 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 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 scientific computation uses a server composed of 2 CPUs and 4 GPUs. Knowing that:

- The $MTTF_{CPU} = 450 days$ and $MTTF_{GPU} = 310 days$.

- The computation to work requires both CPUs and one GPU within the server to be properly working.

What is the reliability value after 2 years, R(2y)? Notes: (i) Use at least 4 decimal digits for all the intermediate calculations; (ii) All the other components within the server can be considered as ideal.

Question 12

We have to design a RAID 0+1 storage architecture composed of an array of 8 disks. Knowing that each disk has a MTTF equal to 400days and that we would like to have a MTTF for the storage infrastructure ($MTTF_{RAID01}$) higher than 12 years, what is the maximum MTTR that we have to consider to satisfy the requirement? Consider all the disks with the same characteristics.

Question 13

Consider a HDD with a data transfer rate of 10 MB/s, a rotation speed of 6000 RPM, a mean seek time of 2 ms, and negligible overhead for the controller. What is the time needed to transfer a 4KB block?

Question 14

Consider an Internet-based application system that includes two web servers, an application server, and a DBMS. The two web servers (WS1 and WS2) are heterogeneous (different service times for the same job $S_{WS1} \neq S_{WS2}$), so they are *load-balanced* to achieve the *same utilization.*

In order to evaluate the system performance, a 30-minute monitoring phase has been performed and the following data have been collected:

- Total number of system-level arrivals and completions, A = C = 1800 ;
- Average number of visits for the DBMS, $V_{DBMS} = 10$;
- Average service time requirement for the DBMS, $S_{DBMS} = 20$ ms ;
- Application server utilization, $U_{AS} = 60\%$;
- Application server total number of completions, $C_{AS} = 3600$;
- Fraction of web pages served by the first web server (WS1), $F_{WS1} = V_{WS1}/V_{WS} = 80\%$ ($V_{WS} = V_{WS1} + V_{WS2}$) ;
- Average population for the two web servers aggregated (web server layer), $N_{WS} = 8$ ($N_{WS} = N_{WS1} + N_{WS2}$) ;
- Average residence time for the two web servers aggregated (web server layer), $R_{WS} = 400$ms ($R_{WS} = R_{WS1} * F_{WS1} + R_{WS2} * (1 - F_{WS1})$) ;
- Average service requirement for the second web server (WS2), $S_{WS2} = 100$ ms.

What is the throughput for the three layers X_{WS} ($X_{WS1} + X_{WS2}$), X_{AS} and X_{DBMS}?

Question 15

Consider the same system and scenario analyzed in *Question 14*, compute the average utilization of the two web servers U_{WS1} and U_{WS2}.

Question 16

Consider the same system and scenario analyzed in *Questions 14 and 15* and the asymptotic bound analysis, what is the maximum reachable system throughput X_{MAX}?

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.
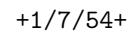
Question 17

⇒ Explain the concept of Wear Leveling in the context of SSD.

Question 18

⇒ Explain clearly why many data centers have a raised floor within the server rooms.

!!!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): ....

Last Name (CAPITAL LETTERS): ....

Student ID (Codice Persona): ....

Question 17

⇒ Explain the concept of Wear Leveling in the context of SSD.

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Answer Sheets (Page 2)

Question 18

⇒ Explain clearly why many data centers have a raised floor within the server rooms.

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Answer Sheets (Page 3)

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

True/False Questions

Question 01 : ☐A ☒B

Question 02 : ☐A ☒B

Question 03 : ☐A ☒B

Question 04 : ☒A ☐B

Question 05 : ☒A ☐B

Question 06 : ☒A ☐B

Question 07 : ☐A ☒B

Question 08 : ☒A ☐B

Question 09 : ☒A ☐B

Question 10 : ☐A ☒B

Exercises

Question 11 : $0,01282$

Question 12 : $1,14$ DAYS $(0,0031\ Y)$

Question 13 : $7,39$ mSEC

Question 14 : $X_{D.grs} = 10\ \frac{J}{SEC}$ $X_{AS} = 2\ \frac{J}{SEC}$ $X_{WS} = 20\ \frac{J}{SEC}$

Question 15 : $U_{WS_1} = 0,4 = U_{WS_2}$

Question 16 : $X_{MAX} = 1,66\ \frac{J}{SEC}$

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