Principles of Computer Systems

19-Dec-2023

This exam has 3 questions, each worth 35 points, totaling 105 points. You have 105 minutes to answer them. If you find yourself spending on any given question more minutes than the number of points attributed to it, you might consider moving on to the next question.

Your answer to each question must be entirely within the box provided on the exam sheet. You have a few spare sheets at the end of the exam. Anything outside the three boxes will be discarded prior to grading.

The exam takes place in room BC 01, and you must be physically present to take it. The exam is a written exam, and you need to bring your own pen. The exam takes place on 19-Dec-2023 from 11:15 to 13:00.

Rules:

- The exam is closed-book. You are not allowed to access any material other than the exam sheet.
- You are not permitted to interact with or receive or give any assistance for the exam except with/from the course staff.
- If you are noise-sensitive, you may wear ear plugs or ear muffs, but no electronic device is permitted (no headphones, no earbuds, no active noise-canceling device, etc.). The staff will inspect everything you wear in or over your ears.
- Any violation of the above rules will be considered cheating and will be prosecuted to the full extent of the EPFL rules on the matter.

Read each question carefully. You need to provide a correct and complete answer to the *correct* question in order to receive full credit. A correct answer to a *wrong or misinterpreted* question will not earn credit. If you have any doubts, raise your hand, and the course staff will come to help.

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Question 1 : RPC semantics (*35 points*)

Design an RPC library for providing exactly-once RPC semantics. Define exactly-once semantics. Explain how your design will ensure exactly-once semantics under normal operation. Define the assumed fault model and explain how exactly-once semantics are guaranteed in the case of failures and subsequent recoveries.

(Write your answer inside the box below. You can use a maximum of 10 sentences.)

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Question 2 : Trace-back for IP packets (*35 points*)

Say you want every Internet destination *D* to be able to: Given any IP packet received by *D* within the last X seconds, *D* can discover all (or at least some part) of the sequence of publicly addressable network-layer devices that forwarded this packet. X is a configurable parameter (the same for all destinations D). One possible use case: if *D* is under attack, receiving undesired packets with spoofed source IP addresses, it can use this capability to figure out where the attack is originating.

Sketch a design for such a capability. State clearly where each functionality resides. How would you pick a good value for X? Clearly state the assumptions you make, as well as the advantages and limitations of your design.

(Write your answer inside the box below. You can use a maximum of 10 sentences.)

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Question 3: Designing a scalable OS kernel (*35 points*)

Consider a hypothetical processor similar to current processors, except that the processor has 10'000 cores. Why is cache coherence a key bottleneck in accessing shared memory on this processor? Design an OS kernel tailored to run efficiently on this processor. Describe the *essential* ways in which your design differs from a traditional monolithic OS kernel, and justify your design choices. (Note that having a shared kernel state replicated on each core is not feasible.) Make sure you think well about how your proposed design handles accesses to shared state, system calls, interrupts, and exceptions.

(Write your answer inside the box below. You can use a maximum of 10 sentences.)

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(You can use the following pages for scratch notes. They will be discarded prior to grading.)