Concurrent and Distributed Systems: Supervision 3

Lectures covered by the supervision: https://www.cl.cam.ac.uk/teaching/2223/ConcDisSys/
- Lecture 9: Distributed systems introduction; Computer networking; Remote Procedure Call
- Lecture 10: Two generals problem; Byzantine generals problem; System models; Fault tolerance
- Lecture 11: Physical time; Clock synchronisation; Causality and happens-before
- Lecture 12: Logical time; Broadcast delivery order; Broadcast algorithms

Previous exams.

Supervision questions:
1. Discuss differences between concurrent and distributed systems. Why do we use distributed systems, what are their benefits, and how do we use distributed systems - use cases.
2. Summarize challenges with using distributed systems – which parameters define these systems?
3. Networks and nodes might fail. What are the implications for code that calls another node through RPC? How is RPC different from a local function call?
4. Discuss point-to-point link, crash-recovery model, and crash-stop model. Provide examples with pseudo code.
5. Describe some problems that may arise from leap second smearing.
6. Discuss happens-before relationship and its implications.
7. Compare Lamport clocks and vector clocks - create examples.
8. Show that for any two events a and b, exactly one of the three following statements must be true: either $a \rightarrow b$, or $b \rightarrow a$, or $a \parallel b$. Discuss and provide a graph.
9. Given the sequence of messages in the execution below (Figure 1), show the Lamport timestamps at each send or receive event. Create a table with different states to show the vector clocks at each send or receive event.

![Figure 1: Example - sequence of messages.](image)

10. In lectures, several types of physical clocks were discussed (time-of-day clocks with NTP, monotonic clocks) and logical clocks. For each of the following uses of time, explain which
type of clock is the most appropriate: process scheduling; I/O; distributed filesystem consistency; cryptographic certificate validity; concurrent database updates.

11. Discuss and compare forms of reliable broadcast discussed in the lectures.
12. Discuss the following terms: partial order relation, strict partial order relation, total order relation, causal order relation, and transitive relation.
13. Prove that causal broadcast also satisfies the requirements of FIFO broadcast, and that FIFO-total order broadcast also satisfies the requirements of causal broadcast.
14. 2020 Paper 5 Question 8 - parts c, d, and e.
15. Discuss what are JSON and REST?
16. Discuss definitions of availability and reliability.
17. Discuss definitions of fault and failure.
20. Summarize in 1-3 sentences Lecture 11.
22. BONUS:
   a. Discuss MPI.
   b. Discuss sources of time non-determinism on node level and network level.
      Discuss average delays present for sources of non-determinism on each level and discuss what are the upper bounds of non-determinism that we as users can expect. Create an example of two nodes, on which some processes and threads might execute concurrently, while nodes communicate over network. In addition, consider there are also some cloud services.
   c. Describe REST's architectural constraints.
   d. Discuss differences between SOA and microservices.
   e. Discuss Java Native Interface and Java Native Access.
   f. Create an example of client/server architecture, where client is in C++ and server is written in Java, and they use gRPC for communication - https://grpc.io/.
   g. Discuss RTOS.
   h. Reordering is a big topic. Discuss where else did we mention reordering, why it is important to have it, and how to deal with it?

Save your answers into MS Teams or email them to me. Please use the following naming pattern:
CDS_Supervision_3_Answers_<last name>_ <first name>_Michaelmas_2022

Send your answers as a pdf, doc, image, or any other format of a document for which there exists an easily available software to open.

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