Exam
DT129G – Programming of Distributed Systems

19th of March 2020

Responsible teacher: Erik Schaffernicht

Aids:	No additional aids besides the task sheets (which include the “cheat sheet”).
Questions:	The teacher can be reached during the exam via phone (019 30) 3227.
Points:	Each task has its point value listed, indicating how extensive the answer is expected to be.
Comments:	**Read the tasks carefully** and answer what the task asks for. Write legibly. Extended bullet points are fine as long as they clearly contain the arguments. There is no need to write an essay. There is neither partial nor total order in which the tasks have to be answered, but clearly indicate which answer refers to which task.

Task 1 – Time (3 points)

A client attempts to synchronize with a time server. It records the round-trip times and timestamps returned by the server in the table below. Which of these times should it use to set its clock? To what time should it set it?

If it is known that the time between sending and receiving a message in the system concerned is at least 4 ms, do your answers change?

Round-trip (ms)	Timestamp (hr:min:sec)
21	10:54:23.674
25	10:54:25.450
23	10:54:28.342

Task 2 – Air Traffic Control (13 points)

There is the air traffic controller (ATC) at a single runway, regional airport, which handles all arriving and departing air traffic.

- Any aircraft that got ATC clearance to either land or depart from the runway will do so within time t and will inform ATC once they departed/vacated the runway.
- Any arriving or departing aircraft will contact ATC with the request for runway access.
- If the runway is currently not cleared for any other aircraft, ATC will grant access.
- If the runway is occupied, ATC will instruct the aircraft to enter a holding pattern (queue) until there is an empty slot, at which point ATC will inform the aircraft.
- If an **arriving** aircraft declares emergency, it will receive the next runway slot.

Assumption: There are **no** communication or node failures, besides the emergency requests, happening in this scenario.

A) Write pseudocode for the ATC and aircrafts, modeling the above behavior through exchanging messages between nodes. Clearly indicate the use of asynchronous and synchronous messages. Ensure that no arriving aircraft is put into the holding pattern for longer than the aircrafts fuel reserves. (6 points)

B) Using your solution, draw a sequence diagram for the following situation: Three aircrafts A, B and C arrive in that order within a time interval t/2. Aircraft C immediately declares an emergency. The diagram ends when all aircraft have landed. (4 points)

C) During night time ATC is shut down due to budget reasons, yet the airport will still accept incoming flights! Extend the aircraft node pseudocode, to coordinate runway access with other arriving flights during night time. (3 points)

Task 3 – Search Engine (3 points)

A search engine is a web server that responds to client requests to search in its stored indexes and (concurrently) runs several web crawler tasks to build and update the indexes. What are the requirements for synchronization and consistency between these concurrent activities?

Task 4 – Failure detection (3 points)

Is it possible to implement either a reliable or an unreliable node failure detector using an unreliable communication channel? Why (not)?

Task 5 – Causal consistency (3 points)

A server manages three objects I, J and K (initialized with value 11 each) with both existing in two replicas. The server provides two operations for its clients (C1 & C2):

- read (I) returns the value of I
- write(I, Value) assigns Value to I.

(Object J & K analog)

Client 1 and 2 are performing concurrently the following sequence of operations

- C1: x1= read(J); y1 = read (I); write(J, 44); write(I, 33)
- C2: x2= read(K); write(I, 55); y2 = read(J); write(J, 66)

Give three sets of x1, x2, y1, and y2 values that are causal consistent with regard to the operations above.