Name________________ Lastname________________ Student number [| | | | | | |]

Distributed Systems
academic year 2008-09

Rules

- This is a closed books exam.
- The operation of any electronic device is prohibited (e.g, no calculator, phone or PDA).
- Answer the questions being *precise, complete,* and *formal.*
- Write as *clearly* as possible, both in terms of handwriting and wording.

Questions

1. Describe the architecture for remote method invocation and the role of the main components (proxy, skeleton, etc.).
2. Illustrate the five phases executed when performing a client request in a passive replication architecture, that is, with a primary back-up.
3. Consider three events a, b, c in a distributed system, each of which occurs in a different processor. State if the following statements hold or not, and explain why (either proove that they are correct or provide a counterexample).
   (a) If ($a \rightarrow b$ AND $b \rightarrow c$) then ($a \rightarrow c$)
   (b) If ($a \rightarrow b$ AND $a \rightarrow c$) then ($b \rightarrow c$)
   (c) If ($a || b$ AND $b \rightarrow c$) then ($a \rightarrow c$)
   (d) If ($a || b$ AND $b || c$) then ($a || c$)
4. Which formal conditions should an algorithm satisfy, so that it solves the consensus problem? Next, consider the Exponential Information Gathering (EIG) for byzantine consensus algorithm. By the theorem about the lower bound on the ratio of faulty processors, the algorithm does not work correctly if n=6 and f=2. Assuming binary consensus (input 0, 1), and the majority vote as the decision function, describe an execution for this system in which the algorithm violates the validity condition. Explain why validity is violated by showing what the resolved value of a non-faulty processor will be. You can choose a default majority value (the one resolved in case of halved votes) that suits you, i.e. is to the advantage of the faulty processors.
5. The GPS system works, in first approximation, in the following way. From any position on the earth, at least four satellites are visible and these emit messages at a constant rate of 50bits/second of 1500 bits in size. Each message includes a clock reading and information on the position of the satellite. A GPS receiver takes the messages sent from the satellites and considering that they travel at the speed of light, it computes its distance from all satellites. One can think of this as taking a sphere centered around the satellite on which the receiver must be located. Ideally, there will be one intersection point of all the spheres which provides the exact location of the receiver. Satellites are equipped with atomic clocks that tick every nanosecond. To be able to locate the receiver, one needs a reading of the time with at most 25 nanoseconds error. Due to relativity theory, satellite clocks will tick more rapidly by about 45.9 microseconds per day because they have a higher gravitational potential, but they will also tick more slowly by about 7.2 microseconds per day due to their relative speed to the earth.
   (a) How much time does a satellite need to emit one message (in seconds)?
   (b) What is the satellite clock resolution (seconds)?
   (c) What is the clocks drift rate due to the relativistic effect (seconds/second)?
   (d) Take clock A and B, synchronize them and assume their drift rate is null. What will be the skew after one day from the synchronization if one is placed on a GPS satellite and the other one is kept on earth (seconds)?
   (e) If with a 25 nanosecond error, a GPS receiver will provide its location with an accuracy of 6.46 meters, what will be the accuracy after one day if the relativistic effects are not compensated for (meters)?