Exam Distributed Algorithms

Free University Amsterdam, 25 May 2010, 8:45-11:30

(At this exam, you may use copies of the slides without handwritten comments. Answers can be given in English or Dutch. Use of textbook, handouts, laptop is not *allowed.)*

(The exercises in this exam sum up to 90 points; each student gets 10 points bonus.)

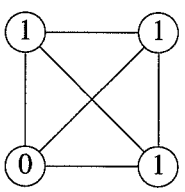
1. Let each process initially carry a random integer value. Adapt the echo algorithm to compute the sum of these integer values. Explain why your algorithm is correct. (8 pts)

2. Assume a Monte Carlo algorithm, and a (deterministic) verification algorithm that checks in finite time whether the Monte Carlo algorithm terminated correctly. Give a Las Vegas algorithm that terminates with probability 1.

   Suppose the Monte Carlo algorithm gives a correct outcome with probability p. How many applications of this algorithm would it take on average to come to a correct outcome? (12 pts)

3. Suppose we have an acyclic orientation of an undirected graph G. Let $\mathcal{P}$ be the collection of paths in G of length $\leq k$. Give an acyclic orientation cover $G_1, \ldots, G_{k+1}$ of $\mathcal{P}$, and argue that indeed all paths in G of length $\leq k$ are covered. (12 pts)

4. Apply the Bracha-Toueg algorithm for 1-Byzantine consensus to the network below.



   Give an execution in which all correct processes decide 0. (12 pts)

5. Explain in detail that the Mellor-Crummey-Scott lock provides mutual exclusion and no starvation. (You should also explain how the exit procedure avoids deadlock.) (12 pts)

6. Given three processes p_0, p_1 and p_2 that are all connected to each other. Let $leader_0 = leader_1 = leader_2 = 3$; $father_0 = 1$, $father_1 = 2$ and $father_2 = 0$; $dist_0 = 1$, $dist_1 = 0$ and $dist_2 = 2$.

   Describe a scenario of the Afek-Kutten-Yung self-stabilizing leader election algorithm, in which eventually p_2 is elected as leader. (14 pts)

7. Let preemptive jobs J_1, J_2 and J_3 arrive at times 2, 1 and 0, respectively, with execution time 2. Let the priorities be $J_1 > J_2 > J_3$. Let J_1 and J_3 use resource R for their entire execution. The jobs are executed using priority ceiling.

   How are the three jobs executed if the arrival of J_1 is known from the start? And how are they executed if the arrival of J_1 is not known before time 2? (10 pts)

8. In case of underflow in weighted reference counting, the weight of the reference is increased, and the object owner is told to increase its weight. Suppose that the process where the underflow occurred does not wait for an acknowledgement from the object owner that it has increased its weight. Give an example to show that then the object can be reclaimed prematurely by the garbage collector. (10 pts)