Exam Distributed Algorithms

VU University Amsterdam, 30 March 2012, 12:00-14:45

(Answers can be given in English or Dutch. You may use the textbook A Cook's Tour of Distributed Algorithms. *Use of slides, handouts, laptop is* not *allowed.)*

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

1. Suppose that the order in which resource requests are granted is predetermined. Give an example of a snapshot with a resource deadlock that isn't discovered by the Bracha-Toueg deadlock detection algorithm.

   Show that in case of a nondeterministic selection which resource request is granted, the deadlock in your example may be avoided. (12 pts)

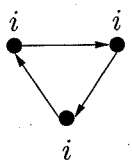
2. Give a computation of Frederickson's algorithm, on a ring of size three and with $\ell = 2$, to show that a **forward** can be sent to a node that isn't a child of the sender. (10 pts)

3. The well-known Dijkstra's single-source shortest path algorithm for undirected weighted networks (for a uniprocessor setting) works as follows. Initially only the initiator is visited, and has distance 0. In subsequent rounds:

   - each visited node p computes for its unvisited neighbors q as distance: the distance of p plus the (positive) weight of the edge pq;
   - if unvisited node q is thus in this round awarded a minimal distance m (among *all* unvisited nodes), then it is added to the visited nodes, with distance m and parent p.

   Develop a distributed version of Dijkstra's algorithm. Also discuss the worst-case message and time complexity of your algorithm. (16 pts)

4. Apply the Itai-Rodeh election algorithm to the following anonymous directed ring, where initial random id's have been chosen. Give an execution in which only two processes progress to round 1, and both choose an id $j < i$.



(10 pts)

5. Consider a complete network of five processes. Apply the Chandra-Toueg 2-crash consensus algorithm, where initially four processes choose the value 0 and one process the value 1. Give an execution in which all correct processes decide for 1. (10 pts)

6. The logical clock values in the Ricart-Agrawala mutual exclusion algorithm are unbounded. Adapt the algorithm such that the range of these values becomes finite. *(Hint: use modulo arithmetic.)* (12 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)