Exam Distributed Algorithms

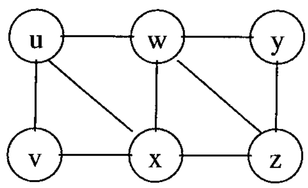
Free University Amsterdam, 30 May 2005, 9:30-12:30

(At this exam, you may use the book Introduction to Distributed Algorithms by Gerard Tel, and copies of the handouts and the slides without handwritten comments.)

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

1. Consider the Merlin-Segall algorithm for computing shortest paths in a weighted, undirected graph. Explain in detail why the worst-case message complexity is $O(|V|^2 \cdot |E|)$, where V is the set of nodes and E the set of edges. (8 pts)

2. Consider the following network:



   Apply Awerbuch's algorithm to traverse this network with a depth-first search, starting at u. Give one possible traversal, together with all messages that are being communicated during this traversal, and the local information that is maintained at each node. (9 pts)

3. Consider the Dolev-Klawe-Rodeh algorithm for leader election in directed rings. Give a probabilistic version of this algorithm to get a Las Vegas algorithm for leader election in *anonymous* directed rings. It should terminate with probability 1; explain why this is the case. (12 pts)

4. Consider the Gallager-Humblet-Spira algorithm for computing minimal spanning trees. Suppose that a process p in a component C sends a **connect** message through some edge pq, toward a component C' having the same level as C. Argue that component C eventually either gets merged with C' or else absorbed into some component that includes C'. (14 pts)

5. Give an example to show that the Chandy-Lamport snapshot algorithm fails if channels are not FIFO. (6 pts)

6. Suppose we adapt the Chandra-Toueg algorithm for t-crash consensus in a complete graph, with an eventually weakly accurate failure detector, as follows. If the coordinator p_c receives *at least* (instead of "more than") t acknowledgements **ack**, then p_c decides for its value. Give an example to show that this could lead to inconsistent decisions. (12 pts)

7. Explain why Dijkstra's Mutual Exclusion Algorithm (with shared variables) guarantees *no deadlock.* (9 pts)

8. Consider a processor with one periodic task $(0, 7, 5)$, and with the EDF scheduler.

   (a) What is the maximum utilization rate $\tilde{u}_s$ for the total bandwidth server? (3 pts)

   (b) Suppose aperiodic jobs A_1, A_2 and A_3 arrive at times 3, 8 and 13, with execution times 1, 2 and 1, respectively. Show how these aperiodic jobs are executed in case of the total bandwidth server with $\tilde{u}_s$ maximal. (Give the subsequent deadlines for the total bandwidth server.) (9 pts)

9. Let 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? In both cases, what is the response time of J_1? (8 pts)