Exam Distributed Algorithms

Vrije Universiteit Amsterdam, 26 October 2016, 8:45-11:30

(You may use the textbook Distributed Algorithms: An Intuitive Approach*. Use of slides, handouts, laptop is* not *allowed.)*

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

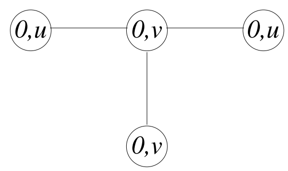
1. Give an algorithm to compute the vector clock at run-time. (10 pts)

2. Draw the wait-for graph for the initial configuration of the tree algorithm, applied to an undirected cycle of three nodes. Give one possible computation of the Bracha-Toueg deadlock detection algorithm on this wait-for graph. (10 pts)

3. Consider the following computation of a decentralized basic algorithm on an undirected ring of size three, with processes p, q and r, where p and q are the initiators. First p sends a message to q and r, and becomes passive, while q sends a message to r. When q receives p's message, it also becomes passive. After reception of the messages from first p and then q, r sends a message to both p and q, and becomes passive. After reception of the message from r, p and q send a message to each other, and after reception of these messages, become passive.

   Extend this basic computation with control messages, to explain how termination is detected using Rana's algorithm. (12 pts)

4. Apply the echo algorithm with extinction to elect a leader in the following anonymous undirected network, where initial random identities have been chosen (and each process is at level 0). All processes are initiators, and know that the network size is 4.



Let $u > v$. Give a computation in which the process at the bottom becomes the leader at level 1. Explain why, in such a computation, at most one of the nodes $(0, u)$ will progress to level 1. (12 pts)

5. Apply the Bracha-Toueg algorithm for 2-crash consensus to a complete network of five processes. Let three processes hold the value 0, while two processes hold the value 1. Give a computation in which all correct processes decide 1. (10 pts)

6. In the t-Byzantine robust synchronizer of Lamport and Melliar-Smith, a correct process p accepts a local clock value of another process q if it differs no more than δ from its own clock value, at the moment of synchronization. Explain in detail why that synchronizer has precision $\frac{3t}{N}\delta$ (versus precision $\frac{2t}{N}\delta$ of the Mahaney-Schneider synchronizer). (12 pts)

7. 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)

8. 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 election algorithm, in which eventually p_2 is elected as leader. (12 pts)