Exam Distributed Algorithms

Free University Amsterdam, 28 May 2009, 12:00-14:45

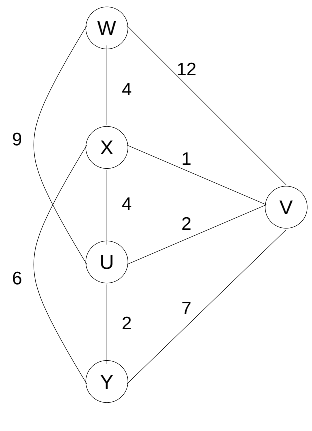
(At this exam, you may use copies of the slides without handwritten comments. Answers can be given in English or Dutch. Use of textbook, handouts, laptop is not *allowed.)*

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

1. Consider Awerbuch's depth-first search algorithm (where a node holding the token for the first time does not send the token to its father and to the node it forwards the token to).

   Give a scenario in which an information message and an acknowledgement are communicated through a tree edge. (6 pts)

2. Run the Merlin-Segall algorithm on the undirected weighted graph below, to compute all shortest paths towards the node Y.

   Give a scenario that takes four update rounds before the correct sink tree has been computed. (12 pts)

3. 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). (14 pts)

4. Let $N = 5$ and $t = 1$, and let the general g be Byzantine. Suppose that in pulse 1, g sends the value 1 to two lieutenants, and the value 0 to the other two lieutenants. Give a scenario of $Broadcast_g(5,1)$, including a definition of the *major* function, such that all lieutenants decide 0. (10 pts)

5. Suppose that in the Ricart-Agrawala algorithm, p sends permission to q. Explain in detail why then p will not get permission from q to enter the critical section until after q has entered and left the critical section. (This observation implies the correctness of the Carvalho-Roucairol optimization.) (8 pts)

6. Consider the Mellor-Crummey-Scott lock. Suppose that when a process q exits the critical section and finds that $next_q = \perp$, it only performs $compare\text{-}and\text{-}swap(q, \perp)$ on *last*, and undertakes no further action when $last \neq q$. Give a scenario to show that in that case the algorithm could deadlock. (10 pts)

7. 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. (12 pts)

8. Consider a processor with one periodic task $(0, 5, 3)$, and with the EDF scheduler.

   (a) Given a total bandwidth server, what is the maximum utilization rate $\tilde{u}_s$? (2 pts)

   (b) Suppose aperiodic jobs A_1, A_2 and A_3 arrive at times 2, 3 and 4 with execution times 1, 2 and 1, respectively. Explain how these aperiodic jobs are executed by the total bandwidth server, with $\tilde{u}_s$ maximal. (Compute the subsequent deadlines for the total bandwidth server.) (10 pts)

9. In weighted reference counting, why is an underflow (weight 1) much more likely to happen than an overflow of a reference counter? (6 pts)