Exam Distributed Algorithms

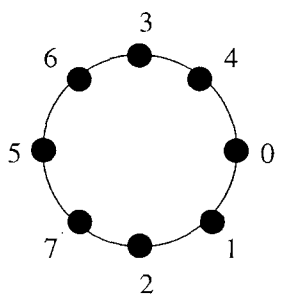
Free University Amsterdam, 21 January 2004, 13:30-16:30

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

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

1. Explain in detail why the worst-case message complexity of Toueg's algorithm for computing routing tables in a weighted, undirected graph is $O(|V|\cdot|E|)$, where V is the set of nodes and E the set of edges. (8 pts)

2. Consider the following unidirectional ring network:



   Describe how the Peterson/Dolev-Klaw-Rodeh algorithm elects a leader. (10 pts)

3. Prove that the forward-count controller allows each move allowed by the backward-count controller, but not vice versa. (10 pts)

4. Consider the Dijkstra-Feijen-van Gasteren algorithm for termination detection in a unidirectional network.

   (a) Explain in detail why this algorithm does not work in case of asynchronous communication. (5 pts)

   (b) Give an example to show that colouring *receiving* nodes black in this algorithm is incorrect. (5 pts)

5. Apply the Itai-Rodeh ring size algorithm to a ring of size 3 in the following two cases:

   (a) Suppose that all three processes initially choose the same identity. Show that the algorithm computes ring size 2. (8 pts)

   (b) Suppose that only two processes initially choose the same identity. Show that the algorithm computes ring size 3. (8 pts)

6. Consider a *complete* network G (i.e., there is a channel between each pair of different processes) of five processes. Let three processes hold the value 0, while two processes hold the value 1.

   (a) Apply the Bracha-Toueg algorithm for 2-crash consensus to G. Give two scenarios: one scenario where all correct processes decide 0, and one scenario where all correct processes decide 1. (14 pts)

   (b) We adapt the Bracha-Toueg algorithm for t-Byzantine consensus by allowing a correct process to decide b if it receives *at least* (instead of more than) $\frac{N+t}{2}$ b-votes in one update round.

   Apply the adapted version of the Bracha-Toueg algorithm for 1-Byzantine consensus to G, and show that it can lead to inconsistent decisions. (12 pts)

7. The requirement of strong accuracy is stronger than the requirement that no correct process is ever suspected:

$$\forall F : \forall H \in \mathcal{D}(F) : \forall t : \forall p \in Corr(F), q \notin F(t) : p \notin H(q,t).$$

   Give an example of a failure pattern and a failure detector history that satisfy this property, but which are not allowed in case of a strongly accurate failure detector. (10 pts)