

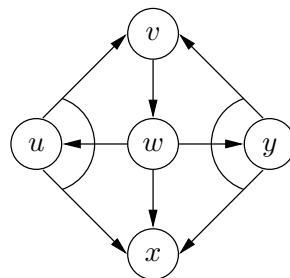
Exam Distributed Algorithms

VU University Amsterdam, 15 December 2014, 12:00-14:45

(Answers can be given in English or Dutch. 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. Let node u initiate a deadlock detection run in which the following wait-for graph is computed.



Give one possible computation of the Bracha-Toueg deadlock detection algorithm on this wait-for graph. (12 pts)

2. Consider the following basic 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 both become passive.

Add the Shavit-Francez termination detection algorithm on top of the basic algorithm, and extend this basic computation with control messages, to show how termination is detected. (10 pts)

3. Consider weighted reference counting, where in case of underflow the reference increases its weight, and tells the object owner to increase its total weight.

Give an example to show that if the process where the weight is increased would not wait for an acknowledgement from the object owner, then the object owner could prematurely mark the object as garbage. (10 pts)

4. In Toueg's routing algorithm, when a process $p \neq r$ in the sink tree of the pivot r receives the distance values of r , let p first for each process q perform the check whether $dist_p(r) + dist_r(q) < dist_p(q)$. Explain why p needs to forward only those values $dist_r(q)$ for which this check yields a positive result. (12 pts)

5. Prove, using an acyclic orientation cover, that there exists a deadlock-free controller for packet switching on a cube (so consisting of eight nodes) which uses only two buffers in each node and allows packets to be routed via minimum-hop paths. (12 pts)

6. Give an example to show that if scheduling of messages is not fair, then the Bracha-Toueg k -crash consensus algorithm (with $k < \frac{N}{2}$) may not terminate with probability one. (10 pts)

7. Apply the Lamport-Shostak-Pease broadcast algorithm to a network with $N = 7$ and $k = 2$ where two of the lieutenants are Byzantine. Let the general initially have the value 0. Describe in detail a computation in which the two Byzantine lieutenants in the subcalls where they play the role of the general broadcast the value 1. (12 pts)

8. Explain in detail why the Carvalho-Roucairol optimization of the Ricart-Agrawala mutual exclusion algorithm is correct. (12 pts)