

UNIVERSITY OF EDINBURGH
COLLEGE OF SCIENCE AND ENGINEERING
SCHOOL OF INFORMATICS

INFR11022 DISTRIBUTED SYSTEMS (LEVEL 11)

Friday 8th May 2015

14:30 to 16:30

INSTRUCTIONS TO CANDIDATES

Answer QUESTION 1 and ONE other question.

Question 1 is COMPULSORY.

All questions carry equal weight.

CALCULATORS MAY NOT BE USED IN THIS EXAMINATION

Year 4 Courses

Convener: I. Stark

External Examiners: A. Cohn, T. Field

THIS EXAMINATION WILL BE MARKED ANONYMOUSLY

1. **You MUST answer this question.**

- (a)
 - i. Define Clock skew and drift. [2 marks]
 - ii. Suppose T_A is the time at clock A , while T is the time on a reference perfect clock. How would you express skew and drift of A in terms of these symbols? [2 marks]
- (b) In leader election:
 - i. Why did we always elect the node with the highest identifier? [2 marks]
 - ii. Suppose we use an aggregation tree for leader election. What would be the advantages and disadvantages of this strategy? [4 marks]
- (c) In Reliable Multicast:
 - i. Why is there a need for a multicast process? [2 marks]
 - ii. What are the receive(m) and deliver(m) events? [2 marks]
 - iii. Why does causal ordering imply FIFO? Does total order also imply FIFO? [3 marks]
- (d) In the ring based mutual exclusion algorithm:
 - i. How long does it take for a process to get the token? [2 marks]
 - ii. What are the disadvantages of this algorithm? [2 marks]
- (e) Even without a deadlock, a poorly designed mutual exclusion algorithm can lead to starvation. Give an example of an algorithm that may lead to starvation. [4 marks]

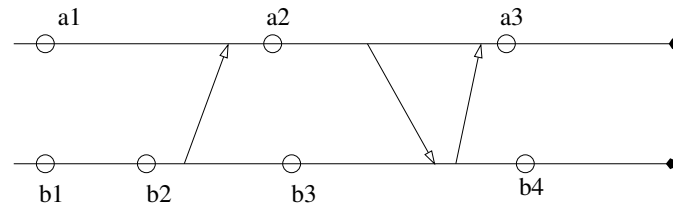


Figure 1: States at process a and b, and message communications between the processes.

2. (a) Which pairs of nodes in Figure 1 above constitute Concurrent states? [5 marks]
- (b) Explain how the bully algorithm can be adapted to deal with temporary network partitions. (That is, when the network is divided into two sets of nodes such that there is no communication between the sets.) If there is no mechanism available to detect network partitions, how would you detect reestablishment of connections between the two sets and adapt the bully algorithm? [7 marks]
- (c) Suppose the communication medium behaves erratically in bursts. That is, there are phases of high bandwidths, interspersed with phases of slow connection and packet loss. Briefly discuss the appropriateness of TCP vs UDP for the following applications or protocols:
 - i. Online video playback (not a live stream). [2 marks]
 - ii. Data (environmental variables like temperature, pressure, light etc) gathering from a network of densely deployed sensors. [3 marks]
- (d) i. Define maximal independent set (MIS). [2 marks]
 - ii. Recall the synchronous and deterministic (non-randomized) MIS algorithm. What set does that algorithm compute in the network in Figure 2? [4 marks]
 - iii. What is the *Maximum Independent Set* in that figure? [2 marks]

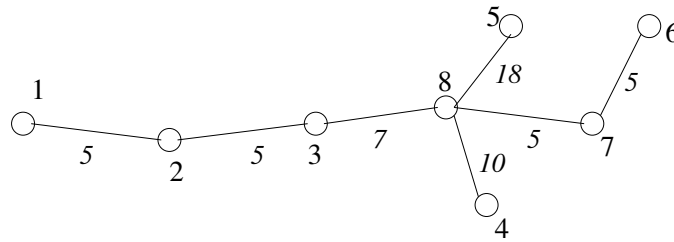


Figure 2: The numbers next to the nodes are their ids, while the numbers next to the edges are their weights/lengths.

3. (a) i. Define diameter and radius in a weighted network. [4 marks]
 ii. Compute the weighted diameter in the network in Figure 2. [2 marks]
- (b) In bittorrent, a client prefers to download from fast peers, since fast peers usually provide faster downloads. Suppose we modify the protocol so that only peers that are sufficiently fast host the file. What are the advantages and disadvantages of the modified protocol? [4 marks]
- (c) Suppose you are using a ring based mutual exclusion algorithm. How will you adapt it to tolerate single process failures? You can assume that failure detection is perfect, that is, when a node fails, its neighbor in the ring is immediately aware of it. How would you adapt your solution when multiple processes can fail? What happens when the network itself is ring structured? [6 marks]
- (d) Suppose each node i in a network of n nodes has a variable v_i . Each node i knows only v_i and its own neighbours in the network. How can node k compute the function $\sum_{i=0}^{n-1} v_i/n$? [2 marks]
- (e) Modify the ring-based leader election algorithm to select k leaders instead of 1 leader. Assume there are n nodes, and each message can be at most $O(\log n)$ in length. [4 marks]
 What is the communication bit complexity of your algorithm? [3 marks]