[CSC3101]

NEWCASTLE UNIVERSITY

SEMESTER 1 2008/09

DISTRIBUTED SYSTEMS

Time allowed - 1½ Hours

Instructions to candidates:

Answer any TWO questions

Marks shown for subsections are indicative only

[Turn over

Question 1.

a) How the 'happened before' relation (denoted usually as $\rightarrow$) is defined over the events of a distributed system? What is meant by 'total order'? [5 marks]

b) Consider a system of distributed processes, $P_1, P_2, .., P_n$, where $n > 3$. At the node of each P_i, $1 \leq i \leq n$, it is required that a *message delivery subsystem* be implemented on top of the local communication subsystem. The delivery subsystem should have the following functionality: Say, messages m and m' are received through the communication subsystem and are to be delivered to P_i. If $m' \rightarrow m$ then m' is delivered to P_i before m. The system context is characterised as follows.

   i) Nodes have physical clocks but have no facility to synchronise those clocks,

   ii) Messages reach their destinations within at most D time units as per the clock of any node, and

   iii) When P_i intends to send a message, it entrusts the message to the delivery subsystem which then forwards it to the communication subsystem for transmission.

   Stating any assumptions you may have to make, provide an efficient algorithm for implementing a message delivery subsystem of the above-mentioned functionality. Also, provide arguments to indicate that your algorithm is correct. [15 marks]

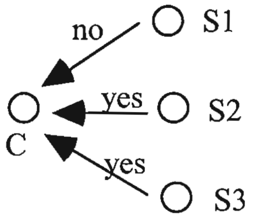
c) Assess whether the delivery subsystem implemented using the algorithms developed in b) can deliver messages in total order, and state the reasons behind your assessment. [5 marks]

Question 2.

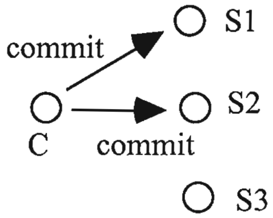
a) Describe the possible RPC semantics that can be obtained in the presence of node crashes and lost messages. [6 Marks]

b) Present the two-phase commit protocol together with necessary assumptions. [7 marks]

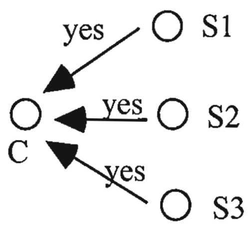
c) The following figures show three possible situations during the execution of the two-phase commit protocol for a transaction that involves four processes (one co-ordinator, C, and three servers, S1, S2, S3). For each of the three cases described below, state the final outcome for the transaction (commit or abort), and indicate how this is achieved.



(i)



(ii)



(iii)

i) Fig. (i): In phase one, the three servers respond to the co-ordinator as shown. Then S2 crashes before it receives the decision from the co-ordinator.

ii) Fig. (ii): In phase two, the co-ordinator has decided to commit, and starts sending the commit decision to the servers; it crashes before sending its decision to S3.

iii) Fig. (iii): In phase one, all three servers respond as shown; the co-ordinator however crashes and does not receive the messages.

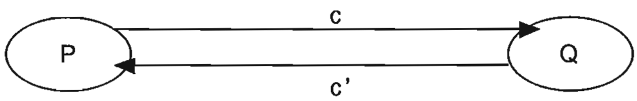
[12 marks]

Question 3.

a) Describe the basic ideas behind *dynamic binding* which enables a client making an RPC to locate the server at run time. [6 marks]

b) What is meant by a *global state* of a system of distributed processes? Discuss why it is difficult in a distributed system for a given process to determine the global system state at any given time. [7 marks]

c) Consider a system of two processes P and Q that are regarded to be connected by unidirectional channels c and c' as shown in the following figure.



During a computation, P sends messages m1, m2, and m3 to Q in that order, and Q sends to P μ1, μ2, and μ3 in that order. S1, S2, S3, and S4 are four global states encountered in that order during the computation and are depicted *only partially* in the table below. For the sake of simplicity, a process's state at a given time is expressed only as an ordered sequence of messages it has sent and received until that time. For example, P's state being <m1, m2, μ1> means that P has sent m1, sent m2, and received μ1 in that order; a channel state being < > means that the channel has no message.

Global State	P	c	c'	Q
S1	<m1, m2, μ1>	?	?	<μ1, m1>
S2	?	< >	<μ2>	?
S3	<m1, m2, μ1, μ2>	?	<μ3>	?
S4	?	<m3>	?	<μ1, m1, m2, μ2, μ3>

Without modifying the global state components shown in the table above, identify the missing components (marked as '?'), given that m2 → μ2 and μ3 → m3 during the computation. For each of the four global states thus completely constructed, explain briefly why it is valid for the computation described. [12 marks]