

Two hours

**UNIVERSITY OF MANCHESTER  
SCHOOL OF COMPUTER SCIENCE**

Distributed Computing

Date: Wednesday 5th June 2013

Time: 09:45 - 11:45

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**Please answer Question ONE and also TWO other Questions  
from the remaining THREE Questions provided**

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This is a CLOSED book examination

The use of electronic calculators is NOT permitted

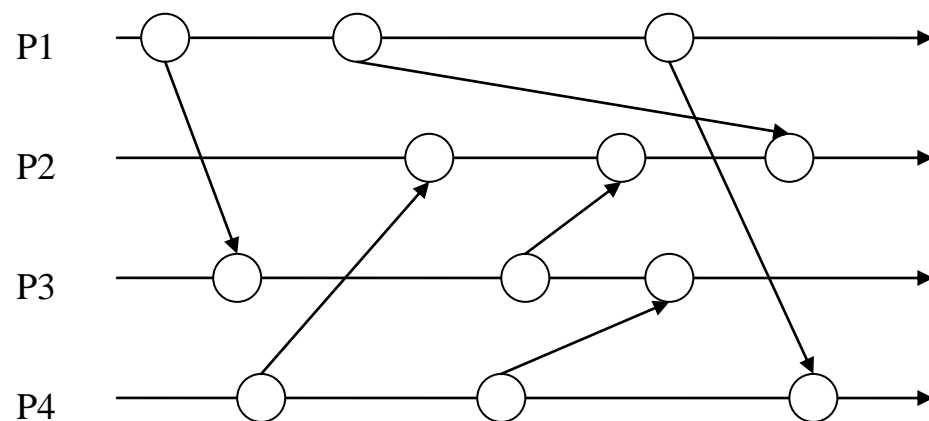
**[PTO]**

1. **Compulsory**

- a) Explain briefly what is meant by the term *middleware*. (2 marks)
- b) Explain briefly what failures are known as *Byzantine failures*. (2 marks)
- c) Describe briefly the *two-phase commit protocol*. (2 marks)
- d) What is meant when a service is provided with *at least once* semantics? (2 marks)
- e) Why is it practically impossible to achieve exact synchronisation of clocks in a distributed system? (2 marks)
- f) When using Java RMI, what is the purpose of the RMI registry? (2 marks)
- g) What is meant by *parameter marshalling*? (2 marks)
- h) What is the key difference between *caching* and *replication*? (2 marks)
- i) Explain briefly what *Little's Law* is. (2 marks)
- j) In the context of lab exercise 2, what would you do to launch a *denial of service attack* against the server? (2 marks)

**Answer any two from Questions TWO, THREE and FOUR**

2. a) Explain briefly why some applications are not parallelisable. Describe Amdahl's law and explain what it can be used for. (4 marks)
- b) Explain briefly what the four properties commonly denoted by the acronym ACID are when referring to transactions. (4 marks)
- c) A service is replicated onto 3 computers.
- The first computer, A, has a mean time between failures of 2 days.
  - The second computer, B, has a mean time between failures of 3.5 days.
  - The third computer, C, has a mean time between failures of 12 days.
- When a failure occurs, it takes on average 12 hours to fix.
- i) What is the availability of the replicated service? (2 marks)
- ii) What would the availability of the replicated service be if only computers A and B were used? (2 marks)
- iii) Describe how in the general case of  $n$  computers, each with a mean time between failures  $f_i$  and a time to fix the failures  $t_i$  you would choose the two computers that provide the highest availability. (2 marks)
- d) Consider the figure below, which shows 4 processes and a number of communication events taking place over a period of time.



Calculate the value of Lamport clocks and vector clocks for each of the 12 events shown above. You can assume that all logical clocks start initially with zeros. (6 marks)

[PTO]

3. a) Explain briefly why the assumption “latency is zero” is considered a common fallacy in distributed computing. (2 marks)
- b) Describe all the operations that take place during a Remote Procedure Call (RPC). (5 marks)
- c) Describe clearly how the Bully algorithm to elect a coordinator works. (5 marks)
- d) The following four processes access a shared variable  $x$ . Each process accesses a different replica of the store used to hold this variable. Before any process starts executing, the value of  $x$  is 0 in all the replicas.

Process 1
 $x=2;$   
 $x=3;$ 
Process 2 $x=1;$ Process 3
 $while(x==0);$   
 $y=x;$   
 $y=4*y+x;$ 
Process 4
 $while(x==0);$   
 $z=x;$   
 $z=4*z+x;$ 

- (i) When all four processes have completed executing the statements given, are 6 and 13 possible values of  $y$  and  $z$  respectively, if the replication uses the sequential consistency model? Justify your answer. (4 marks)
- (ii) When all four processes have completed executing the statements given, are 6 and 13 possible values of  $y$  and  $z$  respectively, if the replication uses the causal consistency model? Justify your answer. (4 marks)

4. a) Give the reasoning that leads to the conclusion that the commanding generals of two separate armies cannot agree a plan of attack using solely a finite sequence of unreliable messages. (3 marks)
- b) Outline the Byzantine Generals problem and illustrate how one of the three being a traitor makes a solution impossible, whereas with one of four it is achievable. (6 marks)
- c) Explain the relevance of parts (a) and (b) above to distributed computing systems. (3 marks)
- d) In a client-server application, assume that each client request is added to a server queue and three servers can serve requests from the queue. Server A can serve 18 requests per second. Server B can serve 26 requests per second. Server B can serve 56 requests per second.
- (i) Assume that at a certain point in time there are 300 requests in the queue. How would you allocate these requests to the servers to achieve load balancing? (2 marks)
- (ii) If at most 50 clients can operate in parallel, how many requests per second would you advise each client to make so that the server queue is not flooded with requests? (2 marks)
- (iii) Describe how in the general case of  $n$  servers, each capable of serving  $s_i$  requests per second, you would allocate  $x$  requests from the queue to achieve load balancing. State any assumptions you make. (4 marks)

**END OF EXAMINATION**