

Two hours - online

**UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE**

Fundamentals of Distributed Systems

Date: Monday 20th May 2019

Time: 14:00 - 16:00

**This is an online examination. Please answer BOTH Questions
Each question is worth 20 marks**

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This is a CLOSED book examination

The use of electronic calculators is permitted provided they
are not programmable and do not store text

[PTO]

1. a) In this course unit, we discussed two types of reasons for using distributing systems. What are these types of reasons? (1 mark)
 - i) What type of reasons lies behind the use of comparison websites, e.g. for insurance policies, hotel bookings, etc.? Briefly explain your answer. (3 marks)
 - ii) It is claimed that the use of cloud computing in its software-as-a-service view, e.g. Google Docs, exemplifies both types of reasons for distributing systems. Briefly explain why this claim is justified. (4 marks)

- b) In this course unit, we discussed *architectural paradigms for distributed systems*.
 - i) Briefly contrast the architectural paradigms known as *direct message-exchange* and *remote procedure call* in terms of message semantics, i.e. the kind of payload, or message content, they carry. (2 marks)
 - ii) In *direct message-exchange*, consider the communication between a sender *S* and a recipient *R*. Briefly explain why the timelines of *S* and *R* need to synchronize. (2 marks)
 - iii) Consider the *remote method invocation (RMI)* architectural paradigm. There are two versions of this paradigm: *early-binding* and *late-binding*. Which version of RMI is used in the W3C web services architecture? What makes this version of RMI possible? (2 marks)

- c) In this course unit, we discussed five computation models for distributed systems. These include the *centralised* model and the *middleware-based* model. List the other three models, and briefly explain the key characteristics of each model. (6 marks)

2. a) Your friend is adamant that HTTP cannot be a stateless protocol, and argues that the fact that you can place items in your ‘shopping basket’ in online shops is evidence that the ‘web remembers things and that means it has state’. Explain what the phrase ‘HTTP is a stateless protocol’ really means, and briefly discuss why statelessness is an important part of the reliability of web-based systems. (3 marks)

- b) Describe two distinct mechanisms by which stateful behaviour can be built on top of HTTP to achieve the kinds of effect your friend has observed. (4 marks)

- c) Your friend calls you up to say that the email with your explanation of statefulness

hasn't arrived, though you are certain you sent it without any obvious problem. Your friend's computer appears to be working fine, and he has received other emails before and after the time you sent yours, and has even received email from you since. Explain to your friend how this is possible by listing the software components involved in sending an email from one user to another, and describing one failure scenario that could explain what has happened. (3 marks)

- d) Explain the purpose and method of the 'Two Phase Commit' protocol. Give an example of its use in the context of transferring money from one bank account to another via a distributed system. (5 marks)
- e) Stateful behaviour in a distributed system introduces the potential for deadlock. Explain the concept of deadlock using an example from a web-based application (the application can be a hypothetical one of your own devising, or a real system). (2 marks)
- f) In this course unit, we discussed the eight axioms of distributed computing. Briefly explain which *three* of these axioms apply to a *multi-CPU system*. Such a system is a kind of modern *chip multi-processor (CMP)* in which processing units are physically separate and communicate via a separate interconnect, i.e. a bus. The bus is thus "the network" referred to in the axioms. (3 marks)