One and a half hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Fundamentals of Distributed Systems

Date: Friday 4th June 2010
Time: 09.45 – 11.15

QUESTION PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

Please answer ALL questions in Section A
and ONE question from Section B

Use separate Answerbooks for EACH section

This is a CLOSED book examination

The use of electronic calculators is NOT permitted.
Section A

Multiple choice section, not published.

All question papers to be returned
SECTION B
Answer exactly one question from this section

B1.  a) Explain why buffers are needed in distributed systems by considering the way VoIP is implemented on personal computers. In giving your answer, explain:

i) What a buffer is, by referring to the ‘leaky bucket’ analogy.
(2 marks)

ii) Why input buffers and output buffers are needed when communicating with concurrent A-to-D and D-to-A conversion processes, as implemented on sound cards or equivalent on-board circuitry.
(4 marks)

iii) Why buffers should not be allowed to overflow or underflow.
(2 marks)

b) Explain why ‘lost packets’ occur when VoIP is conveyed by wired computer networks. Explain how the occurrence of lost packets can be identified at the receiver.
(4 marks)

c) What is meant by ‘jitter’ as observed at a VoIP receiver and what causes it? How can such jitter be measured for two successive packets conveyed by RTP?
(4 marks)

d) Why are ‘jitter-buffers’ required for interactive telephone conversations using VoIP? Explain how the receiver’s jitter-buffer affects the conversation. How would increasing the jitter-buffer size change this effect and what limits the size of jitter-buffer that may be employed with VoIP?
(4 marks)
B2.  

a) Recall how in this course unit, centralized processing was contrasted with its concurrent, parallel and distributed counterparts in terms of how copies of a process get assigned to processors and address spaces. The picture and captions below describe the centralized and concurrent cases. Draw the corresponding pictures, with captions, for the parallel and distributed cases.  

(4 marks)

\[ 
\text{Centralized} 
\begin{align*}
\text{copies } p_1 \text{ and } p_2 \text{ are assigned to a single processor } P \text{ and use strictly different address spaces } A \text{ and } A'.
\end{align*}
\]

\[ 
\text{Concurrent} 
\begin{align*}
\text{copies } p_1 \text{ and } p_2 \text{ are assigned to a single processor } P \text{ and share a single address space } A.
\end{align*}
\]

b) In the course unit, the claim was made that 'A "server" socket behaves more like a dispatcher'. Briefly explain what is meant by this and illustrate your explanation with what you know about the web and HTTP servers.  

(4 marks)

(Question B2 continues on the following page)
c) Imagine the following scenario. You are in the lounge area of an airport. You open your laptop and it offers you a WiFi connection. You go through the procedure for accessing the service and pay for it with your credit card. Once you have gained access, you click on the bookmark for the BBC News website. For the next minute or so, the browser hangs. You give up and try the website of The Guardian. This comes up very quickly. You notice that there is a film clip of an interview you're interested in. You click on it and you wait a little while progress indicators tell you the browser is busy at it. The clip starts playing. After a few seconds, it stalls for a while and then resumes. You remember that a friend gave you a link to the same video in YouTube and you think to yourself "Better try that...". You click the link, you're taken to YouTube but it's all very slow, slower, and slower.

Go through the scenario above and state at least three axioms of distributed computing discussed in this course unit that seem to be proving themselves true in the scenario. In your answer, make sure that you explicitly state the axiom, link it clearly with at least one event in the scenario, and use your understanding of the axiom to briefly justify the latter's connection with the event. (6 marks)

d) Consider a barebones e-commerce website that supports the following simple use-cases:

(U1) product page retrieval: assume that this simply retrieves an HTML page (i.e., ignore the likely involvement of scripts (say, in PHP) to access a database (say, mySQL)).

(U2) order placement: assume that this is a form-based process that activates some functionality in the server (e.g., calling a script, or a servlet) that triggers the purchase process.

(U3) notification of new offers: assume that this is a process by means of which a user can register an interest on new offers, as a result of which the server will send an email to the user whenever a new offer of interest is available.

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Recall the architectural paradigms for distributed computing discussed in this course unit: direct message exchange (DME), mediated message exchange (MME), remote procedure call (RPC), early-binding remote method invocation (E-B RMI) and late-binding remote method invocation (L-B RMI).

For each of the use-cases U1-U3 above, explicitly state which paradigm (exactly one) you believe best explains the use-case and briefly justify your answer. (6 marks)

B3. a) Explain, using at least one diagram, the processes and systems involved in composing, sending, receiving and reading an email. In this explanation, define and describe the role of SMTP and IMAP, illustrating each explanation with a description of a typical interchange between client and server (there is no need to give detailed or accurate commands when describing this interchange). (6 marks)

b) A friend is certain that he has not received an important email that you know you have sent some time ago. A copy of the email exists in your ‘sent items’ mailbox, and there has been no sign of any problems at your end. Your friend’s computer appears to be working fine, and he has received other emails before and after the time you sent yours. Give two distinct examples that show how it is possible for your email to have been lost in transit without either party knowing. (4 marks)

c) Use the example of the missing email from your previous answer to 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)

d) How are deadlocks caused in a distributed system? Use the process of transferring money from one bank account to another to illustrate your answer. Give one example of a deadlock avoidance mechanism, and one example of how deadlocks can be broken once detected. (5 marks)

END OF EXAMINATION

All question papers to be returned