

National Examinations December 2019
17-Comp-B10, Distributed Systems
TIME ALLOWED: 3 HOURS

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.
2. All questions carry equal weight.
3. This is a CLOSED BOOK examination. A Casio or Sharp approved calculator is permitted.
4. Answer any **five of the six** questions. Only the first five questions as they appear in the answer book will be marked.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

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Question 1. Characteristics of distributed systems (20 marks)

- (a) The construction of distributed systems produces many challenges. Briefly discuss about concurrency, heterogeneity, and scalability, three of the most common challenges encountered.
- (b) List the three main software components that may fail when a client process invokes a method in a server object. Give an example of a failure in each case and suggest how the components can be made to tolerate one another's failure.
- (c) A user arrives at a Via Rail train station that she has never visited before, carrying a mobile phone that is capable of wireless networking. Suggest how the user could be provided with information about local services and amenities at that station, without entering the station's name or attributes. What technical challenges must be overcome?
- (d) What are the advantages and disadvantages of HTML, URLs, and HTTP as core technologies for information browsing? Are any of these technologies suitable as a basis for client-server computing in general?

Question 2. Fundamental concepts and mechanisms (20 marks)

- (a) Middleware provides a convenient programming model to application programmers. Describe some of the limitations of middleware and compare the following middleware products and standards: CORBA, Java RMI, and web services.
- (b) Outline and explain three main limitations of IPv4.
- (c) Describe how Network Address Translation works (NAT) and what problem does it solve.
- (d) TCP/IP functionality is divided into five layers, each of which includes specific protocols. Briefly describe the work done by each of the five layers of the TCP/IP model and list some of the most important protocols at each layer.

Question 3. Security

(20 marks)

- (a) Kerberos involves three (bi-directional) exchanges, one between the client and the Key Distribution Center (KDC), one between the client and the Ticket Granting Service (TGS), and one between the client and the server (S) chosen by the client. Describe the main Kerberos components and explain the purpose of each of the three exchanges mentioned above.
- (b) Describe some of how conventional Web applications are vulnerable to eavesdropping, cross-site request forgery, injections, replay and denial of service attacks. Suggest methods by which Web applications could be protected against each of these forms of attack.
- (c) There is no authentication in the Diffie-Hellman key-exchange protocol. By exploiting this property, a malicious third party can easily break into the key exchange taking place between Alice and Bob, and subsequently, ruin the security. Explain how this would work.
- (d) Suppose that you were asked to develop a distributed application that would allow the PEO office to set up exams. Give at least three statements that would be part of the security policy for such an application.

Question 4. Distributed file systems.

(20 marks)

- (a) List and briefly describe five key benefits of a Distributed file system.
- (b) NFS, CIFS, Hadoop, and NetWare are examples of distributed file systems. Compare and contrast, concerning the performance, fault-tolerance, and replication, two of the examples provided above (for instance NFS vs Hadoop).
- (c) What is a stateless server?
- (d) What is the advantage of caching in remote file access? Caching can either be done at a client or in the network (by a proxy server or gateway). Explain the advantages and disadvantages of both strategies.

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Question 5. Transaction processing techniques

(20 marks)

- (a) Consider the following transactions T and U.

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T: x = read(i); write(j,44);  
U: x = write(i,55); write(j,66);
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Assuming that the initial values of a_i and a_j are 10 and 20, respectively. Describe and show an interleaving of the transactions T and U that is serially equivalent.

- (b) What is a Deadlock? How it can be prevented, detected and recovered? Provide some scenarios and concrete examples to answer the questions.
- (c) Describe the two-phase commit protocol distributed algorithm. Use pseudocode to outline the algorithm.
- (d) List and describe the ACID properties of transactions. Provide examples for each of the properties.

Question 6. Client-server systems and inter-process communications.

(20 marks)

- (a) Outline using your preferred programming language how two nodes on a network can communicate. In particular, outline the following concepts: Client and Server sockets and object serialization. You will need to provide code snippets.
- (b) Explain the main differences between UDP and TCP and describe some of the applications where UDP is used.
- (c) Explain and illustrate (in graphical form) the architecture of RPC. Include in your explanation the main components of the architecture of RPC.

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- (d) A single-threaded client makes remote procedure calls to a server. The client takes 6 milliseconds to compute the arguments for each request, and the server takes 10 milliseconds to process each request. The local operating system processing time for each send or receive operation is 0.5 milliseconds, and the network time to transmit each request or reply message is 3 milliseconds. Marshalling or unmarshalling takes 0.25 milliseconds per message. Calculate the time taken by the client to generate and return from two requests. You can ignore context-switching times.

END OF EXAM