UNIVERSITY OF DUBLIN

TRINITY COLLEGE

FACULTY OF ENGINEERING & SYSTEM SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

B.A. (Mod). in Computer Science
Senior Sophister Examination

Trinity Term 2002

4BA8 - Distributed Systems

Thursday 23rd May *MANSION HOUSE* *14.00 - 17.00*

Mr. Jim Dowling, Dr. Vinny Cahill, Mr. Brendan Tangney

Attempt five questions
(all questions carry equal marks)

Q1. Consider the problem of implementing a fault-tolerant service intended to tolerate the failure of the processors(s) on which it executes using *active replication*. In particular, you may assume that the processor service has partial amnesia crash failure semantics and that the service manages persistent data whose consistency must be maintained.

i) Outline the design of such a service exhibiting crash failure semantics and required to tolerate up to k simultaneous processor failures (i.e., assuming that the only source of failure is processor crash).

(12 marks)

ii) In what way would your design need to be modified if the service can exhibit response failures (e.g., assuming that the code for the program is buggy)?

(4 marks)

iii) Comment on the implications of network partition for your design of part i) above.

(4 marks)

Q2. Distributed multi-player games have become very popular on PCs, with games such as Quake and Counter Strike becoming increasingly popular. The next wave of distributed multi-player games to capture the imagination may well be deployed on interacting mobile computers operating in a wireless network, thus opening up new possibilities for the gaming experience, but also introducing new problems that have to be overcome. For example, such games may need to maintain consistency of data, such as the players' scores or other properties and the state of the game space, despite the possibility of the wireless network being partitioned when players move away from each other.

Quazoom is such a multi-player game designed for deployment in a wireless network. In Quazoom, there are 3 different game objects: players, medikits, and flags. Players can move and shoot. Players move around in the game by moving around in the real world. When a player shoots, the first player in their line of fire gets hit, and loses 50% of their health. When a player's health reaches 0, he is killed and the player that shot him gets a point. The first player to reach a score of 3 points wins the game. A dead player cannot do anything, or be shot, for 15 seconds. After 15 seconds, his health is reset to 100% and he can continue in the game. There are medikits in the game. A player can pick these up using a keyboard command, but only if he is within 2 meters of the kit. Only one player is allowed to pickup a kit at a time, after which it disappears for 30 seconds. The kit replenishes the player's health to 100%. Players can pick up medikits even if their health is already at 100%. There is a flag that a player can pick up or drop for a capture the flag type game. The flag has an initial position. When a player carrying the flag dies or leaves the game, it is reset to its original position.

Outline a possible design for Quazoom concentrating on the distributed systems issues arising rather than, for example, the user interface design. In particular, your design should:

- motivate the choice of an appropriate paradigm for building the application; (4 marks)
- include a diagram illustrating the overall architecture of the system including where the player and game state is stored; (4 marks)
- give an overview of the algorithms used to ensure consistency of updates; (7 marks)
- describe how users joining and leaving (for example, because of failure) the game are supported; (3 marks)
- describe the impact of players becoming temporarily disconnected from the game due to mobility. (2 marks)

Q3. Give an overview of the design for a system to support electronic voting in a general election. Use Ireland as an example and assume 1,000,000 votes spread over 50 constituencies. Voting can take place over the Internet or at polling booths located in polling stations. You may ignore issues to do with security but you should describe your design under the following headings: overall architecture (5 marks); fault tolerance (4 marks); performance (3 marks); IPC paradigm (3 marks).

What modifications would be required to handle a general election in India. Assume a voting population of 1 Billion for a 1,000 seat parliament. (5 marks).

Q4.

i) The file caching mechanism in the Andrew File System was designed for a particular set of file usage properties. What were they? (4 marks). Do those properties still apply to the typical usage on the Computer Science undergraduate computing environment in TCD today? (2 marks).

ii) What are the significant changes that you have witnessed in the Computer Science undergraduate computing environment in TCD since you joined the course? What would you expect the environment to be like in another 6 years time.

(6 marks).

iii) Outline the design for the caching mechanism for a file system targeted at the environment you described in part ii).

(8 marks)

Q5 .

i) What is the "End to End Argument" (3 marks)? How is it reflected in the design of Frame Relay protocol (3 marks) and the HDLC protocol (3 marks)?

ii) Describe in detail the different ways in which the Token Ring algorithm handles the problem of two nodes making the same decision at (roughly) the same time.

(7 marks)

iii) How does CSMA/CD manage to avoid the same level of complexity?

(4 marks)

Q6.

i) Compare and contrast CORBA and XML-RPC with respect to:
1. Network error handling at the application level
2. Legacy system integration capability
3. Firewall integration capability
4. Transfer syntax

(8 marks)

ii) Discuss the declarative programming model in Enterprise Java Beans™ and how it allows programmers to "take any Java class and with little effort make it a distributed, secure, transactional class". Make sure to mention the role of the container, the component framework and the deployment tool in your answer.

(12 marks)

Q7. Write brief notes on **ALL** of the following

i) Compare and contrast logical time with vector time. (5 marks)
ii) Why do computer systems fail? (5 Marks)
iii) "There are no fundamental differences between the design embodied in the Cambridge Distributed Computing Systems of the early 1980s and that found in the Computer Science undergraduate computing environment in TCD today" Respond to this statement. (5 marks).
iv) What did you learn in this course? (5 marks).