UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

M.Sc./DIPLOMA IN ARTIFICIAL INTELLIGENCE
M.Sc./DIPLOMA IN COGNITIVE SCIENCE
M.Sc./DIPLOMA IN COMPUTER SCIENCE
M.Sc./DIPLOMA IN INFORMATICS

DISTRIBUTED SYSTEMS

Thursday 25 April 2002

09:30 to 11:00

Examiners:
N. Chater (External)
N. Jennings (External)
E. Hancock (External)
K. Hawick (External)
R.N. Ibbett (Convener)
J. Oberlander (Co-Convener)

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

1. (a) A linearization L is an ordering of the events in a global history that is consistent with the happened-before relation. Given two predicates ϕ and ψ, explain what is meant by

   i. a *safety* property of L with respect to ϕ;

   ii. a *liveness* property of L with respect to ψ. [*4 marks*]

   (b) What are the *safety*, *liveness* and *ordering* properties of mutual exclusion algorithms? [*3 marks*]

   (c) One such algorithm is the "ring-based algorithm" in which processes are assumed to be arranged in a logical ring. Each process has a unique identifier.

   i. Explain the operation of the algorithm.

   ii. Using a small example describe an execution of the algorithm which shows that the ordering property is not necessarily satisfied. [*9 marks*]

   (d) In a certain system, each process typically uses a critical section many times before another process requires it.

   i. Explain why Ricart and Agrawala's multicast mutual exclusion algorithm is inefficient in this case.

   ii. Suggest an adaptation of the algorithm to this particular system which will improve its performance. [*9 marks*]

2. (a) What are the "ACID" properties supported by transaction systems? [*4 marks*]

(b) A server manages objects $a_1, a_2, \ldots, a_n$ and provides two operations for its clients:

`read(i)` returns the value of a_i

`write(i, val)` assigns `val` to a_i

Transactions T and U are defined as

T: `x = read(j); y = read(i); write(j,44);`

U: `v = read(k); write(i,55); w = read(j);`

i. What does the term *serially equivalent* mean when applied to the interleaving of operations of two transactions?

ii. The sequences

- `x = read(j); y = read(i); write(j,44); v = read(k); write(i,55); w = read(j);` and
- `v = read(k); write(i,55); w = read(j); x = read(j); y = read(i); write(j,44);`

are serially equivalent interleavings of T and U. Write down three other serially equivalent interleavings of T and U. [*8 marks*]

(c) Deadlock detection is essential in distributed transaction systems in which concurrency control is based on locks. Describe the *edge-chasing* approach to distributed deadlock detection. [*8 marks*]

(d) A one-phase commit protocol would consist of a message from the coordinator process to the other participants instructing them to commit or abort. Explain why this would be inadequate. [*5 marks*]

3. (a) Explain what is meant by the terms *port* and *socket* in the context of inter-process communication. Your answer should include an explanation of the relationship between these entities. [*4 marks*]

(b) CORBA and DCOM are two distributed object systems supporting remote method invocation.

i. What is the role of the *stub* in CORBA?

ii. What is the role of the *stub* in DCOM?

iii. Explain the sequence of method calls which are made when a client invokes a method using a CORBA object reference. Your answer should include all participants on both client- and server-side. You may include a diagram in your answer. [*12 marks*]

(c) Compare the *mobile agent* programming model and the *remote method invocation* programming model. In particular you should consider performance, fault tolerance and support for mobile devices. [*9 marks*]