UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2000

BEng Honours Degree in Computing Part III
MEng Honours Degree in Information Systems Engineering Part IV
BEng Honours Degree in Mathematics and Computer Science Part III
MEng Honours Degree in Mathematics and Computer Science Part III
MSc in Advanced Computing
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute
This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER C312=I4.4

ADVANCED DATABASES

Tuesday 9 May 2000, 10:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions

1 The following are tables holding the stock of some products, and the stock movements recently recorded for those products. An index exists for the underlined primary keys of each table, and for the `description` field of `stock`.

stock

part	description	category	price	level
8491	Floppy Drive	COMP	5.00	50
8948	CD Player	HIFI	150.00	6
9211	20GB HD	COMP	89.00	10
9533	MD Player	HIFI	239.00	0

movement

mid	part	qty
2100	8491	15
2101	8948	-4
2102	8948	-1
2107	8491	-5

Q_1
```
SELECT part, description, price
FROM stock
WHERE category='COMP'
ORDER BY description
```

Q_2
```
UPDATE stock
SET level=level-10
WHERE part=9211

INSERT INTO movement
VALUES
  (2110, 9211, -10)
```

Q_3
```
UPDATE stock
SET price=0.95*price
```

$H_1 = r_1[s_{9211}], r_1[s_{8948}], r_1[s_{8491}], r_1[s_{9533}], c_1$

$H_3 = r_3[s_{8491}], w_3[s_{8491}], r_3[s_{8948}], w_3[s_{8948}], r_3[s_{9211}], w_3[s_{9211}], r_3[s_{9533}], w_3[s_{9533}], c_3$

a For the concurrent executions below, determine which is CSR, RC, ACA or ST. For those which are not CSR, state what anomaly has occurred.

i) $H_a = r_3[s_{8491}], w_3[s_{8491}], r_3[s_{8948}], w_3[s_{8948}], r_3[s_{9211}], r_1[s_{9211}], r_1[s_{8948}], r_1[s_{8491}], w_3[s_{9211}], r_3[s_{9533}], w_3[s_{9533}], r_1[s_{9533}], c_3, c_1$

ii) $H_b = r_1[s_{9211}], r_3[s_{8491}], r_1[s_{8948}], r_1[s_{8491}], w_3[s_{8491}], r_3[s_{8948}], w_3[s_{8948}], r_3[s_{9211}], w_3[s_{9211}], r_3[s_{9533}], r_1[s_{9533}], c_1, w_3[s_{9533}], c_3$

b Write the sequence of operations H_2 that Q_2 will execute (ignoring locks, as in H_1 and H_3 above).

c Give a concurrent execution of H_1, H_2, H_3 which produces a deadlock state, where all three transactions are unable to proceed.

d Horizontal fragmentation has been applied such that `stock` with `category='COMP'` are held on S_1 and other stock records are held on S_2. Define this fragmentation using the relational algebra, and also define how `movement` should be distributed such that records of movements are held on the same site as the stock item to which they pertain. State what type of fragmentation you used for `movement`.

e Draw the distributed waits-for graph for the answer to (c), using the information from (d) as appropriate.

f If the great majority of queries are of the general form of Q_1 and Q_2, briefly discuss if the distribution of data described in (d) is suited to avoiding distributed deadlocks.

g If in practice it was found that there was a very high occurrence of blocking between transactions of the general form of Q_1 waiting for transactions of the form Q_2, how would you redistribute the data to avoid this blocking?

The seven parts of this question are worth, respectively, 20%, 10%, 14%, 16%, 16%, 10%, and 14% of the total marks

2a In the context of two-phase locking (2PL)

i) Briefly explain what is meant by strict locking, and briefly explain three advantages of using strict locking over general 2PL.

ii) The following is an *incorrect* implementation of 2PL. Determine how the execution fails to meet the general rules of 2PL.
$H_e = b_4, rl_4[o_1], r_4[o_1], wl_4[o_1], w_4[o_1], wu_4[o_1], rl_4[o_2], r_4[o_2], w_4[o_2], ru_4[o_2], c_4$

iii) Rewrite H_e to obey strict 2PL.

iv) Rewrite H_e to obey conservative 2PL.

b The following is a simplified version of the stock and movements database, where we record in `movement` the stock movements on entries in the `stock` table. The `part` field of `movement` is a foreign key of `stock`. If `stock` is held on S_1 and `movement` is held on S_2, and all fields are 4 bytes in size:

stock	
part	level
8491	50
8948	6
9211	10
9533	0

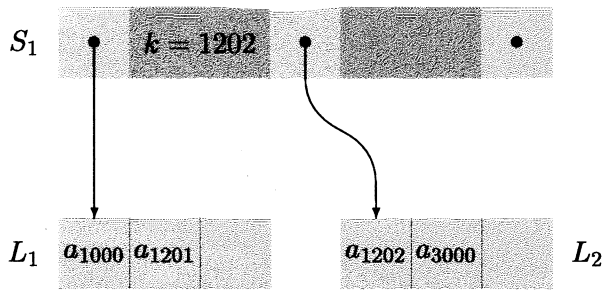
movement		
mid	part	qty
2100	8491	15
2101	8948	-4
2102	8948	-1
2107	8491	-5

i) Compute the cost of performing the natural join between `movement` and `stock` on S_2, using both the direct implementation of join, and using the semi-join method, and demonstrate that the semi-join method is more efficient.

ii) What is the percentage of rows that must match in `stock` before the semi-join method becomes less efficient?

iii) Briefly explain which join method you would expect to be more efficient if the join was processed at S_1.

c The following diagram illustrates the state of a B-tree index for table a where the primary key field is k.



i) Draw the B-tree that would be stored after the following sequence of operations:
$ins_5[a_{4999}], ins_5[a_{1100}], ins_5[a_{1200}]$

ii) Briefly explain which of the inserts in (i) would conflict with $w_6[a_{1202}]$.

The three parts of this question are worth, respectively, 36%, 34%, and 30% of the total marks

3a The following is a series of operations performed by the recovery manager in a DBMS, and *cp* represents a cache consistent checkpoint record occurring during the execution.

$r_7[o_3], r_5[o_1], w_5[o_2], c_5, w_6[o_1], w_8[o_4], cp, r_6[o_2], c_6, w_9[o_2], w_7[o_3], w_8[o_5], a_7$

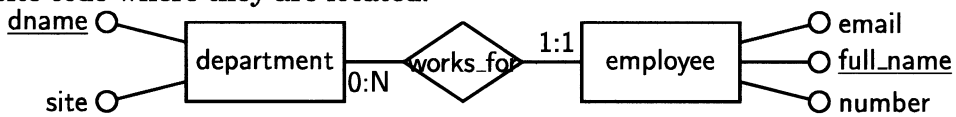
i) Briefly explain what the purpose of *checkpoints* are in general, and briefly outline what are the principal steps in a *cache consistent checkpoint*.

ii) Name the transaction(s) that *must* be listed in the checkpoint record *cp*.

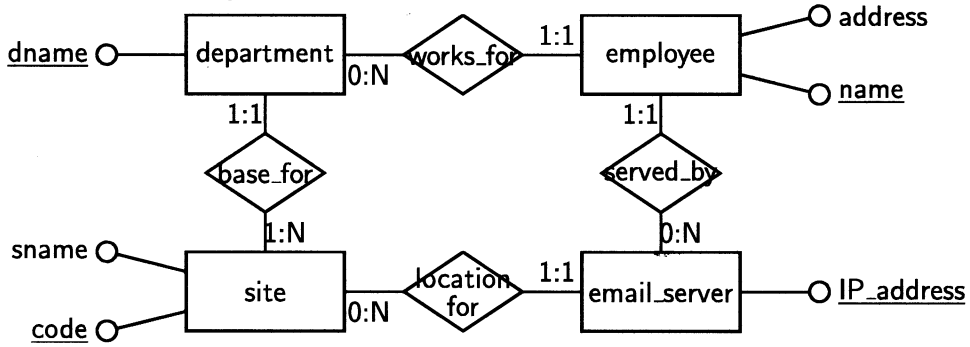
iii) If a recovery operation were to be performed, which operations need to be redone, and which undone?

b Integrate the **telephone** and **email** ER models described below into a single federated ER model. Apart from the final ER model, your answer should clearly enumerate the transformations/deletions of objects used in performing the integration, and give the stage (conforming, merging, or improvement) in the schema integration at which the transformation/deletions were applied. The full answer contains ten steps, where a step is of the form 'rename x to y', 'merge x and y', *etc.* Note that merging two entities and all their associated relationships and attributes counts as one step.

Sales: The ER schema shown below stores records for every employee in Bloggs Ltd, identifying the employee by their full name held in full_name, and recording the internal phone number. A boolean flag email is set TRUE if the person has been allocated an email account, but no other details of the email account are kept. All employees are associated with the department for which they work, departments being identified by their full title dname. A record is kept of the three letter site code where they are located.



Email: The ER schema shown below stores records only for employees in Bloggs Ltd who have an email account. Employees are identified by their full name held in name, and address holds their email address. A record is kept of the departments in which employees work, departments being identified by their full name dname. A record is also kept of the email server used by the employees. Both email servers and departments are located on sites, where sites are identified by a three letter code attribute, and are given a site name sname.



The two parts of this question are worth, respectively, 40% and 60% of the total marks

4a In a database replicated over eight servers, it is found that on average there are 1000 writes per hour, and 800 reads per hour. The following alternative distributed locking mechanisms are available:

i) reads sent to all servers, writes sent to one server.

ii) reads sent to five servers, writes sent to four servers

iii) reads sent to three servers, writes sent to six servers.

iv) reads sent to one server, writes sent to all servers.

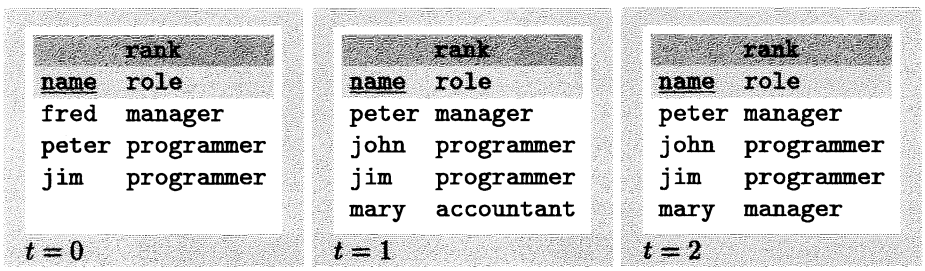
Briefly explain which (if any) of the options are invalid, in the sense of failing to correctly detect some conflicts. For those which you think are valid, calculate the total number of locks required to be made across the database per hour, and hence state which option will give the best performance.

b Briefly explain why *two-phase commit* (2PC) *blocks*. Briefly explain how the following two protocols avoid *blocking* by modifying the basic 2PC protocol. (As part of each answer describe a disadvantage each has when compared with 2PC).

i) Three phase commit (3PC)

ii) Uniform timed reliable broadcast (UTRB)

c The following shows a temporal database represented in the temporal structure for the valid time records of a table recording the rank of people in the company.



rank

name	role
fred	manager
peter	programmer
jim	programmer

$t = 0$

rank

name	role
peter	manager
john	programmer
jim	programmer
mary	accountant

$t = 1$

rank

name	role
peter	manager
john	programmer
jim	programmer
mary	manager

$t = 2$

For each of the following temporal relation algebra queries, list the output relation if the query is run at $t = 3$, and suggest what the query is intended to do (*e.g.* 'Finds all people who have left the company'). Note that ◆ is the *sometime in the past* operator, ● is the *previous* operator, and $rank_1$ and $rank_2$ are aliases for the *rank* relation.

i) $\blacklozenge \pi_{name}\, \sigma_{role='programmer'}\, rank$

ii) $\pi_{rank_1.name,time}\, \sigma_{rank_1.name=rank_2.name \wedge rank_1.role \neq rank_2.role} \blacklozenge (rank_1 \times time \times \bullet rank_2)$

The three parts of this question are worth, respectively, 30%, 36% and 34% of the total marks