UNIVERSITY OF LONDON

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1999

BEng Honours Degree in Computing Part III
BSc Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part III
MEng Honours Degree in Information Systems Engineering Part IV
MSc Degree 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
Diploma of Membership of Imperial College
Associateship of the Royal College of Science

PAPER 3.11 / I 4.4

ADVANCED DATABASES

Monday, May 10th 1999, 10.00 – 12.00

Answer THREE questions

For admin. only:
paper contains 4 questions

1a In the context of distributed databases, explain what is meant by a *minterm predicate.*

Discuss the conditions under which a set of predicates would be considered to be:

i) minimal

ii) complete

By choosing a suitable example, explain why a complete set may not necessarily be minimal.

b Distinguish between *fragmentation transparency* and *replication transparency.*

The information defining the fragmentation to be adopted would often form part of the data dictionary for the database. Discuss how the location of the data dictionary affects the degree of site autonomy that can be achieved.

c The following three relations have been defined and are currently in use in an organisation.

E_1 (EmpNo,Name,Salary,Site)

E_2 (EmpNo,ProjNo,Job,Start-date)

E_3 (ProjNo,Control-site,Duration)

Currently an employee may work at more than one site. Relation E_1 gives the site(s) at which an employee is working, in addition to the employee's personal details.

An employee may be working on more than one project. Relation E_2 gives for each employee the project number(s) on which he is working, and for each such project, his job title and the date he started on the project.

A project is controlled from one site. Relation E_3 gives the control-site and expected duration for each project.

The organisation now wishes to fragment the three relations in the following manner:

E_1 is to be horizontally fragmented on Site

E_2 is to have a fragmentation derived from that of E_1

E_3 is to have a fragmentation derived from that of E_2.

i) Using the *semi-join* operator, give a relational algebra expression to define the fragments that are to be obtained from E_3.

ii) Two of the conditions that should be satisfied by the fragmentation process are *completeness* and *disjointness*. Explain what is meant by these and discuss the assumptions that need to be made and any restrictions that need to be imposed if these conditions are to be met in this example.

iii) Suggest an alternative fragmentation process for E_2 and/or E_3 and discuss any advantages it may have over the fragmentation process proposed above.

The three parts carry, respectively, 25%, 25% and 50% of the marks.

2a Explain what is meant by *transaction atomicity*.

Briefly discuss how atomicity can be achieved in a distributed environment using the two-phase commit (2PC) protocol with a hierarchical communication structure.

b Discuss the effect on the hierarchical 2PC protocol if some of the participating sites are ones at which no updates are being undertaken by the transaction in question (i.e. they are read-only sites). For both phases of the protocol, give details of all the messages sent and all the actions/decisions recorded in the local logs.

c A variation on the 2PC protocol has been suggested whereby whenever a failure occurs and a site is in doubt as to what to do with a transaction (due to the absence of relevant information), the 2PC recovery routine decides to abort the transaction.

Discuss the effect that this variation will have on the information that *needs* to be recorded in the log and on the messages that *need* to be sent during the 2PC protocol.

d If the 2PC protocol were varied such that in the event of a failure and in the absence of relevant information the 2PC recovery routine would commit (rather than abort) the transaction, show that inconsistencies could arise in the database.

The four parts carry, respectively, 15%, 35% , 30% and 20% of the marks

Turn Over .....

3a The following two global relations have been defined:

STAFF (StaffNo, StaffName,Dept)
COURSE (StaffNo, CourseNo,StudentNo,StartDate)

The following query has been formulated and is to be run against the given relations:

Find the StaffName of each member of staff teaching a course on which student with StudentNo = 1234 is registered.

i) Find the corresponding relational algebra expression. Draw the corresponding operator tree and, where necessary, optimise the tree identifying and explaining any equivalence transformations used in the optimisation process.

ii) The relation STAFF has been horizontally fragmented into STAFF1 and STAFF2.

The relation COURSE has been horizontally fragmented into COURSE1, COURSE2 and COURSE3.

Explain what is meant by a *canonical expression* and incorporate the relevant canonical expressions in the optimised operator tree produced in part (i).

Use equivalence transformations to further optimise the operator tree, identifying and explaining any transformations used.

b The following three relations have been defined:

R

A	B
1	e
2	f
3	g

S

B	C
e	u
f	v
g	w

T

C	A
u	2
v	3
w	4

R is held at site 1, S is held at site 2 and T is held at site 3.

A query requires the following relational algebra expression to be evaluated:

$$R \mathbf{JN_B} S \mathbf{JN_C} T$$

i) Give *three* different strategies for the execution of this query. The result of the query is required at site 3.

ii) Define the *semi-join* (**SJ**) operator.

iii) Let M' = M $\mathbf{SJ_A}$ N for two relations M,N with common attribute A.

The operation M $\mathbf{JN_A}$ N can be expressed as M' $\mathbf{JN_A}$ N.

Discuss the circumstances under which it will be beneficial to use the semi-join approach (i.e calculating M' $\mathbf{JN_A}$ N) when evaluating a query as opposed to executing the join directly.

iv) The semi-join approach can be extended to the case where three relations (M,N,P) are to be joined.

In this case M' can be replaced by M **SJ** (N **SJ** P); further reductions can be made by additional chains of semi-joins.

Using the relations R,S, T given above, illustrate the effect of the semi-join approach on relation R.

The two parts carry, respectively, 40% and 60% of the marks.

4a Three transactions T_1, T_2, and T_3 are to be run.

Explain clearly the difference between a *serial* execution and a *serialisable* execution of these three transactions.

Explain what is meant by a *history* and distinguish between *conflict equivalent* and *view equivalent* histories.

The following complete history has been suggested for the concurrent running of the three transactions T_1, T_2, T_3 :

$$W_1[p]\ W_2[p]\ W_2[q]\ C_2\ W_1[q]\ W_3[p]\ W_3[q]\ W_3[r]\ C_3\ W_1[s]\ C_1$$

Determine whether this history is (i) conflict serialisable
(ii) view serialisable

and, where appropriate, give the equivalent serial history/histories.

By choosing a suitable example explain why, in the presence of replicated data, it may be inappropriate to check for the serialisability of an execution by analysing the associated (conflict based) serialisation graph.

b Explain what is meant by a *phantom deadlock*. Discuss how it may arise and suggest a method by which it can be avoided.

Explain what is meant by a *victim* in the context of deadlock recovery.

It is generally agreed that when choosing a victim one attempts to find the *least cost* solution. Explain what is meant by this and discuss how an appropriate victim, that meets this criterion, is chosen. Explain why a victim that is local is often chosen in preference to one at a remote site.

The two parts carry, respectively, 60% and 40% of the marks.

End of Paper