UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1997

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

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

PAPER M3.11 / I3.2

DATABASES

Thursday, May 8th 1997, 10.00 - 12.00

Answer THREE questions

For admin. only: paper contains 4 questions

1a i) State Armstrong's axioms for functional dependencies.

ii) Using only Armstrong's axioms show that

if $(X \rightarrow Y) \wedge (X \rightarrow Z)$ then $X \rightarrow YZ$.

b i) What does it mean to say that two sets F1 and F2 of functional dependencies are equivalent?

ii) Give an irreducible cover for the following set of functional dependencies on attributes A, B, C, D, E, F. Show that your result is equivalent to the original set.

$C \rightarrow A$ $\quad\quad$ $CF \rightarrow BD$

$BC \rightarrow D$ $\quad\quad$ $ACD \rightarrow B$

$CE \rightarrow A$ $\quad\quad$ $D \rightarrow EF$

c Let A, B, C, D be sets of attributes. Show that

if $A \rightarrow B$ and $C \rightarrow D$ then $A \cup (C - B) \rightarrow BD$.

The three parts carry about 30%, 45%, 25% of the marks, respectively.

2a i) Define the Boyce-Codd normal form (BCNF).

ii) A relation R is in fourth normal form (4NF) if and only if whenever there is a multivalued dependency (MVD) $A \rightarrow\rightarrow B$ in R then either it is a trivial MVD or $A \rightarrow R$. Show that according to this definition of 4NF, any 4NF relation is also in BCNF.

b Consider a relation R(A, B, C, D, E, F) with the following set FD of functional dependencies.

FD:

$AB \rightarrow E$ $B \rightarrow F$

$F \rightarrow D$ $C \rightarrow A$

$C \rightarrow D$ $AD \rightarrow C$

i) Given that AB and BC are candidate keys for R show that R is not in BCNF.

ii) Give a lossless decomposition of R into a set of BCNF relations. Show at every step of your decomposition that it is lossless.

iii) Is your decomposition dependency preserving? Explain. There is no need to give the definition of dependency preservation.

Parts a(i), a(ii), b carry about 10%, 30%, 60% of the marks, respectively.

Turn over ...

3a For each of the following state, without explanation, whether it is true or false. $\cap$ denotes intersection, JOIN denotes natural join, $\cup$ denotes union, and * denotes product.

i) A JOIN B = A $\cap$ B if A and B have exactly the same attributes.

ii) (A * B) $\div$ B = A.

iii) (A $\div$ B) * B = A.

iv) A JOIN B = A $\cup$ B if A and B have no attributes in common.

b A hospital keeps records of its staff and surgical operations in relations with the following schema.

Supervise (Consultant, Surgeon)

Staff (Name, Jobtitle, Salary)

Operation (Patient, Opnum, Outcome)

Assist (Opnum, Name)

where a tuple <*cname, sname*> in **Supervise** indicates that surgeon named *sname* is supervised by consultant named *cname*, a tuple <*staffname, job, sal*> in **Staff** indicates that the member of staff named *staffname* earns a salary *sal* with job title *job* (for example, nurse, surgeon, consultant), a tuple <*pname, num, out*> in **Operation** indicates that a patient named *pname* has undergone an operation identified by *num* and the operation has had the outcome *out* (for example, coma, death, success), and a tuple <*num, staffname*> in **Assist** indicates that the member of staff named *staffname* assisted in the operation identified by *num*.

Express the following queries in relational algebra.

i) Give the names of all the surgeons who have assisted in operations that have resulted in coma.

ii) Give the names and job titles of all members of staff who have salaries higher than all the nurses.

iii) Give the names of all consultants each of whom supervise all the surgeons who have assisted in operations that have resulted in coma.

c Express queries b(i) and b(ii) in relational calculus.

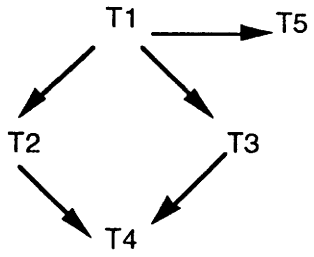
The three parts carry about 20%, 50%, 30% of the marks, respectively.

4a i) Explain when two schedules are conflict equivalent.

ii) Explain what is meant by conflict serialisable and serialisable schedules.

iii) Explain what an arc T1 ⟶ T2 in the precedence graph of a schedule of transactions indicates.

b Consider the following precedence graph of a schedule S involving transactions T1, T2, T3, T4, T5.



i) Give two serialisations for S. What is the minimum total number of serialisations possible for S? Explain, briefly.

ii) In schedule S, suppose T1 finishes after T2 finishes. Suppose further that S runs under the two phase locking protocol (2PL) that acquires shared locks for reading and exclusive locks for writing, and releases the locks acquired by a transaction after it commits.

Show that at some point the "wait-for" graph of locks for S will contain the arc

waits for

T2 ---------->T1.

c Prove that any schedule running under 2PL will be conflict serialisable if it does not deadlock.

The three parts carry about 40%, 40%, 20% of the marks, respectively.

End of paper