UNIVERSITY OF LONDON

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

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MSc Degree in Foundations of Advanced Information Technology
for Internal Students of the Imperial College of Science, Technology and Medicine

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PAPER F4.86

DEDUCTIVE DATABASES

Monday, May 13th 1996, 10.00 - 12.00

Answer THREE questions

For admin. only: paper contains
4 questions
3 pages (excluding cover page)

1 Consider the following set of first-order logic (FOL) sentences DB:

DB = { dept(ears), dept(nose), dept(lungs), dept(legs),
chief(ears, Adam), chief(lungs, Bill),
patient(Frank, lungs), patient(Graham, nose),
primary-physician(Frank, Denis). }

and the sentences

S1. Every department has a chief physician.
S2. Every patient has a 'primary physician'.
S3. For any patient in the nose department, the primary physician is whoever is the chief physician of that department.

a Express S1, S2 and S3 as FOL sentences and explain

i) what is a correct answer to a closed query when a database is regarded as a *theory*;

ii) what answers are correct if FOL sentences S1, S2 and S3 are posed as (closed) queries to the database DB;

iii) whether, viewed as integrity constraints, FOL sentences S1, S2 and S3 are satisfied by DB according to the *consistency* definition of satisfaction;

iv) whether FOL sentences S1, S2 and S3 are satisfied by DB according to the *theoremhood* definition of integrity constraint satisfaction.

b Suppose S1, S2 and S3 are read as metalevel/epistemic constraints on the content of the database. Express this alternative reading of S1, S2 and S3 as KFOPCE sentences, and explain *informally* whether these constraints are satisfied by the database DB.
In the conditions of S2, it is a matter of choice whether you write

$$K\,\exists d\ \text{patient}(x, d) \quad \text{or} \quad \exists d\ K\ \text{patient}(x, d).$$

What is the difference, and why is it of no importance in the case of this particular DB?

c Let database DB1 be DB together with the FOL sentences of part (a) and the following sentence S4:

S4. $\forall x\ [\text{chief}(\text{lungs}, x) \rightarrow \text{chief}(\text{nose}, x)\ ]$

Explain whether the KFOPCE statements of part (b) are satisfied by DB1.

d Suppose DB2 is comp(DB) together with the obvious domain closure axiom.

i) Write down the contents of DB2.

ii) Explain how the theory DB2 can be represented in a relational database RDB, and indicate *precisely* in what sense DB2 and RDB can be said to contain the same information.

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i) Write down the contents of DB2.

ii) Explain how the theory DB2 can be represented in a relational database RDB, and indicate *precisely* in what sense DB2 and RDB can be said to contain the same information.

2 Suppose serves(bar, beer) and likes(person, beer) are 'EDB' predicates stored on some external database, and frequents(person, bar) is an 'IDB' predicate defined by rules, including the following:

F1. Charles frequents all bars that serve beers he likes or Camilla likes.

F2. Will frequents all bars that do not serve beers he does not like.

F3. Diana frequents all bars frequented by Will.

a Express the above rules F1–F3 in the general clausal form $A \leftarrow W$ (A an atom, W any expression of first-order logic), and then show how they can be transformed into an equivalent form to which SLDNF can be applied.
It is not necessary to justify standard logical equivalences.

b Explain what is meant by 'range restriction' and its significance for SLDNF query evaluation. By reference to the clauses in part (a) explain why 'range restriction' is too restrictive in practice. How can the range restriction requirement be relaxed to deal with clauses such as those in part (a)? It is not necessary to give formal definitions or proofs.

c Sketch the main elements of 'coupled' deductive database systems.
Identify the main sources of inefficiency and suggest *briefly* the ways in which they may be overcome or reduced.

d Describe the main elements of the QSQR evaluation procedure. Identify its main shortcoming (besides inability to deal with negation).

3a Describe the basic elements of the AGM theory of belief/theory revision and comment on its possible applicability to the revision/updating of deductive databases.
Concentrate on the main ideas. It is *not* necessary to list all the rationality postulates or to cite detailed formal results.

b Explain what is meant by the 'view update problem' and its generalisation in deductive databases.

The two parts carry, respectively, 70% and 30% of the marks.

Turn over ...

4 Consider the following 'IDB' clauses

$h(u, t) \leftarrow init(u, t)$
$h(u, t) \leftarrow implies(v, u), h(v, t)$
$h(u, t) \leftarrow h(u, t'), next(t', t)$

and the 'EDB':

init(alive, 0), init(rich, 2), init(shot, 4),
implies(rich, happy), implies(shot, dead),
next(0,1), next(1,2), next(2,3), next(3,4), next(4,5), next(5,6).

a Give the magic set transformation of the IDB clauses for the adornment h^{bf}.

b Describe the naive and semi-naive bottom-up evaluation procedures, identifying (without proof) what it is they compute.

c Sketch enough of the computation of queries ?-h(dead, t) (on the original IDB) and ?-h^{bf}(dead, t) (on the version with magic sets) to demonstrate the advantages of

i) semi-naive computation;

ii) the magic set transformation.

d Suppose that the clauses IDB are replaced by the following IDB':

$h(u, t) \leftarrow init(u, t), not\ blocked(u, t)$
$h(u, t) \leftarrow implies(v, u), h(v, t), not\ blocked(u, t)$
$h(u, t) \leftarrow h(u, t'), next(t', t), not\ blocked(u, t)$

$blocked(u, t) \leftarrow incompatible(u, v), init(v, t)$

Construct the ABW (Apt-Blair-Walker) semantics for IDB' $\cup$ EDB', where EDB' is EDB together with the following:

incompatible(alive, shot), incompatible(happy, shot)

It is not necessary to give definitions and proofs but show each step carefully.

e Let IDB" be the set of clauses obtained from IDB' by replacing the clause for blocked by the following:

$blocked(u, t) \leftarrow incompatible(u, v), h(v, t)$

Explain why IDB" $\cup$ EDB' has no ABW semantics.
Explain how the 'stable model' ('answer set') semantics of IDB" $\cup$ EDB' is determined. It is *not* necessary to construct the stable model(s) of IDB" $\cup$ EDB' in full. There is no need to give an account of 'splitting sets'.

End of paper