UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2001

MEng Honours Degrees in Computing Part IV
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

PAPER C491

KNOWLEDGE REPRESENTATION

Thursday 10 May 2001, 14:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

1a i) Define the *extension* of a Reiter default theory (W,D) and give its inductive characterisation.

ii) Write down (without proof) the standard translation of the following Reiter default theory as an equivalent *normal logic program.*

$$D = \{ \quad \frac{b(x) \wedge m(x) : \neg w(x)}{s(x)} \qquad \frac{t(x) : \neg m(x)}{w(x)} \quad \}$$

$$W = \{ \forall x \, (b(x) \rightarrow m(x)), b(g), t(h) \}$$

iii) By identifying a suitable property of the resulting logic program, or otherwise, explain why the default theory of part (ii) has a unique extension. It is not necessary to construct the extension itself. You may state standard results without proof.

b i) State the three defining properties of a *classical consequence operator* Cn.

ii) Let (W,D) be any Reiter default theory. Consider the consequence operator Cn_D defined as: α in $Cn_D(W)$ iff α is in the intersection of all extensions of (W,D).

Show, by means of a suitable example, that Cn_D is non-monotonic.

iii) Show that Cn_D has the other two properties of a classical consequence operator.

c For P any normal logic program, define the (non-monotonic) consequence relation |~ as follows: for any formula α of FOL, P |~ α when α is true in all stable models of P.

Consider the following logic program

$$\begin{aligned} P = \{ \; & a \leftarrow \text{not } b \\ & c \leftarrow a \\ & b \leftarrow c, \text{not } a \; \} \end{aligned}$$

i) Is it the case that P |~ a ? Is it the case that P |~ c ?

ii) Determine whether $P \cup \{c \leftarrow\}$ |~ a.

2 Consider the following set of (defeasible) rules

Alcoholics are (generally) adults.
Adults are (generally) healthy.
Alcoholics are (generally) not healthy.

and (non-defeasible) facts

Adam is an adult.
Bill is an alcoholic.
Colin is not an adult but is an alcoholic.

Show how the above example can be formulated in each of the following formalisms. In each case, explain whether Adam, Bill or Colin is healthy or not, and whether the conclusion depends on a credulous/brave or sceptical/cautious reading. The third rule should be treated as an exception to the second.

You may state any standard results without proof.

a Reiter default logic, using only normal defaults. In this case you should discuss whether the representation captures the exception structure adequately.

b Reiter default logic, without restriction to normal defaults.

c autoepistemic logic.

d circumscription.

3a Consider an argumentation process.

i) Give a brief and schematic account of the four layers under which any argumentation process can be described.

ii) Give an example in natural language of a self-defeating argument.

b Consider the case of fixed point approaches to argumentation as described by Dung (1995).

i) Define the notion of *justified argument*.

ii) State without proof the procedure according to which justified arguments can be calculated.

iii) State the advantages of the above procedure with respect to a calculation based on the definition.

c Consider the fixed point constructions given by Dung (1995) and the following set of arguments Γ, in which an arrow between two arguments indicates that one argument is defeated by another one; i.e., $A \leftarrow B$ stands for "A is defeated by B".

$$\Gamma: \quad A \leftarrow B \leftarrow C \leftarrow D$$

i) What arguments are justified, and why?

ii) Modify Γ by assuming D is self-defeating. What is the new set of justified arguments, and why?

iii) Modify Γ by assuming B is self-defeating. What is the new set of justified arguments, and why?

4 Consider a simple kind of auction in which agents make bids as follows. Any agent may *open* the bidding (when there is no current bid) at an amount N up to some designated maximum. Any agent can *raise* the current bid by N units, where again N must not exceed the designated maximum. Bids can be made by agents in any order, except that no agent may bid twice in succession. An agent may *revoke* his last bid, but only until the next valid bid is made. An agent may *withdraw* from the auction at any time, unless he has made the last (valid) bid. Once withdrawn, an agent may not resume bidding. (The 'winner' is the last agent left in the auction when all others have withdrawn, though for simplicity, this may be ignored.) The terms 'may' and 'can' are to be understood not as permission, but as part of the definition of what counts as a valid bid.

a Describe briefly the main features of the *event calculus* as a formalism for representing and reasoning about *narratives*. It is sufficient to deal with the case where event occurrences are linearly ordered and recorded in the same order in which they occur. Comment on the formulation of 'fluent pre-conditions' (context dependent effects of events).

b Construct a representation of the auction example in the event calculus. The representation should be able to record all attempted bids, revocations, and withdrawals, valid or not, and be able to determine what bids are valid at any time, the value of the current bid, and who may revoke or withdraw at any time. Comment on how your representation is able to distinguish between valid and invalid bids.

c Describe briefly the main features of the action description language $\mathcal{A}$ (Gelfond-Lifschitz) and how it can be used together with a suitable query language to represent and reason about narratives.

d Illustrate your answer to part (c) by showing how the auction example could be formulated using the language $\mathcal{A}$ and a suitable query language. It is not necessary to construct a representation complete in every detail but you must explain how every feature of the example will be treated. Assume that all fluents, such as current_bid(X,N), are propositional (true/false). Variables can be treated as shorthand for all ground instances.

You may ignore the distinction between valid and invalid bids if you judge it to be problematic, as long as you explain the source of the problem.

The four parts carry, respectively, 15%, 35%, 25%, 25% of the marks.

