THE UNIVERSITY
of LIVERPOOL

MAY 2003 EXAMINATIONS

Bachelor of Science : Year 3
Master of Science : Year 1

Multiagent Systems

TIME ALLOWED : $2\frac{1}{2}$ hours

INSTRUCTIONS TO CANDIDATES

This paper contains **five** questions in total. Answer **any four** questions only.

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions will be discarded (starting with your lowest mark).

Question 1

a) Letting $R(Ag, Env)$ denote the set of all possible runs of agent *Ag* in environment *Env*, letting $u(r)$ denote the utility of a run *r*, and letting $P(r \mid Ag, Env)$ denote the probability that run *r* occurs given agent *Ag* is placed in environment *Env*, write an equation that defines the properties of the *optimal* agent given *u* and *Env*.

[5 marks]

b) Consider the environment $Env_1 = \langle E, e_0, \tau \rangle$ defined as follows:

$$E = \{e_0, e_1, e_2, e_3, e_4, e_5\}$$
$$\tau(e_0 \xrightarrow{\alpha_0}) = \{e_1, e_2\}$$
$$\tau(e_0 \xrightarrow{\alpha_1}) = \{e_3, e_4, e_5\}$$

There are just two agents possible with respect to this environment, which we shall refer to as Ag_1 and Ag_2:

$$Ag_1(e_0) = \alpha_0$$
$$Ag_2(e_0) = \alpha_1$$

Assume the probabilities of the various runs are as follows:

$$P(e_0 \xrightarrow{\alpha_0} e_1 \mid Ag_1, Env_1) = 0.4$$
$$P(e_0 \xrightarrow{\alpha_0} e_2 \mid Ag_1, Env_1) = 0.6$$
$$P(e_0 \xrightarrow{\alpha_1} e_3 \mid Ag_2, Env_1) = 0.1$$
$$P(e_0 \xrightarrow{\alpha_1} e_4 \mid Ag_2, Env_1) = 0.2$$
$$P(e_0 \xrightarrow{\alpha_1} e_5 \mid Ag_2, Env_1) = 0.7$$

Finally, assume the utility function u_1 is defined as follows:

$$u_1(e_0 \xrightarrow{\alpha_0} e_1) = 8$$
$$u_1(e_0 \xrightarrow{\alpha_0} e_2) = 11$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_3) = 70$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_4) = 9$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_5) = 10$$

Given these definitions:

i) Determine the expected utility of the agents Ag_1 and Ag_2 with respect to Env_1 and u_1.

[8 marks]

ii) State with explanation which agent is optimal with respect to Env_1 and u_1.

[2 marks]

c) Briefly identify the main advantages and disadvantages of specifying tasks via utility functions over runs, as in part (a), above, and suggest the main alternative.

[10 marks]

Question 2

a) With particular reference to the way in which they communicate with one another, contrast the concept of an object (in the sense of object-oriented programming) with that of an agent (in the sense of multiagent systems).

[5 marks]

b) "In order to successfully communicate, agents require a common ontology of terms". With the aid of examples, and with reference to the Knowledge Interchange Format (KIF), explain what you understand by this statement.

[5 marks]

c) With the aid of examples where appropriate, explain the relative advantages and disadvantages of deliberative, reactive, and hybrid agent architectures.

[15 marks]

Question 3

a) Explain, with the aid of examples where appropriate, what you understand by *coordination* and *coherence* in the context of cooperative distributed problem solving systems.

[5 marks]

b) "The CONTRACT NET protocol takes inspiration from the way in which contracts are put out to tender in human organisations." With reference to the way in which the CONTRACT NET works, and the key issues that must be addressed in implementing it, explain what you understand by this statement.

[10 marks]

c) Suggest how the CONTRACT NET protocol may be implemented in terms of the FIPA agent communication language.

[10 marks]

Question 4

a) In the context of logic-based argument systems:

i) Define the notion of an *argument*.

[1 marks]

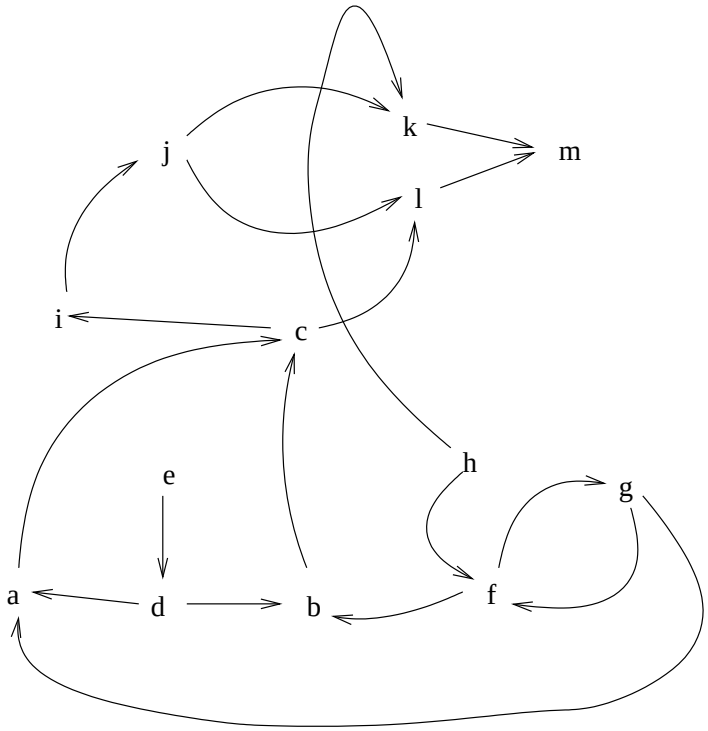
ii) Define the notion of one argument *undercutting* another.

[2 marks]

iii) Define the notion of one argument *rebutting* another.

[2 marks]

b) The following figure shows an abstract argument system.



Explain the status of the following arguments, justifying your answer in each case:

a b c d e f g h i j

[2 marks each]

Question 5

a) Define the *prisoner's dilemma*, and in particular explain why it is a "dilemma".

[4 marks]

b) Define the notion of Nash equilibrium, and identify and explain the single Nash equilibrium in the prisoner's dilemma.

[6 marks]

c) In negotiation scenarios, the *negotiation set* is the set of proposals, or deals, over which the agents are negotiating. It is usually defined as the set of possible deals that are *individual rational* and *Pareto optimal*. Define what is meant by these terms.

[4 marks]

d) Briefly define the *monotonic concession protocol* for negotiation.

[5 marks]

e) The Zeuthen strategy for negotiation answers two questions that must be answered on any given round of negotiation: *who should concede?* and *how much should they concede?* Explain the answers that the Zeuthen strategy provides to these questions.

[6 marks]