PAPER CODE NO. COMP310	EXAMINER : **Dr Shaheen Fatima** DEPARTMENT : Computer Science Tel. No. **46798**

THE UNIVERSITY
of LIVERPOOL

MAY 2006 EXAMINATIONS

Bachelor of Arts: Year 3
Bachelor of Engineering: Year 3
Bachelor of Science: Year 3
Bachelor of Science: Year 4
Doctor of Philosophy: Year 2
Master of Engineering: Year 3
Master of Engineering: Year 4
Master of Philosophy: Year 2
No qualification aimed for: Year 1

MULTIAGENT SYSTEMS

TIME ALLOWED: Two and a Half Hours

INSTRUCTIONS TO CANDIDATES

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

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

THE UNIVERSITY
of LIVERPOOL

Question 1

a) The design of an agent depends on the type of the environment it will inhabit. With the help of examples explain the difference between *deterministic* and *non-deterministic* environments.

[5 marks]

b) Let $R(Ag, Env)$ denote the set of all possible runs of agent Ag in environment Env. Also, let $u(r)$ denote the utility of a run r and $P(r|Ag, Env)$ 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]

c) 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:

$$P(e_0 \xrightarrow{\alpha_0} e_1 \mid Ag_1, Env_1) = 0.6$$
$$P(e_0 \xrightarrow{\alpha_0} e_2 \mid Ag_1, Env_1) = 0.4$$
$$P(e_0 \xrightarrow{\alpha_1} e_3 \mid Ag_2, Env_1) = 0.3$$
$$P(e_0 \xrightarrow{\alpha_1} e_4 \mid Ag_2, Env_1) = 0.4$$
$$P(e_0 \xrightarrow{\alpha_1} e_5 \mid Ag_2, Env_1) = 0.3$$

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

$$u_1(e_0 \xrightarrow{\alpha_0} e_1) = 10$$
$$u_1(e_0 \xrightarrow{\alpha_0} e_2) = 70$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_3) = 8$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_4) = 35$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_5) = 3$$

Given these definitions, determine the expected utility of the agents Ag_1 and Ag_2 with respect to Env_1 and u_1, and explain which agent is optimal with respect to Env_1 and u_1.

[10 marks]

d) An alternative to specifying tasks via utility functions over runs, as in part (c), above, is to specify them as predicates over runs. Briefly explain how tasks are specified as predicates over runs.

[5 marks]

Question 2

a) The concept of an agent is usually defined in terms of its properties, chief among which are the following:

- reactivity
- proactiveness
- social ability

Briefly explain the above three properties.

[6 marks]

b) With 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).

[6 marks]

c) With the aid of an example, explain how decision making is done in a procedural reasoning agent in terms of *deliberation* and *means-ends reasoning*.

[5 marks]

d) Practical reasoning is reasoning directed towards actions – the process of figuring out what to do. Briefly explain the role of *intentions* in practical reasoning.

[8 marks]

Question 3

a) Explain, with the help of examples where appropriate, the difference between *task sharing* and *result sharing* in the context of cooperative distributed problem solving systems.

[5 marks]

b) The CONTRACT NET protocol is one of the most widely used cooperation protocols in multiagent systems. Briefly explain how the protocol works and the main stages of it, making clear how FIPA performatives might be used to implement these stages.

[10 marks]

c) The following is a short KQML/KIF dialogue between two agents, with respect to an engineering domain.

```
(stream-about
     :sender A
     :receiver B
     :language KIF
     :ontology motors
     :reply-with q1
     :content m1
)
(tell
     :sender B
     :receiver A
     :in-reply-to q1
     :content (= (torque m1) (scalar 12 kgf))
)
(tell
     :sender B
     :receiver A
     :in-reply-to q1
     :content (= (status m1) normal)
)
(eos
     :sender B
     :receiver A
     :in-reply-to q1
)
```

Give an interpretation of this dialogue, making clear in your answer the role that the various components of the messages are playing.

[10 marks]

THE UNIVERSITY
of LIVERPOOL

Question 4

a) Consider the following two payoff matrices for agents *i* and *j*:
Payoff matrix A:

		i defect	*i* coop
j	defect	2 / 2	1 / 4
j	coop	4 / 1	3 / 3

Payoff matrix B:

		i defect	*i* coop
j	defect	1 / 1	2 / 4
j	coop	4 / 2	3 / 3

Define the concept of strongly and weakly dominant strategies. With reference to the above two payoff matrices, identify which strategies (if any) are strongly dominant and which are weakly dominant.

[10 marks]

b) Define the concept of Nash equilibrium strategy pair. Explain why the concept of Nash equilibrium strategies is important. Identify with justification which (if any) strategy pairs in the two payoff matrices *A* and *B* in part (a), above, are in Nash equilibrium.

[10 marks]

c) Briefly explain the *monotonic concession protocol* for negotiation.

[5 marks]

Question 5

a) *Mechanism design* is the design of protocols for governing multiagnet interactions, such that the outcomes generated by these protocols have certain desirable properties. Two of these desirable properties are the following:

- Individual rationality
- Pareto optimality

Briefly explain the above properties.

[5 marks]

b) *Auctions* are an important mechanism for buying and selling resources in multiagent systems. With the help of examples explain the difference between the following types of auctions:

- *first price* and *second price auctions*
- *open cry* and *sealed bid auctions*
- *one shot* and *ascending auctions*

[15 marks]

c) 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]