PAPER CODE NO. **COMP310**	EXAMINER : Michael Wooldridge DEPARTMENT : Computer Science Tel. No. 7790

UNIVERSITY OF LIVERPOOL

SECOND SEMESTER 2010/11 EXAMINATIONS

Multiagent Systems

TIME ALLOWED : Two and a Half hours

INSTRUCTIONS TO CANDIDATES

Answer **four** questions.

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

Question 1

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

$$E = \{e_0, e_1, e_2, e_3, e_4, e_5\}$$
$$\tau(e_0 \xrightarrow{\alpha_0}) = \{e_1, e_2, e_3\}$$
$$\tau(e_0 \xrightarrow{\alpha_1}) = \{e_4, e_5, e_6\}$$

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:

$$P(e_0 \xrightarrow{\alpha_0} e_1 \mid Ag_1, Env_1) = 0.7$$
$$P(e_0 \xrightarrow{\alpha_0} e_2 \mid Ag_1, Env_1) = 0.2$$
$$P(e_0 \xrightarrow{\alpha_0} e_3 \mid Ag_1, Env_1) = 0.1$$
$$P(e_0 \xrightarrow{\alpha_1} e_4 \mid Ag_2, Env_1) = 0.6$$
$$P(e_0 \xrightarrow{\alpha_1} e_5 \mid Ag_2, Env_1) = 0.3$$
$$P(e_0 \xrightarrow{\alpha_1} e_6 \mid Ag_2, Env_1) = 0.1$$

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

$$u_1(e_0 \xrightarrow{\alpha_0} e_1) = 10$$
$$u_1(e_0 \xrightarrow{\alpha_0} e_2) = 6$$
$$u_1(e_0 \xrightarrow{\alpha_0} e_3) = 5$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_4) = 12$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_5) = 3$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_6) = 4$$

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.

[15 marks]

[. . . Question 1 continued. . .]

b) According to McCarthy, when is it *legitimate* to use the intentional stance to explain and predict the behaviour of machines?

[5 marks]

c) According to McCarthy, when is it *useful* to use the intentional stance to explain and predict the behaviour of machines?

[5 marks]

Question 2

The following pseudo-code defines a control loop for a practical reasoning (“BDI”) agent.

```
B := B_0;    I := I_0;
while true do
    get next percept ρ;
    B := brf(B, ρ);
    D := options(B, I);
    I := filter(B, D, I);
    π := plan(B, I);
    while not (empty(π) or succeeded(I, B) or impossible(I, B)) do
        α := hd(π);
        execute(α);
        π := tail(π);
        get next percept ρ;
        B := brf(B, ρ);
        if reconsider(I, B) then
            D := options(B, I);
            I := filter(B, D, I);
        end-if
        if not sound(π, I, B) then
            π := plan(B, I)
        end-if
    end-while
end-while
```

With reference to this pseudo-code, explain the purpose/role of the following components:

a) The variables B, D, and I. [6 marks]

b) The percept ρ. [2 marks]

c) The *brf*$(\ldots)$ function. [2 marks]

d) The *options*$(\ldots)$ function. [2 marks]

e) The *filter*$(\ldots)$ function. [2 marks]

f) The *plan*$(\ldots)$ function. [2 marks]

g) The *sound*$(\ldots)$ function. [2 marks]

h) The *succeeded*$(\ldots)$ and *impossible*$(\ldots)$ functions. [2 marks]

i) The *reconsider*$(\ldots)$ function — in your answer to this part of the question, you should make clear what properties this function should have, and the situations in which it can be assumed to be functioning correctly.

[5 marks]

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Question 3

In the answer to this question, you may wish to use some of the notation used in Question 1.

a) It has been argued that the multi-agent systems paradigm emerged from five ongoing trends in computing. Explain what you understand these trends to be.

[5 marks]

b) Explain what is meant by a *predicate task specification*, and how such a specification relates to utility functions over runs.

[5 marks]

c) Explain what is meant by an *achievement goal*.

[5 marks]

d) Explain what is meant by a *maintenance goal*.

[5 marks]

e) Two key problems that arise in deductive/symbolic agent architectures are *transduction* and *representation/reasoning*. Explain what you understand by these problems.

[5 marks]

Question 4

a) "If we choose voting protocols that are hard to manipulate, then computational complexity can come to the rescue of social choice theory." Explain and critically assess this argument, highlighting any practical weaknesses in it.

[15 marks]

b) Explain with the aid of examples how it is possible for an unscrupulous election organiser to manipulate the agenda in sequential pairwise majority elections in order to favour a particular candidate.

[10 marks]

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Question 5

The following payoff matrix (A) is for the “prisoner’s dilemma”.

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

The following payoff matrix (B) is for “matching pennies”.

		i heads	*i* tails
j	heads	-1 1	1 -1
	tails	1 -1	-1 1

The following payoff matrix (C) is for “game of chicken”.

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

a) For each of these payoff matrices:

   i) identify all (pure strategy) Nash equilibria;

   ii) identify all Pareto optimal outcomes;

   iii) identify all outcomes that maximise social welfare.

[18 marks]

b) “Program equilibria make cooperation possible in the one-shot prisoner’s dilemma”. Explain and critically assess this statement.

[7 marks]