UNIVERSITY OF LIVERPOOL

MAY 2010 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) The extent to which it is easy or hard to develop an agent to carry out a task in some environment depends to some extent on whether the agent's environment is (i) accessible *vs* inaccessible; (ii) static *vs* dynamic; (iii) episodic *vs* non-episodic; and (iv) discrete *vs* continuous. With the aid of examples, explain what you understand by these distinctions, and how they relate to the difficulty of agent development.

[12 marks]

b) Explain the key commonalities and differences between the multiagent systems paradigm and the object-oriented programming paradigm.

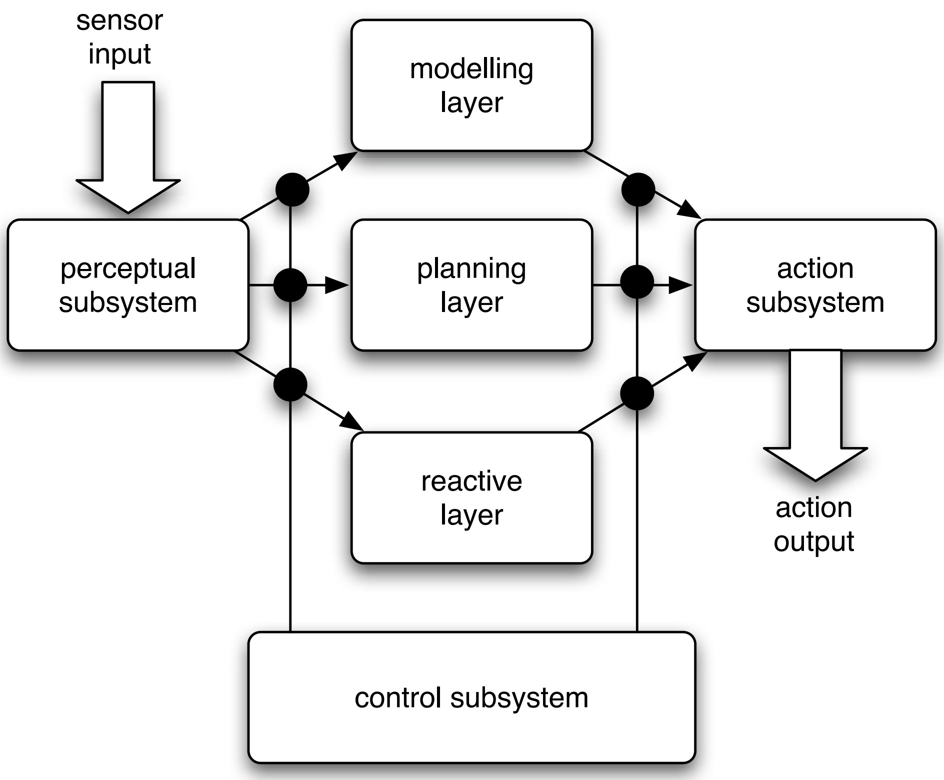
[8 marks]

c) It is commonplace in the multiagent systems literature to use the *intentional stance* to characterise agents. Explain and justify the idea of using the intentional stance in this way.

[5 marks]

Question 2

a) The following diagram illustrates the key subsystems of the TOURINGMACHINES agent architecture:



Describe the overall operation of the architecture, making sure you explain how the three decision layers achieve the goal of reactive, pro-active behaviour.

[15 marks]

b) Brooks' *subsumption architecture* attempts to avoid altogether explicit representations and explicit reasoning in decision making. Explain how it achieves this, giving particular emphasis to the key principles underpinning the architecture.

[10 marks]

Question 3

a) Consider the following marginal contribution net:

$$\begin{array}{rcl} a \wedge b & \longrightarrow & 7 \\ b & \longrightarrow & 4 \\ c & \longrightarrow & 6 \\ b \wedge c & \longrightarrow & 3 \end{array}$$

Let ν be the characteristic function defined by these rules. Give the values of the following:

i) $\nu(\emptyset)$

ii) $\nu(\{a\})$

iii) $\nu(\{b\})$

iv) $\nu(\{a,b\})$

v) $\nu(\{b,c\})$

vi) $\nu(\{a,c\})$

vii) $\nu(\{a,b,c\})$

[14 marks]

b) Informally explain what key properties the *Shapley value* is intended to capture.

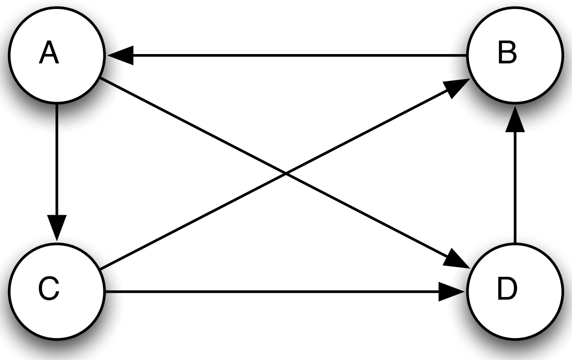
[6 marks]

c) With the aid of explanation, give the Shapley values for the players a, b, and c in the cooperative game defined above.

[5 marks]

Question 4

The following figure shows a majority graph for a social choice scenario.



a) For each of the four candidates, state whether they have any chance of winning in a sequential majority election. Where the answer is "yes", give an example of a linear agenda that would lead to the respective candidate winning.

[10 marks]

b) The *Gibbard-Satterthwaite theorem* seems to be a very negative result in social choice theory. Explain what you understand by the Gibbard-Satterthwaite theorem and its implications, and explain how computational complexity can be viewed as a positive thing with respect to this result.

[10 marks]

c) *Arrow's theorem* is a fundamental impossibility result in social choice theory. Explain what you understand by Arrow's theorem, and its implications.

[5 marks]

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Question 5

a) Consider the following payoff matrix, for the “Prisoner’s dilemma”.

i

		defect		coop	
	defect		2		1
j		2		4	
	coop		4		3
		1		3	

i) With reference to this payoff matrix, state whether or not there are any pure or mixed Nash equilibrium outcomes in the game; if there are, identify them. Justify your answer.

[10 marks]

ii) State with justification which outcomes are Pareto optimal.

[5 marks]

b) The prisoner’s dilemma is often interpreted as being proof that somehow cooperation between self interested agents is impossible. One “solution” to the prisoner’s dilemma is to consider *program equilibria*, in which players submit strategies that may be conditioned on the programs submitted by others. The following is an example of such a program:

```
IF OtherProgram == ThisProgram THEN
  COOPERATE
ELSE
  DEFECT
END-IF.
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With reference to this program, explain how the framework of program equilibria permits cooperation as a rational outcome in the prisoner’s dilemma.

[10 marks]