PAPER CODE NO.	EXAMINER : Dr T. R. Payne	Tel. No. 54251
COMP310	DEPARTMENT : Computer Science	

UNIVERSITY OF LIVERPOOL

SECOND SEMESTER EXAMINATIONS 2013/14

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).

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1. The following pseudo-code defines a control loop for a practical reasoning ("BDI") agent:

```
1.  B := B_0;
2.  I := I_0;
3.  while true do
4.      get next percept ρ;
5.      B := brf(B, ρ);
6.      D := options(B, I);
7.      I := filter(B, D, I);
8.      π := plan(B, I);
9.      while not (empty(π)
                or succeeded(I, B)
                or impossible(I, B)) do
10.         α := hd(π);
11.         execute(α);
12.         π := tail(π);
13.         get next percept ρ;
14.         B := brf(B, ρ);
15.         if reconsider(I, B) then
16.             D := options(B, I);
17.             I := filter(B, D, I);
18.         end-if
19.         if not sound(π, I, B) then
20.             π := plan(B, I);
21.         end-if
22.     end-while
23. end-while
```

(a) Recall that "*Practical Reaoning = deliberation + means end reasoning*". With reference to the above code, answer the following questions:

(i) What commitment protocol is used in this code? (**1 mark**)

Explain the meanings (and outcomes) of the program constructs:

(ii) The $options(B, I)$ function. (**2 marks**)

(iii) The $filter(B, D, I)$ function. (**2 marks**)

(iv) The $succeeded(I, B)$ function. (**2 marks**)

(v) The $impossible(I, B)$ function. (**2 marks**)

(vi) The $reconsider(I, B)$ function. (**2 marks**)

(vii) The $sound(\pi, I, B)$ function. (**2 marks**)

(b) The while loop (lines 9-22) in the above program terminates for each of the following situations. Explain briefly the result of '*deliberation*' scenario for each termination situation.

(i) $empty(\pi)$ is true, $succeeded(I, B)$ is false, and $impossible(I, B)$ is false. (**2 marks**)

(ii) $empty(\pi)$ is false, $succeeded(I, B)$ is false, and $impossible(I, B)$ is true. (**2 marks**)

(iii) $empty(\pi)$ is false, $succeeded(I, B)$ is true, and $impossible(I, B)$ is false. (**2 marks**)

(c) If the environment of the agent is **static**, that is the agent gets the **same percept all the time**, according to the above code answer *True* / *False* for each question below.

(i) The agent need not reconsider (in Step 15) to change its initial set of intentions (computed in Step 7). (**2 marks**)

(ii) The predicate $sound(\pi, I, B)$ will be either true throughout or false throughout. (**2 marks**)

(iii) The agent changes its original plan π (computed in Step 8) at least once. (**2 marks**)

2. (a) Explain what you understand by *Condorcet's Paradox* in the context of plurality elections. (**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 the implications of computational complexity 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**)

3. (a) In the context of cooperative games, consider the following marginal contribution net:

$$\begin{aligned} a \wedge b \wedge d &\rightarrow 7 \\ a \wedge b &\rightarrow 3 \\ d &\rightarrow 5 \\ a \wedge c \wedge d &\rightarrow 4 \\ a \wedge c &\rightarrow 2 \end{aligned}$$

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

(i) $\nu(\{a\})$
(ii) $\nu(\{a, c\})$
(iii) $\nu(\{b, d\})$
(iv) $\nu(\{a, d\})$
(v) $\nu(\{a, b, c, d\})$

(**10 marks**)

(b) A key issue in coalition formation is that of *stability*. Explain what you understand by this issue, and how the *core* tries to capture stability.

(A pass mark in this question may be obtained with an informal answer, but full marks can only be obtained with the formal definition of the core.) (**5 marks**)

(c) Another key issue in coalition formation is that of *fairly distributing coalitional values*. Explain what you understand by this issue, and how the *Shapley value* tries to capture a fair distribution. In your answer, you should clearly explain the properties that the Shapley value satisfies.

(A pass mark in this question may be obtained with an informal answer, but full marks can only be obtained with the formal definition of the Shapley value.) (**10 marks**)

4. (a) In Axelrod's competition, TIT-FOR-TAT seemed to be the most successful overall strategy for playing the iterated Prisoner's Dilemma. Explain the implications of this result, and what Axelrod believed were the reasons for TIT-FOR-TAT's success.

(**5 marks**)

(b) If two players play the Iterated Prisoner's Dilemma an infinite number of times, rationally sustained cooperation is possible. Explain how, assuming that players enter strategies as finite automata. (**10 marks**)

(c) Explain how the framework of *program equilibria* permits cooperation as a rational outcome in the prisoner's dilemma. (**10 marks**)

5. (a) Explain and define the solution concept of *pure strategy Nash equilibrium*. Identify with explanation the pure strategy Nash Equilibrium outcome(s) in the game of chicken, defined by the following payoff matrix:

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

(**10 marks**)

(b) Give an example of a game which has no pure strategy Nash equilibria, and give an example of a mixed strategy Nash equilibrium in this game. (**10 marks**)

(c) Define and give an example of *dominant strategy equilibrium*. (**5 marks**)