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MAY 2009 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) Daniel Dennett proposed the *intentional stance* as a way of explaining and predicting the behaviour of certain complex systems. Explain what you understand by the intentional stance, contrasting it with other possible possible ways of explaining and predicting the behaviour of complex systems, and discussing where it is most appropriately applied and useful. To what extent is it *legitimate* or *useful* to use the intentional stance for explaining, predicting the behaviour of, and programming computer systems?

[10 marks]

b) Shoham's *Agent Oriented Programming* paradigm, as exemplified in the Agent0 language, was a first attempt to program computers using the intentional stance. Figure 1 shows a fragment of Agent0 code. With reference to this code, describe:

- how programs in Agent0 are constructed;

[5 marks]

- the overall control loop for Agent0;

[5 marks]

- how agents in Agent0 communicate.

[5 marks]

```
(defagent plane
  :timegrain 10
  :beliefs '(
       (1 (at 100 100))
       (1 (max-speed 5))
       (1 (CMT plane plane
            (INFORM 2 world (2 (plane p1 100 100))))))

  :commit-rules
  '(

  ( (control REQUEST (DO ?time (be-at ?gx ?gy)))
       () ;; no mental conditions
       control
       (DO now (cap-check ?time 'be-at ?gx ?gy)) )


  ( (control UNREQUEST (DO ?time (be-at ?gx ?gy)))
       (CMT control (DO ?time2 (be-at ?gx ?gy)))
       plane
       (DO now (uncommit ?time2 'be-at ?gx ?gy)) )

  ( () ;; no message condition
       (and (B (now (lowfuel)))
            (CMT ?agent (DO ?time2 (be-at ?z1 ?z2))))
       plane
       (REQUEST now control (UNREQUEST now plane
            (DO ?time2 (be-at ?z1 ?z2)))) )
 [...]
  )        ; ends commitment rules
)      ; ends defagent
```

Figure 1: A fragment of Agent0 code.

Question 2

The following pseudo-code defines a control loop for a practical reasoning agent.

```
B := B0;
I := I0;
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
```

a) "Practical reasoning = deliberation + means ends reasoning". With reference to the above loop, explain what you understand by "deliberation" and "means ends reasoning".

[5 marks]

b) One of the aims of this loop is to be committed to *plans* just as long as it is rational to be committed to them. Explain how the loop achieves this. In your answer, be sure to clearly identify the circumstances under which an agent reconsiders its plans.

[10 marks]

c) Another aim of the control loop is to ensure that the agent is committed to *intentions* as long as it is rational to be committed to them. Explain how the loop achieves this. In your answer, be sure to clearly identify the circumstances under which an agent reconsiders its intentions.

[10 marks]

Question 3

a) Consider the following marginal contribution net:

$$\begin{array}{rcl} a \wedge b & \longrightarrow & 5 \\ b & \longrightarrow & 2 \\ c & \longrightarrow & 4 \\ b \wedge \neg c & \longrightarrow & -2 \end{array}$$

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

i) $\nu(\emptyset)$

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

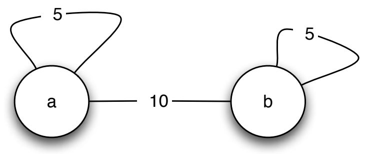
iii) $\nu(\{b\})$

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

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

[10 marks]

b) Consider the following weighted subgraph representation of a characteristic function:



Let ν be the characteristic function defined by this graph.

i) Give the values of $\nu(\{a\})$, $\nu(\{b\})$, and $\nu(\{a, b\})$.

[6 marks]

ii) Give an example of a payoff distribution that is in the core of this game, and an example of a payoff distribution that is *not* in the core of this game. In both cases justify your answer.

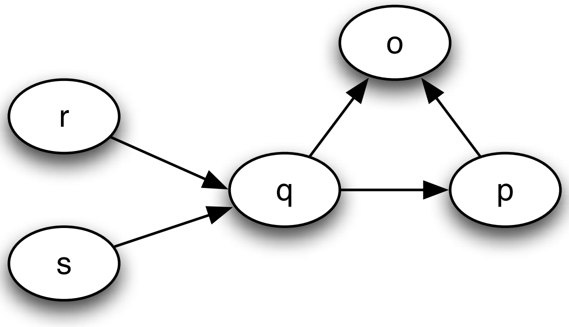
[4 marks]

iii) The Shapley value attempts to define a fair distribution of payoff to players in a coalitional game; in particular, it is the unique solution to three fairness axioms. Define and explain these fairness axioms, and give the Shapley value of players *a* and *b* for this game.

[5 marks]

Question 4

The following figure shows an abstract argument system.



a) Give an example of a non-empty preferred extension for this argument system, if one exists, else justify why none exists.

[5 marks]

b) For each argument in the above argument system, say whether it is *sceptically accepted*, *credulously accepted*, or *neither*.

[5 marks]

c) With reference to the abstract argument system above, compute the *grounded extension*, giving the ultimate status (in or out) of all arguments.

[10 marks]

d) In the context of *deductive argument systems*, we think of arguments attacking each other via *rebuttal* and *undercut*. With the aid of an example, explain these notions.

[5 marks]

Question 5

a) Consider the following payoff matrix, for the game of "matching pennies".

		i	
		defect	coop
j	defect	-1 1	1 -1
	coop	1 -1	-1 1

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 whether any outcomes are Pareto optimal; if there are any, identify them. Justify your answer.

[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.
```

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]