PAPER CODE NO.
COMP310

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Mock (Revision) 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).

1. (a) The *deliberative* or *symbolic* paradigm is historically the dominant approach to building autonomous intelligent agents. There are two fundamental problems to be solved if one aims to build such agents. Describe what you understand by these problems.

(4 marks)

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

(8 marks)

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

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

There are just two agents 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:

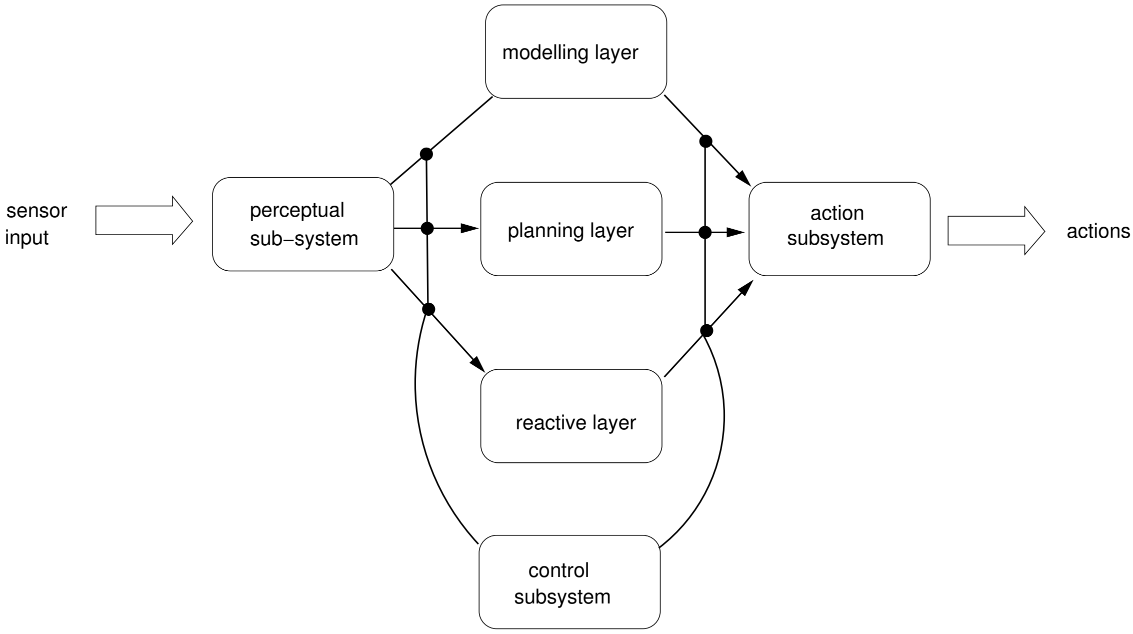
$$P(e_0 \xrightarrow{\alpha_0} e_1 \mid Ag_1, Env_1) = 0.2$$
$$P(e_0 \xrightarrow{\alpha_0} e_2 \mid Ag_1, Env_1) = 0.2$$
$$P(e_0 \xrightarrow{\alpha_0} e_3 \mid Ag_1, Env_1) = 0.6$$
$$P(e_0 \xrightarrow{\alpha_1} e_4 \mid Ag_2, Env_1) = 0.2$$
$$P(e_0 \xrightarrow{\alpha_1} e_5 \mid Ag_2, Env_1) = 0.3$$
$$P(e_0 \xrightarrow{\alpha_1} e_6 \mid Ag_2, Env_1) = 0.5$$

Assume the utility function u_1 is defined as follows:

$$u_1(e_0 \xrightarrow{\alpha_0} e_1) = 8$$
$$u_1(e_0 \xrightarrow{\alpha_0} e_2) = 7$$
$$u_1(e_0 \xrightarrow{\alpha_0} e_3) = 4$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_4) = 8$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_5) = 2$$
$$u_1(e_0 \xrightarrow{\alpha_1} e_6) = 5$$

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. Include an explanation of your calculations in your solution. **(13 marks)**

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) The Blocksworld scenario is represented by an ontology with the following formulae:

$On(x, y)$	obj x on top of obj y
$OnTable(x)$	obj x is on the table
$Clear(x)$	nothing is on top of obj x
$Holding(x)$	arm is holding x

An agent has a set of actions Ac , such that $Ac = \{Stack, UnStack, Pickup, PutDown\}$:

	$Stack(x, y)$
pre	$Clear(y)\ \&\ Holding(x)$
del	$Clear(y)\ \&\ Holding(x)$
add	$ArmEmpty\ \&\ On(x, y)$

	$UnStack(x, y)$
pre	$On(x, y)\ \&\ Clear(x)\ \&\ ArmEmpty$
del	$On(x, y)\ \&\ ArmEmpty$
add	$Holding(x)\ \&\ Clear(y)$

	$Pickup(x)$
pre	$Clear(x)\ \&\ OnTable(x)\ \&\ ArmEmpty$
del	$OnTable(x)\ \&\ ArmEmpty$
add	$Holding(x)$

	$PutDown(x)$
pre	$Holding(x)$
del	$Holding(x)$
add	$OnTable(x)\ \&\ ArmEmpty\ \&\ Clear(x)$

It also has the following beliefs B_0 regarding the three bricks $\{A, B, C\}$, and the intention i:

$Beliefs\ B_0$	$Intention\ i$
$Clear(B)$	$Clear(A)$
$Clear(C)$	$Clear(B)$
$On(C, A)$	$On(B, C)$
$OnTable(A)$	$OnTable(A)$
$OnTable(B)$	$OnTable(C)$
$ArmEmpty$	$ArmEmpty$

Calculate a plan π that would achieve i, given the beliefs B_0. Draw the environment at the beginning of the plan, and after every time a $Stack$ or $UnStack$ action is performed. **(10 marks)**

3. (a) A *coalitional game with transferable payoff* is a structure $\langle Ag, \nu \rangle$. Explain what each of the components in the structure are, what they are intended to represent, and what the computational issues are if such structures are to be used for reasoning about multi-agent systems. **(5 marks)**

(b) In the context of cooperative games, consider the following marginal contribution net:

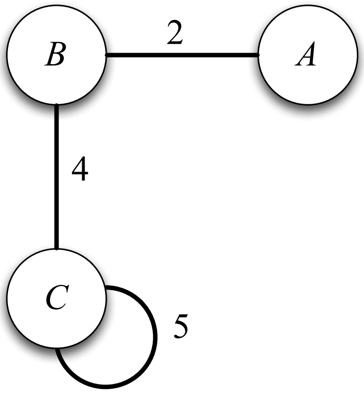
$$\begin{aligned} a \wedge b &\rightarrow 6 \\ b &\rightarrow 3 \\ c &\rightarrow 4 \\ b \wedge \neg c &\rightarrow 2 \end{aligned}$$

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

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

(10 marks)

(c) 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 $\nu(\{A, B\})$, $\nu(\{C\})$, and $\nu(\{A, B, C\})$. **(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)**

4. (a) In a combinatorial auction, a bid is made for the following bundles:

$$B_i = (\{a, b\}, 4)\ XOR\ (\{c, d\}, 7)$$

Calculate what would be paid for the following bundles:

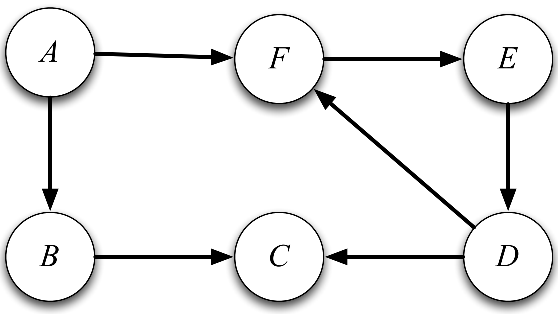
(i) $v_{\beta_1}(\{a\})$
(ii) $v_{\beta_1}(\{a, b\})$
(iii) $v_{\beta_1}(\{a, b, c\})$
(iv) $v_{\beta_1}(\{a, b, c, d\})$

(8 marks)

(b) Describe the *Vickrey Auction*, and explain why it is *incentive compatible*; i.e. it is in the bidder's interest to bid their true value.

(5 marks)

(c) The following figure shows an abstract argumentation system.



Compute the grounded extension of this argument system, giving the status (*in* or *out*) of all of the six arguments in the graph, and explain why they are either *in* or *out*.

(2 marks each, for a total of 12 marks)

5. The following payoff matrix (A) is for the "prisoner's dilemma":

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

The following payoff matrix (B) is for the "stag hunt":

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

The following payoff matrix (C) is for "matching pennies":

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

(a) For each of these payoff matrices:

(i) Identify all (pure strategy) Nash Equilibria;

(i) 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)**