Xi'an Jiaotong-Liverpool University
西交利物浦大学

Module Code	Examiner	Email of Examiner	TEL
CSE 304			

2nd SEMESTER 2019/20 Remote Open-Book Exam

Undergraduate – Year 4

MULTIAGENT SYSTEMS

Exam Duration: *2 Hours*

Crash Time Allowed: *30 Minutes*

INSTRUCTIONS TO CANDIDATES

1. **This is a remote open-book exam. Please sign the integrity disclaimer *immediately after you initiate the online open-book exam on ICE.* Upload your answers on ICE (when ICE Assignment function is used) together with the integrity disclaimer, and complete the assessment independently and honestly.**
2. **This exam consists of five questions. There are a total of 100 marks. The numbers within square brackets or parentheses on the right indicate the marks for each question. Relevant and clear steps should be included in the answers. Answer all questions. There is NO penalty for providing a wrong answer.**
3. **Only English solutions are accepted. *Answers need to be handwritten and fully and clearly scanned or photographed for submission as one single document in PDF format via ICE (Take-home open book exam).***
4. **The duration is *2 hours*, and an additional *30-minute* crash time beyond the exam duration will be allowed for you to report and resolve minor technical issues which may be encountered during the exam. Where there are any major problems preventing you from continuing the exam or submitting your answers in time, please do not hesitate to email the Module Examiner or Assessment Team of Registry.**

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Notes:

- **To obtain full marks for each question, relevant and clear steps must be included in the answers.**
- **Partial marks may be awarded depending on the degree of completeness and clarity.**

Question 1: **[15 marks]**

(a) The *InteRRaP* architecture is classified as a hybrid agent architecture. If you think that this statement is true, explain why and describe the overall operations of the *InteRRaP* architecture. Otherwise, give two reasons to explain why the *InteRRaP* architecture is not classified as a hybrid agent architecture.

(5 marks)

(b) What do you understand by a *Vickrey auction* and an *English auction*? Outline also the difference between a *Vickrey auction* and an *English auction.*

(3 marks)

(c) Consider a 5-by-5 cell *Vacuum World* as follows:

	a	b	c	d	e
5	*				H
4		H			
3			*		
2	R			*	
1		*			H

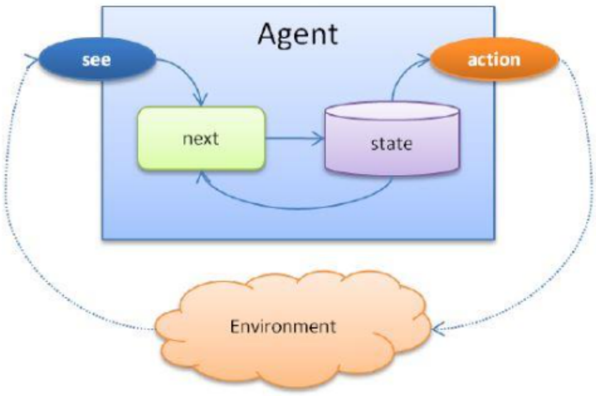
where "R" represents a robot agent, "H" represents a hole and "*" represents dirt.

1. Develop a set of rules (including predicates and actions) that can be used to describe the above 5-by-5 cell *Vacuum World.*
2. Use these rules to instruct the robot agent to clean up all the dirt starting from (2,a) while avoiding falling into any hole.

(7 marks)

Question 2: **[24 marks]**

(a) The following diagram illustrates the schematic of "*an agent architecture*":



State the principal function of each component of the above *agent architecture* and briefly describe how they interact with each other.

(6 marks)

(b) What you understand by "*Commitments*" in *Practical Reasoning* and explain the common three types of commitments in *Practical Reasoning*.

(4 marks)

(c) The following pseudo-code designs a control loop for a *Practical Reasoning* (DBI: *Beliefs-Desires-Intentions*") 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 , Ac);
  while not (false) do
      α := head(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 , Ac);
    end - if
  end - while
end - while
```

With reference to the above code, answer the following four questions:

1. What commitment protocol is used in this code?
2. What should be modified in this code if the commitment protocol "*Open-minded commitment*" is used?
3. What should be modified in this code if the commitment protocol "*Overcommitted*" is used?
4. Assume the commitment protocol "*Single-minded commitment*" is used in the above code. When should an agent stop to reconsider its intentions?

(7 marks)

(d) *Blocks World*: Consider the *initial* configuration in Figure 1 and the *goal* configuration in Figure 2.

1. Define a set (should be as small as possible) of predicates to describe the above two configurations.
2. Design a plan (which consists of a list of actions with "pre-condition list", "delete list" and "add list") that can be used to achieve the goal configuration, starting from the initial configuration.

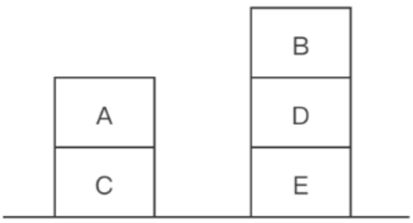


Figure 1: Initial configuration

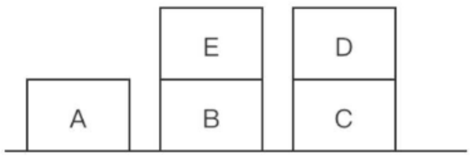


Figure 2: Goal configuration

(7 marks)

Question 3: **[22 marks]**

(a) "*Tile World*" is an example of a "*subsumption architecture*". If you think that this statement is true, describe what a "*subsumption architecture*" is and explain how "*Tile World*" works. Otherwise, give reasons to explain why "*Tile World*" is NOT an example of "*subsumption architecture*".

(4 marks)

(b) Design a subsumption architecture for the 5-by-5 cell *Vacuum World* shown in Question 1.(c) and use inhibition to coordinate the behaviors.

(6 marks)

(c) Consider the *Prisoner's Dilemma*: Prisoner I and Prisoner II are collectively charged with a crime and held in separate cells with no way of meeting or communicating. They are told that: (1) if neither confesses, each will be jailed for 3 years; (2) if one confesses and the other does not, the confessor will be freed and the other will be jailed for 10 years; and (3) if both confess, each will be jailed for 6 years. Answer the following two questions:

1. What is the payoff matrix of the above Prisoner's Dilemma problem?
2. If Prisoner I considers only his/her own interest, what will he/she do?

(5 marks)

(d) For the following three questions, consider the separate payoff matrices shown below for agents a and b that can play the strategy D or C:

Agent a	$a : D$	$a : C$
$b : D$	6	5
$b : C$	8	7

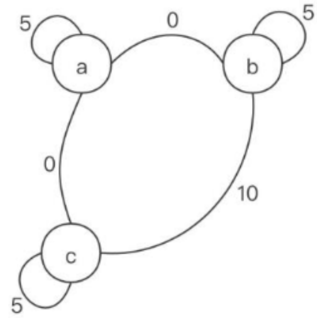
Agent b	$a : D$	$a : C$
$b : D$	6	8
$b : C$	5	7

1. Define the solution concept of *Pure Strategy Nash Equilibrium*. Identify with justification, if any, the pairs of the above payoff matrices that are in pure strategy *Nash equilibrium*.
2. Define the solution concept of *Pareto Optimality*. State whether any outcomes of the above payoff matrices are *Pareto optimal*. Justify your answers.
3. Explain the notion of the *Social Welfare* of an outcome. Identify with justification, if any, the pairs of the above payoff matrices that maximizes the *Social Welfare*.

(7 marks)

Question 4: **[19 marks]**

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



Let v be the characteristic function defined by the above subgraph. Give the values of $v(\{a\})$, $v(\{b\})$, $v(\{c\})$, $v(\{a,b\})$, $v(\{a,c\})$, $v(\{b,c\})$ and $v(\{a,b,c\})$.

(7 marks)

(b) Consider the coalitional game with agents $Ag = \{a,b,c\}$ and characteristic function v defined by the following:

- $v(i) = -1$, where $i \in Ag$
- $v(a,b) = v(a,c) = v(b,c) = 1$

The *Core* of the above coalitional game is empty. If you think that the statement is true, prove it. Otherwise, give a counterexample to show that it is false.

(6 marks)

(c) Consider the classical example: "*the glove game*" of a cooperative game. Let $G = \{Peter, Paul, Mary\}$ and suppose that *Peter* has a left-hand glove, while players *Paul* and *Mary* each have a right-hand glove. All players wish to put together a pair of gloves, which can be sold for value of 1, while unpaired gloves have no value. Thus, $v(N) = 1$ if $N \subset G$ (i.e. the set N is a strict subset of set G) contains both a left and a right glove (e.g. *Peter* and at least one of players between *Paul* and *Mary*) and $v(N) = 0$ otherwise. Compute the *Shapley values* for the *Peter*, *Mary* and *Paul*. You are required to show the relevant steps in the exam script about how you have gotten the values.

(6 marks)

Question 5: **[20 marks]**

(a) What is meant by the "*Cooperative Distributed Problem Solving (CDPS)*"? With the aid of an example, explain how the *CDPS* works. Outline the key problems that need to be fixed in *CDPS*.

(7 marks)

(b) For the following questions, consider an election with 3 candidates {*Lucy*, *David*, *Charles*} and 100 voters. The voters' preferences are shown below:

- 15% of the voters: $Charles \prec Lucy \prec David$
- 40% of the voters: $Charles \prec David \prec Lucy$
- 45% of the voters: $Lucy \prec David \prec Charles$

1. Define a *plurality vote*. Which candidate will win the above election using a *plurality vote*?

(2 marks)

2. What is meant by "*sequential majority elections* with *Lucy*, *David and Charles*". What would be the result of the above election using *sequential majority elections* with *Lucy*, *David*, *and Charles*?

(4 marks)

3. Assume that a new candidate *Nicola* emerges altering the preferences of the voters to the following:
    - 10% of the voters: $Charles \prec Nicola \prec Lucy \prec David$
    - 15% of the voters: $Lucy \prec David \prec Charles \prec Nicola$
    - 35% of the voters: $Nicola \prec Lucy \prec David \prec Charles$
    - 40% of the voters: $Charles \prec Nicola \prec David \prec Lucy$

    Define a *Borda count*. Calculate the *Borda count* starting at 1 for each candidate of the above election (with four candidates) and determine the final winner.

    (4 marks)

4. Draw the *majority graph* for the above election (with four candidates). With the aid of the *majority graph*, state whether there is a *Condorcet winner*.

    (3 marks)

END OF EXAM PAPER