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

PAPER CODE	EXAMINER	DEPARTMENT	TEL
CPT302	K.L. Man	CPT	1509

2021/22 SEMESTER 2 - Final Assessment

BACHELOR DEGREE – Year 4

Multiagent Systems

SUBMISSION DEADLINE: 30/05/2022 at 5pm

INSTRUCTIONS TO CANDIDATES

1. **The Final Assessment should be done individually.**
2. **Total marks available are 100, accounting for 80% of the overall module marks.**
3. **The number in the column on the right indicates the marks for each question.**
4. **Answer all questions.**
5. **Answers should be written in English.**
6. **Relevant and clear steps should be included in your answers.**
7. **You can also handwrite your answers on papers, and clearly scan or photograph them for submission as a single document in PDF format.**
8. **Your solutions should be submitted electronically through the Learning Mall via the submission link.**
9. **The naming of Report (in pdf) is as follows: CPT302_A_001_StudentID.pdf (e.g., CPT302_A_001_1712345.pdf)**

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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: **[20 marks]**

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

(4 marks)

(b) Differentiate the differences 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	B	*			*
1			A		H

where "A" represents a robot agent A, "B" represents another robot agent B, "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 following:
   - the robot agent A starting from (1,c) and the robot agent B starting from (2,a) clean up all the dirt while avoiding falling into any hole;
   - each robot agent must clean up at least one dirt;
   - after having cleaned all the dirt, the robot agent A and the robot agent B are located at (2,e) and (4,a) respectively.

(13 marks)

Question 2: **[25 marks]**

(a) Design "*an agent architecture*". Illustrate the principal function of each component of the *agent architecture* and briefly describe how they interact with each other.

(4 marks)

(b) Explain your understanding of "*Practical Reasoning*". Give an example to show how the *Practical Reasoning* is applied.

(3 marks)

(c) The following pseudo-code shows a control loop for a *Practical Reasoning* (DBI: "*Beliefs-Desires-Intentions"*) agent:

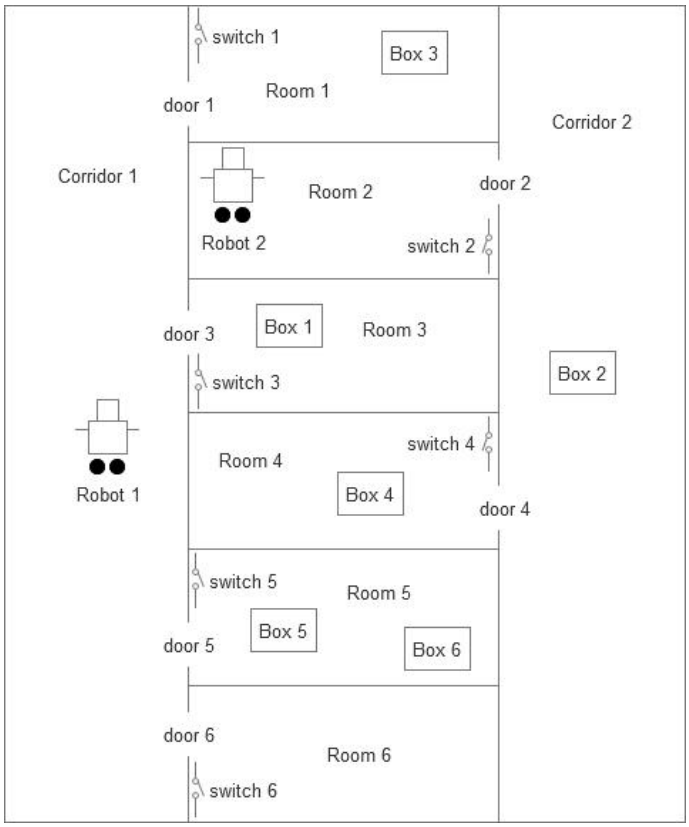
```
1.  B := B0;
2.  I := I0;
3.  while true do
4.    get next percept ρ;
5.    B := brf (B, ρ);
6.    D := options(B, I );
7.    I := filter(B, D, I );
8.    π := plan(B, I , Ac);
9.    while true do
10.       α := head(π);
11.       execute(α);
12.       π := tail(π);
13.       get next percept ρ;
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 , Ac);
21.       end - if
22.     end - while
23. 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 "*Overcommitted"* is used?
3. What should be modified in this code if the commitment protocol "*Open-minded commitment"* 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?

(4 marks)

(d) Consider a classical robot's world which consists of two robots, six rooms, two corridors and six boxes as follows:



Each room has a door and a light switch. The robots can move from anywhere to anywhere through doors, and push the boxes. The robots need to climb on (and down from) the boxes to turn light switches on and off. Initially, all lights are on.

1. Explain "*a STRIPS Planning Strategy*"?
2. Use the STRIPS Planning Strategy to construct a plan to place Box_i into $Room_i$ for $i \in \{1, 2, \ldots, 6\}$ and turn off all lights from the initial state of the robots shown in the figure above.

(14 marks)

Question 3: **[24 marks]**

(a) "*Blocks 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 "*Blocks World*" works. Otherwise, give reasons to explain why "*Blocks World*" is NOT an example of "*subsumption architecture*".

(3 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.

(8 marks)

(c) A game consists of two students: Mary and Peter; and two types of fruits: apples and oranges. Mary likes eating apples but hates eating oranges (this would also mean that the more oranges Mary eats, the worse off she is). Peter likes eating oranges but hates eating apples. There are 7 apples and 7 oranges available. Firstly, explain your understanding about Pareto efficient. Then, for this game, is there any allocation that can be Pareto efficient?

(4 marks)

(d) Given the property that the payoff for player David plays a strategy SD and Player Tina plays a strategy ST is the same as the payoff for Tina if Tina plays SD and David plays ST. Answer the following 5 questions:

1. Give the payoff matrices of the game described above.
2. If you think the given property holds in your given payoff matrices, then prove it. Otherwise, explain why such a property does not hold.
3. Show an example that there is one Nash equilibrium and such an equilibrium is also Pareto efficient in your given payoff matrices. Justify your answers
4. Prove or disprove the above example that is unique.
5. Give another case to show that there are two Nash equilibria in your given payoff matrices.

(9 marks)

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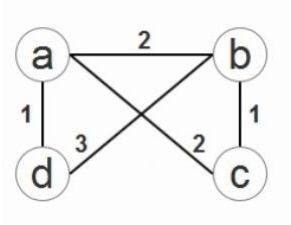
Question 4: **[14 marks]**

(a) Answer the following three questions:

1. What is the *Core* of a coalitional game?
2. Does this question "*is the grand coalition stable?*" imply another question "*is the Core non-empty?*"? (Justify your answers)
3. What will happen when the *Core* is empty?

(3 marks)

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



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

(5 marks)

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

- ν (Ø) = 0
- ν ({i}) = 0, where i = {a, b, c}
- ν ({a, b}) = 1/2
- ν ({a, c}) = 1/6
- ν ({b, c}) = 5/6
- ν ({a, b, c}) = 1

Compute the Shapley values for the agents a, b, and c. You are required to show the relevant steps in your answers about how you have obtained the values.

(6 marks)

Question 5: **[17 marks]**

(a) Discuss whether *Plurality Voting* is not a suitable method to select among four candidates. If you affirm that it is true, explain the reason. Otherwise, give a counter example to show that the statement is false.

(2 marks)

(b) For the following questions, consider an election with 3 candidates {*Lucy*, *Jim*, *Alice*} and 100 voters. The voters' preferences are shown below with preference orders (among *Lucy*, *Jim*, and *Alice*) A, B and C:

- A: 20% of the voters
- B: 35% of the voters
- C: 45% of the voters

1. Design the preference orders A, B and C such that *Alice* will win the above election using a *plurality vote*.

(2 marks)

2. What is meant by "*sequential majority elections* with *Lucy*, *Jim*, and *Alice*"? Based on your given preference orders A, B and C, who will be winner of the above election using *sequential majority elections* with *Lucy*, *Jim*, and *Alice*?

(3 marks)

3. Assume that a new candidate *Bob* emerges altering the preferences of the voters with the preference orders (among *Lucy*, *Jim*, *Alice* and *Bob*) W, X, Y and Z as follows:
   - W: 10% of the voters
   - X: 20% of the voters
   - Y: 30% of the voters
   - Z: 40% of the voters

   Design the preference orders W, X, Y and Z such that *Jim* will be the final winner of the above election using a *Borda count* starting at 1. Justify your answers.

(3 marks)

4. Depict the *majority graph* for the above election (with four candidates) along with your given preference orders. With the aid of the *majority graph*, state whether there is a *Condorcet winner*.

(2 marks)

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(c) What is meant by "*Cooperative Distributed Problem Solving (CDPS)*". By means of an example, you are required to show how *CDPS* works? Also, discuss the main problems that need to be addressed in your example.

(5 marks)

END OF FINAL ASSESSMENT PAPER