

**NANYANG TECHNOLOGICAL UNIVERSITY**  
**SEMESTER 2 EXAMINATION 2022-2023**  
**CE4046/CZ4046/SC4003 – INTELLIGENT AGENTS**

Apr/May 2023

Time Allowed: 2 hours

**INSTRUCTIONS**

1. This paper contains 4 questions and comprises 4 pages.
  2. Answer **ALL** questions.
  3. This is a closed-book examination.
  4. All questions carry equal marks.
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1. (a) List the **FIVE** ongoing trends that have led to the emergence of the multiagent systems field.  
(5 marks)
  - (b) What are the two situations where individual agents are required? Provide an example of such agents for each situation.  
(6 marks)
  - (c) A purely reactive agent can be defined using two functions: *see*:  $E \rightarrow Per$  and *action*:  $Per^* \rightarrow A$ . With the aid of a diagram, explain how these functions define the behaviour of an agent.  
(6 marks)
  - (d) What are the two main steps involved in the *policy iteration* algorithm? Elaborate the purpose of each step.  
(8 marks)

2. A person visits the doctor because he believes that he has the flu. At this particular time of the year, the doctor estimates that 1 out of 1000 persons suffers from the flu. The first thing the doctor examines is whether the person appears to have the standard symptoms of the flu. If the person suffers from the flu, then he will exhibit the symptoms with probability of 0.9, but if he does not have the flu, he may still have these symptoms with probability of 0.05. Then, the doctor can decide to administer a drug that has probability of 0.6 to shorten the sickness period if the person suffers from the flu (if he does not have the flu, the drug has no effect). The cost of administering the drug is \$100. If the sickness period is shortened, the doctor estimates that this is worth \$1000. If the sickness period is not shortened, it is worth nothing.
- (a) What are the three types of nodes in a decision network for this problem?  
(3 marks)
- (b) Draw the decision network for this problem.  
(8 marks)
- (c) Compute the expected utility of administering the drug and of not administering the drug, if the person appears to have standard symptoms of the flu. Note that you may need to apply Bayes' theorem:  

$$P(A | B) = \frac{P(B | A)P(A)}{P(B)}.$$
(12 marks)
- (d) Should the doctor administer the drug to the person?  
(2 marks)
3. (a) In 2019, Google released the Google Research Football Environment where agents aim to master the world's most popular sport—football. Modelled after popular football video games, the Football Environment provides a physics based 3D football simulation where agents control either one or all football players on their team, learn how to pass between them, and manage to overcome their opponent's defense in order to score goals. Lots of researchers are still working on the problem. List and briefly explain a few key ideas in multi-agent systems which can be used to build a successful team of agents for football.  
(5 marks)

Note: Question No. 3 continues on Page 3

- (b) The Contract Net protocol is the most widely studied protocol in cooperative distributed problem solving. Briefly explain sub-contracting in Contract Net and its benefit. (5 marks)
- (c) Briefly explain whether we can apply Vickrey auctions to auctions for bundles of goods (i.e., combinatorial auctions). (5 marks)
- (d) Briefly explain the difference between core and Shapley value. (5 marks)
- (e) Briefly explain the difference between plurality voting procedure and Borda count voting procedure. (5 marks)

4. Consider the payoff matrix in Table Q4. The first number in each entry is the payoff received by the row player A while the second number is the payoff received by the column player B.

**Table Q4**

	B: left	B: middle	B: right
A: up	1, -1	-1, 0	2, 0
A: middle	3, 1	0, 2	1, 1
A: down	2, 2	-1, 1	1, -1

- (a) Identify the dominant strategies (if any) of each player in the payoff matrix. Briefly explain your answer. (5 marks)

Note: Question No. 4 continues on Page 4

- (b) Identify which strategy pairs (if any) in the payoff matrix are in Nash equilibrium. Briefly explain your answer.  
(8 marks)
- (c) Identify which outcomes in the payoff matrix are Pareto optimal. Briefly explain your answer.  
(7 marks)
- (d) Identify which outcomes in the payoff matrix maximize social welfare. Briefly explain your answer.  
(5 marks)

END OF PAPER







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Please read the following instructions carefully:

- 1. Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**
2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.
3. Please write your Matriculation Number on the front of the answer book.
4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.