University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

Autumn, 23/24 TRIMESTER EXAMINATIONS

COMP41400

Multi-Agent Systems

Module Coordinator: Assoc Professor Rem Collier

Student Number

Seat Number

Time Allowed: 120 minutes

Materials Permitted in the Exam Venue:
None

Materials to be Supplied to Students:
None

Instructions to Students:

Answer Question 1 and any two of Questions 2-5

Question 1 (compulsory): Answer All Parts **50 marks in total**

(a) List and define the four features that make up Wooldridge and Jennings *weak notion of agency*.

(8 marks).

(b) What is **Agent-Based Modelling (ABM)** and what is it used for?

(3 marks).

(c) List the five main categories of speech act as identified by Searle and give an example illustrating each category.

(10 marks).

(d) Draw a diagram outlining the main process that underpins GAIA. Include in your diagram the models that are generated and their relationship. Indicate which models are part of the design phase, and which are part of the analysis phase.

(6 marks).

(e) Explain the concepts of **Liveness** and **Safety Responsibilities** in the GAIA Role Model.

(6 marks).

(f) Negotiation is the process by which several agents reach agreement. One approach to implementing negotiation is to use an *auction*. What are the main parameters that underpin an auction and what possible values exist for each parameter?

(8 marks).

(g) The original version of AgentSpeak(L) does not have any explicit concept of iteration or selection. Convert each of the following into rules:

i. if (happy(X)) then print("happy "+X) else print("all sad")
ii. for all values of i in the range 0 to 10 do print(i)
iii. if (hungry(X) & food(Y)) eat(X,Y)

(9 marks).

Question 2. **25 marks in total**

(a) What is an *Agent Communication Language (ACL)*? What is the minimum set of features required for a functioning ACL? Why is this insufficient in practice?

(9 marks).

(b) One of the FIPA standard Interaction Protocols is the FIPA Subscribe Protocol. Draw the Agent UML Interaction Diagram for this protocol.

(7 marks).

(c) A bookstore has decided to launch a FIPA compliant book announcement service. For this service, they expect customer agents to subscribe to the service providing information about the genres the customer likes. The service is managed by a book_service agent, and customer agents are identified by the customer's email address.

Write out the sequence of messages that would be passed between the customer agent and the book_service agent for a customer with email address: bob@mail.com, who likes fantasy and cooking.

The sequence of messages should include details of the book: "Harry Potter and the Philosophers Stone" by J.K. Rowling.

NOTE: Specify the messages transmitted between the book_service and the customer agents in FIPA ACL with the content language being either ASTRA or AgentSpeak(L).

(9 marks).

Question 3. **25 marks in total**

(a) List the reasons why you may need to use coordination.

(5 marks).

(b) Two basic approaches to coordination are *task sharing* and *result sharing*. Describe, using examples, both approaches

(10 marks).

(c) A sensor network is to be developed to monitor pollution levels in a river. In the system design, it is decided that static sensor platforms will be placed at key locations on the riverbank where they will periodically check the water for pollutants. Because the sensors are solar powered (this is used to charge a battery), there is a limit on the number of readings the sensor can make per day. This rate is lower than the rate required to accurately monitor pollution events, so it will be necessary to adapt the sensing rate depending on whether a pollution event is occurring. Because the pollution events will tend to follow the flow of the river, the sensors have been designed to include wireless communication capabilities that allow them to send messages to other sensor platforms that are close by. Finally, each sensor platform will be aware of its location relative to the other sensor platforms (i.e. what nearby sensors are upstream or downstream of it).

Due to the need for each sensor platform to interact with other nearby platforms and for it to be able to adapt its sensing rate, it is decided that they should be managed by a multi-agent system. Consider the situation in which a pollution event is detected by a single sensor in the river. Describe how you would get the agents to coordinate their activities to record the scale and speed of the pollution event. Identify whether the approach you advocate is *task-oriented* or *result-oriented*. Explain your choice.

(10 marks).

Question 4. **25 marks in total**

In the course, we explored how four different types of organisational structure - product hierarchy, functional hierarchy, centralised market, and decentralised market - impacted across three measures: cost, complexity and vulnerability.

(a) Sketch each of the four types of organizational structure and discuss their relative strengths and weaknesses in terms of cost, complexity and vulnerability.

(20 marks).

(b) Recreate the cost comparison matrix for all 4 structures compared against relative cost, complexity and vulnerability. Use L for low cost, M for medium cost, and H for high cost.

(5 marks).

Question 5. **25 marks in total**

In the module, we explored the idea of **Practical Reasoning**. This question focuses on the concept and its realisation within AgentSpeak(L).

(a) Give a definition of practical reasoning. List and describe the two main activities associated with Practical Reasoning. What is the relationship of **intentions** to these activities?

(9 marks).

(b) Reasoning using intentions is susceptible to the **side-effect/package deal** problem. What is this? Illustrate your answer with an example.

(6 marks).

(c) Explain how the practical reasoning concept can be realised in the AgentSpeak(L) programming language. Illustrate your answer with through a simple example program.

(10 marks).

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