Exam for IN1905TU Kennistechnologie

August 28th, 2007

This exam will test your knowledge and understanding of the material provided to you and presented in the lectures and the book of Michael Wooldridge, *An Introduction to Multi-Agent Systems*. Using the book during the examination is *not* allowed. You will have 3 hours (from 9 till 12) to complete the exam. It has 5 questions, for a total of 85 points. Please don't include irrelevant information: you will be marked down for this. Before you hand in your answers, please check that you have put your name and student number on top of every sheet you hand in.

Questions

Question 1 *5 points*

(a) (5 points) Explain what *blind commitment* is.

> **Solution:** See p. 77 of Wooldridge.

Question 2 *25 points*

This question relates to the article *Expert System for the Operative Environmental Diagnostics* by Mkrtchyan Ferdenantand Krapivin Vladimir.

The expert system for the environment diagnostics (ESED) combines mathematical modeling with land and remote observations of the environment. Links between experiments, algorithms, and models of environmental processes and subsystems are developed to realize effective diagnostics of the environment. The ESED functions include:

- Acquisition and accumulation of data by means of in-situ and remote methods and their analysis.
- Evaluation and synthesis of knowledge concerning the atmosphere (e.g. levels of carbondioxide, ozon, etc.), soil-plant cover (percentage of soil covered by plants and forests), and water medium change (e.g. percentage of ice, levels of carbondioxide in water).
- Forecasting diagnostics based upon changes in the environment (e.g. huricanes, etc.)
- Identification of causes of ecological disturbances and danger warning.

The tasks that should be solved are: Collect and analyse data, Detect ecological disturbances, Determine the cause, and type of disturbance, Provide advice for handling any ecological disturbances.

(a) (5 points) Discuss which of the following capabilities are desirable for the ESED system: autonomy, reactiveness, pro-activeness, social ability. Provide an outline of the ESED system as a distributed agent system with various agents performing various functions. Draw the multi-agent system and explain the basic structure.

> **Solution:** The ESED can be designed as a distributed agent system and decomposed into agents more or less in line with the functional capabilities identified above. A natural decomposition would include (i) *data collection agents* for various sorts of data, e.g. for atmospheric data, ecological data about soil and plants, and data about large water masses; (ii) *analysis and data processing agents* that analyse and process the raw data provided by collection agents; (iii) *diagnostic agents* that reason with and derive conclusions from the collected data, e.g. detect ecological disturbances and determine possible causes; (iv) *decision support agents* that provide decision support and advice about dealing with particularly dangerous situations.
>
> For each of the possible agent capabilities, see also Wooldrige, p. 15 and p. 23.
>
> - *Autonomy* relates to actions performed by a system and the capability to decide to exercise a particular action. Such autonomic decision capabilities are not particularly relevant for the ESED diagnostic system; such a system needs to process incoming data, without any additional decision-making going on about this.
> - *Reactiveness* refers to perceiving the environment and responding in a timely fashion. This is clearly of the utmost importance for the ESED system.
> - *Pro-activeness* refers to taking the initiative. There is little room for taking initiative by the ESED system, since all it is supposed to do is process environmental data.
> - *Social ability* refers to the ability to interact with other agents (including human) agents. Since the ESED system is supposed to be able to provide adequate advice and decision support, this capability is desirable and important.

(b) (10 points) Discuss the working of a diagnostic system in terms of the following concepts: actions, triggers, tests, hypotheses. Illustrate and apply each of these concepts by means of the ESED system. Also describe what the general line of reasoning is to solve a diagnostic problem.

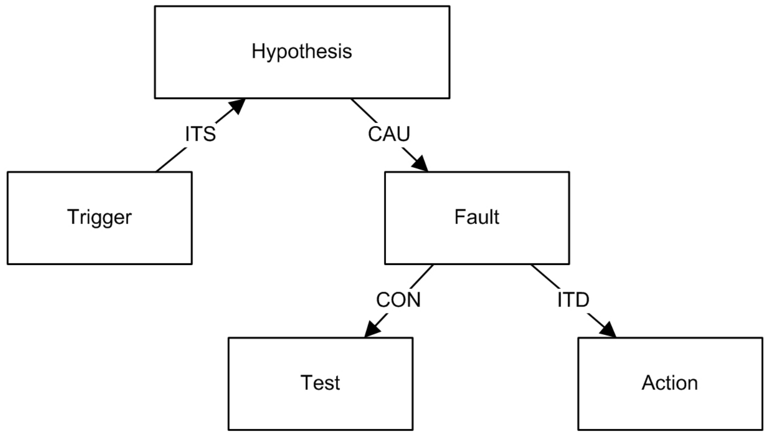

Figure 1: Graphical Representation of Rule-Based Knowledge for Diagnostic System

Solution: According to the ESED system description, extensive knowledge about the relation of experiments, algorithms and environmental processes must be available. It thus is natural to propose to use a knowledge based diagnostic system.

In a typical knowledge based diagnostic problem such as the ESED system, actions cannot be undertaken based directly on observations only. The observation of a disturbance (in diagnostic terms, a 'malfunction' which 'fires' triggers) can be the result of various causes ('faults' in standard diagnostic terminology). Therefore, first a set of hypotheses is generated using observations derived from data collection. To discover the 'true reason', tests are performed on the hypotheses and they are eliminated one by one until a cause ('fault') is discovered.

Typically, the knowledge in a knowledge based diagnostic system is structured as depicted in the picture above.

The knowledge in a diagnostic system is used as follows:

1. Once a trigger(s) has fired a set of hypotheses is generated according the following types of rules:

$$\text{IF } < trigger >= true \text{ THEN } < hyp_A >= true$$

   Since it is unlikely that all such generated hypotheses are true, the hypotheses have to be tested in some order one by one according to a chosen control strategy. This is assured by the following rule that proposes the next hypothesis in the set once the previous one was declined by the test:

$$\text{IF } < trigger >= true \text{ AND } < hyp_A >= false \text{ THEN } < hyp_B >= true$$

2. The following rule determines which test has to be preformed to check the selected hypothesis:

$$\text{IF } < hyp >= true \text{ THEN } perform_test(< test_A >)$$

3. If result of the test is positive, the system can identify the fault:

$$\text{IF } < test >= true \text{ THEN } < fault >= true$$

   In case of the test is negative, the corresponding hypothesis is declined:

$$\text{IF } < last_test >= false \text{ THEN } < hyp >= false$$

4. When a fault is determined, then the system can perform an action:

   IF < *fault* >= *true* THEN < *action* >=< $do_s omething$ >

   The actual values of the antecedents and consequents in the rules above are filled by the system designer during the knowledge elicitation phase.

   Because triggers are the main sources of the information in our system we propose to use forward chaining, which derives new consequents which are added to the system knowledge if an antecedent is true.

(c) (10 points) Discuss which of the following cooperation approaches could be applied by the agents in the ESED system: mutual modelling, joint intentions, partial global planning, contract net protocol, social norms. For the approach you recommend describe what the responsibilities of the various components are and relate that to the tasks mentioned above listed after the bullets.

Solution: See for the cooperation approaches Wooldridge Section 9.2.1 and 9.6.

- The *Contract Net* is not naturally applicable to the ESED system since there is no real task sharing involved nor competition for resources.
- Coordination throught *partial global planning* may be useful in the ESED system if multiple diagnostic agents need to cooperate by sharing data and updating and informing each other of conclusions derived from individual data analysis. It may be that the systems is setup in such a way that diagnostic agents need to team together to provide a complete and coherent analysis and need to arrive at a global plan to achieve this analysis.
- Although the ESED system has a clear overall goal coordination through *joint intentions* is not really applicable since goals of diagnostic agents are more naturally modelled at the local level in a diagnostic system as ESED than at the social level.
- Coordination through *mutual modelling* really is an overkill in a diagnostic system such as ESED, potentially tampering with the requirement of high reactiveness because of the overhead involved in such an approach,
- Coordination through *social norms* is not really applicable either, since such norms do not naturally arise in a diagnostic system about environmental monitoring as ESED.

The recommended approach thus is *partial global planning* because of the need for efficient information exchange to arrive at a common diagnostic analysis. This approach is most usefully applied to the diagnostic agents that are part of the ESED system only. The information that needs to be shared and coordinated involves the evaluation and conclusions derived from data analysis, and possible hypotheses and forecasts generated by diagnostic agents.

Question 3 *20 points*

The tea party problem involves n guests who have to be seated around a circular table. You are given a symmetric matrix *L(i,j)* for 'likes' that determines the extent to which guest i likes guest j. The goal is to find an arrangement that maximizes a cozy feeling among the guests (which is the sum of n values from the $L(i,j)$ matrix, one for each pair of neighbours (adjacently seated pair of guests) at the table).

(a) (10 points) Define the tea party as a search problem. That is, define its initial state, its state (or configuration) space, the associated operators or successor function, a goal test, and a path cost function.

Solution:

- The initial state is an arbitrary arrangement of the guests at the table.
- The state space consists of all possible configurations of seatings of guests at the table.
- The successor function consists of swapping of seatings of two guests at the table.
- The goal test needs to verify whether the seating maximizes the 'cozy feeling' that is possible given the 'likes that' matrix.
- The path cost function is simply the length of the path.

(b) (10 points) Imagine there are only 4 guests named *Anna*, *Boris*, *Carla*, and *David*. Draw part of the breadth-first search tree, up to level 2 deep, with the state in which Anna is sitting next to Boris, Boris is sitting next to Carla, and Carla is sitting next to David who is sitting next to Anna as root. Assume the liking matrix looks like:

	Anna	Boris	Carla	David
Anna	x	1	3	7
Boris	1	x	6	6
Carla	3	6	x	2
David	7	6	2	x

Question 4 *15 points*

Consider the semantic network below:

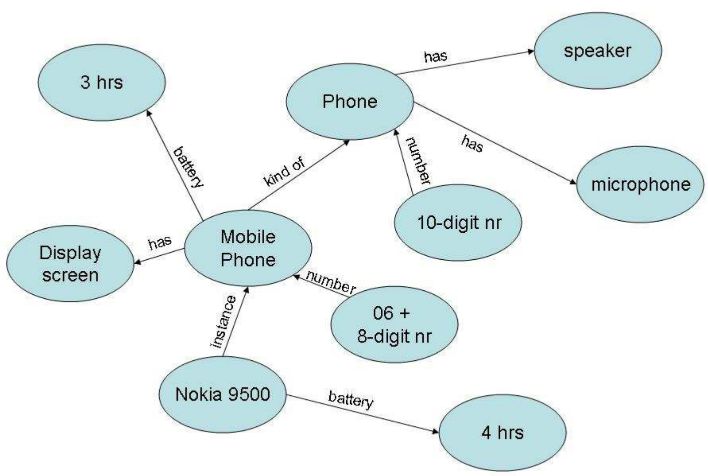

Figure 2: Phone - Semantic Network

(a) (5 points) Describe all the information that can be inferred from the semantic network about the Nokia 9500.

Solution: The Nokia 9500

- is a mobile phone (which is a kind of phone),

- has a speaker,
- has a microphone,
- has a number starting with 06 followed by 8 other digits,
- has a display screen,
- has a battery with battery life of 4 hrs.

(b) (10 points) A typical mobile phone nowadays has many more features than a typical phone at home. Typically it allows sending mail, internetting, gaming, and e.g. calendar management. The Nokia 9500 additionally can provide car navigation support. Suppose moreover that batteries for mobiles may be varied and a battery with either high capacity, medium or low capacity can be chosen. Change the network and extend it with this additional information and draw the extended network.

Question 5 *20 points*

(a) (5 points) Describe and draw a vertical layered two-pass control architecture.

Solution: See Wooldridge, pp. 98-99.

(b) (5 points) Explain the use of multiple layers in a vertical layered architecture.

Solution: See Wooldridge, pp. 98-99.

(c) (10 points) What is the difference between a one-pass and a two-pass control architecture? Provide at least one reason for using a two-pass control architecture instead of a one-pass architecture.

Solution: See Wooldridge, pp. 98-99.

End of exam