Student name: _____Student number:

Faculteit der Exacte Wetenschappen

Exam Design of Multi-Agent Systems

Vrije Universiteit Amsterdam **6 February 2008**

Exercise	**1**	**2**	**3**	**4**	**bonus**
points	25	30	15	20	10

Norm:

The tentamination mark **T** equals (the sum of the points scored for the exercises plus 10 bonus points) divided by 10.

The endmark **E** for the course Design of Multi-Agent Systems is calculated as follows: **E = (T + H + P) / 3**

Where :

T = tentamination mark

H = mark for the home work exercises

P = mark for the small practicum

You find:

4 exercises

5 appendices (1A, 1B, 2, 3, 4)

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Exercise 1 (25 points):

Relevant Appendices: Appendix 1A and Appendix 1B.

This exercise consists of two parts. Motivate your answers.

Exercise 1a (15 points)
In chapter 1 of the syllabus a number of primitive agent concepts have been introduced (see Appendix 1B of the answer sheets). In Appendix 1A, you can find some information on an adaptive cruise control system.
Analyse this information according to the primitive agent concepts and fill out Appendix 1B (3 answer sheets) indicating which agent concepts are relevant for the adaptive cruise control system. Remember to motivate your answers clearly.

Exercise 1b (10 points)
Would you call this system an agent? Motivate your answer.

Exercise 2 (30 points)

Relevant Appendix: Appendix 2 and 3.

This question builds on your understanding of the generic model for Reasoning with and about Assumptions (Chapter 11). For your convenience a rather detailed partial specification of that model is given in Appendix 3. Be careful to focus directly on the parts of the specification that you need, so that you don't waste time. This generic model will be used in this exercise to diagnose sunflower problems. Read Appendix 2 "Sunflower Problem".

Exercise 2a (10 points)
Give a knowledge base for component assumption_determination that reflects the knowledge in Appendix 2. Motivate your answer in a rationale.

Exercise 2b (10 points)
Give a knowledge base of component observation_result_prediction that reflects the knowledge in Appendix 2. Motivate your answer in a rationale.

Exercise 2c (10 points)
Design the information types causes and symptoms for this domain in a graphical format. You can do this in one information type, but you are also allowed to make more levels of abstraction. Motivate your answers, refer back to your answers to questions a) and b) as well.

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Exercise 3 (15 points):

Consider the following information type:

```
information type planes
    sorts          PLANE, BOEING, AIRBUS;
    subsorts       BOEING, AIRBUS: PLANE;
    objects        747, 737: BOEING;
                   A320, A380: AIRBUS;
    relations      mid_sized_plane: PLANE;
                   large_plane: PLANE;
                   is_way_bigger_than: PLANE * PLANE;
end information type
```

And the following knowledge base:

```
knowledge base plane_kb
    information types plane_stuff
contents
    large_plane(747);

    large_plane(A380);

    mid_sized_plane(737);

    is_way_bigger_than(747, A320);

    if is_way_bigger_than(P1:PLANE, P2:PLANE)
     and large_plane(P1:PLANE)
    then mid_sized_plane(P2:PLANE);

    if large_plane(P1:PLANE)
     and mid_sized_plane(P2:PLANE)
    then is_way_bigger_than(P1:PLANE, P2:PLANE);

end knowledge base
```

Give a minimal refinement of information state [ ] that is both closed and consistent with respect to the knowledge base plane_kb.

Exercise 4 (20 points):

Read Appendix 4 and answer the following questions.

Exercise 4a (10 points)

The generic agent model of Chapter 7 consists of 7 components: agent_interaction_management, world_interaction_management, maintenance_of_agent_information, maintenance_of_world_information, own_process_control, and agent_specific_task. Which of these components do you need and which do you not need to model a personal assistant agent of the MOBIE system? Motivate your answer and make explicit references to the text of Appendix 4.

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Exercise 4b (10 points)
The process of interaction that the personal agent needs is rather complicated. The type of communication that it needs with the human customers is rather different from that with the other software agents. Furthermore, for communication with the human user it has different channels. Suppose that component comp_c of the agent is responsible for all this (note that this might be one of the components of the GAM but this is not important for this part). Then component comp_c should be composed. Provide a process composition of comp_c and the links needed within comp_c to model these processes. Motivate your answers in a rationale.

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Appendix 1A: Adaptive Cruise Control System

Safety is a hot issue in the car industry, and new inventions to improve the safety of cars are therefore seen quite often nowadays. The systems are meant to aid the driver in driving as safely as possible. One of such systems which has been introduced by one of the major car manufacturers is *adaptive cruise control*. The system works as follows: The driver activates the system by inputting his desired minimum distance to cars in front of his car and the desired speed of the car. This data is stored within the system. After activation, the system maintains the speed that has been set. Besides that, the system also actively monitors the road ahead of the car by using sensors which are mounted at the front bumper of the car. In case the sensors output that the distance between the car and the car in front is smaller than the distance inputted by the driver, the system immediately shows a warning on the dashboard of the driver, communicating to the driver that a car is approaching ahead. At the same time, the system takes an action in which it has two possibilities: Reducing speed by decreasing the throttle, or in case this is insufficient, use the brakes of the car. After the distance is observed to be sufficient again, speed is set to the old value, or set to a lower value in case the car in front is driving slower, ensuring sufficient distance between the car and the car in front.

The developer of the system, Mr. Ford says the following about the system: *This, among other systems in the car, is meant to cooperate with the driver, not to replace him. The system contributes to the overall goal of the driver and the safety systems within the car to get from A to B as safely as possible.*

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Appendix 1B: Answersheet (1 out of 3)

I. External primitive concepts	
A. Interaction with the world	
passive observations	
active observations	
performing actions	
B. Communication with other agents	
incoming	
outgoing	

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Appendix 1B Answersheet (2 out of 3)

II. Internal primitive concepts	
A. World Model	
B. Agent Models	
C. Self Model	
D. History	
E. Goals	
F. Plans	
G. Group Concepts	
Joint goals	
Joint plans	
Commitments	
Negotiation strategies	

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Appendix 1B Answersheet (3 out of 3)

III. Types of behaviour	
Autonomy	
Responsiveness	
Pro-activeness	
Social behaviour	
Own adaptation and learning	

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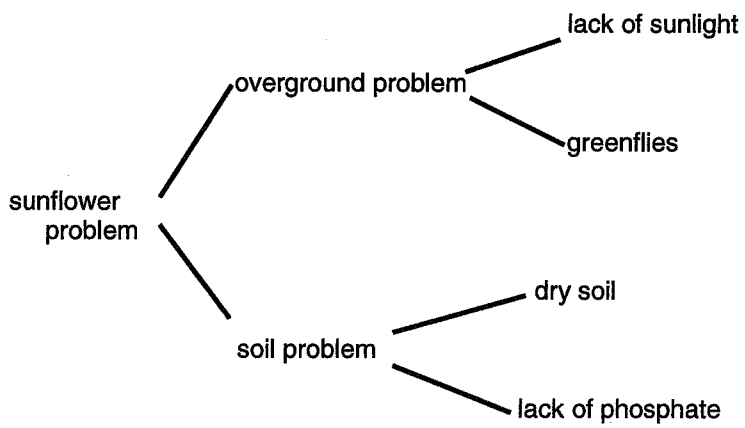
Appendix 2: Sunflower Problem

Consider the following situation, which involves two agents, an owner of a sunflower and a specialist in growing sunflowers. The owner observes that his sunflower is in a poor shape. As he is not able to find out himself why it is so, he decides to call the specialist and ask him to find out the problem causing the current state of the sunflower.

Since the specialist has no possibility to observe the plant, he asks the owner to make certain observations and communicate them back to the specialist.
To determine the nature of the problem, the specialist uses a line of reasoning modelled by the generic model for reasoning with and about assumptions (see Appendix 3). That model proceeds along the following lines: making an assumption, predicting observation results for that assumption, and then evaluating the assumption by making the appropriate observations and comparing them to the assumption. If necessary, the old assumptions are rejected, and new ones are made. The specialist uses the following hierarchy (taxonomy) of the subproblems of sunflower problems, that he uses to efficiently order the assumptions he can make:



The specialist can instruct the owner to make observations on the state of the sunflower leaves (whether they are drying up and damaged), on the height of the plant (whether it is rachitic) and on the state of its flower-head (whether it is wilted).

The relations between causes and symptoms are depicted below:

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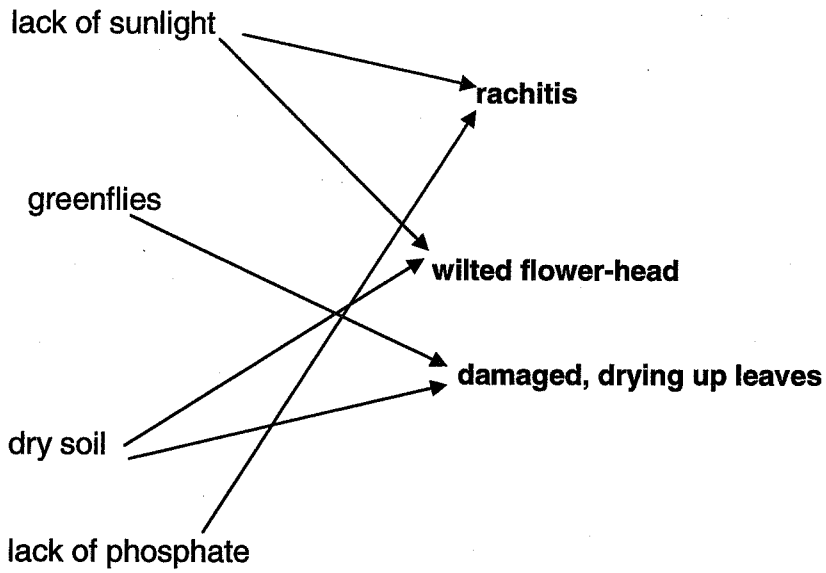

If there is a lack of sunlight then the plant becomes small and stunted (rachitic) and its flower-head becomes wilted. If there are greenflies (bladluizen) they can cause brown, damaged leaves which eventually will dry up. Damaged, drying up leaves can be also a result of dry soil, and the wilted flower-head is often caused by dry soil too. Phosphate is an important chemical ingredient of soil: without it the sunflower becomes rachitic.

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Appendix 3: Reasoning with and about assumptions

information types

information type truth_indication
 sorts SIGN
 objects pos, neg: SIGN;
end information type

information type obs_to_be_performed
 sorts INFO_ELEMENT
 relations to_be_observed: INFO_ELEMENT ;
end information type

information type observation_results
 sorts INFO_ELEMENT,
 SIGN
 relations observation_result: INFO_ELEMENT * SIGN ;
end information type

information type assumptions_hypotheses_and_such
 sorts INFO_ELEMENT, SIGN
 relations assumed: INFO_ELEMENT * SIGN ;
 rejected: INFO_ELEMENT * SIGN ;
 has_been_considered: INFO_ELEMENT * SIGN ;
 possible_assumption: INFO_ELEMENT * SIGN ;
 predicted_for: INFO_ELEMENT * SIGN * INFO_ELEMENT * SIGN ;

end information type

information type causes
 .....
end information type

information type symptoms
 .....
end information type

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information type world_info
information types symptoms, causes;
end information type

information type information_element_info
sorts INFO_ELEMENT
objects ..... : INFO_ELEMENT;
end information type

information type observation_info
information types obs_to_be_performed, information_element_info;
end information type

information type observation_result_info
information types observation_results, information_element_info, truth_indication;
end information type

information type assumption_info
information types assumptions_hypotheses_and_such , information_element_info, truth_indication;
end information type

component assumption_determination

input information types assumption_info, observation_result_info;
output information types assumption_info;

knowledge base assumption_determination_local_kbs
information types assumption_info, observation_result_info;
contents

/ use as many rules as you like, you may also create additional information types if you like. */*

... ...

end knowledge base

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component assumption_evaluation

input information types observation_result_info, assumption_info;
output information types observation_info, assumption_info;

knowledge base assumption_evaluation_local_kbs
information types observation_result_info, assumption_info, observation_info;

contents
if predicted_for(OBS: INFO_ELEMENT, S1: SIGN, HYP: INFO_ELEMENT, S2: SIGN)
then to_be_observed(OBS: INFO_ELEMENT);

if assumed(HYP: INFO_ELEMENT, S: SIGN)
and predicted_for(OBS: INFO_ELEMENT, pos, HYP: INFO_ELEMENT, S: SIGN)
and observation_result(OBS: INFO_ELEMENT, neg)
then rejected(HYP: INFO_ELEMENT, S: SIGN)
and has_been_considered(HYP: INFO_ELEMENT, S: SIGN);

if assumed(HYP: INFO_ELEMENT, S: SIGN)
and predicted_for(OBS: INFO_ELEMENT, neg, HYP: INFO_ELEMENT, S: SIGN)
and observation_result(OBS: INFO_ELEMENT, pos)
then rejected(HYP: INFO_ELEMENT, S: SIGN)
and has_been_considered(HYP: INFO_ELEMENT, S: SIGN);

end knowledge base

component observation_result_prediction

input information types assumption_info;
output information type assumption_info;

knowledge base observation_result_prediction_local_kbs
information types assumption_info;

contents

/ use as many rules as you like */*

end knowledge base

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information links

private link assumptions
domain assumption_determination
    information type assumption_info;
co-domain observation_result_prediction
    information type assumption_info;

sort links identity
object links identity
term links identity
atom links
    (possible_assumption(HYP: INFO_ELEMENT, S: SIGN),
        possible_assumption (HYP: INFO_ELEMENT, S: SIGN)) :
            <<true, true>, <false,false>>;
end link

private link predictions
domain observation_result_prediction
    information type assumption_info;
co-domain assumption_evaluation
    information type assumption_info;

sort links identity
object links identity
term links identity
atom links
    (predicted_for(OBS: INFO_ELEMENT, S1: SIGN, HYP: INFO_ELEMENT, S2: SIGN),
        predicted_for(OBS: INFO_ELEMENT, S1: SIGN, HYP: INFO_ELEMENT, S2: SIGN)) :
            <<true, true>, <false,false>>;
end link

private link hypotheses
domain assumption_determination
    information type assumption_info;
co-domain assumption_evaluation
    information type assumption_info;

sort links identity
object links identity

Student name: _____Student number:

```
term links identity
atom links
  (possible_assumption(HYP: INFO_ELEMENT, S: SIGN),
        assumed(HYP: INFO_ELEMENT, S: SIGN)): <<true,true>, <false,false>>;
end link

private link assessments
domain assumption_evaluation
        information type assumption_info;
co-domain assumption_determination
        information type assumption_info;

sort links identity
object links identity
term links identity
atom links
        (rejected(HYP: INFO_ELEMENT, S: SIGN),
                rejected(HYP: INFO_ELEMENT, S: SIGN)):  <<true, true>, <false, false>>;

        (has_been_considered(HYP: INFO_ELEMENT, S: SIGN),
        has_been_considered(HYP: INFO_ELEMENT, S: SIGN)):       <<true, true>, <false, false>>;
end link
private link required_observations
domain assumption_evaluation
        information type observation_info;
co-domain external_world
        information type observation_info;
sort links identity
object links identity
term links identity
atom links
        (to_be_observed(OBS: INFO_ELEMENT),
                to_be_observed(OBS: INFO_ELEMENT)) :
                        <<true, true>, <false,false>>;
end link


private link observation_results
domain external_world
        information type observation_result_info;
```

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co-domain assumption_evaluation

information type observation_result_info;

sort links identity

object links identity

term links identity

atom links

(observation_result(OBS: INFO_ELEMENT, S:SIGN),

observation_result(OBS: INFO_ELEMENT, S:SIGN)) :

<<true, true>,<false,false>>;

end link

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Appendix 4 The MOBIE system

Prepay usage as a percentage of overall mobile (also called cell) phone access has increased sharply over the past several years. However, the recharging process of the prepaid balance is still largely manual with personalization provided by the user. A system is needed capable of automatically recharging the prepaid account of a mobile phone in a personalized manner. This visionary system is called MOBIE. The MOBIE multi-agent system consists of personal assistant agents for the consumers and business agents for the mobile telecommunication service providers. The MOBIE system has to take care of the personalization of the agents, security, and human agent interaction modalities.

To accommodate the automated recharging process for the user the mobile phone service providers need to be able to interact with the personal assistant agents in a reliable and secure manner. Because of the expected high frequency of such interactions the service providers need to automate these customer interactions. The option chosen in this exercise is to introduce business agents that are capable of the required interactions with the personal agents of the users. The personal assistant agent that represents the customer is capable of the following main tasks.

1. The personal agent creates and maintains a profile of the customer. The profile contains at least:
    a. The criteria that tell the agent when to recharge the account.
    b. The information needed to execute recharging, like the amounts it can use, and payment information.
2. The personal agent matches the criteria against the actual balance of the prepaid account.
3. The personal agent requests the necessary information from the business such as:
    a. The balance of the prepaid account.
    b. The actual usage pattern of the phone for a specified period of time.
4. The personal agent is capable of recharging the prepaid account.
5. The personal agent can ask the telecom companies (through the business agents that represent them) to recharge the prepaid account with amount x.
6. The personal agent is responsible for keeping the customer informed in accordance to the customer profile.
7. The personal agent is able to interact with the customer through different channels:
    a. web-based,
    b. WAP (for those customers that have a WAP enabled mobile phone)
    c. voice. Due to inherent restrictions of current WAP implementations and of mobile devices in general, we think that a voice-enabled interface has high potential.

The personal assistant agents function within MOBIE in an environment consisting of business agents that represent the different telecom companies, and financial institutions (like banks, with whom the actual payment is to be arranged). The personal assistant agents do not contact the financial institutions themselves. They can ask a telecom

company to recharge the prepaid account, the telecom company will then contact the appropriate financial institution.