Student name: _____ Student number:

Faculteit der Exacte Wetenschappen

Exam Design of Multi-Agent Systems

Vrije Universiteit Amsterdam **14 January 2010**

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**. In order to get an endmark, T needs to be ≥ 5.5

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 Intelligent Diabetes Support.
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 Intelligent Diabetes Support. 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 digital camera problems. Read Appendix 2 "Digital Camera 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 car_stuff
    sorts          CAR, FORD, VOLKSWAGEN;
    subsorts       FORD, VOLKSWAGEN: CAR;
    objects        focus, mondeo: FORD;
                   golf, passat: VOLKSWAGEN;
    relations      mid_sized_car: CAR;
                   large_car: CAR;
                   is_way_bigger_than: CAR * CAR;
end information type
```

And the following knowledge base:

```
knowledge base car_kb
    information types car_stuff
contents
    large_car(mondeo);

    mid_sized_car(golf);

    mid_sized_car(focus);

    is_way_bigger_than(passat, golf);

    if is_way_bigger_than(C1:CAR, C2:CAR)
     and large_car(C1:CAR)
    then mid_sized_car(C2:CAR);

    if large_car(C1:CAR)
     and mid_sized_car(C2:CAR)
    then is_way_bigger_than(C1:CAR, C2:CAR);

end knowledge base
```

Give a minimal refinement of information state [ ] that is both closed and consistent with respect to the knowledge base car_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 6 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 OVCC ? 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 these interactions (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: Intelligent Diabetes Support

Nowadays, an increasing number of people is suffering from diabetes, and some of those patients have to inject insulin into their body to regulate their glucose levels in an appropriate way. Knowing exactly when to inject insulin and how much is however not a trivial matter, it depends on many factors, such as the precise glucose intake (including a prediction for the coming time period) and also on the individual characteristics of the person. To support diabetes patients, an intelligent support system is being developed, which is explained below.

The support system consists of a device which is able to measure the current glucose and insulin levels inside the human body. Next to this information, the system also requests the patient to insert the planning of meals, and prospected types and quantities of food to be eaten during these meals. In addition, the system also asks the patient to insert daily schedules with activities. Based upon this information, the system gives a warning when it considers it to be the appropriate time to inject insulin. It also informs the patient on how much insulin the patient should inject at that time. Hereby, the system also "thinks along with the patient" by trying to optimize the injections with the daily scheduled activities, for instance trying to avoid insulin intake during meetings, etcetera.

Next to the support facility for scheduling the insulin intake, the system also functions as a safety net for the patient. In case dangerously low glucose levels are seen the system can, on its own initiative, warn the patient or, in case the patient is not responding, even warn a doctor.

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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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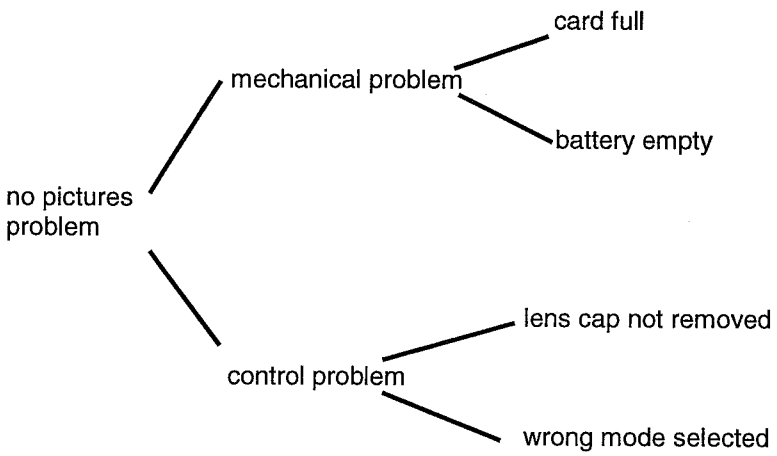
Appendix 2: Digital Camera Problem

Consider the following situation, which involves two agents, an owner of a digital camera and a specialist in digital camera repairs. The owner observes that the camera is not functioning properly, the camera is not taking any pictures when pressing the shoot button. 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 camera not being able to take pictures.

Since the specialist has no possibility to observe the digital camera, 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 digital camera 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 camera: (1) whether the power light is on green, (2) whether the screen is all black (not showing anything), (3) whether the screen is showing an icon that the camera is in picture taking mode, and (4) whether the full card icon is shown on the display.

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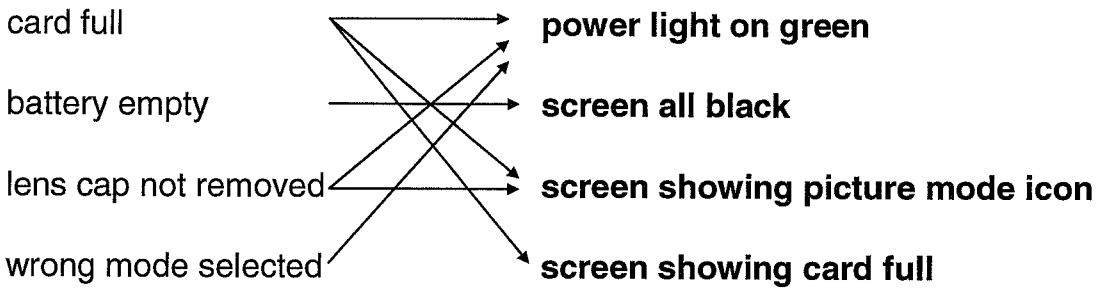
The relations between causes and symptoms are depicted below:



In case the card is full, then the power light will be green, the display will show picture mode icon, but also the card full icon will be visible. In case the battery is empty, the screen will just be all black. The lens cap not having been removed causes the power light to be green, and the screen showing the picture mode icon. Finally, in case the wrong mode is selected, only the power light will be green.

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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

Student name: _____ Student number:

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

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```
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 OVCC system

Nowadays, more and more people are using the OV chip card in the public transportation system in the Netherlands. However, the recharging process of the OV chip card is largely manual with personalization provided by the user. A system is needed capable of automatically recharging the OV chip card in a personalized manner. This visionary system is called OVCC. The OVCC multi-agent system consists of personal assistant agents for the consumers and business agents for the service providers. The OVCC 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 public transport 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 public transport 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 OV chip card.
    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 OV chip card.
3. The personal agent is capable of recharging the OV chip card.
4. The personal agent can ask the public transport companies (through the business agents that represent them) to recharge the OV chip card with amount x.
5. The personal agent is responsible for keeping the customer informed in accordance to the customer profile.
6. The personal agent is able to interact with the customer through different channels:
    a. Mobile Internet (for those customers that have an Internet enabled mobile phone)
    b. Voice. Due to huge variety of prospected users (also older users), we think that a voice-enabled interface has high potential.

The personal assistant agents function within OVCC 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 the public transport service provider to recharge the prepaid account, the public transport service provider will then contact the appropriate financial institution.