Student name: _____ Student number:

\Faculteit der Exacte Wetenschappen

Tentamen Ontwerp van Multi-agentsystemen / Design of Multi-Agent Systems

Vrije Universiteit Amsterdam **21 december 2004**

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

Normering:	*Norm:*
Het **tentamencijfer T** is gelijk aan het totaal behaalde punten voor de tentamenopgaven plus de bonus punten gedeeld door 10.	The tentamination mark **T** equals sum of the points scored for the exercises plus 10 bonus points divided by 10.
Het **Eindcijfer** voor het hoorcollege Ontwerp van Multi-agentsystemen wordt als volgt berekend.	The endmark **Eindcijfer** for the course Design of Multi-Agent Systems is calculated as follows:
Eindcijfer = (T + H + P) / 3	
Waarbij	Where
T = (voldoende) tentamencijfer H = cijfer huiswerkopgave P = cijfer voor het klein practicum	T = tentamination mark H = mark for the home work exercises P = mark for the small practicum

U treft aan:

5 opgaven
5 appendices

You find:

5 exercises
5 appendices

Student name: _____ Student number:

Opgave 1 (25 punten)

Deze opgave bestaat uit twee onderdelen. Motiveer Uw antwoorden.

Opgave 1a (15 punten)

In hoofdstuk 1 van de syllabus zijn een aantal primitive agentconcepten geïntroduceerd (zie Appendix 1B van de antwoordvellen). In Appendix 1A kun je wat informatie vinden over assistente Q. Analyseer deze informatie aan de hand van de primitieve agentconcepten en vul Appendix 1B (3 antwoordvellen) in. Als de informatie in Appendix 1A naar je zin niet precies genoeg is om de tabel goed te kunnen invullen, dan mag je er zelf informatie bij verzinnen. Denk er aan dat je je antwoorden goed motiveert.

Opgave 1b (10 punten)

In het generieke agentmodel (hoofdstuk 7 van de syllabus) komen een aantal componenten voor:

agent_interaction_management,
world_interaction_management,
maintenance_of_agent_information,
maintenance_of_world_information,
own_process_control,
agent_specific_task.

Stel dat je het generieke agentmodel zou gebruiken om een artificiële agent te ontwerpen die Q's taak zou kunnen overnemen. Gebruik je antwoord op vraag 1a om te beslissen welke van deze componenten je nodig hebt in je ontwerp. Motiveer waarvoor een component nodig is, motiveer ook waarom een component eventueel niet nodig is.

English:

Question 1 (25 points)

This question consists of two parts. Motivate your answers.

Question 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 assistant of a Film Director Q.

Analyse this information according to the primitive agent concepts and fill out Appendix 1B (3 answer sheets). In case you feel the information in Appendix 1A is not detailed

Student name: _____ Student number:

enough to fill out the table properly, you are allowed to make up additional information. Remember to motivate your answers clearly.

Question 1b (10 points)

In the generic agent model (chapter 7 of the syllabus), there are a number of components:
agent_interaction_management,
world_interaction_management,
maintenance_of_agent_information,
maintenance_of_world_information,
own_process_control,
agent_specific_task.

Suppose you would use the generic agent model to design an artificial agent that can take over Q's task. Use your answer to question 1a to decide which of these components you need in your design. Motivate why a component is needed; in case you left out a component, motivate why this component is not necessary.

Question 2 (30 points). Een Nederlandse vertaling van Question 2 is niet beschikbaar.

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 the problems of growing sunflowers. Read Appendix 2 "Sunflower Problem".

a) (15 points) Give a knowledge base for component assumption_determination that reflects the knowledge in Appendix 2. Motivate your answer in a rationale.
b) (15 points) Give a knowledge base of component observation_result_prediction that reflects the knowledge in Appendix 2. Motivate your answer in a rationale.

Opgave 3 (15 punten).

Het doel van deze opgave is het bestuderen van het revisie proces. Beschouw weer de partiele specificatie van Appendix 3. Neem aan dat de informatie types causes and symptoms hebben de volgende specificatie:

information type **causes**
relations a;
end information type

information type **symptoms**

Student name: _____ Student number:

relations b;
end information type

Geef een trace van het gedrag van component assumption_evaluation gegeven dat de achtereenvolgende **input informatie toestanden** van die component als in Appendix 4 gepresenteerd zijn. Gebruik de speciale antwoordformulieren uit Appendix 4.

English:
Question 3 (15 points).

The purpose of this question is to study the revision process. The partial specification of Appendix 3 is used again. Suppose that the information types causes and symptoms are specified as follows:

information type **causes**
relations a;
end information type

information type **symptoms**
relations b;
end information type

Give a trace of the behaviour of component assumption_evaluation given that the subsequent **input information states** of that component are as is presented in Appendix 4. Use the answer sheet and fill in your answer in Appendix 4.

Opgave 4 (20 punten)

Opgave 1a (10 punten)

Geef een grafische representatie van het top-level van een proces abstractie voor het MOBIE systeem (zie Appendix 5). Laat de menselijke klanten als agenten voorkomen. Motiveer elke link die je tussen processen aanbrengt en leg uit welke soorten informatie worden uitgewisseld.

Student name: _____ Student number:

Opgave 1b (10 points)

In hoofdstuk 7 van de syllabus bestaat de meest complexe agent uit 6 verschillende componenten: agent_interaction_management, world_interaction_management, maintenance_of_agent_information, maintenance_of_world_information, own_process_control, en agent_specific_task. Welk van deze componenten heb je nodig en welke niet om een persoonlijk assistent agent van het MOBIE systeem te modelleren? Motiveer je antwoord en refereer expliciet aan de beschrijving van het MOBIE systeem.

English:
Question 4 (20 points).

Question 1a (10 points)

Provide a graphical representation of the top-level of process abstraction for the MOBIE system (zie Appendix 5). Include the human customers as agents in that picture. Motivate each link between processes, and explain the types of information exchanged.

Question 2a (10 points)

In Chapter 7 the most complex agent is composed of 6 different 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 description of the MOBIE system.

Student name: _____ Student number:

Appendix 1A: (Een Nederlandse vertaling van Question 2 is niet beschikbaar.)

Assistant of a film director

Q is an assistant of a film director. A big part of her duties is to recruit actors for new roles. She investigates the suitability of an actor with respect to different types of roles, e.g. whether he is capable to play the role of a villain, a hero, etc. In that connection, Q regularly looks for new actors on the Internet and also attends new plays in theaters watching actors performance on stage. She discusses the conclusions of her investigations with the director, and later on she announces to the actors the director's decisions. The actors in their turn ask Q professional advice on their performance and make various requests to Q such as copying scripts, etc. It is her duty to fulfil such requests.

Another part of her obligations is passive monitoring of the filming conditions such as lighting of the stage, sound effects, etc. She discusses her observations with the director, and after receiving his instructions Q informs stage workers and actors what must be improved.

Together with the director and the crew she does her best to produce a film good enough to be nominated for a national film festival. Together with the director she is responsible for making a schedule, so that the film is finished in time.
We asked the director about Q's personal characteristics. Below is the interview with him.
I know Q for five years. She is an energetic person committed to our plans to produce a best film possible. So I need not check her work constantly and give her certain freedom in her decisions.
She started with this job five years ago and was inexperienced. She has learned a lot over the years on this job and became an excellent assistant. She is indispensable in our group. Creative people like us often have difficult features in their characters. I have a bad tempo and never want to go into details of any routine matter and my actors are capricious and demanding. Q often takes initiative to mediate our conflicts and always finds unexpected and effective solutions.
Q is ambitious. In time she wants to be a film director herself, so she studies my work carefully and this year she will negotiate with investors to get money for a small budget movie she is planning to shoot herself.

Student name: _____ Student number:

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	

Student name: _____ Student number:

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	

Student name: _____ Student number:

Appendix 1B Answersheet (3 out of 3)

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

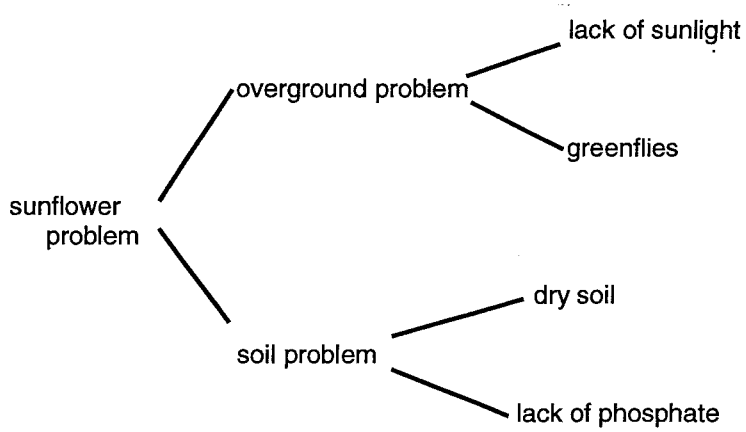
Student name: _____ Student number:

Appendix 2: Sunflower Problem

(Een Nederlandse vertaling van Sunflower Problem is niet beschikbaar.)

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.

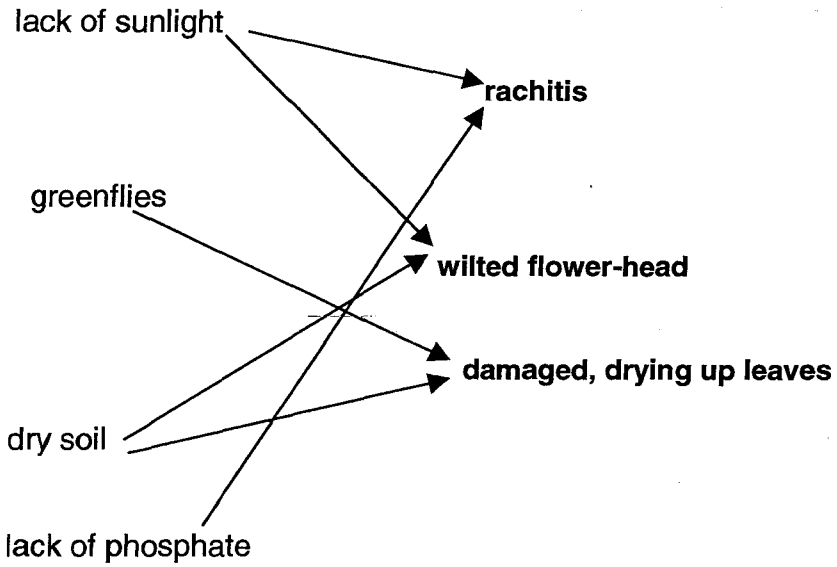
Since the specialist has no possibility to observe the plant, he asks the owner to make certain observations and communicate them back to the specialist.
To determine the nature of the problem, the specialist uses a line of reasoning modelled by the generic model for reasoning with and about assumptions (see Appendix 3). That model proceeds along the following lines: making assumptions (in some kind of order), 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:

Student name: _____ Student number:



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.

Student name: _____ Student number:

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
relations lack_of_sunlight, greenflies , dry_soil , lack_of_phosphate: CAUSES;
end information type
information type symptoms
relations rachitis, wilted_flower_head, drying_up_leaves: 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 lack_of_sunlight, greenflies , dry_soil , lack_of_phosphate , rachitis,
wilted_flower_head, drying_up_leaves : 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

Student name: _____ Student number:

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

Student name: _____ Student number:

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;
```

Student name: _____ Student number:

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

Student name: _____ Student number:

Appendix 4 Answersheet (1 out of 1)

Input (1)	[assumed(a, pos), predicted_for(b, pos, a, pos)]
Output after revision but before reasoning	[ ] (given)
Output after reasoning	
Input (2)	[assumed(a, pos), predicted_for(b, pos, a, pos), observation_result(b, neg)]
Output after revision but before reasoning	
Output after reasoning	
Input (3)	[assumed(a, neg), predicted_for(b, neg, a, neg), observation_result(b, neg)]
Output after revision but before reasoning	
Output after reasoning	

Student name: _____ Student number:

APPENDIX 5 Het MOBIE systeem (also in English)

Het gebruik van prepay mobiele telefoons is de laatste jaren sterk toegenomen. Het aanvullen van het bel-tegoed moet echter nog steeds vrijwel geheel door de gebruiker zelf worden uitgevoerd. Er is een systeem nodig dat het bel-tegoed van een gebruiker automatisch kan ophogen en zich daarbij houdt aan de persoonlijke wensen van die gebruiker. Dit systeem gaat MOBIE heten. Het MOBIE multi-agent systeem bestaat uit persoonlijke assistent agenten voor de klanten en zakelijke agenten voor de aanbieders van mobiele diensten. Het MOBIE systeem moet zorgen voor de personalisatie van de agenten, voor veiligheid, en moet de mens verschillende modaliteiten voor interactie bieden.

Om automatisch het bel-tegoed op te kunnen hogen moeten de aanbieders van telefonische diensten op een stabiele en betrouwbare manier met de persoonlijk assistent agenten kunnen interacteren. Gegeven het grote aantal van dat soort interacties, moet ook dit proces geautomatiseerd worden. In dit project is de keuze is om speciale zakelijke agenten te introduceren die deze interacties aankunnen.

De persoonlijk agenten die de gebruikers moeten vertegenwoordigen kunnen de volgende hoofdtaken uitvoeren:

1. De persoonlijke agent createert en onderhoudt een profiel van de gebruiker. Het profiel bevat tenminste:
    a. De criteria waaronder de agent het bel-tegoed moet ophogen.
    b. De informatie die nodig is om de ophoging uit te kunnen voeren, zoals de bedragen waarmee de agent mag ophogen, en informatie waarmee de betaling kan worden uitgevoerd.
2. De persoonlijke agent vergelijkt de criteria tegen het actuele bel-tegoed.
3. De persoonlijke agent vraagt de zakelijke agent om noodzakelijke informatie zoals:
    a. Het huidige bel-tegoed.
    b. Het gebruiks-patroon van het mobieltje voor een specifieke periode.
4. De persoonlijke agent om het bel-tegoed op te hogen.
5. De persoonlijke agent kan de aanbieder van de telefonische diensten (via de zakelijke agent) vragen om het bel-tegoed van de gebruiker met bedrag x op te hogen.
6. In overeenstemming met het klantprofiel houdt de persoonlijke agent de klant op de hoogte.
7. De persoonlijke agent via de volgende kanalen met de klant interacteren:
    a. Het Internet,
    b. WAP (als de klant een WAP telefoon heeft)
    c. Spraak.

De persoonlijke assistent agenten functioneren in een omgeving die bestaat uit zakelijke agenten die de aanbieders van telefonische diensten vertegenwoordigen, financiele instellingen (zoals banken waarmee de betaling uiteindelijk mee geregeld moet worden) en de klanten. De persoonlijk assistent agenten nemen niet zelf contact op met de financiele instellingen. Ze vragen de aanbieder van de telefonische diensten om het bel-tegoed op te hogen, de aanbieder neemt dan contact op met de juiste financiele instelling.

Student name: _____ Student number:

APPENDIX 5 The MOBIE system (ook in het NL)

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 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 project 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.

The personal assistant agents function within MOBIE in an environment consisting of business agents that represent the different telecom companies, financial institutions (like banks, with whom the actual payment is to be arrange d), and human customers. The personal assistant agents do not contact the financial institutions themselves. They can ask telecom company to recharge the prepaid account, the telecom company will then contact the appropriate financial institution.