Student name: _____Student number:

Faculteit der Exacte Wetenschappen

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

Vrije Universiteit Amsterdam **15 februari 2006**

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:

4 opgaven
5 appendices

You find:

4 exercises
5 appendices

Student name: _____Student number:

Opgave 1 (25 punten) *[Nederlands]:*

Relevante Appendix: Appendix 1A en Appendix 1B.
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 *Intelligent cars*. Analyseer deze informatie aan de hand van de primitieve agentconcepten. Welke agentconcepten zijn relevant voor het *adaptive cruise control* system? Vul Appendix 1B (3 antwoordvellen) in. Denk er aan dat je je antwoorden goed motiveert.

Opgave 1b (10 punten)

Zou jij dit systeem een agent noemen? Motiveer je antwoord in hooguit 15 woorden.

Exercise 1 (25 points) *[English]:*

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 *Intelligent cars*.
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.

Student name: _____Student number:

Exercise 1b (10 points)

Would you call this system an agent? Motivate your answers in a maximum of 15 words.

Exercise 2 (30 points) *[English]:*

Een Nederlandse vertaling van Exercise 2 is niet beschikbaar.

Relevant Appendices: Appendix 2 and Appendix 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 the problems of turbulence. Read Appendix 2 "Turbulence 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.

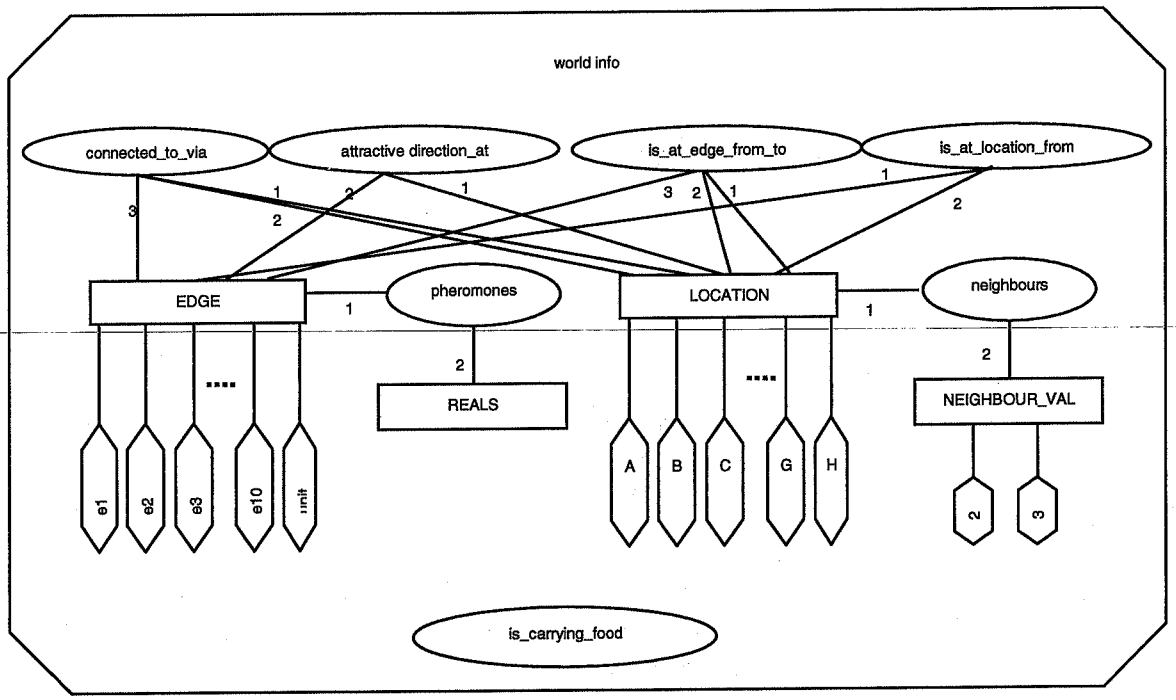
Exercise 3 (15 points) *[English]:*

Een Nederlandse vertaling van Exercise 3 is niet beschikbaar.

Relevant Appendix: Appendix 4.

Consider the information type world_info as shown in the Figure below. In Appendix 4 you can find a table consisting of a number of strings. Which of these strings are terms considering the information type world_info? Which are atoms? Which of the terms are well formed? Which of the atoms are well formed? Fill in your answer in the table in Appendix 4.

Student name: _____Student number:



Opgave 4 (20 punten) *[Nederlands]:*

Lees Appendix 5 en beantwoord de volgende twee vragen.

Opgave 1a (10 points)

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

Opgave 1b (10 points)

In hoofdstuk 6 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.

Exercise 4 (20 points) *[English]:*

Read Appendix 5 and answer the following two questions.

Question 1a (10 points)

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

Question 1b (10 points)

In Chapter 6 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:

Intelligent cars

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 safe as possible. One such system 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 safe as possible.*

End Appendix 1A.

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	

End Appendix 1B.

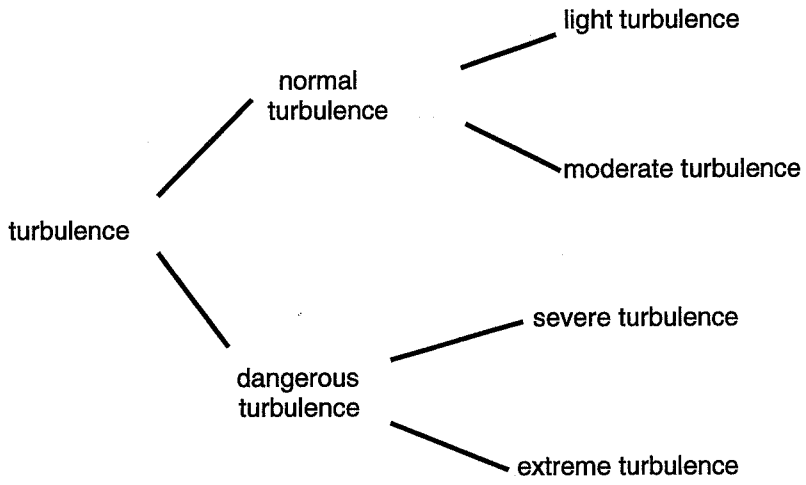
Student name: _____Student number:

Appendix 2 Turbulence Problem

Many air travellers have experienced turbulence, an irregular air motion that often occurs unexpectedly. This sudden and vicious phenomenon is invisible to radars, and when it occurs the pilots must report the occurrence back to flight control for it might have most dramatic consequences for the crew and passengers. To diagnose the type of turbulence they use their knowledge of symptoms of different types of turbulence.

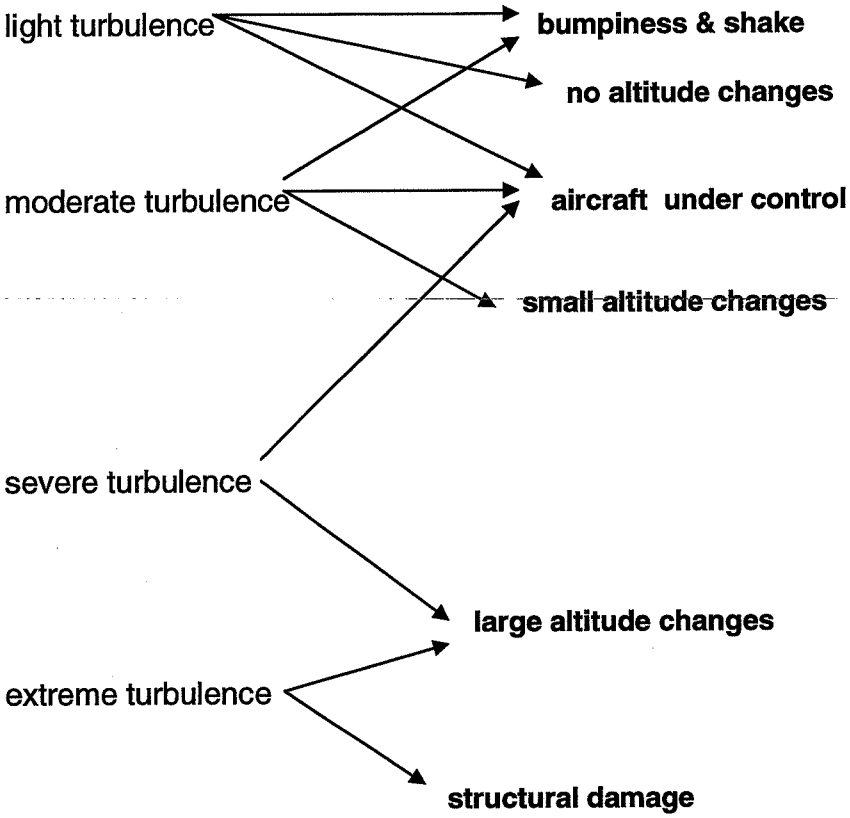
Suppose we have modelled an agent who would take over this duty.
To determine the type of the turbulence, our agent uses a line of reasoning modelled by the generic model for reasoning with and about assumptions (see Appendix 3). This model proceeds along the following lines: making assumptions (in some 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 agent uses the following hierarchy (taxonomy) of types of turbulence, that he uses to efficiently order the possible assumptions:



The relations between causes and symptoms are depicted below:

Student name: _____Student number:



If light turbulence occurs, then the passengers experience light bumpiness and shake without noticeable changes in altitude, and the aircraft remains fully under the pilot's control. During moderate turbulence passengers and crew notice bumps and jolts and small changes in altitude are possible, and the aircraft is under control at all times. Severe turbulence causes large, abrupt changes in altitude, although the crew keeps the aircraft under control. This may cause injury to passengers but the aircraft itself experiences no damage.
In case of extreme turbulence, a very dangerous event, the aircraft is impossible to control. It is violently tossed about and this mostly results in structural damage to the aircraft.

End Appendix 2.

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
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 light _turbulence, medium_turbulence, severe _turbulence,
extreme _turbulence;
end information type
information type symptoms
relations bumpiness_&_shake, no_altitude_changes, aircraft_under_control,
small_altitude_changes, large_altitude_changes, structural_damage;
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 light _turbulence, medium_turbulence, severe _turbulence,
extreme _turbulence, bumpiness_&_shake, no_altitude_changes,
aircraft_under_control, small_altitude_changes, large_altitude_changes,
structural_damage: 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 , 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 */

... ...

Student name: _____Student number:

end knowledge base

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

Student name: _____Student number:

/ USE as MANY RULES as YOU LIKE */*

end knowledge base

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;

Student name: _____Student number:

```
co-domain assumption_evaluation
        information type assumption_info;

sort links identity
object links identity
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
```

Student name: _____Student number:

private link observation_results
domain external_world
    information type observation_result_info;
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

End Appendix 3.

Student name: _____Student number:

Appendix 4: Answersheet for Exercise 3.

	term	atom	well-formed
neighbours(2, G)			
is_at_edge_from_to(L1:LOCATION, L2:LOCATION, E:EDGE)			
LOCATION: G			
is_carrying_food			
attractive_direction_at(X:LOCATION, B)			
e13			
is_at_location_from(e1, A)			
connected_to_via(X:LOCATION, e1, G)			

End Appendix 4.

Student name: _____Student number:

Appendix 5

Het MOBIE systeem [*Nederlands*]

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 beltegoed op te hogen, de aanbieder neemt dan contact op met de juiste financiele instelling.

The MOBIE system [*English*]

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.

End Appendix 5.
End of the examination text.