Faculteit der Exacte Wetenschappen	Tentamen Ontwerp van Multi-agentsystemen
Vrije Universiteit Amsterdam	21 januari 2000

Opgave	**1**	**2**	**3**	**4**	**5**	**bonus**
Punten	20	15	20	20	15	10

Normering:
Het **tentamencijfer** T is gelijk aan (het totaal behaalde punten voor de tentamenopgaven plus 10 punten bonus) gedeeld door 10.

Het **eindcijfer** voor het hoorcollege Ontwerp van Multi-agentsystemen wordt als volgt berekend:

Eindcijfer = (T + H + P) / 3,

waarbij
T = tentamencijfer,
H = cijfer huiswerkopgaven,
P = cijfer voor 1 punts practisch werk.

Verzoek:
U wordt vriendelijk verzocht om voor Uw antwoorden op opgave 4 gebruik te maken van de speciale **antwoordvellen**.

U treft aan:
5 opgaven
appendices
2 antwoordvellen

Opgave 1 (20 punten)

Het generieke agent model beschreven in Chapter 6 van de syllabus bestaat uit 7 componenten: own process control, world interaction management, agent interaction management, maintenance of world information, maintenance of agent information, cooperation management, and agent specific task. Lees Appendix 1 en beantwoord de volgende vragen.

Welk van deze componenten heb je wel en welke heb je niet nodig om Columbus te modelleren? Motiveer je antwoord en refereer expliciet naar de tekst in Appendix 1.

Opgave 2 (15 punten)

De kennis die Columbus nodig heeft om zijn doelen te bepalen moet worden gespecificeerd in een van de generieke componenten. Laten we deze component even comp_c noemen om geen invloed uit te oefenen op je antwoord op vraag 1. In Appendix 2 is een partiële specificatie gegeven van comp_c.

a) Completeer de kennisbank van de sub-component goal_determination van comp_c (10 punten). Zorg ervoor dat voor alle mogelijke karakters van Columbus de kennisbank bruikbaar is om te bepalen wanneer er moet worden verkend (explore) en wanneer er moet worden teruggegaan om Columbus opnieuw te bevoorraden (back to resupply). De voorzichtige verkenner gaat er van uit dat hij met halfvolle tanks in staat zou moeten zijn om terug te komen op de laatste plek waar hij zijn voorraden heeft bijgevuld.

b) Licht in gewone woorden elke regel toe die je aan de kennisbank hebt toegevoegd (5 punten).

Opgave 3 (20 punten)

Ga er van uit dat op zeker moment de object level **output** informatietoestand van component goal_determination de toestand S is.

S = [current_goal(back_to_resupply), next_goal(explore), not current_goal(explore)].

Beschouw de drie meta-informatietoestanden M1, M2 en M3 van Appendix 3.

a) Geef voor elk van de volgende paren van informatietoestanden aan of zij wel of niet level coherent zijn: paar (S, M1), paar (S, M2), paar (S, M3).

b) Leg voor elk paar dat niet level coherent is uit waarom dit paar dat niet is.

Opgave 4 (20 punten)

Stel dat de input and output informatietoestanden van component goal_determination voor executie van de links reset_old_goals, and set_new_goals zijn zoals beschreven is in tabel 1. Eerst wordt de link reset_old_goals geëxecuteerd, daarna wordt ook de link set_new_goals geëxecuteerd. De specificatie van dese links kan gevonden worden in Appendix 2. Focus je alleen op die atomen die kunnen worden gerepresenteerd met behulp van het informatietype goal_info.

a) Geef de **input meta-**level informatietoestand van component goal_determination na uitvoering van de link **reset_old_goals**.

b) Geef de **input object** level informatietoestand van component goal_determination na uitvoering van de link **reset_old_goals** (en na uitvoering van de neerwaartse reflectie).

c) Geef de **input meta**-level informatietoestand van component goal_determination na uitvoering van delink **set_new_goals**. Let op de veranderingen die je hebt aangebracht ten behoeve van opgaven 4a and 4b; denk eraan dat deze link wordt uitgevoerd na de veranderingen die jij hebt aangebracht.

d) Geef de **input object** level informatietoestand van component goal_determination na uitvoering van delink **set_new_goals** (en na uitvoering van deneerwaartse reflectie. Let op de veranderingen die je hebt aangebracht ten behoeve van opgaven 4a, 4b en 4c; denk eraan dat deze link wordt uitgevoerd na de veranderingen die jij hebt aangebracht.

object level input:	meta-level input:	object level output:
current_goal(explore): false	assumption(current_goal(explore), pos): unknown	next_goal(explore): true
current_goal(back_to_resupply): true	assumption(current_goal(explore), neg): true	current_goal(explore): false
	assumption(current_goal(back_to_resupply), pos): true	current_goal(back_to_resupply): true
	assumption(current_goal(back_to_resupply), neg): unknown	
	assumption(next_goal(explore), pos): unknown	
	assumption(next_goal(explore), neg): unknown	
	assumption(next_goal(back_to_resupply), pos): unknown	
	assumption(next_goal(back_to_resupply), neg): unknown	

Tabel 1 informatietoestanden met betrekking tot informatietype goal_info

Opgave 5 (15 punten)

Beschouw het domein van tafeldekken voor vier personen, zie Figuur 2. Het dekken van een tafel kan worden beschouwd als een proces dat moet worden bestuurd. In het ontwerp van een procesbesturingssysteem voor dit domein wordt gebruik gemaakt van het model voor procesbesturing zoals beschreven is in Chapter 3 van de syllabus. De domeinspecifieke informatietypes moeten worden aangepast.

a) Ontwerp het informatietype domain info voor dit domein. Je kunt dit in één informatietype doen, maar je mag ook meer abstractieniveaus aanbrengen.

b) Ontwerp het informatietype domain actions voor dit domein. Je kunt dit in één informatietype doen, maar je mag ook meer abstractieniveaus aanbrengen.

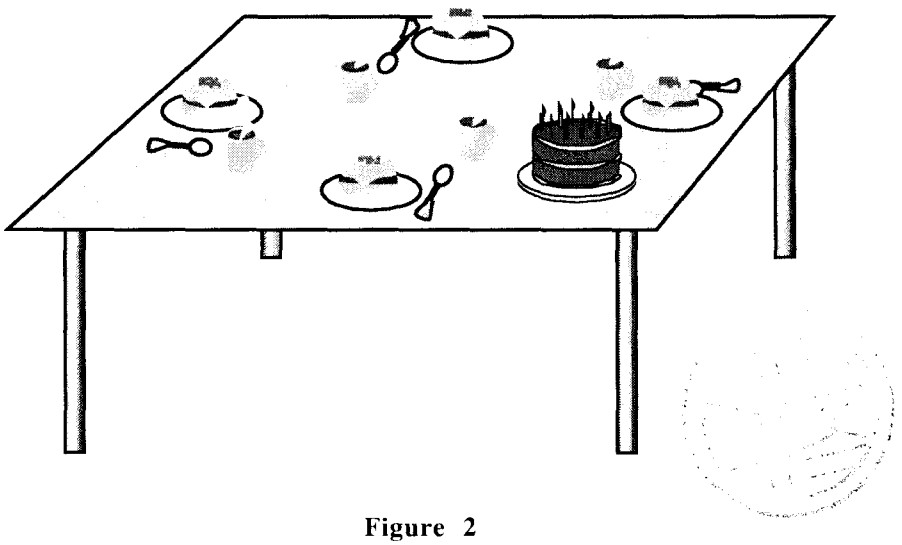


Figure 2

Appendix 1 Columbus: exploring space!

Only some 600 years ago the people that sailed the seven seas were often conftronted with the unknown. Large areas of Earth were still unmapped and maps that were available were often incomplete and not very accurate. Explorers were often considered heroes (only if they returned to tell their stories) or fools (those that did not come back). Experience learned that the major problem (next to plain disasters like shipwrecks) is that if you do some serious exploring then you tend to run out of supplies. With the start of the new millenium, your help is requested in designing the next generation of explorers.

In this new millenium a serious start will be made to explore space. Instead of sending people onto these very dangerous travels, the unmanned spacecraft will play a central role in this endeavour. The idea is to send out a mass of small spacecrafts that have the ability to observe their environment and are capable of resupplying themselves if they are able to find supplies in space. The first prototype called Columbus is almost ready; Columbus has everything it needs but for a reasoning component. That component will be responsible for Columbus' behaviour, it needs to be modelled according to the following requirements.

Columbus needs to be an agent (according to the weak notion of agenthood), for it will have to be totally self dependent (Earth will soon be too far away to be able to influence its behaviour). The main reason to send out Columbus is the need for space maps that contain lots of information about the planets, stars, asteroids, blackholes, and others the Columbus encounters during its travels. However, these travels take energy for the sensors and fuel for the engines that Columbus needs to steer itself and to get away from gravitation fields. Of course Columbus only gets a limited amount of supplies when it sets of on its voyage, further on more information on this point can be found.

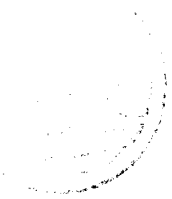
The voyage Columbus is making is only useful to Earth if, every now and then, Columbus communicates to Earth a report containing the star map it has made so far. Earth is unable to reply to these messages. The map contains all information that Columbus picked up on its scanners and sensors and Columbus adds the space coordinates for that information (time stamp, current location, speed, direction, etc.). Columbus also has special sensors with which it can monitor its own state of supplies: **almost empty**, **half full**, **almost full**, **full**.

In the exploration of space the major problem that Columbus has to face is that it could run out of supplies. Hopefully, Columbus will discover new places to resupply itself during its explorations. The ship's sensors are fully capable of recognizing different materials that can be used as supplies. Of course Columbus needs to remember where these supplies are, and since it has to make a space map anyway, the information of where supplies can be found has to be added to the space map. While exploring space the supplies will slowly run out and there will be a point where Columbus has to decide whether to turn back to one of the places it knows it can resupply or whether to press on in the hope that a new supply will be discovered before the current supply runs out. So the question always is: does it continue to travel into the unknown (**explore**), or does it go back to a place where it knows it can resupply (**back to resupply**)? This decision process is not only based on Columbus's beliefs about its environment and its

own status, but also on its own character, since Columbus can eiter be **reckless**, **cautious**, or a **coward**.

Important is that Columbus always has a goal!

You can assume, that initially, Columbus, has the goal to explore and not to go back to resupply, and it has one of the above mentioned characters. You can further assume that Columbus will resupply at every opportunity unless its tanks are full.



Appendix 2 A part of the specification for Columbus

2.1 top-level

information type agent_characteristics
  sorts CHARACTERISTIC;
  relations own_characteristic: CHARACTERISTIC;
end information type

information type domain_agent_characteristics
  sorts CHARACTERISTIC;
  objects reckless, cautious, coward: CHARACTERISTIC;
end information type

information type agent_characteristics_info
  information types agent_characteristics, domain_agent_characteristics;
end information type

information type goal_info
  sorts GOAL
  objects explore, back_to_resupply: GOAL;
  relations current_goal, next_goal: GOAL;
end information type

2.2 component comp_c

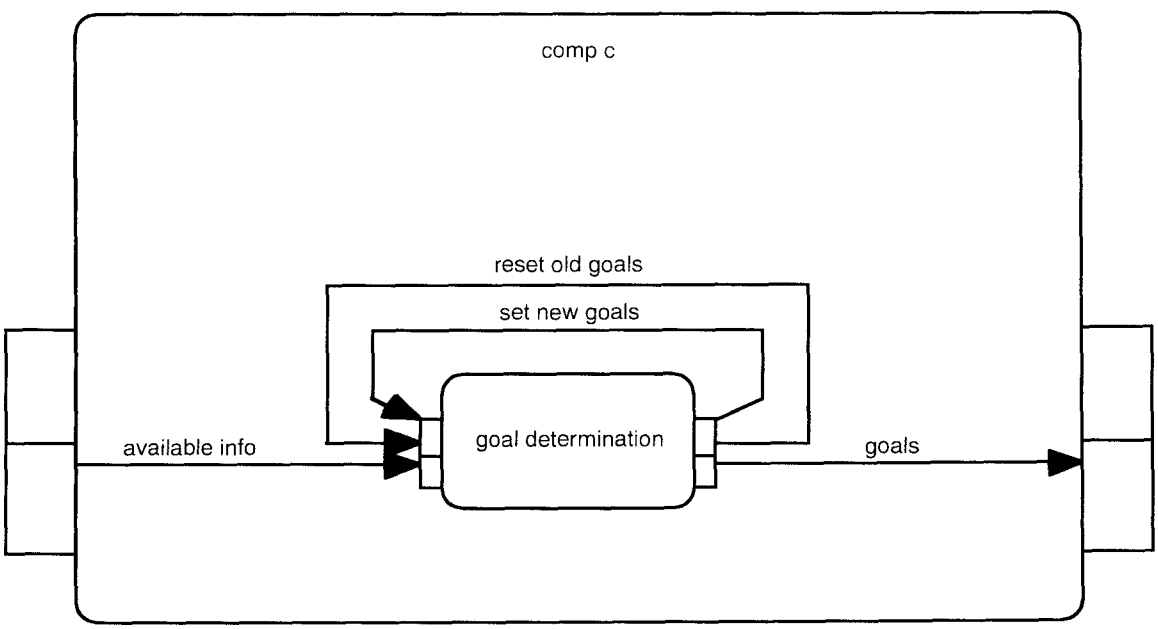


Figure 3 A partial view on comp_c

```
task control knowledge base of comp_c
   if    start
   then next_component_state(goal_determination, awake)
     and      next_link_state(available_info, awake);

   if    evaluation(goal_determination, next_goal_determined, any, succeeded)
     and      not component_state(goal_determination, busy)
     and      previous_component_state(goal_determination, busy)
   then next_link_sequence_state([ goals, reset_old_goals, set_new_goals], uptodate);
end task control kb

private link reset_old_goals: epistemic - assumption
   domain goal_determination
        level GD_meta_level
        information types epistemic_goal_info
        /* the standard epistemic information type with respect to information type goal_info */
   co-domain goal_determination
        level GD_meta_level
        information types assumption_goal_info
        /* the standard assumption information type with respect to information type goal_info */
   sort links identity
   term links identity
   atom links (true(current_goal(G: GOAL)), assumption(current_goal(G: GOAL), neg)): <<true, true>>;
end link

private link set_new_goals: epistemic - assumption
   domain goal_determination
        level GD_meta_level
        information types epistemic_goal_info
        /* the standard epistemic information type with respect to information type goal_info */
   co-domain goal_determination
        level GD_meta_level
        information types assumption_goal_info
        /* the standard assumption information type with respect to information type goal_info */
sort links identity
term links identity
atom links (true(next_goal(G: GOAL)), assumption(current_goal(G: GOAL), pos)): <<true, true>>;
end link
```

mediating link available_info: **object - object**

domain comp_c

level comp_c_object_level

information types agent_characteristics_info, belief_info

co-domain goal_determination

level GD_object_level

information types agent_characteristics_info, belief_info

sort links identity

term links identity

atom links identity

end link

mediating link goals: **object - object**

domain goal_determination

level GD_object_level

information types goal_info

co-domain comp_c

level comp_c_object_level

information types goal_info

sort links identity

term links identity

atom links

(next_goal(G: GOAL), current_goal(G: GOAL)): <<true,true>, <unknown,unknown>, <false, false>>;

end link

component goal_determination

input information types agent_characteristics_info, belief_info, goal_info;

output information types goal_info;

task information evaluation criterion: next_goal_determined

initial task information: target(next_goal_determined, next_goal(G: GOAL), confirm);

knowledge base goal_determination_kb

information types agent_characteristics_info, belief_info, goal_info;

contents

if own_characteristic(reckless)

and belief(suppy_status(almost_empty), neg)

then next_goal(explore);

if own_characteristic(cautious)

/* you can use more rules if you want or need to */

.....

.....

then next_goal(explore);

```
    if    own_characteristic(coward)
      and     belief(suppy_status(almost_full), pos)
    then next_goal(explore);

    if    own_characteristic(coward)
      and     belief(suppy_status(full), pos)
    then next_goal(explore);

    if    own_characteristic(reckless)
      and     belief(suppy_status(almost_empty), pos)
    then next_goal(back_to_resupply);

    if    own_characteristic(cautious)
    /* you can use more rules if you want or need to */
    .....
    .....
    then next_goal(back_to_resupply);

    if    own_characteristic(coward)
      and     belief(suppy_status(half_full), pos)
    then next_goal(back_to_resupply);

    if    own_characteristic(coward)
      and     belief(suppy_status(almost_empty), pos)
    then next_goal(back_to_resupply);
end knowledge base

contents goal_determination_kb;
end component
```

Appendix 3

De drie informatietoestanden voor opgave 3.

```
M1 = [
known(current_goal(explore)),      not true(current_goal(explore)),      false(current_goal(explore)),
known(current_goal(                true(current_goal(                    not false(current_goal(
    back_to_resupply)),                back_to_resupply)),                   back_to_resupply)),
known(next_goal(explore)),         true(next_goal(explore)),             not false(next_goal(explore)),
not known(next_goal(               not true(next_goal(                   not false(next_goal(
    back_to_resupply)),                back_to_resupply)),                   back_to_resupply))
]

M2 = [
known(current_goal(explore)),      not true(current_goal(explore)),      false(current_goal(explore)),
known(current_goal(                true(current_goal(                    not false(current_goal(
    back_to_resupply)),                back_to_resupply)),                   back_to_resupply)),
known(next_goal(explore)),         true(next_goal(explore)),             not false(next_goal(explore)),
known(next_goal(                   not true(next_goal(                   false(next_goal(
    back_to_resupply)),                back_to_resupply)),                   back_to_resupply))
]

M3 = [
not known(current_goal(explore)),  not true(current_goal(explore)),      false(current_goal(explore)),
not known(current_goal(            true(current_goal(                    not false(current_goal(
    back_to_resupply)),                back_to_resupply)),                   back_to_resupply)),
not known(next_goal(explore)),     true(next_goal(explore)),             not false(next_goal(explore)),
known(next_goal(
    back_to_resupply))
]
```

Antwoordvellen Student: Lichting:

Antwoorden op de vragen 4a en 4b

meta level input na executie van reset_old_goals voor neerwaartse reflectie		**object level input** na executie van reset_old_goals en na neerwaartse reflectie	
atoom	truth-value	atoom	truth-value
assumption(current_goal(explore), pos)			
assumption(current_goal(explore), neg)			
assumption(current_goal(back_to_resupply), pos)			
assumption(current_goal(back_to_resupply), neg)			
assumption(next_goal(explore), pos)			
assumption(next_goal(explore), neg)			
assumption(next_goal(back_to_resupply), pos)			
assumption(next_goal(back_to_resupply), neg)			

Tabel 4

Antwoordvellen Student: Lichting:

Antwoorden op de vragen 4c en 4d
(houdt rekening met wat je in tabel 4 hebt ingevuld!)

meta level input na executie van set_new_goals voor neerwaartse reflectie		**object level input** na executie van set_new_goals en na neerwaartse reflectie	
atoom	truth-value	atoom	truth-value
assumption(current_goal(explore), pos)			
assumption(current_goal(explore), neg)			
assumption(current_goal(back_to_resupply), pos)			
assumption(current_goal(back_to_resupply), neg)			
assumption(next_goal(explore), pos)			
assumption(next_goal(explore), neg)			
assumption(next_goal(back_to_resupply), pos)			
assumption(next_goal(back_to_resupply), neg)			

Tabel 5

Antwoordvellen Student: Lichting:

Antwoorden op de vragen 4c en 4d
(houdt rekening met wat je in tabel 4 hebt ingevuld!)

meta level input na executie van set_new_goals voor neerwaartse reflectie		**object level input** na executie van set_new_goals en na neerwaartse reflectie	
atoom	truth-value	atoom	truth-value
assumption(current_goal(explore), pos)			
assumption(current_goal(explore), neg)			
assumption(current_goal(back_to_resupply), pos)			
assumption(current_goal(back_to_resupply), neg)			
assumption(next_goal(explore), pos)			
assumption(next_goal(explore), neg)			
assumption(next_goal(back_to_resupply), pos)			
assumption(next_goal(back_to_resupply), neg)			

Tabel 5