

## **Integrative Modelling 2 – Exam 24-03-2010**

The time available for completing this exam is 2 hours and 45 minutes. The final grade for the exam E will be calculated as follows:  $E = (S+10)/10$ , where S is the sum of the points obtained for the individual questions. The overall grade for the course G is calculated as follows:  $G = (E + H) / 2$  where H is the average grade for the homework assignments. Note that the average is only calculated in case  $E \geq 5$ ; otherwise  $G = E$ .

### **Part 1 - Theoretical Questions (45 pts)**

Answer the following questions:

- a) Give four examples of concepts that are usually used to model processes at the cognitive level. (5)
- b) Explain the *Hebbian learning principle* and provide a formal specification of this principle. (10)
- c) Describe the four different types of interlevel-relations that can be established to relate models at different levels of the process abstraction dimension to each other. (5)
- d) A specific case of a temporal interlevel relation can be applied when both the temporally higher level and lower level model are executable (for example specified in LEADSTO). In this case the *behaviour* of the higher level model can be related to the *behaviour* of the lower level model. Explain in three steps how this can be done. (5)
- e) Suppose that a numerical approach is used for modeling a process at a global cluster level; what do the numbers used for the global cluster level concepts represent? (5)
- f) What are the basic elements of a temporally local specification of a dynamic property at the global cluster level? (5)
- g) What are the two main mechanisms required to specify relations between the individual agent level and the agent cluster level? (10)

## Part 2 - Practical Case Study (45 pts)

Consider a domain model for trust, which is described by the following five dynamic properties:

### Dynamic Property 1

$\forall A_i: \text{AGENT}, E: \text{EXPERIENCE}, A: \text{AGENT}$   
 $\text{communication}(A_i, E, A) \rightarrow \text{belief}(A, \text{exp}(A_i, E))$

### Dynamic Property 2

$\forall A, A_1, \dots, A_n: \text{AGENT}, E_i: \text{EXPERIENCE}, TR_1, \dots, TR_n \text{ TRUST\_VALUE}$   
 $\text{belief}(A, \text{exp}(A_i, E_i)) \ \& \ \text{trust}(A, A_1, TR_1) \ \& \ \dots \ \& \ \text{trust}(A, A_n, TR_n)$   
 $\rightarrow \text{trust}(A, A_i, TR_i + (\beta * (E - TR_i + \eta * (TR_i - \sum_{j=1}^n \frac{TR_j}{n}))) - \gamma * TR_i) * \Delta t)$

### Dynamic Property 3

$\forall A, A_1, \dots, A_n: \text{AGENT}, TR_1, \dots, TR_n \text{ TRUST\_VALUE}$   
 $\text{trust}(A, A_1, TR_1) \ \& \ \dots \ \& \ \text{trust}(A, A_n, TR_n) \ \& \ TR_i > TR_1 \ \& \ \dots \ \& \ TR_i > TR_n \ \& \ \text{desire}(A, \text{select\_most\_trusted})$   
 $\rightarrow \text{intention}(A, \text{select}(A_i))$

### Dynamic Property 4

$\forall A, A_i: \text{AGENT}, TR_1, \dots, TR_n \text{ TRUST\_VALUE}$   
 $\text{intention}(A, \text{select}(A_i)) \rightarrow \text{communication}(A, \text{give\_exp}, A_i)$

### Dynamic Property 5

$\forall A: \text{AGENT}$   
 $\text{desire}(A, \text{select\_most\_trusted}) \rightarrow \text{desire}(A, \text{select\_most\_trusted})$

- Explain the location of this domain model in the 3D classification scheme of domain models. (5)
- Describe the working of the formal model as presented above in an informal manner. (10)
- Express two formal properties of a model on the same agent cluster and process abstraction level but on a different temporal level. The two properties you distinguish should each be of a different type (whereby the property types can be achievement property, equilibrium property, maintenance property, time comparison property, trace comparison property, backward representation relation, forward representation relation). (10)

Now consider one dynamic property of another model for trust:

**Dynamic Property 6**

$\forall \gamma, t, A, A_1, \dots, A_n, TR_1, \dots, TR_n, E_1, \dots, E_n$   
 $[ A_1 \neq A_2 \& \dots \& A_{n-1} \neq A_n \&$   
 $state(\gamma, t) \models communication(A_1, E_1, A) \& \dots \&$   
 $state(\gamma, t) \models communication(A_n, E_n, A) \&$   
 $trust(\gamma, t, TR_1, A_1) \& \dots \&$   
 $trust(\gamma, t, TR_n, A_n) \& TR_i > TR_1 \& \dots \& TR_i > TR_n$   
 $\Rightarrow state(\gamma, t+4) \models communication(A, give\_exp, A_i)$

Where

**trust( $\gamma$ :TRACE,  $t$ :TIME,  $TR_i$ :REAL,  $A_i$ :AGENT)  $\equiv$**

$[ t = 0 \Rightarrow TR_i = 0 ] \&$   
 $[ t > 0 \&$   
 $\forall TR_{i2}, \dots, TR_{n2}, A_1, \dots, A_n, E$   
 $[ A_1 \neq A_2 \& \dots \& A_{n-1} \neq A_n \&$   
 $trust(\gamma, t-1, TR_{i2}, A_i) \& \dots \& trust(\gamma, t-1, TR_{n2}, A_n) \&$   
 $state(\gamma, t) \models communication(A_i, E, A) \Rightarrow$   
 $TR_i = TR_{i2} + (\beta^*(E - TR_{i2} + \eta^*(TR_{i2} - \sum_{j=1}^n \frac{TR_{j2}}{n})) - \gamma^*TR_{i2})^* \Delta t ] ]$

- d) Explain the location of this domain model in the 3D classification scheme of domain models. (5)
- e) Give an accurate and precise natural language description of Dynamic Property 6. (5)
- f) Explain in your own words how the first domain model introduced above (i.e., Dynamic Property 1-5) can be related to the second domain model (i.e., Dynamic Property 6). (10)