An Ambient Agent Model for Group Development Support

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Abstract

This paper introduces an agent-based support model for group development and leadership, to be used by ambient systems to support a group leader in the development of group members. Using model-based reasoning, an ambient agent analyses the development level of the group (member) and provides support to the group by proposing the most effective leadership behaviour to the group leader. The support model has been formally designed and within a dedicated software environment, simulation experiments have been performed.

1. Introduction

Leadership can be defined as the process of influencing activities of an individual or a group towards goal achievement in a given situation [1, p. 86]. Different leadership models focus on different aspects that can define how effective a leader can be in guiding the team or individual towards a goal. Some models focus on the traits of the leader and followers [2], others on their attitudes and even other models on the situational context or organisational dynamics. Examples of the attitudinal approaches to leadership are the studies in [7], [8]. The current paper introduces a support model which is based on the situational leadership model of Hersey and Blanchard [1, p.171-204]. Their model differs from most other leadership models in that they added a third dimension of leadership behaviour: the *effectiveness* dimension. The other two dimensions of leadership behaviour are the *task-oriented* and *relationship oriented* behaviours taken from [7], [8]. With the integration of the third dimension, it is now possible to predict the effectiveness of the different leadership styles in the specific situational context or situational demands.

At present no computational models of (situational) leadership are available. The motivation for formalising a computational leadership model is originated in the goal to design an ambient software agent that can support effective team performance. This paper explores the possibility of a support model for group development based on a situational leadership model. The idea is that an ambient agent can estimate the development level of the group (member) and match this with the correct leadership style. Then, based on the leadership style and the context, which also reflects the history and communication with the group (member), it can propose effective leadership behaviours to the team leader.

In the description of the detailed model in the next sections, the temporal relation $a \twoheadrightarrow b$ denotes that when a state property a occurs, then after a certain time delay (which for each relation instance can be specified as any positive real number), state property b will occur. In this language (called LEADSTO) both temporal logical relationships and numerical calculations can be specified, and a dedicated software environment is available to support specification and simulation; for more details see [4].

Below, in Section 2, a detailed model of development level is explained and formalised. Section 3 introduces the main aspects of a multi-agent support model for group development, which can be used by an ambient agent to provide support to the group by proposing the group leader the most effective leadership behaviour. In Section 4, simulation results of the group development level and the support mechanisms are shown. Finally, Section 5 concludes the paper with a discussion.

2. A Model for Development Levels

Multiple (informal) models of group development have been suggested by different researchers; for

example, see [5] and [6]. For the current paper the Situational Leadership Theory [1] was adopted. In this theory, the group leader is responsive to the behaviour of the group member, which he categorises in one of four development levels. In this way the group member's behaviour determines the group leader's behaviour. With the correct leadership behaviour, the group member can grow to a higher development level.

In [1] the authors define development levels as what they call 'readiness' levels of the group or individual person. They define readiness as the extent to which a group (member) shows the *ability* and *willingness* to accomplish a specific task. Readiness is not a personality characteristic, but is a concept that is being used in a specific situation, for a specific task. Their theory states that readiness exists of two components: ability and willingness. They define ability as the experience, skill or knowledge of the person or group and willingness as the degree of confidence, commitment and motivation a person or group has in accomplishing a specific task.

The interaction between the two components ability and willingness defines the current development level of a person or group. A person or group can be able or unable and willing or unwilling in task performance. Of these four states, four combinations can be made, which define the four development levels or readiness levels of a person or group. Thus the continuum of possibilities of the readiness of a person or group can be structured according to four levels: R1, R2, R3 and R4, see Figure 1 (comparable to Figure 8-2, p.177 in [1]). Here R1 defines a development level where the person or group is unable and unwilling. The unwillingness is either the lack of commitment and motivation or the lack of confidence in task performance. In R2 the group or person is unable but willing. Willingness can be either motivation and commitment the group or person demonstrates, or the confidence the person or group demonstrates in the guided task performance. In development level R3, the person or group is able but unwilling. This means that the group or person now has the ability (experience, skill and knowledge) to perform a task, but that the group or person lacks commitment and motivation or lacks confidence. In R4 the group or person is able and willing. This means that the group or person is able to perform a task and has the motivation and commitment or shows confidence in performing the task.

The current development level of a group (member) is reflected in the aspect g_R with possible values *R1, R2, R3* and *R4* for *R*. For each of the four development levels multiple profile attributes p_{ij} have been determined, which correspond with the behavioural indicators introduced by [1]; see Table 1.

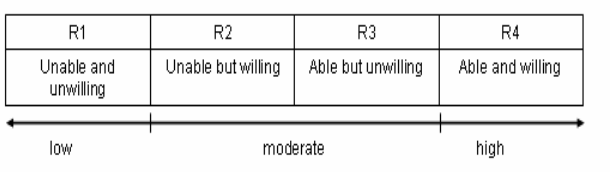

Figure 1 Continuum of readiness

Profile attribute		+ or -	p_{ij} *value* v_{ij}	*Experience*	
attr p_{ij}	*name*			*name* n_{ij}	*value* e_{ij}
Development level R1					
p_{11}	Defensive_behaviour	-	v_{11}	n_{11}	e_{11}
p_{12}	Complaining_behaviour	-	v_{12}	n_{12}	e_{12}
p_{13}	Intense_frustration	-	v_{13}	n_{13}	e_{13}
p_{14}	Late_task_completion	-	v_{14}	n_{14}	e_{14}
p_{15}	Performance_only_to_exact_request	-	v_{15}	n_{15}	e_{15}
p_{16}	Argumentative_behaviour	-	v_{16}	n_{16}	e_{16}
p_{17}	Discomfort_in_body_language	-	v_{17}	n_{17}	e_{17}
p_{18}	Confused_unclear_behaviour:	-	v_{18}	n_{18}	e_{18}
p_{19}	Fear_of_failure	-	v_{19}	n_{19}	e_{19}
p_{110}	Concern_over_possible_outcomes	-	v_{110}	n_{110}	e_{110}
Development level R2					
p_{21}	Nodding_head	+	v_{21}	n_{21}	e_{21}
p_{22}	Seeming_eager	+	v_{22}	n_{22}	e_{22}
p_{23}	Speaking_intense_and_quickly	+	v_{23}	n_{23}	e_{23}
p_{24}	Listening_carefully	+	v_{24}	n_{24}	e_{24}
p_{25}	Accepting_tasks	+	v_{25}	n_{25}	e_{25}
p_{26}	Acting_quickly	+	v_{26}	n_{26}	e_{26}
p_{27}	Seeking_clarity	+	v_{27}	n_{27}	e_{27}
p_{28}	Making_yes_I_know_comments	+	v_{28}	n_{28}	e_{28}
p_{29}	Answering_questions_superficially	-	v_{29}	n_{29}	e_{29}
Development level R3					
p_{31}	Being_hesitant	-	v_{31}	n_{31}	e_{31}
p_{32}	Being_resistant	-	v_{32}	n_{32}	e_{32}
p_{33}	Feeling_overworked	-	v_{33}	n_{33}	e_{33}
p_{34}	Seeking_reinforcement	-	v_{34}	n_{34}	e_{34}
p_{35}	Feeling_over-obligated	-	v_{35}	n_{35}	e_{35}
p_{36}	Lacking_self-esteem	-	v_{36}	n_{36}	e_{36}
p_{37}	Focusing_on_potential_problems	+	v_{37}	n_{37}	e_{37}
Development level R4					
p_{41}	Sharing_creative_ideas	+	v_{41}	n_{41}	e_{41}
p_{42}	Being_result-oriented	+	v_{42}	n_{42}	e_{42}
p_{43}	Being_willing_to_help_others	+	v_{43}	n_{43}	e_{43}
p_{44}	Keeping_boss_informed_of_task_progress	+	v_{44}	n_{44}	e_{44}
p_{45}	Shows_confidence	+	v_{45}	n_{45}	e_{45}
p_{46}	Making_efficient_use_of_resources	+	v_{46}	n_{46}	e_{46}
p_{47}	Being_responsible	+	v_{47}	n_{47}	e_{47}

Table 1 Formal representations of the behavioural indicators of the four readiness levels, Profile Attribute Names/Values and Experience Names/Values

Each profile attribute p_{ij} can be seen as a category or behavioural category of a certain development level. Index *i* defines the development level: $i \in \{1,2,3,4\}$. Index *j* defines the attribute name/position within this development level, for example for $i = 1$: $j \in \{1,2,3,4, 5, 6, 7, 8, 9, 10\}$. For example profile attribute p_{11} 'defensive_behaviour' belongs to development level R1 and is the first attribute name of this development

level. This profile attribute reflects the degree to which the group (member) shows defensive behaviour. Therefore it has a negative meaning. In the proposed model of group development, 10 profile attributes are suggested for development level R1, 9 for development level R2 and 7 both for levels R3 and R4, see Table 1.

Table 1 also shows that each profile attribute p_{ij} has a profile attribute value v_{ij} which reflects how often the group (member) has shown certain behaviours that indicate the specific profile attribute. Aspect v_{ij} has been formalised numerically by numbers in the interval [*0*, *1*]. For example v_{47} = 0.5 means that the group (member) has shown certain behaviours that indicate that the group member is being responsible. The exact dynamics of these profile attribute values depend on the settings of the other parameters, as explained below. Each profile attribute p_{ij} has a default profile attribute value v_{ij}. The default value of v_{ij} depends on the positive or negative meaning of the profile attribute $p_{ij.}$ A profile attribute p_{ij} with a positive meaning has a default value 0.1 for v_{ij} and one with a negative meaning has a default value of 0.9 for v_{ij}. For example the profile attribute p_{18} which is 'confused_unclear_behaviour' has a negative meaning. For this reason it is chosen that the default profile value of v_{18} is 0.9. Whenever the group (member) will show behaviour that corresponds with this profile attribute p_{18}, the profile attribute value v_{18} will decrease. A profile attribute p_{ij} with a positive meaning, for example p_{25} 'accepting_tasks', will have a default value of 0.1 for v_{25}. If the group (member) shows behaviour that corresponds with this profile attribute p_{25}, this profile attribute value v_{25} will increase. The idea is that the group (member) will follow the group development level from R1, to R2, to R3 to R4, by slowly increasing or decreasing certain profile attribute values p_{ij}. How this mechanism works is explained using the other aspects shown in Table 1.

In Table 1 also the concept experience name n_{ij} with experience value e_{ij} is introduced, which reflects the degree to which certain behaviour indicates a certain profile attribute p_{ij}. Aspect e_{ij} has been formalised numerically by numbers in the interval [*0*, *1*]. If a profile attribute value p_{ij} has a positive meaning, then the higher the value of e_{ij} the more this behaviour is an indication of the corresponding profile attribute p_{ij}. This is opposed to e_{ij}'s that indicate profile attribute behaviours with a negative meaning. Therefore a value of *0.2* for e_{11} reflects the same degree of p_{11} as the value of *0.8* for e_{21} that reflects $p_{21.}$ More specifically, in both cases the behaviour indicates the profile attribute to an extent of 80%. For example, behaviour 'crossed_arms' has an experience value e_{11} of 0.2 (negative meaning), and behaviour 'nods_head' has an experience value e_{21} of 0.8 (positive meaning). In this example 'crossed_arms' indicates profile attribute p_{11} 'defensive_behaviour' just as strong as 'nods_head' indicates profile attribute p_{21} 'nodding_head', namely they both indicate their p_{ij} with 80%.

The next step is to maintain each profile attribute value $v_{ij.}$ The formula for updating the profile attribute values v_{ij} is expressed as follows:

If v_{ij} has a positive meaning
then new $v_{ij} = \alpha\, v_{ij} + (1-\alpha)e_{ij}$
If v_{ij} has a negative meaning
then new $v_{ij} = 1-[\alpha(1-v_{ij}) + (1-\alpha)(1-e_{ij})]$

Here α is a number in the interval [*0, 1*] which reflects how persistent the p_{ij} value is. If $\alpha = 0$ then every new experience 'overwrites' the old profile attribute value v_{ij} completely. If α is a high number, like *0.8*, then the 'old' profile attribute value v_{ij} is very persisting, since the new experience can adjust only 20% of the 'old' profile attribute v_{ij} into the 'new' profile attribute v_{ij}. Note that for the second formula:

$1-$ *new* $v_{ij} = \alpha(1-v_{ij}) + (1-\alpha)(1-e_{ij})$,

is equivalent with:

new $v_{ij} = 1-[\alpha(1-v_{ij}) + (1-\alpha)(1-e_{ij})]$.

As an example: if the value of v_{11} (negative meaning) is *0.9* at time point *1*, the group shows a defensive behaviour with e_{11} = *0.2*, and α is set to *0.5*. Then the new value for v_{11} at time point 2 will be: $1-[0.5(1-0.9) +0.5(1-0.2)] = 0.55$.

Expressed in differential equation format, the update mechanism for profile attribute p_{ij} is as follows:

$$p_{ij}(t+\Delta t) = p_{ij}(t) + \beta\,(e_{ij}(t) - p_{ij}(t))\,\Delta t$$
$$d\,p_{ij}(t)/dt = \beta\,(e_{ij}(t) - p_{ij}(t))$$

where $\beta = 1 - \alpha$ can be considered a flexibility factor.

The final step is to calculate q_i for each development level, which indicates the degree the group (member) has shown behaviours of the specific development level. Aspect q_i has been formalised numerically by numbers in the interval [*0*, *1*] and reflects the average of the profile attribute values p_{ij} of the corresponding development level. For example, q_1 is the average of all p_{ij} with index i = 1. If q_1 is *0.1*, then the group (member) has not shown any behaviours yet that are indicative of development level R1, since it is the average of all (rescaled) default profile values v_{1j}. The formula for averaging the profile attributes p_{ij} into q_i is:

$$q_i = \sum_{j=1}^{n} w_{ij} / n_j$$

where, $n_1 = 10$, $n_2 = 9$, $n_3 = 7$ and $n_4 = 7$, and $w_{ij} = v_{ij}$ if the meaning is positive and $w_{ij} = 1-v_{ij}$ if the meaning is negative.

The group (member) will reach a next development level by exceeding a certain threshold for each q_i. Below a threshold of *0.6* was chosen, but the threshold can be set to any other number that will provide

predictive behaviour of the group. The mechanism of transferring to a next development level by exceeding a threshold is expressed by the following four rules:

If $q_1 < 0.6$ & $q_2 < 0.6$ & $q_3 < 0.6$
then development level is g_{R1}

If $q_1 \geq 0.6$ & $q_2 < 0.6$ & $q_3 < 0.6$
then development level is g_{R2}

If $q_1 \geq 0.6$ & $q_2 \geq 0.6$ & $q_3 < 0.6$
then development level is g_{R3}

If $q_1 \geq 0.6$ & $q_2 \geq 0.6$ & $q_3 \geq 0.6$
then development level is g_{R4}

3. The Leadership Support Model

In the previous section, the development level model has been discussed. In this section, a support model is introduced that uses this model to provide intelligent support to the group leader by proposing the most effective leadership behaviour to the group leader. The idea here is that an ambient agent can estimate the development level of the group (member) and match this with the appropriate leadership style. Then based on the leadership style and the context, which reflects the history and communication with the group (member), it can propose the most effective leadership behaviours to the team leader. In Figure 2 below, in overview of these processes of the support model is depicted. Although the proposed model is not a classification model, it has an overall structure similar to what is sometimes used in classification models [9], namely: abstraction, matching and refinement. The left part of Figure 2 (abstraction) represents model-based reasoning using the development level model described in the previous section to analyse the group member behaviour, and the right part (refinement) represents how to obtain support based on the analysis.

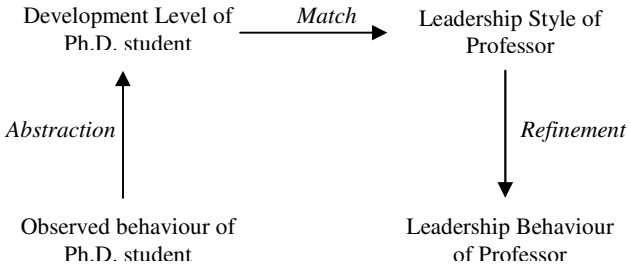

Figure 2 Abstract view of Leadership Support Model

The matching process in Figure 2 is based on [1], where four leadership styles are proposed that match with one of the four development levels discussed in previous section. The four leadership styles {S1, S2, S3, S4} are four different combinations of behaviours that are low or high on two dimensions: *task behaviour* and *relationship behaviour*. Typical task behaviour is telling people what to do, how to do it, where to do it and who should do it. The leader spells out the responsibilities and duties of the group (member). Relationship behaviour is characterised by two-way communication: the encouragement, listening, facilitating, and supportive behaviours. Figure 3 (upper part), (inspired from Figure 8-7 in [1, p.182]) gives an overview of the four leadership styles.

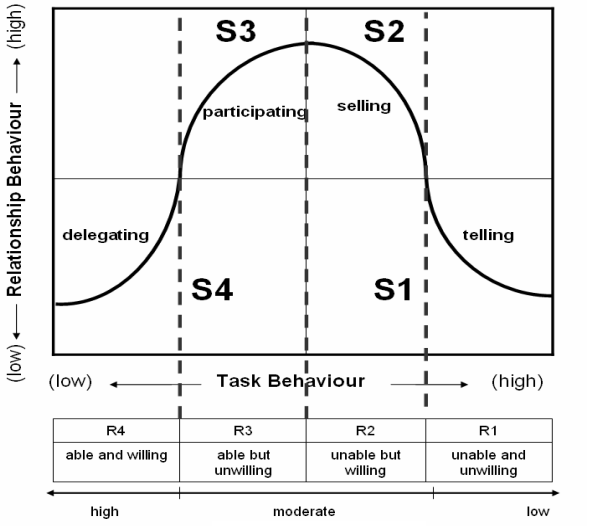

Figure 3 Situational Leadership Model: Leadership styles in four quadrants (upper part), related to the four readiness levels (lower part)

The correct matches of each leadership style with one of the readiness levels of the group member(s) are defined in [1] as: R1 matches S1, R2 matches S2, R3 matches S3 and R4 matches S4. In [1] depicted this is depicted as a Gaussian curve that goes through the four leadership style quadrants (see Figure. 3, upper part). Beneath the four quadrants, the four development stages are depicted. The developmental stage that matches with an interval on the horizontal axis of the quadrants, matches with part of the Gaussian curve in that interval. The quadrant that is traversed by the Gaussian curve in that interval is the matching leadership style for that development level.

In order for the ambient system to support the group leader in the development of group member(s) in an appropriate manner, LEADSTO [4] rules are specified. Table 2 shows the ontology needed to express such rules. The contents of Table 2 belong to an example scenario (also used to simulate in the next section) that represents a situation in which a PhD student is developing himself in conducting explorative research and is guided in his development by a professor.

SORT	Description
AGENTS	The group members: student STU and professor PRO
BODY_LANGUAGE	Body language BL of group members
COMMUNICATION	Communication of group members
PNAME	Profile attributes
CONTEXT	Context C reflects the situation and history of the student's behaviours
LEADERSHIP STYLES	The 4 leadership styles Si of the professor
DEVELOPMENT LEVELS	The 4 development levels Ri of the student

Table 2 Sort Description

Below, the detailed specification of the leadership support model is explained in terms of LEADSTO specifications (executable temporal rules; cf. [4]). The abstraction process starts with the ambient agent observing the behaviour of the Ph.D. student and generating a belief about the student's behaviour. This is shown in rule BS1. Rule BS2 represents the update process of one attribute value. Here, only one rule is given for the update of a certain profile attribute value, in case the Ph.D. student did show a behaviour indicating this profile attribute, otherwise the profile attribute value persists. After all profile attribute values are updated, the ambient agent calculates the four q-values. The calculation of the q-value for R1 is reflected in rule BS3. Next in rule BS4 the ambient agent calculates which q-value is highest. The highest q-value is used by the agent in rule BS5 to generate the belief about the development level of the student.

BS1 Generating a belief on the Ph.D. student's behaviour from an observation

If the ambient agent observes body language BL of STU in a certain context C

then the ambient agent will believe that STU has body language BL in a certain context C

observation_result(body_language_of_in(BL, STU, C))
→ belief(body_language_of_in(BL, STU, C))

BS2 Analysing the Ph.D. student's behaviour in terms of profile attribute values

If the ambient agent believes that STU has behaviour BL in a certain context C

and the ambient agent believes that body language BL of STU has profile attribute value PVALUE for profile attribute PNAME

and the ambient agent believes that the experience value for BL for profile attribute PNAME is E

then the ambient agent will believe that the profile attribute value of profile attribute PNAME of body language BL of STU is ALPHA*PVALUE+ (1-ALPHA)*E

belief(body_language_of_in(BL, STU, C)) &
belief(p_values_for_of_in(PNAME, PVALUE, BL, STU)) &
belief(e_value_of_for(E, PNAME, BL)) &
→ belief(p_values_for_of_in(PNAME,
ALPHA*PVALUE+ (1-ALPHA)*E, BL, STU))

BS3 Calculating the estimated q-value of R1

If the ambient agent believes that the first profile attribute PNAME1 of development level R1 has profile attribute value PVALUE1 for STU

and the ambient agent believes that the second profile attribute PNAME2 of development level R1 has profile attribute value PVALUE2 for STU

…

and the ambient agent believes that the tenth profile attribute PNAME10 of development level R1 has profile attribute value PVALUE10 for STU

then the ambient agent will believe that the estimated q value of the development level R1 for STU is the average of these 10 PVALUES

belief(highest_value_of_for(PVALUE1, PNAME1, r1, STU)) &
belief(highest_value_of_for(PVALUE2, PNAME2, r1, STU)) &
…
belief(highest_value_of_for(PVALUE10, PNAME10, r1, STU))
→ belief(estimated_qvalue_of(
(PVALUE1+ PVALUE2+… + PVALUE10)/10, r1, STU))

BS4 Calculating the highest estimated q-value

If the ambient agent believes that the estimated q-value of development level R1 of STU is X1

and the ambient agent believes that the estimated q-value of development level R2 of STU is X2

and the ambient agent believes that the estimated q-value of development level R3 of STU is X3

and the ambient agent believes that the estimated q-value of development level R4 of STU is X4

then the ambient agent will believe that the highest estimated q-value for STU is the maximum of X1, X2, X3 and X4

belief(estimated_qvalue_of(X1, r1, STU)) &
belief(estimated_qvalue_of(X2, r2, STU)) &
belief(estimated_qvalue_of(X3, r3, STU)) &
belief(estimated_qvalue_of(X4, r4, STU))
→ belief(highest_estimated_qvalue_of(
max(X1,X2,X3,X4), STU))

BS5 Assessing the development level of the Ph.D. student

If the ambient agent believes that the estimated q value of development level R1, namely X1, is the highest of the four estimated q-values for STU

then the ambient agent will assess that the development level of STU in context C is R1

belief(highest_estimated_qvalue_of(X1, STU))
→ assessment(development_level_for_in(R1, STU, C))

After the abstraction process, the next process in Figure 2 is the matching process. In the matching process, the ambient agent generates its desire for the most effective leadership style of the group leader based on the group's development level. Determining which leadership style is most effective (*S1, S2, S3* or

S4) is done in [1] by the following straightforward generic matching rule, which has been incorporated in the ambient agent:

If R_i *then* S_i where $i \in \{1, 2, 3, 4\}$

Below, rule BS6 models this matching process. In this rule the development level of the student agent is matched with the most effective leadership style of the professor agent.

BS6 Matching leadership style with development level
If the ambient agent assesses that the development level of STU in context C is Ri
then the ambient agent will desire that the leadership style for STU in context C is Si

assessment(development_level_for_in(Ri, STU, C))
→ desire(leadership_style_for_in(Si, STU, C))

In the refinement process, the ambient agent determines which leadership behaviours are appropriate in the given context, which it then proposes to the group leader. This is represented in rule BS7 below. The context reflects the history and communication with the student. The ambient agent has internal knowledge about which behaviours are most effective for which leadership style and in which context.

BS7 Choosing the appropriate communication response for the professor
If the ambient agent desires that the leadership style for STU in context C is Si
and the appropriate communication response of PRO is COMM to the behaviour BL of STU in context C
then the ambient agent will propose to PRO to respond with the communication COMM to STU in context C

desire(leadership_style_for_in(Si, STU, C)) &
belief(comm_response_to_in_for(COMM, BL, C, Si))
→ proposal(communication_by_to_in(COMM, PRO, STU, C))

4. Simulation Results

To illustrate the group development support model described above by a concrete example, a specific scenario is addressed. The simulation for the group development level model is discussed in Section 4.1. Section 4.2 shows the simulation for the support model.

4.1. Simulation of the development model

Simulations for an example case have been generated in the LEADSTO software environment [4]. The following example scenario represents a situation in which a Ph.D. student is developing himself in conducting explorative research. In the scenario the student can show behaviours of three types: body language, task performance and communication. These behaviours are indicators of certain profile attributes p_{ij}, which in turn are indicative for one of the four development levels, according to [1].

Before the student agent has decided which behaviour to perform, all possibilities for behaviour that suit the situational context are derived. These are called 'action_possibilities_student' in the simulation trace. E.g., there are 7 behaviours possible for the student in the given context 'c(4)', see Fig. 4 (showing time on the x-axis and state properties on the y-axis).

When the behaviour possibilities are derived, only the possible behaviours that match with the student's current development level are chosen. For example, Figure 5 shows that, the development level of the student first is R1 and later R2. The student's development level can also be derived from the values of q_i which are shown in the graphs in Figure 6. This figure shows that from about time point 145, q_i is above the threshold of 0.6. From this time point on the student is in the next development level: R2.

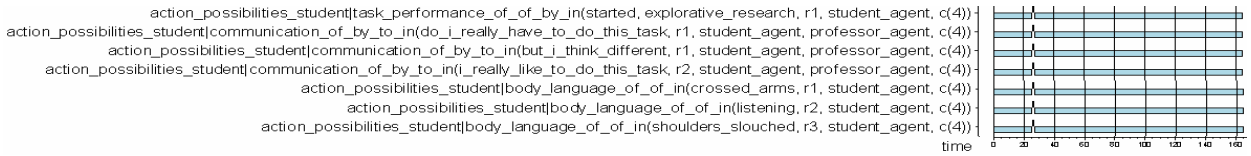

Figure 4 simulation trace: action possibilities for student agent

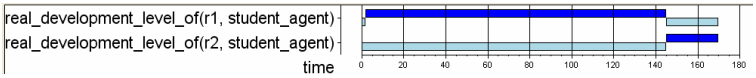

Figure 5 simulation trace: real development level of the student

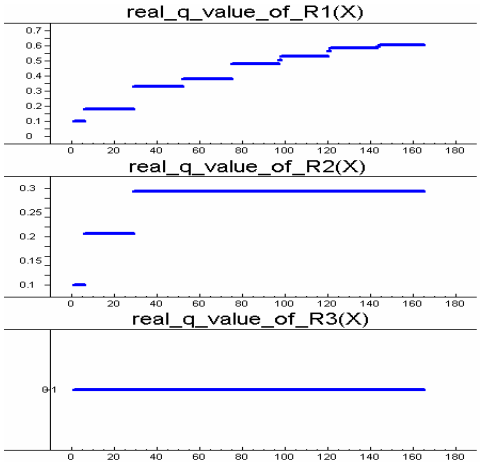

Figure 6 Simulation trace: q_i values for R1, R2 and R3 of the student

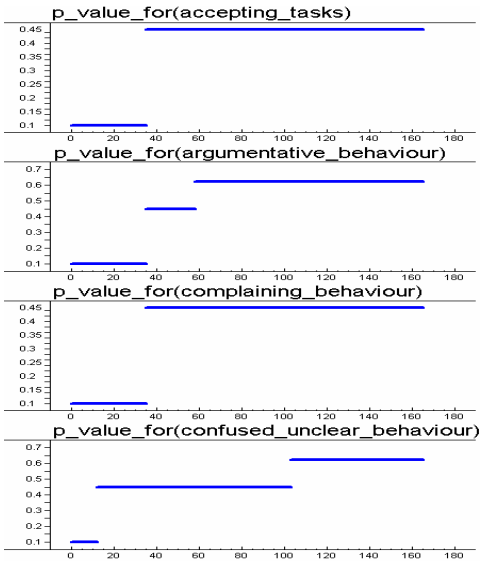

Figure 7 Estimated profile attribute values v_{ij}

4.2. Simulation of the support process

The ambient agent analyses the student's development level and determines the most effective leadership behaviours for the professor. The idea is that the ambient agent estimates the development level of the student based on his behaviours. After each behaviour of the student, the ambient agent updates the estimations of the student's current profile attribute values from which the estimated q_i's are calculated. In Figure 7 the updates of the estimated profile attribute values v_{ij} are shown.

In Figure 8 the *estimated* values of q_i are shown. In contrast, Figure 6 showed the *real* values of q_i, but they are identical to the ambient agent's estimates in Figure 8, only the ambient agent derives the values at a later time point, since it first needs to observe the behaviours that the student performs. After the ambient agent has estimated the current development level of the student, it derives appropriate leadership behaviours within the current context and the most effective leadership style.

Figure 9 shows that the input of the ambient agent's reasoning component 'action_selection' is the belief that the most effective leadership style is S2. Thereafter this component outputs a leadership style behaviour 'smiling' which corresponds with the leadership style S2 and with the current context c(5). In Figure 10 this leadership behaviour will be outputted by the ambient agent as a proposal to the team leader. The ambient agent is called 'professor_agent' in the simulation trace. The full LEADSTO specification can be found at: http://www.cs.vu.nl/~treur/gd-support.lt.

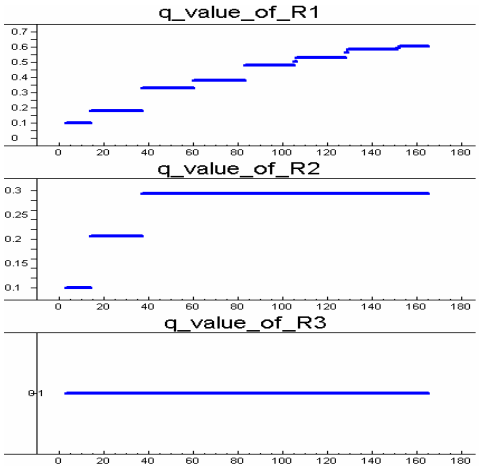

Figure 8 Simulation trace: professor estimates of q_i's.

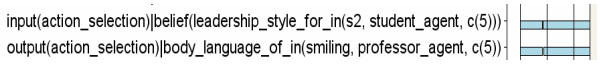

Figure 9 Simulation trace: deriving appropriate leadership behaviour

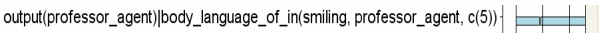

Figure 10 Simulation trace: output of the correct leadership behaviour

5. Discussion

Leadership can be defined as the process of influencing activities of an individual or a group towards goal achievement in a given situation. See [1, p. 86]. Many informal models on leadership exist these days. However, to our knowledge, no computational models of leadership concerning group (member) development exists yet. This paper presents a first exploration into computational modelling of such a leadership model. The group development model from the situational leadership theory in [1] was chosen as the basis for the support model. This model was chosen because it focuses on the behaviour of the group member and because the integration of the effectiveness dimension makes it possible to predict the effectiveness of the different leadership styles in the specific situational context or situational demands.

An agent-based approach to formalise and simulate group development and leadership support was chosen. Simulations of an example scenario of a Ph.D. student developing his skills in conducting explorative research, showed that the model is able to show how the student develops from one development level to another. The simulations also showed how the support model is able to estimate the group development level and to derive the appropriate behaviours for the group leader.

As a next step, various extensions of the support model will be explored. For example, the concept of context, which reflects the history and communication between team leader and the group (member) can be modelled in more detail. Furthermore there is the possibility that the ambient agent does not estimate the group development correctly. In that case, a possibility could be that the ambient agent is able to learn from its errors by adapting the parameters by which it estimates the development level.

A more extensive external validation of the model is also part of future work, although the model is based on the situational leadership theory in [1], which itself has been validated empirically. Nevertheless, several laboratory experiments are part of planned future work. The idea is to develop an ambient agent that is able to monitor the development of a team in a particular environment (e.g., a team of operators on a naval vessel, a team of employees in an organisation, or a sports team), and to provide support to the team leader in the form of behaviour proposals. For this, the ambient agent should be able to observe and interpret body language, communication and task performance.

6. References

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