The Roles of Roles in Agent Communication Languages

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Abstract

We consider agents having multiple communication sessions at the same time. We assume that FIPA semantics of agent communication languages can still be used when we attribute mental attitudes for each session, which we call the roles of the agents, and we assume that we have to distinguish the mental attitudes attributed to the roles from the mental attitudes of the agents. We consider several consequences of the distinction between the mental attitudes attributed to the roles and the mental attitudes attributed to the agent. First, in attributing mental attitudes to an agent or to one of its roles, we argue that only mental attributes are attributed to an agent's role when these attributes follow directly from the agent's communication. They are therefore public in the sense that every agent who has overheard the session, has the same beliefs about the mental attitudes of the role. Second, the moves permitted to the dialogue participants in the same dialogue game are based on the role only, such that different kind of moves can be specified in different types of dialogue games. Obligations are associated to roles related to institutions which can enforce them by means of sanctions. Third, expectations are based both on the mental attitudes ascribed to the agent and to the role.

1 Multiple sessions at the same time

Consider an agent who informs another agent that his web services can be used by all other agents, informs a third agent that his services can only be used by agents with the appropriate certificates, requests from a fourth agent a document, and informs a fifth agent that he does not have a goal to obtain this document. The semantics of speech acts in mentalistic approaches like FIPA [8], specified in terms of plan operators whose preconditions refer to the beliefs, goals and intentions of agents, cannot model such an insincere agent. In this paper we therefore generalize the FIPA model for the various sessions or dialogues of such an agent.

2 Mental attitudes for each session

Though an agent may tell two agents incompatible stories, it seems much less useful that an agent is allowed to tell incompatible stories to the same agent. Multiple sessions are therefore not a problem for FIPA, because we can just make another 'copy' of the agent for each session. In other words, we assume that FIPA semantics can still be used, when we attribute mental attitudes for each session. We refer to each 'copy' as a role instance, which is made precise only later in this paper.

The role of roles in agent communication is controversial in the following sense. On the one hand, communication among agents is often associated with the roles agents play in the social activity that is automated by the system. The GAIA methodology for agent-based software design [16] proposes interaction rules to specify communication among roles, the ROADMAP methodology [10] specifies in a so called social model the relations among roles, and in AALAADIN [7] interaction is defined only between the roles of a group: "The communication model within a group can be more easily described by an abstracted interaction scheme between roles like the 'bidder' and the 'manager' roles rather than between individual, actual agents".

On the other hand, most approaches to the semantics of agent communication languages do not take into account the fact that communication always takes place among agents in a role. Role names, like 'speaker' and 'addressee' or 'buyer' and 'seller' are often mentioned in the definition of agent communications languages. However, these terms only serve to bind individual agents to the speech acts in the protocol, but they are not associated with a state which changes during the conversation.

The function of roles in dialogue we study in this paper is similar to the function they play in an organization, where they define the power of agents to create institutional facts, like commitments. As in organizations, it is possible that the same agent plays different roles, thus determining ambiguities and conflicts. For example, a command issued by a friend may not be effective, unless the friend is also the addressee's boss.

3 The agent versus its roles

We assume also that we have to distinguish the mental attitudes associated with the role instances from the mental attitudes of the agents. For example, if we can inspect the knowledge base of an agent, then we should attribute the knowledge not to one of its roles, but to the agent itself. Moreover, we need to represent the mental attitudes of the agent itself if we wish to model that the agent is lying. Therefore, our model of a dialogue between two agents can be visualized as in Figure 1. The circles x and y represent two agents playing respectively roles r_1 and r_2 in the dialogue game. We use indices i, j to range over role instances, so in the figure we have $i = x : r_1, j = y : r_2$.

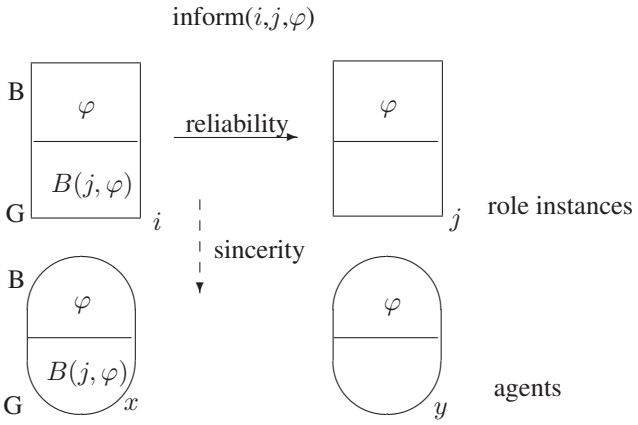

Figure 1. The role model.

If we wish to attribute mental attitudes, the distinction between the agent and its roles raises the question whether we attribute these mental attitudes to the agent, or to one of its roles. We propose that only those mental attitudes are attributed to the role, which follow directly from the agent's communication or from commonly held beliefs about the attitudes of particular roles (e.g. a buyer in a negotiation is expected to prefer a lower price); all other mental attitudes are attributed to the agent itself. In other words, the mental attitudes of the role are public in the sense that every agent who has overheard the conversation and knows the beliefs typically attributed to roles, has the same beliefs about the mental attitudes of the role.

The distinction between the agent and its roles allows to account for divergences between the private mental attitudes and the public ones. This possibility is not necessary in deliberation or information seeking, but it is necessary in competitive situations, like persuasion or negotiation. In a negotiation situation the agents have only the common goal of reaching an agreement, but there is no need that the communicate to each other truthful information or their real preferences. In particular, in a negotiation a bid does not need to correspond to the actual reservation price of the agent. In persuasion, if the aim is to win a dispute, an agent can adopt a point of view "for the sake of the argument", in order to show its inconsistency or bad consequences, without actually endorsing the view himself.

We explain the distinction in Figure 1. The constitutive rules of the communication game operate on the mental states of the role instances. Because of the feasibility precondition, an *inform* puts a proposition p to the beliefs of the speaker i, and a goal that j will come to believe p. If the hearer j believes that the speaker is reliable, rule (1) transfers the belief to the hearer. In a similar way, a successful request adds an intention to the goals of the hearer. This happens only when we have an axiom such as (2), that the hearer is cooperative. Cooperativity and reliability are role-role relationships, that depend on the social context in which an interaction takes place. For some interaction types, like information seeking or deliberation, these assumptions make sense. For other interaction types, like persuasion or negotiation, these properties will need to be altered or dropped.

$$B(j, G(i, B(j, \varphi))) \wedge B(j, \text{reliable}(i, \varphi)) \rightarrow B(j, \varphi) \quad (1)$$

$$B(j, G(i, \varphi)) \wedge B(j, \text{cooperative}(j, i)) \rightarrow G(j, \varphi) \quad (2)$$

In addition to role-role properties, there are also role-agent properties, that regulate the transfer of beliefs between the role instance and the agent. In particular, an external assumption like sincerity, as in rule (3) or (4), attributes the roles' beliefs or goals also to the agents themselves. Such assumptions are not part of the game.

$$B(x : r, \varphi) \wedge \text{sincere}(x, r) \rightarrow B(x, \varphi) \quad (3)$$

$$G(x : r, \varphi) \wedge \text{sincere}(x, r) \rightarrow G(x, \varphi) \quad (4)$$

The beliefs of the role are attributed also to the agent if he is considered sincere. Thus, the agent can be considered sincere in one role and insincere in another.

Sincerity is part of a larger class of agent-role properties, that regulate the possible transfer of beliefs and goals between role instances and agents. An interesting example, has to do with privacy and secrecy (the example is due to Huib Aldewereld, personal communication). Consider an intelligent agent application, that makes inferences on the basis of police records. To this end, it automatically connects to various police databases throughout the country, using some ACL. However, a police officer is not allowed to see personal characteristics of suspects, unless he or she is assigned to that specific case. Therefore, when displaying the results of the inference in a public ACL message, the agent should filter out any personal characteristics. By contrast, if the same software is used by a police officer assigned to the case, no such privacy filter has to be installed. Thus, a filter rule may block transfer from the individual agent's beliefs, to the role's beliefs.

4 Roles as prescriptions

Roles in a social institution are traditionally used to determine the obligations, permissions and institutional powers of an agent. Roles prescribe which possible speech acts are allowed for an agent, and possibly which acts must be used to respond. This idea is most prominent in the ISLANDER system [6], in which the roles of agents determine the interface with the environment. In our role model presented in [4] roles are always associated to some kind of institution, , see e.g. [11], which is described by constitutive rules. In the case of dialogue, the institution is represented by the current dialogue game played by the participants.

In the role based semantics introduced in this paper, the moves available to the dialogue participants in the same dialogue game are based on the mental attributes of the roles only, not on the mental attitudes of the agent. Since an agent enters in a dialogue only in a certain role, the communicative actions at his disposal, depend on the role. Thus, agents participating in a dialogue in different roles can perform different kinds of actions. This is due to the fact that the communicative action performed depends on the constitutive rules of the dialogue game: if an agent utters a sentence which is not recognized as a communicative action since the agent is not playing the right role, the communicative action is considered not to be performed.

A typical situation is represented by the Contract Net Protocol [15] where the initiator role and the participant role can perform different actions, e.g., call for proposal and proposal respectively. The initiator and participant role are already present in the Contract Net Protocol. The distinguishing property of our approach is that roles are not simply labels, but they are associated with instances representing the state of the participant in the interaction. The state is represented as a set of beliefs and goals attributed to the role enacting agent. Such state is modified by the communicative actions performed during the dialogue according to the constitutive rules of the dialogue game.

Each instance of a dialogue game is associated with instances of the roles played by the agents; so each agent is associated with a different state of the interaction in each dialogue he is participating in. For example, an agent who is playing the role of participant in a negotiation can at the same time participate as initiator in another negotiation to subcontract part of the task. In each of his roles (one as participant and many as initiator) the agent is associated with a set of beliefs and goals representing the situation of the conversation thus far. Moreover, the price the agent as initiator can pay to a sub-contractor, depends on the price for which it undertook the task, as participant. So all the roles must be related to a common agent, who has to direct the different negotiations according to his private reservation price and to the outcome of the other interactions.

5 Roles as expectations

Agents can make predictions, and use these predictions to coordinate their behaviour with an agent, due to the fact that the agent enacts a particular role. This predictive aspect is common in the social sciences, made famous by restaurant script Schank and Abelson [14] and emphasized in agent theory by Castelfranchi [5]. An example from human life, is the fact that the car of someone taking driving lessons, is clearly marked with a sign, like 'L' or 'E'. This sign does not change the prescriptive status – the traffic code applies just as much – but it signals to other drivers to be careful and more considerate.

In our role-based semantics, expectations are based both on the mental attitudes ascribed to the agent and to the role. To play a role, an agent is expected to act *as if* the beliefs and goals of the role were its own, and to keep them coherent, as it does for its own mental attitudes. It should adopt his role's goals and carry them out according to his role's beliefs. This holds despite the fact that the model remains neutral with respect to the motivations that agents have when they play a role, since the agents can adopt the mental attitudes attributed to roles as a form of cooperation, or they can be publicly committed to their roles. The roles' attitudes represent what the agent is publicly held responsible for: if the agent does not adhere to his role, he can be sanctioned or blamed.

Expectations follow also from the objectives of the agents. For agent communication languages, the most convincing example has to do with bargaining. In protocols like the Contract Net, listed above, there are no constraints on the content of the proposals. However, purely based on the apparent objectives of agents in entering into a conversation in a particular role, of this type in the first place, we can infer a number of preferences:

- the initiator wants to have some task achieved, otherwise he would not send the call for proposals
- the initiator wants to give up as little as possible, in return
- a participant, may either want to achieve the task, or not. In the first case, he will send some offer. In the last case he will send a reject, or fail to reply.
- if a participant is interested, he will want as much as possible in return for doing the task

From such preferences, we can infer some coherence conditions on the content of proposals. For example, it will be very unlikely that a participant will first offer to do the task for 40, and later to do the task for 50, because the participant does not expect the initiator to accept the higher offer, after the lower offer was declined.

6 Concluding remarks

The attribution of mental attitudes both to roles and agents forces us to reconsider several notions in agent communication. For example, Pasquier and Chaib-draa [13] argue that dialogue arises from the need to maintain coherence of mental states: "two agents communicate if an incoherence forces them to do so. [...] Conversation might be seen [...] as a generic procedure for attempting to reduce incoherence". In our role-based semantics, we can distinguish between incoherence between the mental states attributed to the roles, and the mental states attributed to the agents. We believe that an agent engaged in the dialogue tries to avoid contradictions, not with its private mental states, but with the public image of its role. As long as an agent plays a game following its constitutive rules, it cannot refuse that what it has said will be considered as a public display of its position in the game, according to its role. Consider the example of a liar, who once he starts lying, has to continue the dialogue consistently with what he said before, independently of his real beliefs. So, an agent may be sincere, in the sense that he really acts as expected from its role, out of pure cooperativity, or for fear of a sanction. An agent can play a role out of pure cooperativity, or for some external reason, like a reward or sanction. Sincerity is not requested, but an agent may act sincere, act as expected from its role, for the fear of losing reputation.

Another issue raised by our generalization is whether semantics on social commitments are compatible with semantics based on mental attitudes. Elsewhere we argue that role based semantics can embed the two main traditions in defining a semantics for agent communication languages [3, 1, 2]. Moreover, the question should be raised how such an embedding can be compared with alternative embeddings like grounding [9] or maintaining public ostensible beliefs [12]. For example, how do the alternative approaches incorporate the prescriptive and descriptive aspects of roles discussed in this paper, and how can they distinguish the following three kinds of roles. *Turn taking roles*, such as speaker, addressee, or (over)hearer, alternate repeatedly, based on which agent has the turn. *Participant roles*, such proponent or opponent in a persuasion dialogue, or buyer and seller in a negotiation dialogue, remain stable during a dialogue. *Social roles*, like teacher and pupil, or defense and prosecution, extend beyond single dialogues. Their scope depends on the social setting or institution.

There are several other subjects for further study. The institutional aspects of communication can be made explicit in our role based semantics. The consequences for the design of agent communication languages and protocols may be considered. Finally, other more general theories of roles can be developed and tested in this application of role theory.

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