

Semantics and Pragmatics for Agent Communication

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Abstract. For the successful management of interactions in open multi-agent systems, a social framework is needed to complement a standard semantics and interaction protocols for agent communication. In this paper a rights-based framework in which interaction protocols and conversation policies acquire their meaning is presented. Rights improve interaction and facilitate social action in multi-agent domains. Rights allow agents enough freedom, and at the same time constrain them (prohibiting specific actions). A general framework for agent communication languages (ACLs) is proposed, defining a set of performatives (semantics) and showing why a set of conversation policies to guide agent's interactions (pragmatics) is needed. Finally, we show how it is possible to model interaction protocols within a rights-based normative open MAS.

1 Introduction

One of the distinguishing properties of Multi-Agent Systems (MAS) is the ability of their members to interact with one other. Communication is a kind of interaction that should not affect the autonomy or heterogeneity of the agents, in the sense that agents are not forced to send or receive messages; in theory, agents are free to reject requests or not to answer any received messages. This is particularly true in open environments, such as the electronic commerce applications based on the Internet, where agents are designed by different constructors and work for their individual interests. The adoption of a standard Agent Communication Language (ACL) is crucial for artificial agents to interact in open environments.

Following the main tradition in this research area, the specification of a standard ACL is based on speech act theory [18]. Organizations like FIPA (Foundation for Intelligent Physical Agents [9]), define an ACL from a *mentalistic* point of view: The meaning of the performatives are defined in terms of the mental states of the agents, namely, beliefs, intentions and desires. It has been argued that the mentalistic approach can be useful for *cooperative* agents. However, in open environments, in which agents are heterogeneous and competitive, it is not sensible for agents to trust their opponents in a negotiation process, or to make assumptions about their current beliefs or intentions ([19,10]). We believe that these criticisms are partially motivated by not distinguishing between the

semantics and the pragmatics of the ACLs. Traditionally, the pragmatic level consist only of the definition of Interaction Protocols (IPs) to be applied in particular scenarios (e.g., auctions). These protocols merely dictate the order in which performatives are to be used, but they do not take into account the social consequences that the use of a particular performative may cause.

We understand agent communication as an activity in which agents' actions entail social consequences. However, unlike other social approaches ([19,10]) in which the semantics of the communicative actions are defined in terms of commitments, we understand that the social aspect of agent communication is a constituent of the pragmatics of the language. In our approach, the social consequences of sending a message are regulated by conversation policies (CPs) which help agents to both interpret and send an appropriate answer upon the reception of a message. For example, CPs may give the right to an agent to send a query, or obliging it to refuse a particular proposal.

It is argued here that the concept of commitment is not sufficient to express all the social aspects involved in communicative interaction, but a more general framework of coordination is needed. Unlike other approaches based on the idea of institution ([11]), our right-based approach, while maintaining agents' autonomy, can establish a mechanism of sanction. Besides, given its social nature, a rights-based ACL is public, so it is possible to determine whether an agent is acting according to the pragmatics of the language (conversation policies).

In this paper we provide a set of normative notions such as right, permission, obligation, which are used to model agents' social and communicative interactions within a normative framework. This enable us to define interaction protocols based on a meaningful set of messages. ACLs based on a semantics approach take only into account the isolated action of the utterance. They do not consider the sequences of interactions which are established in a conversation.

Interaction protocols represent the conventions adopted by agents when exchanging messages. In particular, these conventions represent the *legal* sequence of messages that agents have to follow. It has been argued ([19]) that focusing only on the specification of protocols (e.g., [12,4]) limit agents' autonomy. It also transforms communication in a meaningless exchange of ordered tokens since agent's behaviour is reduced to follow a predetermined conversational template. Conversely, we believe that interaction protocols should rely on a standard set of communicative actions which guarantees that the communication is meaningful. Besides, it should be possible to determine whether agents are behaving according to the specified protocol. Other approaches [8] take into account the meaning of the performatives, but they are not based on a standard ACL but on a set of *ad hoc* defined messages. In our approach, interaction protocols are defined on the basis of a previously defined set of communicative actions.

The remainder of the paper is structured as follows: In the next section, we define the main components needed to define a complete standard ACL. In Section 3, a set of communicative actions (semantics) and their STRIPS-based semantics are provided. Section 4 formally specifies, using CTL with deontic operators, the normative notions (rights) needed to define a set of conversa-