An operational model for mutual awareness

Flavien Balbo[1,2], Julien Saunier[1], Suzanne Pinson[1], Mahdi Zargayouna[1,2]

[1] LAMSADE, Université Paris-Dauphine
Place du Maréchal de Lattre de Tassigny, Paris Cedex 16
[2] INRETS/GRETIA, 2, Avenue du Général Malleret-Joinville, F-94114 Arcueil
{balbo,pinson,saunier,zargayou}@lamsade.dauphine.fr

Abstract. Typical interaction models as addressed messages present several pitfalls. To overcome these limits, new interactional models close to the concept of mutual awareness have been proposed. These models enable the agents to share their interactions and to reason about them. However, the use of mutual awareness by these models is restrictive and presents several limits. To overcome them, we propose a generic and operational model for mutual awareness.

1 Introduction

Because of the sole use of dyadic interaction in cognitive MAS, a large part of potential interactions remain unexploited. Nevertheless, several recent works propose to use some kind of *mutual awareness*, such as *overhearing*, to deal with interaction. This is, for an agent, to be able to intercept messages which were not initially addressed to it. This paradigm enables agents to share their interaction and so to exploit them. In section 2, we describe what is called *mutual awareness*. In section 3, we propose EASI (Environment as Active Support of Interaction), a generic and operational model for mutual awareness.

2 Mutual awareness

Interaction sharing is fundamental, as a big part of the solicitations in real-life situations come from other means than direct transmissions [3]. This fact has led simulation designers to simulate this means of communication [7]. In the context of teams of autonomous agents the coherence of the team increases significantly with the use of a protocol based on overhearing [5]. Overhearing has also been used in several works to monitor MASs, as in STEAM [4]. These three systems highlight the usefulness of the concept of overhearing, but their implementation using massive broadcast or subscription limits their usableness.

In order to limit the communication cost, channelled multicast [2] proposes a focused broadcast, by means of dedicated channels of communication where agents subscribe and/or emit. Nevertheless, two limits can be underlined: (1) the complexity of the system increases proportionally to the number of channels; (2) the sender still has to assume the emission of the messages to every agent.

However, we observe that proposing a solution for overhearing has also led to an improvement for the sender: it can choose to emit a message through a channel, which is the visible expression of the interests of the agents, instead of using addresses or capability (via middle-agents). This unified ability to emit and perceive via the accessible intentions of the agents is the major distinction we make between mutual awareness and overhearing – the latter only permitting the interception.

To facilitate its use in the multi-agent community, the mutual awareness paradigm must have a formal model. Tummolini [8] defines the concept of *Behavioral Implicit Communication* (BIC), within the framework of cooperative systems for task realization, as the set of every interaction that can be observed in an implicit way, i.e. information conveyed by actions or communications of the other agents. However, the properties that are required to fulfill BICs, like the ability for the agents to anticipate the effects of their own actions on the other agents, make this framework hardly useable. It needs very cooperative agents, that is why it is hard to model and implement in an heterogeneous and open system. Platon's model of overhearing [6] is the most generic to our knowledge, as it considers overhearing independently of the domain of the application. Nevertheless, their proposition has not already been implemented.

3 The EASI model

As formal models can not be implemented directly, except in restricted domains, and as real applications are functionally limited by the use of inadequate technologies, there is a need for a more operational model. Our new communication model has to exhibit the following features: (1) The messages may be received by unpredicted agents. Therefore, it is not indiscreet listening, because private communications can be executed via other means of communication, more secure according to the needs. (2) The reception of the messages is not based on an explicit agreement of the sender. (3) The messages must not be broadcasted because it means that every agent has to process every messages, even the useless ones, and because it has a high cost in terms of pass band. (4) There is no subscription process, because it has a high message cost, and it limits the interactional autonomy of an agent. So, if it is not the agents which assure the message broadcast, we propose to use the environment as an active and intelligent entity which can send the right information to the right agent at the right time.

Mutual awareness is based on the sharing of interactions. To be efficient, this principle implies that agents share a common communication media. In the reactive agent community, the environment is already used as a common media of interaction. In the cognitive agent community, we have proposed the EASI model [1]. It enables cognitive agents to use the environment to exchange messages and, more precisely, it enables an agent to send messages to an other agent that is located by the environment and it enables agents to perceive every exchanged message. In our work, we consider that environment contains descriptions of

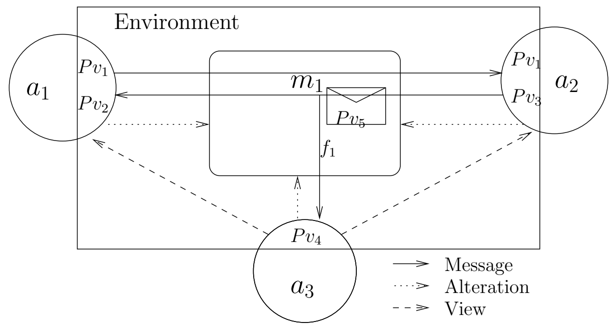

Fig. 1. Interaction for mutual awareness. The agents A1 and A2 exchange messages, and the second is intercepted by the agent A3. Each entity, agents and messages, has visible properties Pv_i. The message is broadcast via the set of filters f_i.

messages and agents. The interactional problem is to make possible for agents to use these descriptions to locate messages according to the environment state, that implies the matching between those properties and the needs of the agents.

We therefore propose to represent every component of the environment (e.g. the external properties of the environment itself as well as the agents and messages) as *entities*. Every entity has its *visible properties*, accessible via the environment, and the ability to put *filters* in the environment. These filters are logical expressions on properties, and determines, when a message is added to the environment, whether the agent is interested in it, in which case it will receive it, or not. In our EASI model, we have added this notation to formalize the knowledge about the description of interaction components (messages and agents). Because it enables to represent the agents, it makes possible for agents to create their interactional context as a set of filters. Each agent description is updated by the agent itself, modifying dynamically the value of its visible properties.

In Fig. 1, we represent graphically our model. The arrows that we called *alteration* show the agent capability to add, modify or remove its filters, and thus the way the environment will dynamically handle future messages. The arrows we called *view* show the capability of the agents to get the properties of the other entities, and so to refine their knowledge of the world by means of the environment. The new distribution of the messaging task via the environment permits us to extend the classical interactions to a property-based communication.

This model has been integrated in three different contexts. In a diagnosis transportation system, mutual awareness permits to reduce communication costs and improve faults detection thanks to the interception of every interesting message by the agents. In an agent server for a traveler information system, mutual awareness permits to add flexibility and personalization to the service, the attention of the agents headed toward its itinerary. Finally, in a classical multiagent platform, we have improved the interactions capabilities of the agent to the mutual awareness full extent, thus permitting its use in various domains.

4 Conclusions and Future Directions

We have shortly presented the Environment as Active Support of Interaction model, a new Interaction Model that has some useful characteristics, like the property-based communication and which helps to deal with the increasing complexity of interactional needs in MAS.

The distribution of the interaction between the agents and the environment leads to a new system design, which allows to decrease communication costs. The matching of the properties of the agents with those of the messages permits each agent to perceive all and only the interactions relevant to it.

In the near future some topics should be explored, one of them is the extension of our model to integrate the discovery and management of available interactions in the environment. Additional objectives are considered, such as to add multiple communication environments or to add heterogeneous agents.

References

1. Balbo, F., Pinson, S.: Toward a Multi-Agent Modelling Approach for Urban Public Transportation Systems. Omicini A., Petta P. et Tolksdorf R. (eds), Engineering Societies in the Agent World II, LNAI **2203**, Springer Verlag (2001) 160–174
2. Busetta, P., Don, A., Nori, M.: Channeled Multicast for group communications. Proceedings of the first international joint conference on Autonomous Agents and MultiAgent Systems AAMAS (2002) 1280–1287
3. Dugdale, J., Pavard, J., Soubie, B.: A Pragmatic Development of a Computer Simulation of an emergency Call Center. Designing Cooperative System, Frontiers in Artificial Intelligence and Applications, Rose Dieng et al, IOS Press' (2000)
4. Kaminka, G., Pynadath, C., Tambe, M.: Monitoring teams by overhearing: A mutli-agent plan-recognition approach. Journal of Artificial Intelligence Research vol. **17** (2002) 83–135
5. Legras, F. Tessier, C.: Lotto: Group formation by overhearing in large teams. Proceedings of AAMAS, Melbourne Australia, Springer Verlag (2003) 425–432
6. Platon, E., Sabouret, N. Honiden,S.: T-compound: An Agent-Specific Design Pattern and its environment. Proceeding of the 3rd international workshop on Agent Oriented Methodologies at OOPSLA (2004) 63–74
7. Traum, D., Rickel, J.: Embodied agents for multi-party dialogue in immersive virtual worlds. Proceedings of the first international joint conference on Autonomous agents and multiagent systems, part 2 (2002) 766–773
8. Tummolini, L., Castelfranchi, C., Ricci, A., Viroli, M. Omicini, A.: "Exhibitionists" and "voyeurs" do it better: A shared environment approach for flexible coordination with tacit messages. Proceedings of Workshop on Environments for Multi-Agent Systems (E4MAS) LNAI **3374** Springer Verlag (2004) 215–231