Reliable Group Communication and Institutional Action in a Multi-Agent Trading Scenario

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ABSTRACT

This paper proposes the use of reliable group communication as a complement to traditional asynchronous messaging in multi-agent systems. In particular, the mechanism of message publication on a virtually synchronous group communication channel is described and an example electronic trading scenario (the game of Pit) is used to illustrate how this form of communication supports the design of interaction protocols in which a shared perception of the order of messages is important. It is also shown that this style of messaging can be used to support the definition of social commitments based on a shared understanding of message order within a conversation.

Categories and Subject Descriptors

I.2.11 [**Computing Methodologies**]: Artificial Intelligence—*Multi-agent systems*

Keywords

Reliable group communication, interaction protocols, Pit, commitments

1. INTRODUCTION

Research on communication in multi-agent systems has largely focused on asynchronous modes of communication. However, there is a need for agent communications infrastructure that provides a range of communication mechanisms, including those with stronger guarantees than are provided by asynchronous messaging. These mechanisms should include the ability to reliably multicast messages to groups of agents. This paper focuses on a particular model of reliable group communication: the use of named channels that can be configured to guarantee the property of *virtual synchrony*: all agents connected to the same channel will perceive all message 'publication' and agent joining and leaving events in the same order. There are many situations, particularly in e-business, where the order of a set of messages sent by various agents is highly significant. In a distributed system with asynchronous communication, interaction protocols for such scenarios are complicated by the need to ensure that the agents involved reach a common understanding of the interaction state. Implementing virtually synchronous group communication channels within the agent infrastructure, and extending interaction protocol notations to include the publication of messages on such channels, should allow simpler interaction protocols to be developed for such situations. We outline the use of this mechanism within an interaction protocol for an electronic trading scenario: an electronic version of the card game Pit.

There is increasing interest in models of agent communication that are based on social semantics, and in particular the notion of public commitments made between agents is a subject of much research. Following this approach we show how publications on a virtually synchronous channel can be defined to count as institutional acts representing the making of commitments that are conditional on a shared understanding of the interaction history—a useful feature for the development of agent-based e-business systems.

2. RELIABLE GROUP COMMUNICATION

Busetta et al. [2] have proposed the use of channeled multicasting for agent communication where messages can be addressed to named channels and agents can "tune in" to channels of interest. This paper extends their work by considering the use of *reliable* group communication channels for agent communication. Researchers into data replication, failure detection and failure recovery in distributed systems have developed protocols that provide applications with multicast primitives having various reliability guarantees [1]. A particularly strong reliability property is that of *virtual synchrony*: all processes observe all messages in the same order, including notifications of processes joining or leaving a group. This property (amongst others) is supported by the JGroups Java library [4] which implements reliable channel-based group communication. In this paper we assume that the following operations (supported by JGroups) are available to agents:

Join a named group: An agent can connect to a virtually synchronous channel associated with a group.

Submit a message for "publication" on a group's channel: An agent can submit a message to a channel so that it will be sent to all members of a group (including the sender).

Leave a named group: An agent can leave a group by disconnecting from the associated channel, or this event may be considered by other group members to have implicitly occurred if the agent channel fails to respond to pings (in JGroups these are optionally sent as part of the channel's protocol stack).

In addition, whenever an agent joins or leaves a group all group members receive a message from the channel containing an updated "view" of the group membership.

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&\mathit{CountsAs}(\mathit{submit}(\mathit{att}(a,n,b),\{a,b\}),\\
&\quad \mathit{mc}(a,b,(\quad (\mathit{Done}(a,\mathit{observe\_pub}(b,\mathit{att}(b,n,a),\{a,b\}))\\
&\qquad\qquad \wedge (\neg \mathit{Done}(a,\mathit{observe\_pub}(a,\mathit{cancelled}(a,n,b),\{a,b\}))\ \mathsf{U}^-\ \mathit{Done}(a,\mathit{observe\_pub}(a,\mathit{att}(a,n,b),\{a,b\}))))\\
&\qquad\quad \vee (\mathit{Done}(a,\mathit{observe\_pub}(a,\mathit{att}(a,n,b),\{a,b\}))\\
&\qquad\qquad \wedge (\neg \mathit{Done}(a,\mathit{observe\_pub}(b,\mathit{cancelled}(b,n,a),\{a,b\}))\ \mathsf{U}^-\ \mathit{Done}(a,\mathit{observe\_pub}(b,\mathit{att}(b,n,a),\{a,b\})))))\\
&\qquad\quad \mathsf{S}^+\\
&\qquad\quad \mathit{Done}(a,\mathit{change\_state}(\mathit{SeekingPartner}(b),\mathit{TradingWith}(b),\ \mathit{pit}))))
\end{aligned}
$$

Figure 1: The institutional meaning of submitting an agreement to trade

3. EXAMPLE SCENARIO: THE PIT GAME

Pit [5] is a card game dating from 1904 that simulates commodity trading in the American Corn Exchange of that era. As an application involving concurrent activity, competitive behaviour and rules designed to ensure fair play, Pit is a good testbed application for investigating issues of electronic agent communication and institutional rules and actions.

In Pit, players advertise their desire to trade a certain number of cards, and when a potential trading partner is found they attempt to complete a card exchange with that partner. At this point there is an important transition in the system. A player beginning a card exchange with another player must focus on that operation and is therefore forgoing the chance to actively seek a possibly preferred trading partner. It is therefore important to have a *seek trade agreement* protocol that can culminate in both parties changing to a subsequent *trading* protocol at the same (logical) time.

The reliable group communication operations can be used to implement a *seek trade agreement* protocol as follows. A player a attempts to "catch the eye" of another player b by connecting to a channel for the group $\{a, b\}$. Upon connection, the channel sends the current list of group members to a, and this is repeated whenever the membership changes. If b joins the group before a timeout period, a submits the statement $\mathit{att}(a, n, b)$, meaning "a agrees to trade n cards with b", to the channel. For the two players to know that each other is committed to trading, they must each have submitted matching *att* statements to the group. If neither player has crashed or dropped off the network, these messages will eventually be published by the channel and received by each player. However, if a player wishes to withdraw its agreement before receiving the agreement of the other, it can submit a *cancelled(att(...))* message to its channel. This is where the virtually synchronous property of the channels come into play: all membership messages received (e.g., if a player disconnects from their channel), and *att* and *cancelled* publications will be received in the same order by both players. A cancellation is only deemed valid if it is received before the other player's agreement arrives, and virtual synchrony guarantees that both players agree on the validity of any cancellation publications. If player a observes its own and player b's *att* statements without observing any cancellations in between, then it changes to state $\mathit{TradingWith}(b)$ and begins to follow the *trading* protocol.

4. PUBLICATION AND COMMITMENTS

The use of virtually synchronous group multicasting ensures that the two players have a consistent view of the outcome of the negotiation. If both players correctly follow the protocol then they should each change to the card trading protocol. However, in an open system correct behaviour cannot be guaranteed and social mechanisms must be used to encourage compliance. In this section we show how the submission of an *att* message to a channel can be considered to "count as" (in the institution of Pit) the making of a conditional commitment to change to a trading state if the two negotiating parties' *att* messages are published with no intervening *cancelled* message. By allowing other parties (e.g. special auditor agents) to listen in on the channel, these commitments can be recorded as matters of public record.

Using the formalism of Verdicchio and Colombetti [6] for modelling commitments, agent communication and institutional action, the publication mechanism can be modelled by a number of rules in a branching time temporal logic. The institutional meaning of submitting an *att* message to the channel can then be defined within the institution of Pit as shown in Figure 1. This asserts that the action of submitting the message $\mathit{att}(a, n, b)$ to the channel for group $\{a, b\}$ counts as a making a commitment (*mc*) to b that as soon as the condition on the left of S^+ is satisfied, then a will change from state $\mathit{SeekingPartner}(b)$ to state $\mathit{TradingWith}(b)$. The condition to the left of S^+ is that whenever a publication from one of the two agents is observed, when looking backwards to find the matching publication from the other agent no cancellation of that publication has occurred more recently.

5. CONCLUSION

This paper has proposed the use of reliable group communication mechanisms in multi-agent systems and demonstrated its utility in a peer-to-peer electronic trading scenario where agents may require some guarantees about the state of other agents. It has also shown how publication on a virtually synchronous group communication channel can be formally defined to count as the establishment of a commitment that is dependent on the commonly understood order of future publications—thus allowing distributed agents to have a shared understanding of each other's commitments. Further details, a discussion of related work, and acknowledgements can be found in the full version of this paper [3].

6. REFERENCES

[1] K. P. Birman and T. A. Joseph. Reliable communication in the presence of failures. *ACM Transactions on Computer Systems*, 5(1):47–76, 1987.

[2] P. Busetta, A. Donà, and M. Nori. Channeled multicast for group communications. In *Proc. of the 1st International Joint Conference on Autonomous Agents and Multiagent Systems*, pages 1280–1287. ACM Press, 2002.

[3] S. Cranefield. Reliable group communication and institutional action in a multi-agent trading scenario. In *Proceedings of the AAMAS 2005 Workshop on Agent Communication*, 2005.

[4] JGroups project home page. http://www.jgroups.org, 2004.

[5] Parker Brothers. Pit rules. http://www.hasbro.com/common/instruct/pit.pdf, 1904.

[6] M. Verdicchio and M. Colombetti. A logical model of social commitment for agent communication. In *Proc. of the 2nd International Joint Conference on Autonomous Agents and Multiagent Systems*, pages 528–535. ACM Press, 2003.