Building a Multi-Agent System for Automatic Negotiation in Web Service Applications

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Abstract

Within the last decade, much effort has been put into the development of standards and technologies that enable the integration of Internet applications and the interoperability of Web services. The ultimate goal of these initiatives is to increase the automation of business processes. However many challenges remain to be addressed in order to reach a high-level of automation in Internet-based applications. Automatic negotiation is one of these challenges. In this paper we propose the Collaborative Agreement for Automatic Trading (CAAT), a Multi-Agent System framework that enables automatic negotiation in the context of a trading-based Web service.

1. Introduction

In some Web service scenarios, parties must negotiate the terms that will govern their business interaction. This is especially the case for trading-based Web service applications. Consequently, a complete automation in the context of these Web service scenarios requires the automation of the negotiation process. The Collaborative Agreement for Automatic Trading (CAAT) initiative is intended to deal with this issue. The CAAT specification is built on top of the FIPA Agent Architecture model. It has three main components: the *CAAT Business Interaction Model*, presented in Section 3, defines the operational context of the CAAT specification; the *CAAT Interaction Protocol*, presented in Section 4, defines an interaction mechanism for controlling a one-to-one trading-based negotiation process; and the *CAAT Ontology*, presented in Section 5, defines the semantics of the communication between trading agents.

2. CAAT in the Web Service Choreography

The CAAT specification works as follows. Suppose *Company A* has a service that is operated by an agent built in compliance with CAAT specification. During the service description phase, the Web Service Description Language (WSDL) document must have an entry that describes the profile of *Company A*'s agent. The description of the profile includes the identifier of the agent, its transport addresses, and the languages, protocols and ontologies supported by the agent. When *Company B* discovers *Company A*'s service, with the description of the agent profile provided in the WSDL document, it can automatically engage its own agent built in compliance with the CAAT specification in a business interaction with *Company A*'s agent.

3. CAAT Business Interaction Model

An agent is a computer program that has some specific abilities like *autonomy*, *reactivity*, *pro-activity*, *sociability* and *rationality* [1]. These abilities also include *honesty*, *trustworthiness* and *reliability*, which are of first importance in a negotiation environment where a group of agents operating independently must cooperate to achieve their self-interested goals [2, 3]. For a negotiation to take place efficiently, there are three basic requirements that need to be well circumscribed [4]: the *negotiation space*, i.e. the space of possible and acceptable deals, a *negotiation protocol*, i.e. the interaction mechanism that the agents must follow to come to an agreement, and an *ontology*, i.e. the semantics of the communication between the agents. The first two requirements deal with the rules that the agents must conform to in formulating their intentions at each step of the negotiation. In agent-mediated e-commerce applications [5], it is the responsibility of the market owner, i.e. the individual or organization that controls the environment in which buyers and sellers trade, to provide these basic requirements. Depending on the business interaction model, the multi-agent system that supports the negotiation can technically be built in a way that prevents agents from making deals that are out of the negotiation space.

The CAAT Business Interaction model supports two interaction modes: the *bilateral* interaction mode and the *trilateral* interaction mode. In the *bilateral* interaction

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mode, only the two trading agents are concerned with the interaction. In this interaction mode, each agent program must implement the validation rules that define the negotiation space, as well as the mechanisms to authenticate each other. In the *trilateral* interaction mode, the interaction includes a third party: the *trade facilitator agent,* which is not part of the negotiation process but acts to authenticate the trading agents and certify deals. In this interaction mode, the validation rules are implemented within the trade facilitator agent program.

4. CAAT Interaction Protocol

In an argumentation-based one-to-one negotiation, the two parties involved try to come to a mutually acceptable agreement by making deals that represent mutual concessions on their initial intentions [6]. The CAAT protocol defines the valid sequences of interactions according to the content of the deals. The deals themselves are conveyed by messages constructed using FIPA Agent Communication Language (ACL) specifications for message content representation and interpretation. Figure 1 depicts the CAAT interaction protocol flow using a set of performatives taken from the *FIPA Communicative Act Library Specification* [7].

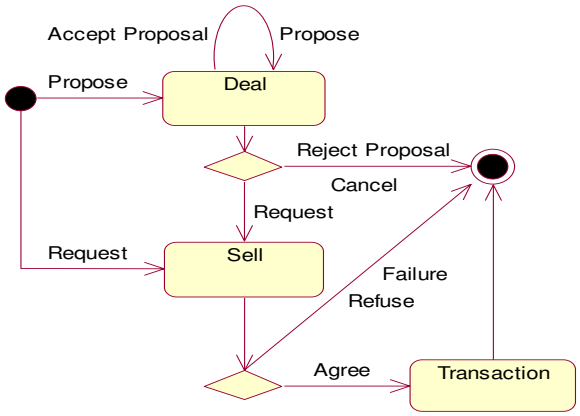

Figure 1. CAAT Interaction Protocol

5. CAAT Ontology

The CAAT Ontology defines the semantics of the communication between agents in a trading-based one-to-one negotiation scenario. Figure 2 describes the CAAT Ontology structure. In the context of the FIPA–ACL, the content of a message is either a proposition (*Predicate*) or an agent action (*AgentAction*). A *Predicate* or an *AgentAction* is a complex element, which is composed of *concepts* or *basic types* like *string*, *integer*, *decimal*, etc. The *ObjectREF* concept is a pointer to the traded good, which can be of any type and description. This mechanism ensures scalability, as well as the extensibility of the specification to any negotiation scenario that fits into its application scope. The *Authentication* and *certification* concepts are for the purpose of authenticating trading agents and validating deals for trilateral interactions.

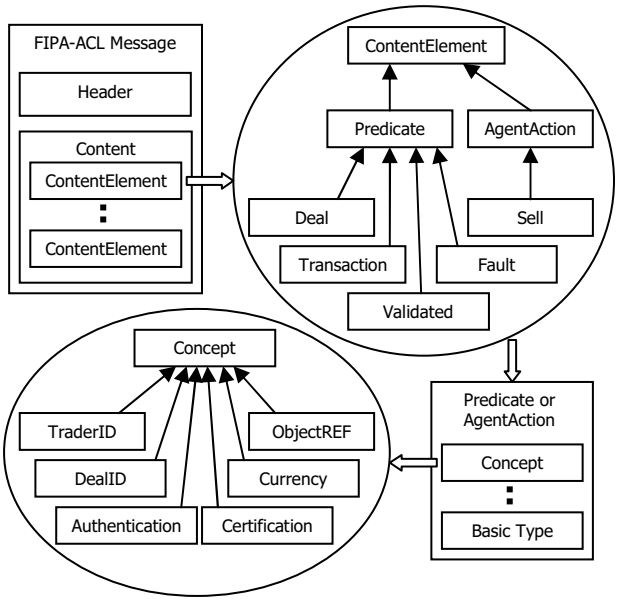

Figure 2. CAAT Ontology structure

6. Conclusion – Acknowledgement

In this paper, we presented the CAAT specification, a framework intended for the design of multi-agent systems for automatic negotiation in the context of a trading-based Web service application. The specification is designed to work tightly with the Web Services standards. It is built on top of the FIPA Agent Architecture model, which uses the Agent Communication Language specifications as support for the communication between trading agents. We have implemented a prototype of all the specifications—called *CocoaBeans*—which is currently under validation.

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6. References

[1] M. Wooldridge, *An Introduction to MultiAgent Systems*, Michael John Wiley & Sons, 2001.
[2] J. Ferber, *Multi-Agent Systems: An Introduction to Distributed Artificial Intelligence*, Addison Wesley, 1999.
[3] W. Brenner, R. Zarnekow, H. Wittig, *Intelligent Software Agents: Foundations and Applications*, Springer-Verlag, 1998.
[4] J.S. Rosenschein, G. Zlotkin, *Rules of Encounter*, the MIT Press, 1994.
[5] M. He, N. R. Jennings, H. Leung, "On Agent-Mediated Electronic Commerce", *IEEE Transactions on Knowledge and Data Engineering* **15**(4), 2003, pp. 985–1003.
[6] S. Kraus, *Strategic Negotiation in Multi-Agent Environments*, the MIT Press, 2001.
[7] FIPA, FIPA Communicative Act Library Specification, Document SC00037J, http://www.fipa.org/, 2003.

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