Combining FIPA ACL With DAML+OIL – A Case Study

Agent Communication with CIA, FIPA ACL and Techniques of the Semantic Web

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ABSTRACT

The Collaboration and Coordination Infrastructure for personal Agents (CIA) is a Java-based multi-agent framework for personal assistance. Until now, inter-agent communication in CIA is done via topic-based communication channels with Java-based event classes. Information within these events is represented in proprietary classes, which are serialized for transfer. As a result, agent communication is limited to an a priori defined domain of information chunks to which collaborating agents have to be tailored. In order to achieve wider inter-operability we are currently evaluating the combination of two techniques. For standardized communication between heterogeneous agents we will use the FIPA Agent Communication Language (ACL). The DARPA Agent Communication Language / Ontology Inference Layer (DAML+OIL[1]) will serve as content language for the ACL. This architecture seems to be a promising combination because of two reasons. First, agents of this kind are able to collaborate with other heterogenous agents in an ad hoc manner because of the standardized FIPA communication interface. Second, they do not have to be tailored to proprietary content vocabularies in advance, because they can use ontology-based Semantic Web techniques as a mechanism for identification of the meaning of the terms they communicate. However, it has to be figured out if these two techniques fit seamlessly into a given agent architecture like CIA. Potential problems include the semantic compatibility of DAML and ACL for example. These and other questions have to be considered with respect to the highly dynamic infrastructure of a CIA system.

Keywords

Ontologies and communication languages, DAML, OIL, Applications of ontologies, Ontology translation/mapping, Agent communication, FIPA ACL, Lightweight agent systems

1. LIMITATIONS OF CURRENT AGENT ARCHITECTURES

It is commonly believed that personalized software agents will make daily work more efficient by collaboration with other available agents relying on distributed information on the Web. Achieving this will require a flexible agent architecture, a standardized communication protocol and an adequate link-up with knowledge representation technologies of the next generation Web.

Looking at current agent systems, the following limitations can be discovered:

- If agent communication is restricted to specific and proprietary protocols, ad hoc communication of unacquainted agents is mostly not possible. Therefore the usage of standardized communication languages is highly desirable.
- Agent systems need many resources for reasoning and interference mechanisms. In a more and more global and connected world with constantly upcoming smaller computers (e.g. wearables, handhelds and cellulars) being an ideal environment for personal agent systems, the need for small-sized agent systems supporting these heavyweight mechanisms is obvious.
- Using isolated and pre-defined terminologies for inter-agent communication leads to agents which are tailored to specific vocabularies. In a global world where even general terms (e. g. time, location) are represented in different manners, mechanisms for identification of shared meanings are needed. Otherwise, totally unacquainted agents will mostly not be able to communicate successfully.

2. COMBINING NEW TECHNOLOGIES

In order to redress these restrictions we suggest to combine three technologies addressing different levels of agent communication. We will describe them shortly and argue their reasonable combination.

2.1 The CIA Multi-Agent Framework

CIA is a multi-agent framework for personal assistance [5] in highly dynamic environments. The main idea is to provide an infrastructure for personal agents with various basic services like hardware- and location-independent communication, persistence, security, mobility and user interaction. By using these services, an agent programmer is able to concentrate on implementing the actual application logic. Personal agents of one user are combined in a so-called agent cluster which may be split over several physical hosts. CIA allows the integration of agents from external agent clusters and even from different agent systems. Agents communicate with events via topic-based channels using the asynchronous publish/subscriber event model [6]. The underlying implementation of the communication infrastructure is

[1]In the following we will use the term DAML for short.

exchangeable in order to support any physical network connection and therefore enables the integration of CIA systems in highly dynamic networks and in special on small devices. Event types are pre-defined serializable Java classes consisting of a type, a set of pre-defined headers and a body. The pre-defined headers are internally used for technical information (e. g. routing or quality-of-service) in order to deliver events accurately and reliably. The body contains instances of any serializable Java class. It is used in combination with the event type to define application specific information or queries. Communication partners must have the same information about these class definitions and consequently, later extensions are impossible. Moreover, for every application the conversation procedure must be implemented again.

2.2 The FIPA Agent Communication Language

The intention of FIPA ACL [3] is to provide conversational logic to agents, thus raising the semantic level of agent communication to a higher level than existing technologies, e. g. event-based communication in CIA. In order to achieve this, each of the FIPA ACL communication primitives, called Communicative Acts, is given a precise semantics by providing pre- and postconditions expressed in a first order modal logic. With this semantics, the agent is able to express his personal attitude (e. g. belief, uncertainty, choice, intention) towards his achieved knowledge rather than the semantics of the knowledge itself. Based on this underlying semantic model, the agent can compile sensible options for his next action. An alternative approach for setting up intelligent conversations is to identify certain repeatedly used conversation patterns called Interaction Protocols (IPs) by examining typical agent application areas, e. g. an auction. Agents can communicate by agreeing to an FIPA IP and engage in a meaningful conversation simply by following a path within this IP. FIPA ACL merely places few constraints on the content language (CL) itself (how the content of a message is expressed). It only provides the conversation envelope for the actual information being exchanged.

2.3 Ontology Languages and the Semantic Web

The vision of the Semantic Web is to bring meaning and structure into information stored in Web sites or exchanged between Web-enabled agents [1]. Information on the Web will then migrate to knowledge due to annotated or inherent terms which are interconnected with terms of other sites, plus a set of explicit assumptions expressing the intended meaning of those terms. In the Semantic Web terminology such a set of knowledge terms is commonly called an ontology. A promising candidate for a Web-based ontology modeling language is DAML [4]. DAML provides a shared vocabulary of terms with formal semantics and is therefore suitable for inter-agent knowledge exchange. A necessary precondition is that agents relate the terms of their own knowledge base with corresponding terms of ontologies somewhere in the Semantic Web. Mutual understanding of agents can be accomplished if a semantic interconnection between the terminologies of the communicating agents can be found. DAML-enabled inference engines will help to make these semantic relationships automatically explicit. Appropriate reasoning systems for this purpose are currently developed utilizing research results from the established field of knowledge representation.

We believe that the previously mentioned technologies fit perfectly together in order to build a framework for communication between heterogeneous agents (other related work relies on similar assumptions, see [2] for example). CIA provides a robust architecture for multi-agent communication in highly dynamic environments. FIPA ACL is well suited to serve as conversational logic on top of the technical framework CIA. An ontology language like DAML enables agents to negotiate about arbitrary domains without narrowing on specific terms in advance.

3. PROBLEMS TO BE SOLVED

As explained above these three technologies are well suitable for sophisticated inter-agent communication systems. However, we still have to cope with the problem of combining them in a reasonable and efficient way. Integration of FIPA ACL within CIA can take place by embedding ACL messages as text-based XML into CIA event bodies. Involving the complete FIPA standard requires additional examinations since the user-centered agent cluster in CIA differs from FIPA's view of an agent platform. The combination of FIPA ACL with DAML leads to some interesting open questions we are currently working on:

- Does the CL have to represent modal operators, objects, proposition or actions of the FIPA ACL semantics? If so, which is the minimal set of elements a CL has to cover, esp. w.r.t. the desired expressiveness for CIA applications?
- Do the semantics of both languages have to be disjoint in any case?
- What are the additional requirements for CLs? Does every CL have to provide a possibility for querying in order to be a candidate for a FIPA CL?

The subject of our investigation will be how DAML can meet the requirements that FIPA imposes on CLs.
Concerning CIA and DAML the challenge is to provide heavy weight reasoning services for agents running on small portable devices using remote reasoning service invocation. We intend to make this service available through a special reasoning agent running on a powerful host within the pertaining agent cluster.

4. REFERENCES

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