Integrating Semantic Web technologies and Multi-Agent Systems: a Semantic Description of Multi-Agent Organizations*

Alexandra-Mădălina Zarafin[1] and Antoine Zimmermann[2] and Olivier Boissier[2]

[1] University Politehnica of Bucharest, Romania
[2] École Nationale Supérieure des Mines, FAYOL-ENSMSE, LSTI, F-42023 Saint-Étienne, France

Introduction. Decentralization and openness are inherent properties of multi-agent systems (MAS). The technologies they provide are thus the right abstraction for developing Web-oriented applications. Moreover, different works have been proposed to use Semantic Web technologies (SWT) for representing various dimensions of MAS (e.g., interaction protocols, norms, organizations). Given these facts, we think it is time to go a step further by integrating SWT and MAS in order to improve reusability of data, knowledge, coordination strategies, etc. on the Web and across systems. In this paper, we take a first step in this direction by proposing a semantic description of multi-agent organizations, showing the benefit regarding integration with Web ontologies.

Position. The Web is pervasive, populated with data, services, people and things, connected to each other, based on Web Standards. In such an environment, knowledge and semantic technologies become a necessity and a reality. Indeed, the Semantic Web has seen an increasing use not only for Web applications but in many areas of computer sciences. It encourages uniformity of data formats, as well as modularization and reuse of specifications (ontologies), by making it possible for ontologies to include and refer to information provided by other ontologies. Consequently, recent research in MAS have seen an intensive use of Knowledge representation together with increasing use of SWT. We envision that SWT will ultimately play a central role in all parts of MAS. Thus far, work combining MAS and SWT have only been concerned about addressing one dimension of MAS at a time. Also, they were mostly tackling the agent [6, 4] and interaction dimensions [10, 1] to ease communications, especially on domain knowledge. Other works have used those technologies to model part of the organization structure [8], norms and commitment [3], reputation [7] and more. The situation shows that it is time to go beyond these ad hoc solutions and integrate the pieces into a complete Semantic-Web-based infrastructure. We observe too that none of the mentioned contributions were really taking advantage of the Web aspect of these technologies, except some Web *service* integration. We want to provide the specifications as Web *data* as well, such that agents can uniformly query and reason about agent systems, Web services, data and ontologies.

Semantic Web technologies and Multi-Agent Organizations. We made a step in this direction, focusing on the organizational aspect of MAS, which has

* AT2012, 15-16 October 2012, Dubrovnik, Croatia.

been little addressed, although human organizations are of prominent interest to the Semantic Web community [9]. We used OWL to make an ontology of the organizational specification of the MOISE model [5], taking analysis of [2] as a basis. A given organization is described in RDF by instantiating the classes of the main ontology. The specification is made available at a SPARQL query endpoint, provided by an organizational artifact, so that agents who need to enter the organization can ask for relevant information on, e.g., roles or goals. Interestingly, agents can combine this with other data sources on the Web, using the same query language and protocol. Moreover, the specification can be combined with the agent's knowledge, who can specify constraining axioms in OWL (e.g., agents with whom I'm working must be disjoint from my friends) to detect undesired situations with consistency checks. Following Semantic Web good practices, we designed the ontology modularly and made it available online[3]. To allow compatibility with the existing implementation of MOISE, we implemented a two-way transformation.

Conclusion. MAS are increasingly interacting with the Web and we expect this to require the use of (1) Web standards and (2) semantic technologies. Therefore we want to encourage the use of SWT to enable the next generation of MAS. We contributed to this overall goal by providing an ontology for organization specifications.

References

1. OWL-DL as a FIPA-ACL content language. In *Proc. of FOCA 2006*, 2006.
2. L. Coutinho, J. Sichman, and O. Boissier. Modelling Dimensions for Agent Organizations. In *Handbook of Research on Multi-Agent Systems: Semantics and Dynamics of Organizational Models*, pages 18–50. 2009.
3. N. Fornara and M. Colombetti. Representation and monitoring of commitments and norms using OWL. *AI Comm.*, 23(4):341–356, 2010.
4. M. Hadzic, E. Chang, and P. Wongthongtham. *Ontology-Based Multi-Agent Systems*. Springer, 2009.
5. J. Hübner, J. Sichman, and O. Boissier. A Model for the Structural, Functional, and Deontic Specification of Organizations in Multiagent Systems. In *Proc. of SBIA 2002*, pages 118–128, 2002.
6. T. Klapiscak and R. Bordini. JASDL: A Practical Programming Approach Combining Agent and Semantic Web Technologies. In *Proc. of DALT 2008*, pages 91–110, 2009.
7. L. Nardin, A. Brandão, and J. Sichman. Experiments on semantic interoperability of agent reputation models using the SOARI architecture. *Eng. Appl. of AI*, 24(8):1461–1471, 2011.
8. D. Okouya, L. Penserini, S. Saudrais, A. Staikopoulos, V. Dignum, and S. Clarke. Designing MAS Organisation through an Integrated MDA/Ontology Approach. In *Proc. of TWOMDE 2008*, pages 55–60, 2008.
9. D. Reynolds. An organization ontology - W3C Working Draft 05 April 2012. Working draft, 2012. http://www.w3.org/TR/2012/WD-vocab-org-20120405/.
10. Y. Zou, T. Finin, Y. Peng, A. Joshi, and R. S. Cost. Agent Communication in DAML World. In *Proc. of WRAC 2002*, pages 347–354, 2002.

[3] http://purl.org/NET/maorg/moise