Practical Application of a Multi-Agent Systems Society for Energy Management and Control

Demonstration

Tiago Pinto
GECAD research group.
Polytechnic of Porto
Porto, Portugal
tcp@isep.ipp.pt

Gabriel Santos
GECAD research group.
Polytechnic of Porto
Porto, Portugal
gajls@isep.ipp.pt

Zita Vale
Polytechnic of Porto
Porto, Portugal
zav@isep.ipp.pt

ABSTRACT

Power and energy systems lack decision-support systems that enable studying big problems as a whole. The interoperability between multi-agent systems that address specific parts of the global problem is essential. Ontologies ease interoperability between heterogeneous systems providing semantic meaning to the information exchanged between the various parties. This paper presents the practical application of a society of multi-agent systems, which uses ontologies to enable the interoperability between different types of agent-based simulators, directed to the simulation and operation of electricity markets, smart grids and residential energy management. Real data-based demonstration shows the proposed approach advantages in enabling comprehensive, autonomous and intelligent power system simulation studies.

KEYWORDS

Multi-agent simulation; power and energy systems, semantic interoperability

ACM Reference format:

Tiago Pinto, Gabriel Santos and Zita Vale,. 2018. Practical application of a multi-agent systems society for energy management and control: Demonstration. In *Proc. of the 18th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2019), May 13-17, 2019, Montréal, Canada.* IFAAMAS, 3 pages.

1 INTRODUCTION

One of the key challenges in the field of power and energy is the development of decision-support systems that enable addressing the problem as a whole. For this, achieving interoperability between different systems that study specific parts of the global problem is essential [1]. Ontologies facilitate the interoperability between heterogeneous systems giving semantic meaning to the information exchanged between the various parts [2]. The advantage is that all members in a particular domain know them, understand and agree with the concepts defined therein. There are several proposals for the use of ontologies within Smart Grids (SG) [3-5]. All are based on the Common Information Model (CIM), which defines a common vocabulary describing the basic components used in electricity transportation and distribution. However, these ontologies are focused on the operators and big utilities' needs, leaving the relevant information to the clients. The development of ontologies that allow the representation of diverse knowledge sources is essential to facilitate interaction between entities of different natures, the interoperability between heterogeneous systems, and considering distinct information sources. Demonstration video available: https://youtu.be/Xf4ree3yWaI.

2 PROPOSED APPROACH

This work proposes a solution to ensure the interoperability between heterogeneous multiagent systems (MAS) directed to the study, simulation, analysis and management of Electricity Markets (EM), SG [6], and buildings energy management [7]. To this end, this paper presents the practical application of a society of MAS aimed at the simulation and study of energy systems, taking ad-vantage of existing simulation and decision-support tools, namely MASCEM (Multi-Agent Simulator of Competitive Electricity Markets) [8] AiD-EM (Adaptive Decision Support for Electricity Market Negotiations) [9] and MASGriP (Multi-Agent Smart Grid Platform) [10]. The developed ontologies not only enable the interoperability between different MAS but also represent the concepts needed to understand and use real data, from different sources (Fig.1). These can be acquired in real time through analysers/sensors, or even databases available online. For that, the developed ontologies al-low the representation of knowledge in a common vocabulary, regardless of the source; thus facilitating interoperability between the various heterogeneous systems and data, information and knowledge sources.

Proc. of the 18th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2019), N. Agmon, M. E. Taylor, E. Elkind, M. Veloso (eds.), May 13-17, 2019, Montréal, Canada. © 2019, International Foundation for Autonomous Agents and Multiagent Systems (www.ifaamas.org). All rights reserved.

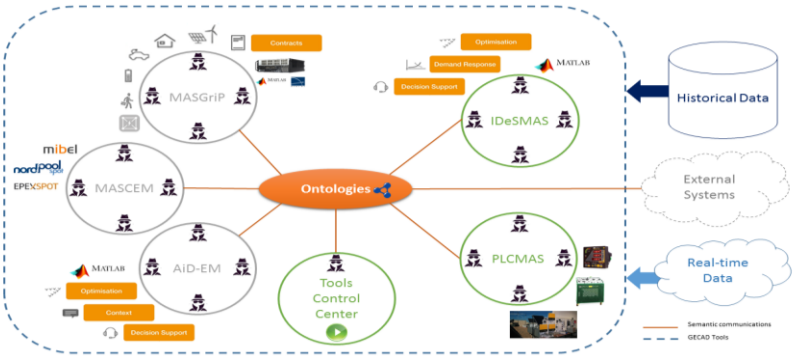

Figure 1: Society of Multi-Agent Systems

3 ORIGINALITY/VALUE

This work focuses on the development and demonstration of ontologies, appropriate to the various identified domain models (business, entities and algorithms), allowing uniform representation of data acquired from heterogeneous sources, while facilitating the interoperability between different MAS for EM, SG and consumers energy management. For this, the concepts necessary for the interactions between the various involved agents are represented in the ontologies. The ontologies are developed based on extensions existing ontologies, whenever possible, namely the ontologies developed within the framework of FP7 SEAS and FUSE-IT and H2020 project DREAM-GO. The design and development of the MAS society allows integrating the various MAS, which enables the simulation of scenarios involving entities from the final consumer, through the management of resources by aggregators, to participants and operators of wholesale EM. In this way it is possible to undertake joint simulations between the various systems, allowing a more comprehensive study; and to enable the joint management of multiple knowledge sources from different natures, by integrating the systems with the several sources of data, through a common language.

4 PRACTICAL IMPLICATIONS

The agent society considers the use of the developed ontologies for the interoperability between the diverse systems and for the representation of the knowledge in a vocabulary common to all the participants of the multiagent society, allowing them to communicate with external entities in the same language, thus facilitating their interaction. For this purpose, MAS servers for certain services are provided with the flexibility to communicate in different existing RDF languages (RDF/XML, JSON-LD, N3, etc.). In this way, the interaction with further external systems and knowledge sources is facilitated, as these can use their own language (as long as it is a valid RDF), or the language that best suits them. Through the alignment of the ontologies, any external system that complies with this can be easily integrated in the proposed MAS society. Finally, an innovative tool is also used for the control and simulation of the MAS society. This Tools Control Centre (TOOCC) allows the simulation of the various systems/algorithms independently, as well as the joint simulation of some or all systems present in the agent society. TOOCC also facilitates the automatic analysis of the various simulations and knowledge sources, in an integrated manner, as depicted in Fig. 2.

ACKNOWLEDGMENTS

This work has been developed under the MAS-SOCIETY project - PTDC/EEI-EEE/28954/2017 and has received funding from UID/EEA/00760/2019, funded by FEDER Funds through COMPETE and by National Funds through FCT.

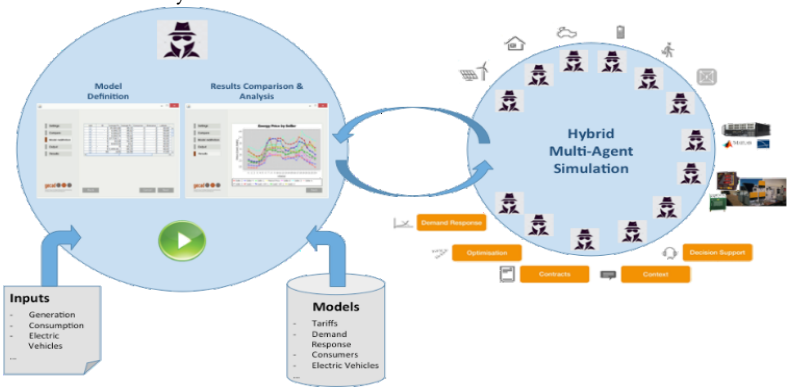

Figure 2: Tools Control Center (TOOCC)

REFERENCES

[1] G. Korkmaz et al (2018). Coordination and Common Knowledge on Communication Networks. Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), M. Dastani, G. Sukthankar, E. André, S. Koenig (eds.), July 10–15, 2018, Stockholm, Sweden

[2] P. Chocron and M. Schorlemmer (2018). Inferring Commitment Semantics in Multi-Agent Interactions. Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), M. Dastani, G. Sukthankar, E. André, S. Koenig (eds.), July 10–15, 2018, Stockholm, Sweden

[3] Y. Pradeep, S.A. Khaparde and R.K. Joshi (2012). High Level Event Ontology for Multiarea Power System. IEEE Transactions on Smart Grid, 3(1), 193-202

[4] E. Doğdu et al (2014). Ontology-centric Data Modelling and Decision Support in Smart Grid Applications A Distribution Service Operator Perspective. Intelligent Energy and Power Systems (IEPS), 2014 IEEE International Conference on. June 2014.

[5] F. Hartog, L. Daniele and J. Roes (2015). Toward semantic interoperability of energy using and producing appliances in residential environments. 2015 12th Annual IEEE Consumer Communications and Networking Conference.

[6] M. Weerdt, M. Albert, V. Conitzer and K. van der Linden (2018). Complexity of Scheduling Charging in the Smart Grid. Proc. of the 27th International International Joint Conference on Artificial Intelligence (IJCAI 2018), July 13–19, 2018, Stockholm, Sweden

[7] H. Kazmi, J. Suykens, J. Driesen (2018). Valuing Knowledge, Information and Agency in Multi-agent Reinforcement Learning: A Case Study in Smart Buildings. Proc. of the 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2018), M. Dastani, G. Sukthankar, E. André, S. Koenig (eds.), July 10–15, 2018, Stockholm, Sweden

[8] G. Santos, T. Pinto., I. Praça and Z. Vale (2016). MASCEM: Optimizing the performance of a multi-agent system. Energy, 111, 513-524

[9] T. Pinto., H. Morais., T. Sousa., E.J.S. Pires,, Z. Vale Z. and I. Praça (2015). Adaptive Portfolio Optimization for Multiple Electricity Markets Participation. IEEE Transactions on Neural Networks and Learning Systems.

[10] L. Gomes., P. Faria., H. Morais and Z. Vale (2014). Distributed, Agent-Based Intelligent System for Demand Response Program Simulation in Smart Grids. IEEE Intelligent Systems