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Framework to Enable Heterogeneous Systems Interoperability

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Abstract

The electricity markets have been suffering profound changes over the years. Nowadays, the European Union comes to reformulate its politics related with renewable energy sources, in order to encourage microgeneration, having demand response as one of the biggest challenges. Various simulators have been developed that intend to give decision support to the various entities. However, they present the limitation of being designed to answer specific problems. This paper proposes the framework Tools Control Center (TOOCC) as the mechanism to integrate various independent and heterogeneous simulators, so they operate as a unique simulation tool and become capable of answering to more complex problems.

Keywords: agent-based systems, demand response, ontologies, systems interoperability

1. Introduction

The use of energy from renewable sources is one of the major concerns of today's society. In recent years, the European Union has been changing legislation and implementing policies aimed at promoting its investment and encouraging its use in order to reduce the emission of greenhouse gases [1]. This leads to the emergence of a new paradigm in the energy sector, where there is a strong growth of microgeneration, which injects greater complexity into the Energy Markets (EM). Now, the entities that usually were consumers can also be producers, selling surplus energy to the network. As a result, new challenges arise, particularly in the production, distribution, storage and consumption of energy. By studying data collected from the network, it is possible to formulate strategies that make the system more sustainable, reliable and efficient, preventing waste and minimizing resources [2]. The use of simulators that use this information as a basis is an essential tool for decision support. However, the high complexity characteristic of the sector becomes a challenge [3] because there are several dimensions that influence the behavior of EM, and most of these tools are focused on a specific area of the problem. It is in this context that the Tools Control Center (TOOCC) emerges, a tool that allows interoperability between heterogeneous systems, in order to act as a single system. Thus, the various systems, focused on different problems, can work together to study energy systems, allowing the simulation of scenarios with a high degree of complexity.

2. The Framework

TOOCC is a multi-agent tool designed to allow the strategic communication of heterogeneous energy systems. The combination of their individual capacities creates a super system, providing results for more complete and complex scenarios, allowing to carry out more realistic studies on the sector. However, it is also possible to execute these systems/algorithms individually. Thus, TOOCC acts as a central entity, responsible for the setup, execution and analysis of different scenarios, which can use one or more systems, depending on the user objective. The agents were developed in JADE, which implements FIPA specifications.

To perform the simulation, TOOCC creates an agent for each scenario to execute, which is responsible for establishing communication with the required systems. The communication is made through ontologies, allowing the use of the same vocabulary in their interaction. In this way, it is guaranteed that the systems are able to understand each other and act in the way that is expected.

Currently, TOOCC is integrated with several energy systems, namely the Intelligence and Decision Support multi-agent system (IDeS), which executes the different DR, optimization, scheduling, forecasting, and decision support algorithms; Multi-Agent Simulator of Competitive Electricity Markets (MASCEM) [4], that runs electricity market simulations; Adaptive Decision Support for Electricity Market Negotiation (AiD-EM) [5], which provides intelligent support for player's decisions in electricity market negotiations; Network Manager (NM) [6], that enables the energy management for a grid (Smart/Micro); Facility Manager (FM) [7], that manages facilities' energy resources; and Programmable Logic Controller Multi-Agent System (PLCMAS). However, the use of ontologies allows other external systems to easily communicate and interact with those presented here. Fig. 1 intends to present an overview of TOOCC execution process.

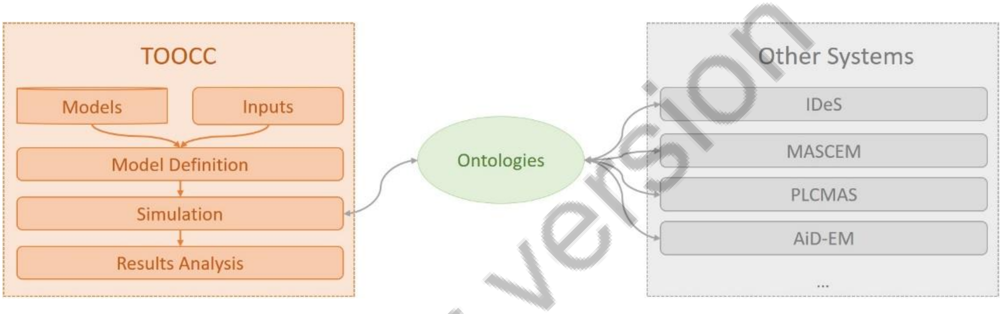

Fig. 1: TOOCC overview.

In addition, TOOCC has a mechanism for scheduling agents, guaranteeing that they will be (re)allocated to a machine that has the processing capacity, as well as the software needed to perform its task.

3. Demonstration

Due to the dynamism of the configuration of a scenario, TOOCC has a graphical interface that allows the user to configure it, in a process consisting of three phases: modeling, simulation and analysis. The user has a left menu which allows to user go back and make changes.

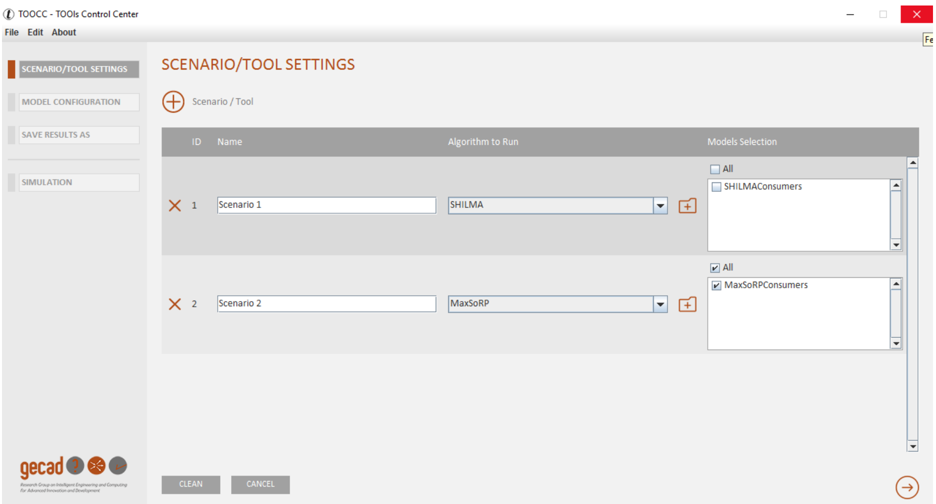

Fig. 2: TOOCC scenarios creation.

In the modeling phase, the created scenario (Fig. 2) is fed by stored models and input data. These models include the definition of distributed network components (storage units, loads and electric vehicles), demand response programs, energy tariffs, consumer definition, among others. In turn, the input data includes the parameterization required for the correct functioning of the systems/algorithms. Fig. 3 refers to an example of DR. This shows the TOOCC panel that allows the registration of consumer flexibility to shift its consumption for other hours. This information is important for the aggregator/manager entity, to know how the energy supply can be managed, in order to prevent the waste of energy, taking into account the consumer's preferences.

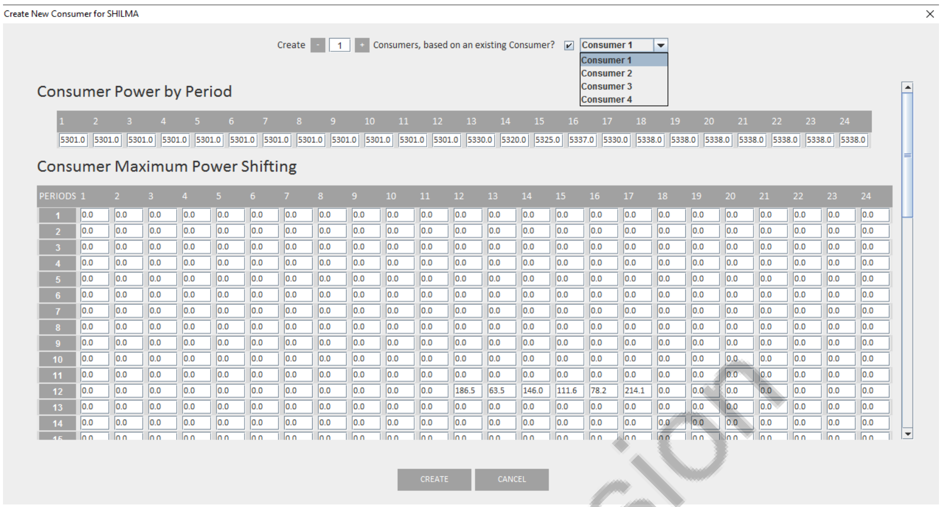

Fig. 3: Schematic of VPP in power market.

In the simulation phase, the agent responsible for the execution of the scenario will communicate with the necessary systems. For this, it uses ontologies designed for this purpose, which are available in [8]. During execution, agents may need to request a machine change in order to continue the simulation.

Finally, the last phase allows the user to analyze the results obtained from the execution, through graphs and drawn tables. These charts and tables can be saved for future use.

4. Conclusion

The growth in the use of renewable energy sources is increasing the complexity of EM. In this way, it is essential that its players can use mechanisms to support decision making, in order to deal with the unpredictability of the sector. There are several simulators that allow the study of EM, however, in that they act to respond to a specific problem.

In order to study the impact of all variables in EM, the TOOCC tool is proposed for the interoperability of heterogeneous energy systems, in order to allow the formulation of more complete and complex scenarios through the use of ontologies. In addition, this tool has a set of characteristics that gives it a great dynamism, because it allows the definition of the scenarios, and the configuration of models, which introduces the specification of simulation scenarios with very distinct natures and characteristics.

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