Organization-based Multi-Agent System of Local Electricity Market: Bottom-Up Approach

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Abstract. This work proposes a organization-based Multi-Agent System that models Local Electricity Market (MASLEM). A bottom-up approach is implemented to manage energy in this work. In this context, agents are able to connect to each other and the power grid to transact electrical energy, and manage their inside electrical energy independently. A Demand Response Program (DRP) based on Indirect Load Control (ILC) method is also used. The performance of our work is evaluated through an Agent Based Modeling (ABM) implementation.

1 Introduction

In the recent decade, Electricity Markets (EMs) have made competitive environments for complex power systems. Besides, the fast growth of Distributed Energy Resources (DERs) has created new challenges up-keeping system reliability and stability for the system. However, conventional energy management strategies will not be able to resolve these concerns centrally due to DERs generation volatility and lack of dispatch control [1]. Nonetheless, this need is felt on demand-side of the power systems, such as the distribution or retail participants who want to clarify real and fair price in medium- and low-voltage distribution network locations. Furthermore, centralized EMs are not complete enough at present, and cannot provide dynamic reserves that follow consumer behavior due to demand response programs. Also, DERs cannot indicate their potentialities entirely because of the rules of EMs. As a result, centralized EMs transfer to decentralized and Local EMs (LEMs). Several researches have presented energy management of smart distribution networks. In [2], smart homes are connected to transactive energy nodes. Moreover, the co-simulation of smart homes and the transactive energy market has been studied in [2]. In [3], a distributed energy management strategy has been defined by a price-based control method. Also, the authors have decomposed the global optimization problem into independent local optimization problems. While there have been researches that discussed local energy and electricity markets and decentralized energy management problems, none have presented a complete solution to how global optimum solutions can be obtained through local decisions. This work proposes a bottom-up energy management approach of an organization-based MASLEM.

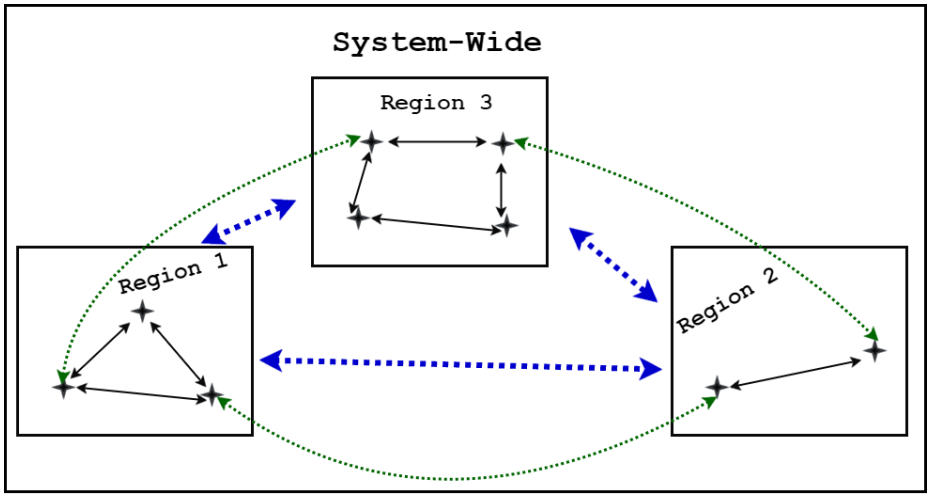

Fig. 1. MASLEM organization.

2 Proposal

MASLEM is defined as a class of organization-based multi-agent system (MAS), where each agent has different tasks. These agents consist of DERs, electrical consumers, retailers, aggregators, and etc. This structure contains different layers. It is noticeable that the proposed market structure of the smart distribution grid is based on the bottom-up approach. According to this approach, decisions of agents in the bottom layer have priority in comparison to agents' decisions in the upper layer. Moreover, price-based control strategy will be utilized in this model, it requires low-ranged bandwidth communication and control protocols, and JADE is used to implement MASLEM. Although, in this work, we proposed a strategy to manage energy locally, we pursue to optimize global-social decisions. In other words, this strategy provides global-wide, local, nodal, and time scalable decisions. In each layer, different types of electricity commodity- e.g. energy and reserve- can be traded in the LEMs. Hence, agents are enabled to participate in their regional LEM to trade electrical energy at the day-ahead multi-period markets, and reschedule their dispatched energy at the hour-ahead adjustment markets according to the existing uncertainties in the system. Furthermore, the agents of each region can contract bilaterally with other agents in their own region or other regions. These contracts can conclude long-term obligations to the second and real-time scale. If, local and global decisions were not in the same direction, then flexibility is defined as one type of ancillary services to support global optimization and local-autonomous decisions. Moreover, new structures will be proposed how LEMs can transact energy and ancillary services with the wholesale EM for the first time in this work. The organization of

MASLEM's agents is illustrated in Fig. 1. In our future works, different structure of LEMs, aggregation of DRPs, and transaction strategies between demand-side agents will be proposed.

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