Chapter 12
Management of Distributed Energy Resources Using Intelligent Multi-Agent System

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ABSTRACT

The technology of intelligent Multi-Agent System (MAS) has radically altered the way in which complex, distributed, open systems are conceptualized. This chapter presents the application of multi-agent technology to design and deployment of a distributed, cross platform, secure multi-agent framework to model a restructured energy market, where multi players dynamically interact with each other to achieve mutually satisfying outcomes. Apart from the security implementations, some of the best practices in Artificial Intelligence (AI) techniques were employed in the agent oriented programming to deliver customized, powerful, intelligent, distributed application software which simulates the new restructured energy market. The AI algorithm implemented as a rule-based system yielded accurate market outcomes.

INTRODUCTION

The electricity grid is the backbone of the power network and is at the focal point of technological innovations. Utilities need to introduce distributed intelligence into their existing infrastructure to make them more reliable, efficient, and capable of exploiting and integrating alternative sources of energy. The intelligent grid includes the infrastructure and technologies required to allow distributed generation of energy with increasing the operational efficiency through distributed control and monitoring of resources.

Intelligent grid should be self-healing and reconfigurable to guard against man-made and natural disasters. One way to assure such characteristics in an electric power grid is to design small and autonomous subsets of the larger grid. These subsets are called intelligent microgrids which are used as a test bed for conglomerate innovations in communication technologies, smart metering, co-generation, and distributed intelligence and control. The test bed serves to showcase the capabilities of the developed systems, thereby ac-

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celerating the commercialization of technologies and solutions for smart grids all over the world.

Multi-agent system is one of the most exciting and fastest growing domain in agent oriented technology which deals with modeling of autonomous decision making entities. Multi-agent based modeling of a microgrid is the best choice to form an intelligent microgrid (Rahman, Pipattanasomporn, & Teklu, 2007; Hatziargyriou, Dimeas, Tsikalakis, Lopes, Kariniotakis, & Oyarzabal, 2005; Dimeas & Hatziargyriou, 2007), where each necessary element in a microgrid is represented by an intelligent agent that uses a combination of AI-based and mathematical models to decide on optimal actions.

Recent developments (Rahman, Pipattanasomporn, & Teklu, 2007; Hatziargyriou, Dimeas, Tsikalakis, Lopes, Kariniotakis, & Oyarzabal, 2005; Sueyoshi & Tadiparthi, 2007) in multi-agent system have shown very encouraging results in handling multi-player interactive systems. In particular, multi-agent system approach has been adopted to simulate, validate and test the open deregulated energy market in some recent works (Sueyoshi & Tadiparthi, 2007; Bagnall & Smith, 2005; Praça, Ramos, Vale, & Cordeiro, 2003; Logenthiran, Srinivasan, & Wong, 2008). Each participant in the market is modeled as an autonomous agent with independent bidding strategies and responses to bidding outcomes. They are able to operate autonomously and interact pro-actively within their environment. Such characteristics of agents are best employed in situations where the role identities are to be simulated as in a deregulated energy market simulation.

The dawn of the 21st century has seen numerous countries de-regulating or lobbying for deregulation of their vertically integrated power industry. Electric power industry has seen an evolution from a regulated to a competitive industry. The whole industry of generation, transmission and distribution has been unbundled into individual competing entities. Although the journey has been far from seamless as observed in the California’ electricity crisis (Budhraja, 2001), many critics have agreed that deregulation is indeed a noble endeavour. The problem associated with deregulation can be solved with structural adjustments to the markets and learning from past mistakes.

This chapter shows the development and implementation of multi-agent application to deregulated energy market. The developed application software is a testament of the multi-agent framework implementation and effectiveness of dynamic modeling of multi-agent environment where the internal tasks of each agent are executed concurrently with external inputs from the agent world. Successful deployment of the application software coupled with high degree of robustness indicates the relevance and operational level of multi-agent system based application software development. User can use the software for any size of power system by defining the number of agents in the system and inserting the associated information.

The structure of the remaining chapter is as follows: Section 2 provides the introduction of microgrid and Distributed Energy Resource (DER), and Section 3 gives an introduction of restructured electricity market. Section 4 describes the implementation of multi-agent system based application software for PoolCo energy market simulation. Section 5 demonstrates the flow of simulation of the implemented application software. Section 6 discusses results of PoolCo outcome of a sample microgrid. Finally, it is concluded in the seventh section.

BACKGROUND

Microgrid and Distributed Energy Resource

Over the years, the computer industry has been evolving continuously and the power industry has remained relatively stable. In the past few years, the power industry also has seen many
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