International Journal of Fog Computing
Volume 5 • Issue 1

Distributed Consensus Based and Network Economic Control of Energy Internet Management

Yee-Ming Chen, Yuan Ze University, Taiwan*
Chung-Hung Hsieh, Yuan Ze University, Taiwan

ABSTRACT

Energy internet (EI) was proposed to improve the utilization of multiple energy and meet the growing demand for energy. This paper proposes the distributed consensus control algorithm combined with a multi-agent system (MAS) which is applied to distributed generators in the energy internet. By selecting the incremental cost (IC) of each generation unit as the consensus variable, the algorithm is able to solve the conventional centralized economic dispatch (ED) problem in a distributed scheduling manner. The proposed algorithm is verið̃ed in the MAS layer and through a simulation model of the EI network in the MATLAB software. Simulation results conclude that incremental cost converges to its optimal value whether load demand is varying or generators plug-and-play. Distributed consensus control algorithm can provide better service for EI, it is immune to topological variations and accommodate desired plug-and-play features, and it enables real-time modeling and simulation of complex power systems.

KEYWORDS

Distributed Consensus Control, Economic Dispatch, Multi-Agent System

1. INTRODUCTION

Energy Internet (EI) is a decentralized energy supply-demand sides by developing a revolutionary paradigm of smart grids into the Internet. Internet of Things (IoT) is the paradigm that creates an internet-connected devices, where all the everyday devices capture data from EI environment and adapt it to both the supply and demand side need. EI is one of the scenarios in which IoT is applied to achieve efficient energy use. An IoT-based energy management system is a crucial component in building EI architectures, as it not only enables new energy-related value-added services but also intelligently facilitates the integration of various energy sources and efficient operation control. Due to the complexity of the IoT-based energy management environment, which includes distribution networks, participants (i.e. producers, pronsumers and users) transaction, and so on, numerous types of information need to be transferred in real time. For example, electricity peak smoothing requires information about energy profiles as well as users' acceptable level. The mechanism of transactive energy is mainly to cope with fluctuating energy sources and consumption can effective energy resource management and allow a dynamic balance of multi-energy supply and active demand. These requirements prompt the EI to employ new information and communication technologies, such as

DOI: 10.4018/IJFC.309140 *Corresponding Author

5G and edge computing technology need an effective way to offload computational task to the edge side of 5G networks. As edge computing can provide the computing services at the network "edge" near EI devices, it allows for more secure and efficient data processing in real time, achieving better performance and results. The edge computing is collected by sensors and sent to the aggregators to be associated to the preferences set by the EI's participants or devices. These preferences can be modified by the participants of the consensus process who take collaborative decisions by following the consensus algorithm taking into account the gathered data and engendered decisions.

Moreover, with the increase of collected data from EI, it becomes a key point to effectively improve the computing power of edge nodes in edge computing to monitor and transmit data. The economic dispatch problem (EDP) is one of the most fundamental decisions in power systems, so it also exists in EI. EDP is essentially an optimization decision that assigns the required power generation to a number of generating units to meet the active load demand. The objective of economic dispatch(ED) is to minimize the total power generation cost, subject to several constraints (Han and Gooi, 2007). In the last, ED is usually conducted in a central controller, who is able to access global information. However, EI envisions an incremental number of network nodes, flexible architecture, and plug-and-play(PnP) characters, and it is only with some decentralized edge computing controllers that better performance is achieved. Decentralized control doesn't mean these controllers have no relationship among them. Oppositely, they not only have individual goal, but also hold the reliable exchange of the information with neighbors. Therefore, every decentralized controller can be modeled as an intelligent agent and a consensus algorithm is an iterative interaction rule that specifies the information exchange between an agent and all of its neighbors in the EI network.

Consensus problems have a long history in computer science and form the foundation of the field of distributed computing (Pipattanasomporn et.al, 2009). The definition of consensus problem is a strategy by means of which all agents can update themselves so that they ultimately agree upon some universal shared information. Numbers of researchers have been into this area for decades, the representative researchers like Jadbabaie (2003), Olfati-Saber and Murray *et al* (2007). have established the basic theoretical framework for analysis of consensus algorithms based on methods from matrix theory, algebraic graph theory, and control theory (Cao and Ren,2010). Some recent papers related to the consensus-based energy management algorithms are briefly reviewed herein. In (Zhang and Chow,2012), the incremental cost is chosen as the consensus variable and is used to determine the power dispatch of generation units. Ziang Zhang *et al*. proposed incremental cost consensus (ICC) algorithm solving EDP in smart grid environment. Practical implementations of distributed control algorithms could be found using low-cost single board microcontrollers, such as Raspberry Pi (Eriksson et.al, 2015) and Cubieboard A20 (Pourbabak et.al, 2018).

Additionally, EI will have a higher generation mix of renewable energy sources and a large load of electrical vehicles, with the possibility of bi-directional power flow. With the increasing penetration of distributed generation, the PnP energy resources or energy storage devices will become a required functionality of future EI systems. Effective distributed control algorithms could be allowed interoperability within a EI at MAS layer as well as allows for online re-configuration upon topology alteration. It also need to allocate energy among the generating systems economically dispatch when a PnP operation is performed. In order to overcome the aforementioned challenges, this paper proposes a distributed consensus control algorithm combined with the MAS to EDP in the Energy Internet. The incremental cost of each generator is chosen as the consensus variable in order to meet the optimization requirement. To satisfy the power balance, the mismatch between the demand and total generations is fed back to the consensus control algorithm so that the incremental cost will converge to the optimal value. The proposed algorithm does not require any initial assumption for generation demand mismatch. Only local power mismatch information is shared with adjacent neighbors to ensure the privacy of each participant. Particularly, the proposed algorithm scheme to implement interoperability within a EI with PnP feature at the agent layer of distributed consensus control. As illustrated concept in Figure 1, EI framework break down into three layers: a physical layer which

Related Content