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A Novel QoS-Enabled Load Scheduling Algorithm Based on Reinforcement Learning in Software-Defined Energy Internet

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***Abstract*—Recently, smart grid and Energy Internet (EI) are proposed to solve energy crisis and global warming, where improved communication mechanisms are important. Software-defined networking (SDN) has been used in smart grid for real-time monitoring and communicating, which requires steady web-environment with no packet loss and less time delay. With the explosion of network scales, the idea of multiple controllers has been proposed, where the problem of load scheduling needs to be solved. However, some traditional load scheduling algorithms have inferior robustness under the complicated environments in smart grid, and inferior time efficiency without pre-strategy, which are hard to meet the requirement of smart grid. Therefore, we present a novel controller mind (CM) framework to implement automatic management among multiple controllers. Specially, in order to solve the problem of complexity and pre-strategy in the system, we propose a novel Quality of Service (QoS) enabled load scheduling algorithm based on reinforcement learning in this paper. Simulation results show the effectiveness of our proposed scheme in the aspects of load variation and time efficiency.**

***Index Terms*—Reinforcement learning, software-defined networking, load scheduling, Quality of Service (QoS), energy Internet, smart grid.**

I. Introduction

ENERGE resources crisis and global warming have become two global concerns [1]. As reasonable solutions, smart grid [2] and Energy Internet (EI) [3] are seen as the new generation of energy provision paradigm, where improved communication mechanisms are important to enable end-to-end communication. Software-defined networking (SDN) [4] is seen as a promising paradigm shift to reshape future network architecture, as well as smart grid and EI, called software-defined EI (SDEI). Using SDN enables to improve smart grid and EI by providing an abstraction of underlying network resources, forming global view for applications from upper layers, and decoupling infrastructures and control plane to enhance the flexibility and reliability of the system [5]. Noteworthy, the control plane is considered as the brain of SDN [6]. With the explosion of network scales and network traffic, overload in a single controller is one of the most intractable issues [7]. There is a growing consensus that the control plane should be designed as a multiple controllers plane to constitute a logically centralized but physically distributed model [8]–[10]. So far, the issues of multiple controllers have been studied in literature. Except for addressing the consistency problem of global view among distributed control plane, another key issue is how to schedule loads among multiple controllers so as to mitigate the risk of overloads and failures in one single controller.

On the other hand, the most important application of SDN in smart grid is real-time monitoring and communicating. It follows that these applications require steady web-environment with no packet loss and less time delay to keep high accuracy and real time capability [11].

Traditionally, load scheduling algorithms make load scheduling decisions after the overload problems have happened [12]. In general, the traditional algorithms have three steps, including collecting load information, making load scheduling decisions, and sending load scheduling commands to the corresponding controllers. For example, the work in [13], load scheduling decision is made after the problem of overload. In addition, current CPU usage, current memory usage, current hard disk usage, and weight coefficient need to be exchanged among controllers when new load scheduling decision is made, which occupies lots of extra time so as to decrease time efficiency.

Recently, Machine learning (ML) has emerged as a novel