Intelligent Control of Micro Grid: A Big Data-Based Control Center

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Abstract. In this paper, a structure of micro grid system with big data-based control center is introduced. Energy data from distributed generation, storage and load are analyzed through the control center, and from the results new trends will be predicted and applied as a feedback to optimize the control. Therefore, each step proceeded in micro grid can be adjusted and organized in a form of comprehensive management. A framework of real-time data collection, data processing and data analysis will be proposed by employing big data technology. Consequently, an integrated distributed generation and an optimized energy storage and transmission process can be implemented in the micro grid system.

1. Introduction

The generation of micro grid mainly depends on renewable energy and clean energy, which plays an important role in alleviating energy shortage and restraining the deteriorative environment. In recent years, micro grid has been widely studied by many experts and scholars in the matter of distributed generation system, energy storage system and load. Ustun and co-workers have discussed the development of micro-grid in 2011, and analysed the distributed generation system in Europe, North America and some other regions [1, 2]. In 2017, concerning the micro-grid power generation system, the different ways of distributed generation in China's remote and underdeveloped regions have been discussed [3], and the complementary of hydro power, photovoltaic and wind power also have been studied in Rio de Janeiro [4]. With the development of sensing technology and the growth of micro grid data, the distributed renewable energy generation system can be predicted and controlled by utilizing artificial neural network algorithm [5], and a distributed optimization algorithm is also able to be applied to manage the control of micro-grid in the energy storage and load side [6].

With the integration of smart, digital grid devices and technologies, more data sources have been used to micro grid system. Thus, the micro grid has produced a large number of data with diverse structure and complex sources. These data are not isolated from each other, but are interrelated and interact with a complex relationship. Based on this, we focus on the study of micro grid system from the perspective of big data control. Then, to design the control centre of micro grid system by applying the idea and technology of big data, and further to realize the coordinated control and management in distributed generation, the optimal storage and delivery scheduling. This paper is structured as follows. In Section 2, we describe data source within micro grid system, including the whole structure of micro
grid and characteristics of data generation. Section 3 covers the implementation and application of control center and big data technology architecture. Our main conclusion is drawn in Section 4.

2. Micro Grid System

2.1. Architecture of Micro Grid System

The components of micro grid system are distributed generation system, energy storage system and load, as depicted in Figure 1. Distributed generations mainly refer to traditional power grid and renewable energy sources such as solar, wind and biofuels; Energy storage system includes an energy storage power supply, i.e., storage battery, fuel cells; Load consists of users and organizations (household load and industrial load).

Figure 1 also shows the whole process of micro grid system. Firstly, the item of distributed generations provides stable and continuous power, meanwhile, it accepts energy generated from any source by location-centralized or distributed; Secondly, the storage part can lay efficiently in various forms of energy, at the same time, energy storage can transport electric energy to load reasonably; Lastly, the load has a stable energy usage.

Figure 1. Components of micro grid system and the working processes therein.

2.2. Generating Data from Micro Grid System

At present, many intelligent sensing and monitoring devices have been employed within each part of the micro grid system, which have generated a large amount of data per hour [7]. Meanwhile, due to various functions of the micro grid system, it tends to equip with different sensors and monitoring equipment. These can bring a variety of data type including the structure data from the traditional power
system, the semi-structure and non-structure data from the micro grid systems like cameras, weather forecast system, network, and map, etc. With the wide application of telecommunication and network, the speed of data generated from various smart devices of the micro grid is obviously improved. Therefore, the generated data have three characteristics of volume, variety and velocity in the micro grid system, which can be called electrical big data.

3. Design of Control Centre in Micro Grid

3.1. The Control Centre

Because of the fast speed produced character of data in micro grid system, the control center of micro grid must be collected, stored and analyzed in real time. Besides, the data produced by micro grid system also has the characteristics of variety and structure diversity. Thus, the control center of micro grid needs to build a distributed framework to complete the process of data processing and analysis. Accordingly, the data classifications are carried out depending on the business requirements during the data process, so that the efficiency of data analysis can be improved. More importantly, the control center needs to respond and make decision in almost real-time during the collection of data, data process and data analysis, to control the entire micro grid system. Based on the new trends of data in micro grid system, we propose a proper big data-based micro grid control center. This control center provides the intelligent management of distributed generation and local demand as well as making an improved link of all the available energy distributed generations, the storage system and loads within the micro grid.

Figure 2. Three parts of control center and the control processes therewith.

As mentioned previously, the control center includes the collection of data, the distributed data processing framework, and the data analysis platform, as shown in Figure 2. Firstly, to collect the scattered data from micro grid system in real time, such as some detective and sensitive data produced by distributed generation system of renewable energy and traditional grid, the data related to the
efficiency in energy storage system, and detailed power data from load; Secondly, a distributed framework is established for data process, which mainly integrates and classifies the scattered data in the first step to provide the basis for the further data analysis; Thirdly, the data analysis platform is built to analyse data and excavate data. What’s more, through the analysis and prediction of this platform the whole process are adjusted based on the data and overall to achieve an automatic control for micro-grid system.

Using the control Centre, we can make a wide range of forecasts on:

- how to generate stable power supply for distributed generation system
- how to regulate efficient energy storage for energy storage system
- how to manage the safety, and predict when and where the equipment are most likely to occur breakdown for load

In general, a smart management of increasingly complex micro-grid system will be achieved through the control center. More precisely, a big data-based control center can allocate the energy in a reasonable plan and effectively improve the security and reliability of micro grid system, thereby promoting the micro grid with an intelligent development.

3.2. Technological Solutions

To support the increasing growth of big data created by the smart meter and sensor, this control center refers to big data platform on creating a cluster. The data center depends on the big data technology including Storm, Hadoop, HBase and analytical software, as shown in Figure 3.

The collection of data is implemented through Storm; the common platform mainly includes the process and analysis of data, which is built by Hadoop and HBase; the analysis platform consists of statistical analysis software and big data analysis plugin. Firstly, Storm collects the data from smart devices and sensors in micro grid system, and then these data are stored in HBase. Secondly, utilizing distributed computational model MapReduce in Hadoop to deal with data, and completing classification for data according to demands. We use statistical methods and big data algorithm to analyse data. In the end, these data are stored in HBase again and a human-computer interaction is used to realize the coordinating control of micro grid system. A friendly human-computer interaction is convenient for the
management and control of micro grid system. At the same time, managers can also help the control center to configure the parameters of micro grid reasonably through specific analysis.

4. Conclusion
The purpose of this work is to propose a big data-based control center in micro grid system to achieve an intelligent control process. Through analysing the generated data from the micro grid system, the concept of big data control is designed by applying technologies and methods logically, which mainly includes Hadoop, Storm, HBase, statistical software, and human-computer interaction technology and so on.

With the wide applications of smart sensors and monitoring equipment on various components, large amount of micro grid data are generated from the distributed generation system, energy storage system and load. According to the characteristics of these data, a micro grid control center including real-time data collection, data distributed processing framework, and data analysis platform is developed to optimize the control process. Meanwhile, intelligent decisions and responses need to be made by real time in the whole processes for generating stable power supply, delivering efficient energy storage and managing security.

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