Application of Data Mining in Smart Grid Technology

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INTRODUCTION

Smart grid technology is a radical and creative approach for improvisation in existing passive power grid. Assimilation of power and communication infrastructures is inevitable for the design and deployment of an imminent smart grid technology. The grid is called 'Smart' as it is accomplished with intelligent devices for decision making. Some of the substantial features of smart grid technology are bidirectional communication, renewable integration, active consumer participation, distribution automation, advanced metering infrastructure, supervisory control and data acquisition and complete management of entire power grid through wireless communication protocols and technologies. Smart grid communication infrastructure is a gigantic architecture with massive amount of data communication between various hierarchical network layers (Farooq & Jung, 2014). Full duplex data communication is required for monitoring, control, security, management and fault diagnosis of entire power grid (Mahmood et al., 2015). Management of complex, hierarchical and heterogeneous smart grid communication infrastructure necessitates data collection, storage, processing, analysis, retrieval and communication for self-healing and complete automation. Collection, interpretation and analysis of massive quantity of data generated in smart grid operation are critical, inevitable and complex tasks (Gungor et al., 2010). Data mining techniques can be an effective solution for smart grid operation and management. Data mining is essential for converting information into knowledge (Wijaya, T., 2013). Knowledge discovery and data mining are interdisciplinary tasks in the context of smart grid network. Database management and data mining are the two significant aspects of a database system. Database management deals with processing and storage of data and data mining deals with discovery and abstraction of knowledge for the purpose of decision making. Data mining is a computational process for data scrutiny and analysis. Data analysis is unavoidable for unambiguous knowledge discovery as well as decision making practices. Data mining is necessary for analysis of various statistics associated with power generation, distribution automation, data communications, billing, consumer participation, and fault diagnosis in smart power grid. In Smart grid, accumulation of real time data is inevitable. Data mining techniques are required when data is continuously collected on real time basis (Atzmueller et al., 2013). The pattern of gigantic sets of data

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can be effectively extracted and scrutinized with the use of different data mining techniques for energy efficiency, reliability and real time decision making. This chapter is expected to serve as a comprehensive analysis and review of application of data mining techniques in generation, transmission, distribution and utilization of energy in smart grid infrastructure.

BACKGROUND

An electrical power grid carries the electricity from generation unit to the consumption unit. An existing power grid is being transformed through the design, development and deployment of smart grid technology. An existing grid is passive in terms of real time monitoring, control, consumer participation, fault diagnosis, disaster recovery, and real time communication of energy related statistics. There are enormous challenges such as theft and distribution losses, scarcity of primary energy sources, aging and underperformance of coal based power plants etc. An existing grid is incapable of addressing these issue in effective manner due to lack of data communication between various components of energy generation, transmission, distribution and utilization. Smart grid can be defined in diverse ways as per its functional, technological or constructive aspects. (United States Department of Energy, 2009) defines the Smart Grid as: ''A smart grid uses digital technology to improve reliability, security, and efficiency (both economic and energy) of the electric system from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources." Smart Grid includes various communications protocols and hierarchical network layers. (Farooq & Jung, 2014) have discussed various choices available for realization of smart grid communication networks. The hierarchical design of Smart power grid comprises of home, neighborhood and wide area networks. These hierarchical networks exchange information for monitoring and control of smart grid operations. Mahmood et al. have discussed and reviewed various wireless communication protocols for smart grid applications. Massive quantity of data communication is required for the realization of smart grid technology. An unambiguous knowledge discovery along with data analysis is vital for reliable and proficient management of smart grid. The prime concern is an extraction, analysis, interpretation and management of exploded data from various measurement devices and sensors in smart grid. Smart grid is a multifaceted technology. Moreover, the nature of data in smart grid technology is dynamic and distributed (Saputro et al., 2012). The traditional data mining processes are focused, centralized, static, bounded and non-real time. It does not have energy or speed constraints. Smart grid technology incorporates wireless sensor networks and Internet of Things which are two diverse areas in terms of data mining and knowledge detection processes. The traditional data mining techniques cannot be directly applied to wireless sensor networks due to their restricted computational, power and storage capabilities. Internet of things is meant for dynamic, swift and near real time data which necessitates novel data mining approach. This chapter illustrates conceptual description of smart grid technology and application of data mining techniques in generation, transmission, distribution and utilization of electrical energy.

CONCEPT OF SMART GRID TECHNOLOGY

An existing electrical grid is being transformed through deployment of smart grid technology. The main difference between an existing power grid and smart grid is in terms of full duplex communication and real time management of energy statistics. Smart grid is an assimilation of power as well as information