

INTERNET OF THINGS IN SMART GRID AN OVERVIEW

By

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ABSTRACT

Smart grid is the new concept of traditional grid. A traditional grid is having unidirectional flow of information and also having some problems like power depletion, rising power requirement, healing, consistency and most important safety. Smart grid replaced regular grid and presented bidirectional flow of energy from service providers to end users. Smart grid deals with power production, transmission, distribution and consumption. It employs different gadgets for observing, analyzing, and regulating the network. Different types of sensors actuators and smart meters are used for analyzing the network with connectivity, computerization plus chasing of such gadgets. This all can be implemented only by using Internet of Things (IoT). It's a new technique which relates people with things every moment anywhere. IoT is having a lot of applications such as intelligent transportation, environmental monitoring etc, out of which the most important application and means of promote the development of smart grid. Using internet of things technique one can combine the available resources in communication and electrical power system, enhancing the level of information of power network, and get better the consumption of infrastructures of the present grid. The requirements of smart grid where IoT has to be implemented with suitable devices are also pointed out in this paper.

Keywords: Communication Technology, Energy, Internet of Things (IoT), Security, Sensors, Smart Grid, Smart Meters.

INTRODUCTION

Smart grids are the innovative edition of main grid which employed the recent communication and control methods with physical grid. It digitally improves the toughness, competence and elasticity. Smart or elegant grid (network) is the combination of 20th century conventional electrical energy network mainly by means of latest 21st telecommunication and information schemes. Within traditional power grid which is used for power generation, transmission and distribution power flow takes place unidirectional i.e. since supplier to end user. But in smart grid which makes sufficient utilization of energy resources, its consumption and organize all distributed energy sources to exchange the generated power. It means here flow of power takes place in two ways (Anvari-Moghaddam, Monsef, & Rahimi-Kian, 2014; Wu, Lau, Tsang, Qian, & Meng, 2013; Han, Choi, Park, Lee,

& Kim, 2014). This provides a new concept for the generation and consumption of electricity. Now many companies started to install renewable energy resources like solar, wind etc nearby the consumption places so they can fulfill the demand of customer. Also, some residential start to use smart home appliances and distributed generations in their campus to produce and consume electrical power resourcefully (Jaradat, Jarrah, Jararweh, Al-Ayyoub, & Bousselham, 2014; Missaoui, Joumaa, Ploix, & Bacha, 2014). In the last few years smart grid concept is emerged very fast growing topic for the research in this field. The National Institute of Standards and Technology (NIST) give a theoretical model of the smart grid for its better understanding. NIST conceptual model consist of seven field namely: bulk generation, transmission, distribution, consumers, markets, operations and service providers (FitzPatrick, & Wollman, 2010). In order to make

stable bidirectional transmission of data flow, control and monitoring instructions between smart grid and utilities control centers, it is necessary to connect intelligent electronic devices in distributed locations in smart grid communication network. Two main communication technologies wired and wireless can be used for data transmission. Wireless techniques low cost infrastructure and ease of connection to difficult or unreachable areas where wired solutions do not have interference problems and their functions are not dependent on batteries, as wireless solutions do (Soni, & Talwekar, 2016).

Internet of Things (IoT) is a current topic which involves connection of machines and public towards connecting smart objects or things. IoT is a new information processing and attainable scheme which includes many technologies like Radio frequency identification (RFID) technology, sensor technology, smart technology, nano technology and many more. It is the third one latest topic used in industries after computer, internet and mobile communication system. At present IoT is widely used in all the fields of our life like intelligent transportation, industrial and environment monitoring, Military and defense, etc (Liu, 2002; Liu, Han, & Liu, 2013). Smart grid is the new technology of producing and distributing of power; both IoT and smart grid have a good space to fusion (Sun & Guan, 2012). One can also use IoT in generation and consumption of power sector. Because smart grid is the grid of 20th century and having real time parameters to control and monitoring, so by using IoT in this field one can get automation, information and communication in the complete system of smart grid.

This paper gives an overview of IoT in smart grid. Section 2 describes basic fundamental of smart grid and IoT. Section 3 introduces IoT based smart grid with a literature review. Section 4 describes the requirements of smart grid within IoT and section 5 gives the discussion part. Section 6 gives recommendation about the technology used in IoT. In the last section paper is concluded.

1. Smart Grid and Internet of Things (IoT)

1.1 Smart Grid

In the 21st century, requirement of green, inexpensive and

controllable energy has been ever expanding. Conventional grids are not capable of matching such needs (Committee, 2009; Smart Grid 101, 2013; Federal Energy Regulatory Commission, 2008). These needs seek the growth of latest solutions such as the smart grid which are modeled to fill the progressive requirement of electrical energy by enhancing the efficiency of production, transmission and distribution (NIST, 2012; NIST, 2014; NIST, 2011). Smart grid is a fresh and novel power grid which is highly incorporated with latest technology like sensor measurement scheme, information and communication method analysis of decision making technology, automation and control method and its infrastructures. On comparison with regular power grid, smart grid promoted as a promising solution for reducing the wastage of electrical energy and also gives a better control of power, flexibility of grid structure, allocation of resources and improves the quality of power. Smart grid has many advantages like self healing, well suited for all energy production, economy, mutual operation and effective management of resources etc. (Zhang 2012; Xiong, 2010; Morgan, et al., 2009; Petinrin & Shaaban, 2012).

Smart grid in its normal form is the expansion of conventional grid uses ICT technologies (software, hardware and networks), in addition with the enhancement of distributed generated renewable energies and its storage capacities. There are two way flows in smart grid as shown in Figure 1

- Electric Flow (Dashed line) from the power production to the end user, it is the main flow of conventional power grid. But in smart grid this flow will be bidirectional it means user will buy and can also sell



Figure 1. The Smart Grid Conceptual model (NIST, 2014)

power.

- Information flow (Regular lines): In this, two way communications takes place between number of shareholders and main parts of smart grid. Most of the communication depends on large number of sensors, actuators and other smart objects other than the distribution fields.

1.2 Internet of Things (IoT)

The term Internet of Things was suggested in 1999 by Ashton Kevin. Mr. Ashton wrote that "The Internet of Things in the real world thinks matter more than ideas" in 22 June 2009 (RFID Journal). IoT also involve other concepts like Internet of Services, Internet of Everything's, and Web of Things which of course represent IoT.

The IoT describes a system that can attach any thing with the internet based procedure for exchanging information and communication between numerous smart devices in order to get monitoring, tracking management and location identification goals (Wang, Li, Liu, & Wang, 2014). It is also known as Internet of objects which will modify everything involving ourselves. It affects all the fields of daily life such as education, communication, business, science, government and humanity (Ezechina, Okwara, & Ugboaja, 2015). Now a days, internet is one of the most important and influential conception in all of human past and currently the idea of the internet of things, internet develops a well defined smart life in all part of view.

By using internet of things, things are identified itself and worked out as programmed and provide the information about themselves. This information is communicated to other device for further process. With the IoT one can access internet and share anything anywhere at any time, this concept gives rise to some new applications which may involve smart vehicle and smart home to gives many ideas regarding announcements, defense, energy saving, computerization, communication and entertainment (Saranya & Nitha, 2015; Kaur & Singh, 2016). Figure 2 shows the use of IoT by anyone for anything from anywhere.

By 2020, smart environment can be established by implementing IoT technology (Misra, Maheswaran, &

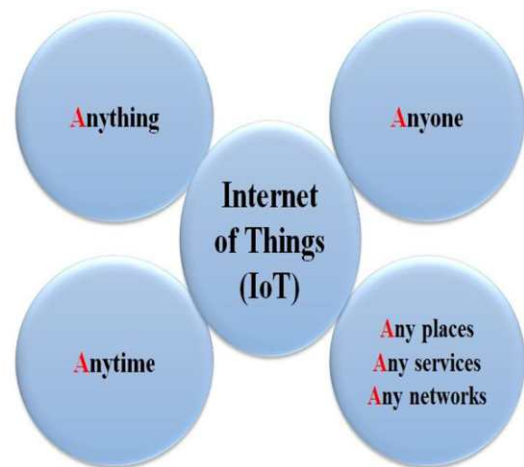


Figure 2. Internet of Things Concept

Hashmi, 2017). It is expected that storage and communication services will be invasive and disseminated where people, machines smart things, surrounding area all are interconnected with wired or wireless which will make a dynamic system (Vongsingthong, & Smachat, 2015).

Understanding of IoT centered on three main perceptions, namely things oriented, Internet oriented and semantic oriented. Things oriented idea gives smart devices like sensors, actuators, cameras, lasers, Global Positioning System etc. Number of communication technologies like Zigbee, WiFi, Bluetooth and cellular communication method which makes communication among smart devices to the internet. Semantic oriented idea provides a number of applications with the help of smart devices.

2. Internet of Things Aided Smart Grid

Internet of thing is a latest technology having importance from researchers due to its application in every part of our life. Different IoT elements formed a complete smart grid system. Smart grid has been already adopted in information sensing, transmission and processing, now IoT plays an important role in grid structure. To make each part of smart grid able to listen and talk and also to get automation, planning, maintenance and working of smart grid should be improved (Rouse, 2018). In all this process IoT must having be used and each component of smart grid must have IP address and would be able of two way communication. IoT gives interaction between

users and devices through different communication technologies and make real time system connection. It increases stability and efficiency of smart grid (Yun & Yuxin, 2010). This purpose of IoT in smart grid can be classified into three different layers based on IoT architecture (Yaqoob, et al., 2017). First layer is the perception layer in which IoT smart devices are installed for monitoring the position of equipment. Second layer is the network layer in which different communication technologies are used for accumulating information of the equipment. Lastly, the application layer is implemented to control the application of smart grid. IoT technology also play important role in grid structure involving data sensing and transmission for the smart grid helping in system construction, operation safety management, maintenance, security monitoring and user interaction. Furthermore, the IoT allows the extension of information flow, power flow and distribution flow in a smart grid (Liu, Li, Chen, Zhen, & Zeng, 2011; Zaveri, Pandey, & Kumar, 2016). Moreover, smart grid chiefly focus on the needs of power distributors to organize the complete power grid (Samarakoon, Ekanayake, & Jenkins, 2013).

IoT is supporting smart grid which can improve the ability of smart grid in processing, warning, self healing disaster recovery and reliability. The fusion of smart grid with IoT imposes a new technique in the growth of smart terminals, meters and sensors, machinery and communication devices. IoT can send and receive data or information

from each part of smart grid using wire and wireless communication infrastructures.

In electricity production, IoT can monitor the production of various types of power plants and can also save all the real time data for the further purpose. This technology can also used for to get energy consumption and to monitor and protect transmission lines. It may be used for controlling equipment and in smart meters for measuring various types of parameters, charging and discharging of electric vehicles, managing energy efficiency and power demand.

3. Literature Survey

Most of the surveys are done on smart home, transmission line monitoring, electric vehicles, smart metering and its infrastructure. Following table shows a survey of Internet of Things in smart grid.

3.1 Requirements for using IoT in Smart Grid

To use IoT in SG, we should have some technologies and satisfy some requirements which are listed as follows:

In the current scenario, IoT is used in smart grid, to put up this technology in smart grid, there are few conditions which must be satisfied as listed below:

1. *Communication technologies:* Different communication methods are used for receiving and transmitting collected information about the real position of smart grid's devices. For long range communication, one can use optical fibers, wireless cellular networks such

	Findings	References	Publication Year
Internet of Things aided smart grid	AMI and Smart Metering technologies for the monitoring of reliability and power quality in IoT-aided SG systems	Al-Turjman and Abujubbeh (2019)	2019
	This paper shows the use of advance metering infrastructure and smart metering methods for observing the consistency and power feature.	Gupta, Anpalagan, Carvalho, Guan, and Woungang (2019)	2019
	Security issues are reviewed particularly susceptibility, safety threads and their respond for the evaluation.	Torre, Rad, and Choo (2019)	2019
	Examining deep packet assessment as a safety tool.	(Bedi, Venayagamoorthy, Singh, Brooks, and Wang, (2018)	2018
	This proposed a theory how to execute IoT in power network.	Reka and Dragicevic (2018)	2018
	It gives a consciousness to people related to smart grid and internet of things.	Sohraby, Minoli, Occhiogrosso, and Wang (2018)	2017
	This investigates devices used in smart grid like satellite plus wireless based machine to machine.	(Jain et al., 2014)	2014
	This provides a review on smart grid schemes related to smart metering, internet of things & power organization.	(Ali, 2015)	2015
	Suggested a theoretical form of smart grid in respect of internet of things.	(Viswanath et al., 2016)	2016
	Presented an application of internet of things in smart home depending on power management network.	(Yang, 2019)	2019

Table 1. Summary of Associated Reviews of IoT-Aided Smart Grid

as 3G, 4G, power line communication and satellite communication. On the other hand, for short range one can use Zigbee, Bluetooth and ultra wideband technologies.

2. *Data fusion Techniques*: This type of methods is used to increase the efficiency of information. Due to limited availability of IoT resources (such as batteries, memory and bandwidth) it is not possible to transmit all the information to the end.

3. *Energy harvesting process*: It is very significant process in IoT applications. Battery is the one of the primary power sources in most of the IoT devices, so energy harvesting is very significant process. Using different kind of sensors and cameras one can monitor various components of smart grid.

4. *Operating in harsh environments*: As IoT devices are installed in high voltage transmission lines and substations are located and worked in ruthless environment. So one has to use sensors having high or low temperature resistant, water proof and anti electromagnetic to extend their lifetime.

5. *Reliability*: Reliability is very essential in every aspect of operation. IoT works in different environment so reliability or self healing is required there. On the basis of real time data suitable IoT devices must be used to overcome environment issues.

6. *Security*: Information leakage and losses should be neglected, so in IoT some security schemes must be implemented in all IoT to collect, transmit or manage data.

7. *Sensors*: A variety of sensors are used in IoT technology which convey raw data such as current, voltage, frequency temperature etc for processing, transmitting and analyzing. Newly, nanotechnology is used to give high performance material for various sensor applications.

4. Discussion

For the more development of smart grid, IoT is used with the basic idea for the improvement of following task.

- Upgrading the existing grid to smart distribution grids

- More utilization of Renewable energy resources
- Development of microgrids in rural areas where there is no electricity
- Development of new infrastructures for building new information communication system for two directional flow.
- To make a new smart sensor network
- To build a new energy market

While the use of IoT is very noted in the smart grid, it would lead disaster also. Smart grid having critical infrastructure, one can do cyber attacks since its monitoring and control can be based on internet protocols and standard. Due to this cyber attack financial losses are taken and also may damage electrical assets. Some security issues and challenges are there. On the basis of cyber physical network, IoT based smart grid will face number of security issues like impersonation, eavesdropping, data tampering, authorization and control access issues, Availability issues and many more. Similarly, when dealing with security protocols, standards and policies, various challenges are to be faced like mobility, deployment, heterogeneity, interoperability, bootstrapping, time constraints etc. In order to remain safe and to prevent the electrical equipments, sensors, actuators and other parts of the grid, security services must be implemented with IoT aided Smart grid.

5. Recommendation

The common use of IoT in smart grid has the contribution of both the electrical engineering and Information and communication technology (ICT) departments. The offered IoT used in smartgrids is a footstep in the direction of standardization which plays a significant part in the smart grid projects & their upgrading. But there are numerous challenges and security issues are also. IoT gadgets are worked in various environments which may be bad such as heat, high or low temperatures, high voltages, working in water, its exposures and many more. So it may design in such a way that has to satisfy all the working conditions with full reliability and security. The security issues for IoT based smart grid are validation, Data reliability, discretion, User's Privacy, Approval and Control

Access.

There are different applications of IoT in smart grid such as user dealings through consequent computerization systems maintained by machine to machine communications, smart metering, energy harvesting, control of energy generation, transmission and distribution, all areas must be covered with fully maintenance. In this field investigation of data taken from IoT sensors and another smart appliance parallel with prognostic methodical data can give the advancement in smartgrid with logical decision. For this type of analysis one can use different technologies in IoT like cloud computing, big data, distributed computing and fog computing.

Different scientific principles, communications policies and a broad collection of information resources are needed to be credibly expanded in IoT system for smart grid. With this meticulous protocol, procedures and security constraints are to be implemented for data transmission within smart grid. Therefore, an improvement of interoperable principles, design of extended software in a cost effective approach with the involvement of present challenges of privacy and security are the main aims of the future study area of IoT execution

Conclusion

Smart grid is the modernization of traditional grid which replaces the unidirectional information flow and solves the problems of normal grid like energy wastage, growing energy demand, healing, reliability and most important security. IoT technique gives an attachment of anything anywhere at any time. This is the new and unique idea of monitoring, controlling and communicating the information. Different types of sensors actuators and smart meters are used for analyzing the grid as well as connectivity, computerization and chasing of such devices. This recognized the IoT aided smart grid network which coordinates and get better system functions at the power generation, transmission distribution and consumption.

The suggested IoT podium used in smart grid is a pace towards the standardization of protocols which is having a

significant role in the smart grid projects. The goal of this paper is to represent IoT technology as a support for smart grid development and it is helpful for monitoring real time information and controlling the different parameters online. There are also some problems, security issues and challenges in implementing IoT in smart grids. It is found that only some applications of IoT are worked out still and many research has to be done on the different applications of IoT aided smart grid.

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