A REVIEW-SMART GRID TECHNOLOGY: TECHNOLOGIES AND STANDARDS

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***Abstract*- Present power grid is unable to meet up the demands of the consumers. To face all the challenges of the existing power grid, a new technology has been emerged i.e., smart grid. A smart grid is an evolved grid system that manages electricity demand in a sustainable, reliable and economic manner, built on advanced infrastructure and termed to facilitate the integration of all involved with higher efficiency and modern energy management techniques based on the optimization of demand, energy and network availability and so on. This paper presents the issues with smart grid technologies concerned with information and communication technology and their opportunities. The main aim of this paper is to focus at present situation of technologies in smart grid communications and to discuss the issues related to it. It is anticipated that this paper will provide a better understanding of the technologies available and the research in the smart grid.**

I. INTRODUCTION

Our present electrical infrastructure has been unchanged for about 100 years. The electrical grid has been ageing; whereas the demand for electricity is gradually increasing. Presently used electric power distribution system is very complex and is unable to meet up to the demands of the 21st century. A lack of Automated analysis, poor visibility, mechanical switches causing slow response times and lack of situational awareness etc. are a few deficiencies that our present power grid comprises of. Some additional factors like growing population, increasing demand for energy, global climate change too affects the power system

To get rid of all such deficiencies, anew electric power system has emerged and it is 'smart grid'. A smart grid is an evolved grid system that manages electricity demand in a sustainable, reliable and economic manner, built on advanced infrastructure and termed to facilitate the integration of all involved. It includes a variety of operational and energy measures involved. It includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources and energy efficient resources. The existing grid lacks in communication capabilities, while a smart power grid infrastructure is full of enhanced sensing and computing abilities.

In the smart grid, reliable and real time information becomes the key factor for reliable delivery of power from the generating units to the end-users. The U.S., Canada, China, South Korea, Australia and European community countries have started doing research and development on smart grid applications and technologies. Local Distribution Companies (LDCs) are integrating advanced metering and two-way communication, automation technologies to their distribution system. In general, the (AMI) Advanced Metering Infrastructure is a two-way communications network and is the integration of advanced sensors, smart meters, monitoring systems, computer hardware, software and also management system that enables the collection and distribution of information between meters and utilities

II. COMMUNICATION TECHNOLOGIES AVAILABLE FOR SMART GRID

A communication system is the key component of the smart grid infrastructure. By the integration of advanced technologies and their applications for achieving a smarter electricity grid infrastructure, a huge amount of data will be generated from various applications for their analysis, control and real-time pricing methods. So, it is very difficult for electrical utilities to handle such huge output data and deliver a reliable, secure and cost effective service throughout the complete system.

All the available different communications technologies are based on two main communications media i.e., wired and wireless. These communications media are used for data transmission between smart meters and electric

utilities. Instances like low-cost infrastructure and ease of connection to difficult or unreachable areas, wireless communication has some advantage over wired communication. Whereas in wired solutions there is no attenuation or interference problem and their functions are independent of batteries.

For information flow in a smart grid system, two types of information infrastructure are required. First flow is from sensor and electrical appliances to smart meters, and second is between smart meters and utility's data centers. First data flow can be achieved through power line communication or wireless communications such as ZigBee, 6LowPAN and others. And for second information flow, cellular technologies or the internet can be used. Some of the communications technologies are discussed under:-

(A)ZigBee **–** ZigBee is a wireless technology developed as an open global standard to address the unique needs of low cost, low power wireless M2M networks. The ZigBee network layer natively supports star and tree networks, and generic mesh networking. Some advantages of zigbee technology are listed below:-

1. ZigBee has 16 channels in the 2.4 GHz band, each with 5 MHz of bandwidth.
2. 0dBm (1mW) is the maximum output power of the radios with a transmission range between 1 and 100m with a 250 kbps data rate.
3. Ideal for smart grid implementations along with its simplicity, mobility, robustness, low cost of deployment.

Some disadvantages of ZigBee technology are discussed below:-

1. Low processing capabilities, small memory size, small delay requirements and being subject to interference with other appliances
2. Which share the same transmission medium.
3. To overcome such constraints interference detection schemes, interference avoidance schemes and energy efficient routing protocols should be implemented to extend the network life time and provide a reliable and energy efficient network performance.

(B)Wireless Mesh **–** A wireless mesh network is a communications network made up of radio nodes originated in a mesh topology. It is also a form of wireless ad hoc network. It is a flexible network consists of a group of nodes, where new nodes can join the group and each node can act as an independent router. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more (intelligent) intermediate modes.

Advantages:-

I. A cost effective solution with dynamic self organization.
II. Wireless mesh networks can self form and self heal.
III. High scalability.
IV. Good coverage can be provided in urban and suburban areas with the ability of multichip routing.

Disadvantages:-

I. Network capacity, fading and interference constraints in wireless mesh network.
II. A third party company is required to manage the network, and since metering information passes through every access point, some encryption techniques are applied to the data for security purposes.
III. Loop problems causing additional overheads in the communication channel.

(C)Cellular Network **–** A cellular network or mobile network is a communication network where the last link is wireless. The network is distributed over land areas called cells, each served by at least one fixed location transceiver, known as base station. This base station provides the cell with the network coverage which can be used for transmission of voice, data and others. Cellular network solutions also enable smart metering deployments spreading to a wide area environment. 2G, 2.5G, 3G, WiMax, and LTE are the cellular communication technologies available to utilities for smart metering deployment WiMax technology is also being used for communication between smart meters and utilities. WiMax chip sets are embedded into the smart meters and wireless communications is dedicated between smart meters and central system.

Advantages of wireless system are as follows:

1. Cellular networks already exist, so utilities don't need to work for building the communications infrastructure required for smart grid which saves the money to be spent on it.
2. Wide-spread and cost-effective benefits.
3. Lower cost, better coverage, lower maintenance costs and fast installation feature.

Disadvantages:-

1. A few power grid applications need a continuous availability of communications which sometimes may

cause network congestion or decrease in network performance.
2. IN abnormal conditions, such as a wind storm, cellular network providers may not provide guarantee service

(D)Power Line Communication – Power Line Communication (PLC) is a communication protocol that uses electrical wiring to simultaneously carry both data and Alternating Current (AC) electric power distribution. It is also known as power line carrier, power line digital subscriber line. PLC has been always the first choice for communication with the electricity meter due to direct connection with the meter and successful implementations of AMI in urban areas where other solutions struggle to meet up the needs of utilities. In a PLC network, smart meters are connected to data concentrator through power lines and data is transferred to data center via cellular network technologies.
Advantages:-

- Existing infrastructure decreases the installation cost of the communication infrastructure.
- Cost-effective and widely available infrastructure of PLZ.
- Confidentiality, authentication, integrity and user intervention.

Disadvantages:-

- Power Line transmission medium is a harsh and noisy environment that makes the channel difficult to be modeled.
- Low bandwidth characteristic.

(E)Digital Subscriber Lines – Digital Subscriber Line is a family of technologies that are used to transmit digital data over telephone lines. DSL service can be delivered simultaneously with wired telephone service on the same telephone line. This is because DSL uses higher frequency bands for data. The throughput of the DSL connection depends on how far away the subscriber is from serving telephone exchange and this makes it difficult to characterize the performance of DSL technology.
The bit rate of consumer DSL services typically ranges from 256 kbps to 100 mbps in direction to customer, depend on DSL.
Advantages:-

- Widespread availability.
- Low-cost and high bandwidth.
- When these two are combined it makes the application best to be used for power grid

Disadvantages:-
1. Low reliability.
2. Low potential down time.
3.Distance dependence and lack of standardization.

III. SMART GRID COMMUNICATIONS REQUIREMENTS

Requirements that are to be fulfilled in the communication infrastructure between energy generation, transmission and distribution and consumption are two-way communication, interoperability between advanced applications.
Following are the smart grid communications requirement:-

I. Security – Secure information storage and transportation are essentially required for power utilities especially for billing purposes and grid control. For avoiding cyber attacks, efficient, security mechanisms should be developed and standardized efforts concerned to the security of power grid to be made.

II. System reliability, robustness and availability – A reliable system is the most prioritized requirement for power utility. Ageing infrastructure and increasing energy consumption and peak demand are some of the factors that create grid unreliable. Faster and robust control devices, embedded Intelligent Devices (IEDs) for the entire grid from substation and feeder to consumer resources will strengthen the system reliability and robustness. To provide system reliability, robustness and availability at the same time with appropriate installation costs, a hybrid communication technology mixed with wired and wireless solutions can be used. As, wired and wireless technologies have their own advantages on their own.

III. Scalability – A smart grid should be scalable enough to facilitate the operation of power grid. Many smart meters, smart sensor nodes, smart data collectors and renewable energy sources are joining the communications networks. Hence, smart grid should be scalable enough to handle the scalability of grid with the integration of

advanced functionalities, such as self-configuration.

IV. **Quality-of-Service (QoS) –** The communication between the power supplier and power customers is a key issue of the smart grid. Performance degradation like delay or outage may compromise stability, therefore, a QoS mechanism must be provided to satisfy.

Main aim for smart grid standards is that the overall smart grid system is lacking widely accepted standards and this situation prevents the integration of advanced applications, smart meters, smart devices and renewable energy sources. Robust information security and communication exchange are some of the objectives that can be achieved with smart grid standardization efforts. American National Institute (ANSI), the International Electro Technical Commission (IEC), the Institute of Electrical and Electronics Engineers (IEEE), the International Organization for Standardization (ISO), the International Telecommunication Union (ITU) are the recognized standard development organizations that are worth to be mentioned under this.

1. Revenue Metering Information Model

i. **ANSI C12.19** – It is an ANSI standard for utility industry end device data tables. This standard defines a table structure for data transmission between an end device and a computer for utility applications using binary codes and XML content.

ii. **M-Bus –** M-Bus is a European standard, and provides the requirement for remotely reading all kinds of utility meters.

2. Building Automations

2.BACnet – It is a standard communication protocol that was developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for building automation and control networks and support the implementation of intelligent buildings with full integration of computer-based building automation and multiple manufacturers.

1. Power Line Monitoring

i. **Home Plug** – It is a power line technology and the existing home electricity is used to connect the smart appliances to Home Area network (HAN).

ii. **PRIME** – It is an open, global and power line standard that provides multivendor interoperability and welcomes several utilities to its body.

2. Substation Automation

i. **IEC 61850** – It is a flexible, open standard that defines the communication between devices in transmission, distribution and substation automation systems.

3. Home Area Network Device Communication Measure and Control

i. **U-SNAP** – It basically enables the standardization of a connector and serial interface, physical dimensions and data transfer, message contents and protocol specifies for HAN devices to provide many communication protocols.

ii. **Z-Wave –** It is an alternative solution to ZigBee that handles the interference with 802.11/b/g since it operates in the 800 MHz range. Z-wave is not an open standard and developed by the Z-wave alliance.

4. Cyber Security

i. **IEC 62351 –** It defines cyber security for the communication protocols defined by the previous four sets. Especially vulnerable to attacks because of the two-way communication between devices and the utility grid.

5. Electric Vehicles

i. **SAE J2293** – This standard was developed by the Hybrid committee that is a part of SAE international and provides requirements of electric vehicles.

ii. **SAE J2836** – This protocol supports use cases for communication between plug-in electric vehicles and the power grid for energy transfer and other applications.

IV. CONCLUSION

Electric power system have been evolved to smart grid because of the increasing diffusion of distributed generation by renewable sources, nut with an additional aim to increase efficiency, reliability and safety of existing power grid. By this, remote and timely information gathering about equipment failures, capacity limitations etc., and real time and reliable diagnosis of possible failures in the smart grid. This makes cost-effective remote sensing technologies vital for safe, seamless and efficient power delivery in the smart grid.

In this paper, communication technologies and requirements for smart grid have been discussed. There are many issues for realization of smart grid communications and applications. In this, future work includes discussion of grid characteristics, architecture, applications and projects in order to give a complete overview in this subject

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