# Wireless Communication Application in Smart Grid: An Overview

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*Abstract*— **Smart grid environments require high standard of consistent communication technologies to support various types of electrical services and applications .there are many application which are based on Wireless communication in Smart Grid. so, in this paper we can discuss about the some wireless technology like Wireless Automatic Meter Reading (WMAR), Real Time Pricing, Enhanced transformer different protection, remote meter reading. Also discuss the Wireless Mesh Network and Wireless Sensor Network Application in smart grid. most recently, wireless sensor networks have been considered as an opening to realize dependable and low-cost remote monitoring systems for smart grid.**

***Keywords- Smart Grid, Smart Grid Key Technology, Wireless Sensor Network (WSN), Wireless Mesh Network (WMN).***

## I. INTRODUCTION

Smart Grid is considered to join together advanced communication/networking technologies into electrical power grids to compose them "smarter''. Current situation is that most of the power failure and voltage drop. the power electronic grid has been used in our daily life and industry. It can resolved many issues like voltages sags, power failure and day to day population size will increased ,so it can added new appliances into customer's houses and buildings. It involves reliability, scalability, manageability, and extensibility, but also should be interoperable, secure, and cost effective. this electronic infrastructure is also called "Smart Grid" in figure.1.It maximizes the throughput of the system and reduces the consumption of the system [1].

Smart Grid is a communication network included with Electronic Grid that gather and evaluate data captured into actual time about power distribution, transmission and consumption. NIST [National Institute of Standards and Technology] has developed the architecture of Smart grid.

### *A. Smart Grid key Technology:*

NETL[National Engineering Technology and Laboratory] described the key technology areas of smart Grid are as follows in fig.2 :

1) *Integrated Communication:* it is a key component of Smart Grid and it is used to define the communication requirements and it also handles the output data and cost effective service in the communication infrastructure.

2) *Sensing Communication*: smart grid is also used for the WMN .these types of technology will increase the power system measurements and enable the transformation of data into information .they can help to relieve congestion.

3) *Advanced component***:** it determines the grid behavior .they will produce high power densities, greater reliability and power Quality.

4) *Advanced control method*: it will support the market pricing and operation efficiency.

5) *Improved interfaces and decision support*: it will require wide, real time use of application and tools that enables to grid operations and managers to make decisions.

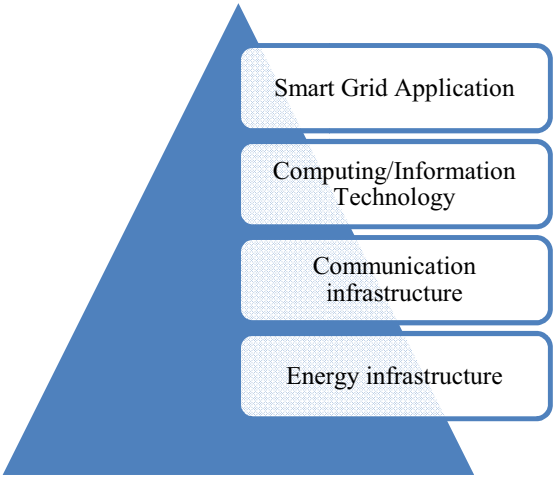


Figure 1. Smart Grid Definition. (1)

### *B. Mathmaical model*

This mathmatical model provides the Quantative description of Smart Grid system requirements [2]. So following notations

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are as follows [3]:

- $G_l(t)$ electricity power generation of power plant l;
- $r_l^u(t)$ : ramp-up function for $G_l(t)$;
- $r_l^d(t)$ : ramp-down function for $G_l(t)$;
- $\Delta_i(t)$ : safety margin of power plant I;
- $l_d(t)$ : loss of electricity power in distance;
- $S_j(t)$ : storage capacity of storage plant j;
- $l_s(t)$ : loss of electricity power in storage;
- $g_{ik}(t)$ :local/distributed electricity generation in branch k of power plant I;
- $U_{lmn}(t)$ : Electricity power consumption of utility n served by power plant l and branch m.

Then, an equation was given as follows [3]:

$$\sum_i \left[ G_i(t) r_i(t) - \Delta_i(t) + \sum_k g_{ik}(t) \right] = \sum_l \left[ L_1 + \sum_m \left( L_2 + \sum_n u_{lmn}(t) \right) \right] + \sum_j \left[ S_j(t) - l_s(t) \right] \quad (1)$$

$$\sum_i \left[ \frac{dG_i(t)}{dt} r_i(t) + \sum_k \frac{dg_{ik}(t)}{dt} \right] = \sum_l \sum_m \sum_n \frac{du_{lmn}(t)}{dt} + \sum_j \left[ \frac{dS_j(t)}{dt} - \frac{dl_s(t)}{dt} \right] \quad (2)$$

Equation 2 suggests there is no need to report everything for global optimization of smart grid.

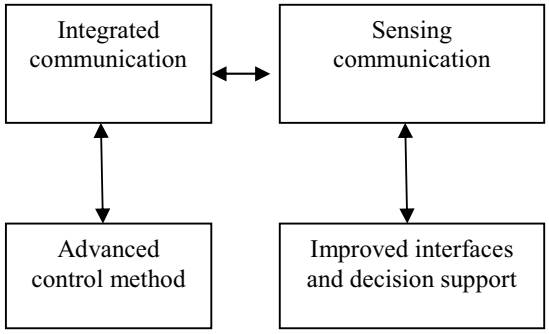


Figure 2. Smart Grid Key Technology.

## II.ARCHITECTURE AND WIRELESS COMMUNICATION TECHNOLOGY FOR SMART GRID

### *A. Architecture of Smart Grid*

A Smart Grid is a creative user centric system that will promote the conventional power grid system to one that functions more communally, responsively and economically in figure 2. A reliable and well-organized communication and networking infrastructure will connect the efficient elements with the smart grids. The presented grid is lack of communication capabilities but the smart grid communication and computing ability,

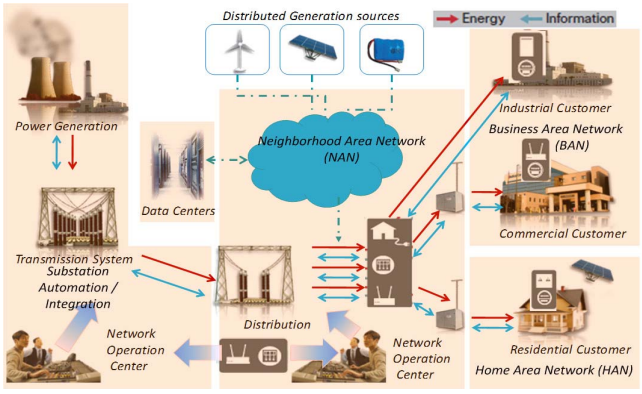


Figure 3. Wireless communication for Smart Grid. (4)

Different components of the systems are linked together with communications paths and sensor nodes to provide interoperability between them example transmission, distribution and other like commercial and industrial sites.

### *B. Wireless Communication of Smart Grid*

Many types of network technology used for communication in the transmission,distribution,customer domains in the smart grid.it find the help the best communication infrastructure to handle output data and deliever a reliable ,secure and cost effective service[5] .in this section we can described the differnet types of wireless communication technologies, which are used for the Smart Grid applications as shown as Table. 1.

*1) WiMax (World Interoperability For Microwave Access) :* this technology is a part of 802.16 series standard for wireless Metropolitan Area network (WMAN)[16].the wide operating range of 802.16 is 10-66 Ghz for communication infrastructure .for the fixed communication 3.5 and 5.8Ghz bands and for mobile communication 2.3,2.5,3.5Ghz and 5.8 GHz is unlicensed Spectrum[5]. WiMax application for Smart Grid is Wireless Automatic Meter Reading (WMAR), Real Time Pricing, Outage Detection and Restoration.

*2) Wireless LAN:* IEEE 802.11 based on Wireless LAN. This technology provides robust, high speed point –to-point and point-to-multipoint communication. Its adopted spectrum technology because it help to allowed multiple users to occupy the same frequency band [6]. It covers the Frequency Hopping Spread Spectrum (FHSS), Direct Sequence Spread Spectrum (DSSS) and Infrared (IR) at 1 and 2Mbps data rates. the currently technology which are based on WLAN are IEEE 802.11a, IEEE 802.11b,IEEE 802.11g .WLAN application for Smart Grid based are communication aided line protection,

Enhanced transformer different protection, Redundant link for distribution automation system.

*3) ZiggBee*:it is a Wireless communication technology and which provides low power,data rate,complexity and cost of deployment.it operate unlicensed fequency range up to 868 Hhz,(15 Mhz and 2.4 Ghz with DSSS modulation.the data rate 20-250kbps and coverage area 10-100m.it is widely used for building,security system , remote meter reading and remote control.the main application of Zig Bee for Smart Grid are Control for home appliances,Direct Load control [7].

*4) Cellular*: the 3G and 4G are the cellular technology which operates on the spectrum range of 824-894 Mhz.this cellular network topology consists of cells.the main advantages of cellular network are huge the large amount of data and improved QOS very fast[8].The main application Cellular network for Smart Grid are SCADA interface remote distribution substation,Monitoring and metering of remote DERs.

TABLE I . WIRELESS TECHNOLOGY.

| **Wireless Technology** | **Data Rate** | **Coverage Area** | **Application for Smart Grid** |
|---|---|---|---|
| WLAN | 1-54 mps | 100 m | communication aided line protection, Enhanced transformer different protection |
| ZigBee | 20-250 kbps | 10-100m | Control for home appliances,Direct Load control. |
| Cellular | 60-240kbps | 10-50km | SCADA interface remote distribution substation |
| WiMax | 70mbps | 48km | Automatic Meter Reading(WMAR),Real Time Pricing |
| Bluetooth | 721kbps | 1-100m | Local online monitoring application. |

## III. WIRELESS SENSOR NETWORK APPLICATION IN SMART GRID:

The research and development field in wireless communication network is focused in some parameters like latency, reliability, energy and stability. These packets are used to deliver the data packets in WSN. it contain the number sensor nodes .these nodes is called WSN. it used in many applications like environment monitoring, energy management ,military surveillance etc. but now a day's WSN is used in Smart Grid. it is widely applied in wireless automatic reading(WAMR) system. WSN also used with grid-based deployments, that approach is autonomous grid-shape and random errors [9]. In this section we can discuss about the wireless technology i.e. WSN and WMN in Smart Grid.WSN application for smart grid will be discussed as follows in the perspective of, power delivery power generation, and power utilization.

*1) Power Utilization:* Home Area Networks (HANs) can be used in WSNs. Wireless Automatic Meter Reading (WAMR) is an application of WSN. it can resolve the real-time energy consumption of the consumer as consumer, it can download their records and take it to meter reading during a mobile device. With the help of WAMR, we can improve the business performance and technical reliability for power utility operations .the customer and the utility, and the smart meter within HANs perform as an interface that translates, summarizes, and aggregates data of power usage and presents it to the power utility [10]. In Fig. 3, inside home, a WSN can connect the various utensils and a central power router .this network connects with the smart meter. This meter is interface between the operational signal metering and data carried by WSN.

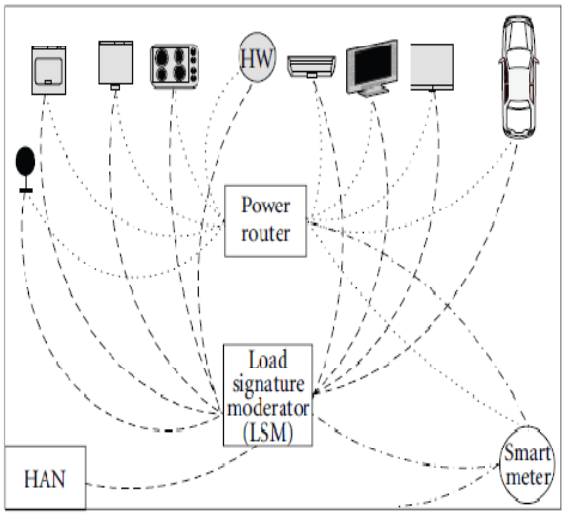


Figure 4. Home Area Network. (9)

*2.2) Power Delivery :* Electric power and substation automation is used in WSN. it can provide a possible and cost effective communication result for remote system monitoring systems. The generation units, transformers, transmission Lines and motors can be monitored by the extensive deployment of smart sensor nodes in a distant, and these Nodes can be established on the critical equipment of smart grid. it can also monitoring the transformers, circuit breakers, and switches in a substation or a distribution station, power quality sensors, transformer temperature sensors, and breaker position[11].

*2.3) Power Generation:* A large generation plant may contain several generation units, and several hundred actuators may control fuel, air, and water flows to optimize heat rate and correct the output of each unit. Wireless sensors network can installed the generation system in power plants [12, 13].

## IV. WIRELESS MESH NETWORK APPLICATION IN SMART GRID

WMN are Ad hoc Wireless Network that are formed to provide an alternate communication infrastructure for mobile or fixed node without the spectrum reuse constraints and the required of network planning of cellular network. The mesh topology provides many alternate paths to transmit the data session between sources to destination; each user may easily send data to source to destination. At the time of data transfers, if any nodes are failure to transmit the data then it Reconfiguration the path among source to destination. It is used in many applications such as broadband wireless access, industrial applications, transportation systems, health monitoring, military etc. this technology also used in Smart grid. This network also used in Virtual Access Network Embedding (VANE). In which each access node is based on Orthogonal Frequency Division Multiple Access (OFDMA) dual-radio architecture [14].

IEEE 802.11s standard is based on WMN. it can provide the high reliability as well as high performance in the smart grid communication [13,15].WMN is used in application like Home Area Network (HAN), Neighbor Area Network (NAN), Wide Area Network (WAN).so, if we receive the data from multiple source then uses the NAN ,it maintain their own application like power management, power surveillance. the default unique routing link cost is not suitable for the unique smart grid. it arises the problem of airtime cost in (3).so ,this problem is resolved by the IEEE 802.11s when decrease the packet delivery ratio in the network and modified the airtime cost as shown in (4).

$$C_a = \left[ O + \frac{B_t}{r} \right] \frac{1}{1 - e_f} . \quad (3)$$

Where O=channel access overhead, $B_r$=size of transmission frame, r=data rate, $e_f$=error rate.

$$e_f = \frac{M_{n^* \frac{1}{P_n}}}{R_{\max}} . \quad (4)$$

Where P=total number of packets transmitted by nodes n, M=total number of MAC level transmission node by node, $R_{max}$ = allowed maximum retransmission on count [16, 17].

## V. CONCULSION

In the first part of the paper , we can discuss about the Smart grid technology and wireless communication in Smart Grid.the some smart grid wireless application are:WiMax ,Bluetooth, ZigBee, Wireless LAN presented in this paper.these technology have own advantages and disadvantages.we also described the WMN and WSN in brief. some application of WSN in Smart Grid are : power delivery, power generation and Power utilization and explain the aircost problem in WMN and its modified.in future we develop the wireless communication technology for security and enhancement in network lifetime.

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