



Review on Heterogeneous Network Technologies in Smart Grid

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Abstract: In technological world smart grid helps in two way communication along with the transmission of the electricity on the same transmission line which strives to improve performance, security, reliabilities and lifetime of the heterogeneous network when deployed in building or industries. In this paper we discuss about architecture of smart grid, Technologies and standard protocols adopted which support the interoperability in smart grid and influence of heterogeneous infrastructure on improvising the latency, number of hops and life time.

Keywords: Smart Grid, Power Grid, Network Performance, Lifetime, Mesh Network, Latency.

1. INTRODUCTION

Smart grid can provide digital help in two way communication where it includes the properties like Self-monitoring, Self-healing and Adaptive. Smart grid is explained as modern electrical grid which uses communication and information technology to collect the information or measurement from different behavior and forward to base station. To perform the various Distributed Energy Management (DEM) activities smart grid requires a large number of protection, control and monitoring devices which is distributed over the large geographical area. Hence these above devices along with the communication infrastructure form heterogeneous network.

The official Definition of smart grid provided by National Institute of Standards and Technology (NIST), USA as “A restructured grid that allows bidirectional flows of energy and practices two-way communication. It control capabilities that will lead to an array of new functionalities and applications” [1]. IEEE defines the smart grid as “Smart grid is a large System of Systems, where each functional domain consists of three layers: the power and energy layer, the communication layer, the IT/computer layer. The importance of smart grid are reliability, increased lifetime, network efficiency and demand

2. ARCHITECTURE OF SMART GRID

Smart grid architecture is similar to Internet architecture which is hierarchical network consisting of different layers which is classified as Home Area Network (HAN), Neighbours Area Network (NAN), and Wide Area Network (WAN) in order to address scalability and heterogeneity requirements in Smart grid.

[2]In HAN layer communication is carried out using various technology like Wi-Fi, blue-tooth and power line

carrier. The component enclosed in HAN are measuring meters, measuring devices and Electric vehicles. Next layer above HAN is NAN which consist of component such as digital systems subscriber, intelligent Electronic Devices (IEDS), substation and Distribution center. The characteristic of NAN includes the communication between smart meter to IED and the technology used is WIMAX.

The top most layer in the smart grid architecture is Wide Area Network (WAN) which is the core utility backbone of smart grid and primary functions are generation, transmission, and customer service. The technology used in WAN are satellite communication, fiber optics based communication technology, available in this layer help to interact with other layers. The success of smart grid depends upon the co-operation between the layers comprising of diverse communication network technology and smart grid devices.

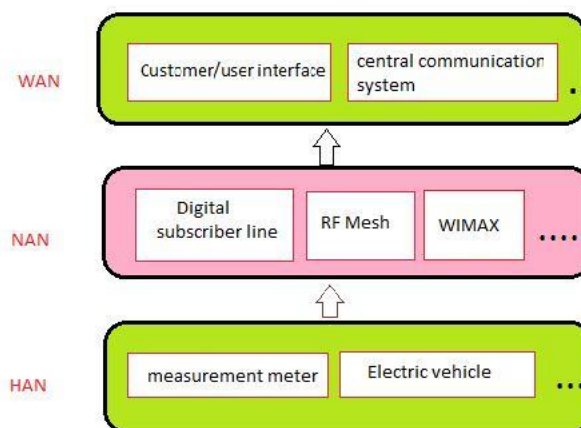


FIG-01 OVERVIEW OF SMART GRID ARCHITECTURE



3. TECHNOLOGIES AND STANDARD

Smart grid application uses various communication technologies and protocols. Few of them are discussed listed below:

- WIFI
- ZIGBEE
- WIMAX
- BLUETOOTH
- INTERNET OF THINGS(IOT)

3.1 Wi-Fi technology usage in Smart grid

Wi-Fi technology has an enduring roadmap of innovation and established mechanisms for collaboration (via the Wi-Fi Alliance and IEEE) to meet the changing requirements of Smart Grid applications well into the future. IEEE P2030 Standard which provides the two-way communication, having the characteristics such as power system operator can monitor their own system as well as neighboring system, reduce cybercrime risk and collaborate the power system with emerging technologies [3].

Carlos recommended Wi-Fi technology usage in smart grid. Since Wi-Fi is available in unlicensed spectrum smart cities opting 802.11 prototype can manage their own private network. 802.11 helps in network management by measuring traffic characteristic, enabling [4] Hoi yang Tung et al proposed Wi-Fi is a wireless application for computer communication and Ethernet network. It uses a standard of IEEE 802.11 family for wireless local area network such as 802.11g, 802.11n. The modulation scheme used in 802.11g is Direct Sequence Spread Spectrum (DSSS) inheriting 802.11a modulation and 802.11g. 802.11n is improved upon the 802.11 standards by adding Multiple Input Multiple Output (MIMO) techniques. Benefits are:

Scheduling event and report, Device configuration and reconfiguration, Measurable performance and usage devices. But IEEE P2030 is still in progress, Offers natural redundancy, unlicensed spectrum band range is used.

3.2 Zig-Bee

Zig-Bee is Wireless personal Area Network (WPAN) which incorporates standard provided by IEEE 802.15. It has following characteristics such as short-range transmission, low cost of production, low data rate and low power consumption. It can be in form of star, cluster-tree, and mesh topology. Mesh topology guarantees connection to the data's destination even when a link fails. If two network points are unable to communicate as intended, transmission is dynamically routed from the blocked node to a router. It provide low cost of production and low power consumption, the life-span of Zig-Bee can last for more years. It cannot handle the high density environment and does not support heavy traffic loading and weak signal propagation.

3.3 WIMAX

[5] Agustin Zaballa's, Alex Vallejo, and Joseph M. Selga, proposed worldwide interoperability for microwave access (WIMAX) uses the standard provided by 802.16 for the wireless wideband access. It provide two different forms of topology such as point to multi point and mesh topology. In the mesh topology all the nodes are connected to the central node so there are active nodes that periodically announce mesh network configuration (MSH-NCFG) which also provide the information for the identification of base station. Other standard that can be implemented in WIMAX are 802.11, 802.22, 801.15.4, 802.15.5.

IEEE 802.11 defines how the wireless network can be connected to form the adhoc network these standard are provided over the physical layer.

IEEE 802.22 standard is for cognitive radio techniques where there is broadband access in area with low population and where the signals are difficult to reach.

IEEE 80.15.4 implemented in smart utility network and also Task Group 4g was created using this standards. This standard is defined over MAC (medium access control) layer and also physical layer of OSI model provide the global standard for very large scale network deployment. IEEE 802.15.5 defines the mesh architecture in personal Area network (PAN). It create a unified information communication technology (ICT) frame work capable of comprehensible support and Communication architecture must be able to integrate whichever technology it be considered.

3.4 Bluetooth

[6] Mario Collotta, and Giovanni Pau, introduced Fuzzy Logic Controller (FC) in Bluetooth Low Energy (BLE) in order to improve a Home Energy Management (HEM) system. Home automation (HA) is the automatic control of different home based activities. it provides a centralized control over the electrical appliances, such as air conditioners, lighting and security systems and even a home theater with intelligence added to the home environment. HEM lead to a socially and economically-beneficial environment by addressing consumer utilities. Bluetooth Low Energy provide less power consumption, it is present in mobile phones and many personal computers, which provide the necessary user interface for smart energy applications. [7] Abdurrahman Yarali explained it as, "Bluetooth is the professional name for a wireless personal area network (WPAN). It utilizes frequency hopping during, main features is the ease of "pairing" between two devices so that they can communicate". It has not made a large impact in the HAN/smart home system. Bluetooth addresses are not encrypted during transmission.

3.5 IOT

Upcoming technologies have emerged to reduce the communication protocols and handle large amounts of data. The Internet of Things (IoT) is one the most recent



enabler for the smart grid. In smart homes, each device in the substation is considered as an object and is assigned a unique IP address. Each object can transmit its status and receive control commands from the utility authorized operator via the Internet [8] explained by A. R. Al-Ali, Raafat Aburukba. Benefits are:

- Efficient resource utilization.
- Manage distributed energy sources. Smart grid environment requires related computational power, storage, and high availability of resources.

4. INFLUENCE OF HETEROGENEOUS INFRASTRUCTURE

This heterogeneous architecture is made of sensor/actuator and PLC associated with it form the RF-PLC gateway. This network adopted the IEEE 802.15.4 standard protocol where PLC 802.15.4 is dominant protocol over the Radio transceiver [9].

RF network which is known as wireless sensor network whose usability has increased in current development of smart grid, it help in conservation of energy and reduce the wastage of energy, and deployment of radio transceiver in building is difficult task. This network is made of up the low cost and battery powered devices where those devices are considered as nodes. Nodes in the building help to collaborate the measurement and forward to base station. These nodes are located far away from the base station which can results in loss of information or packet from node to the base station hence for this reason the sensor are kept in between so that the data is not loss or information is safely reached to the base station hence the sensor located between the nodes and base station is known as hole.

The network lifetime is small as there is inclusion of sensor which causes the premature death of network if it is located farther distance from base station, special nodes are considered without any energy constraint which is called as sink. PLC is the device that enables the data transfer communication at the rate 200m bytes per second home plug along with it coupling devices are used to ensure good propagation medium. The hybrid of RF-only and PLC-only use the same protocol provided by the 802.15.4 driver independent of media being used.it is observed from the performance measurement in real and stimulated PLC network[10]

Topologies are represented as directed acyclic graphs (DAGs).In Fig 2 DAG is formed by the three types of nodes considered those are RF-only, PLC-only and RF-PLC nodes.by the RF-PLC gateways placement there is resolution obtained where the sensor reach to the base station by one hop and lifetime of network increases. The simulation of above network produces the following Results given below

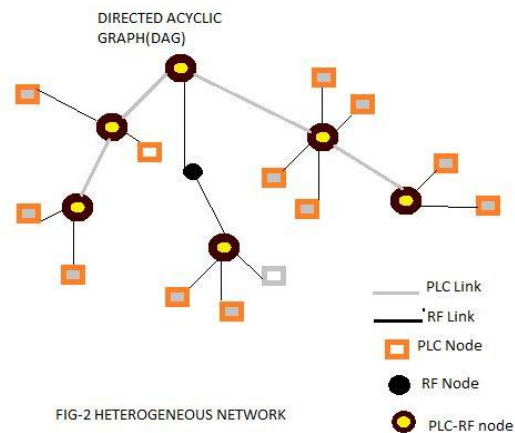


FIG-2 HETEROGENEOUS NETWORK

4.1 Number of hops required to reach server

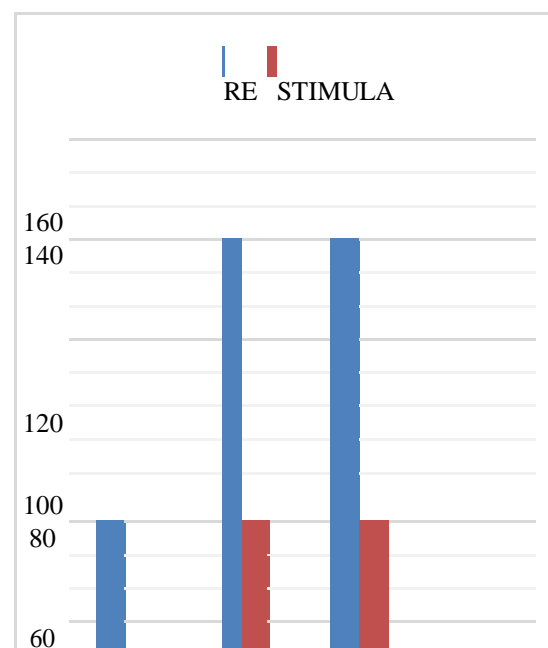
Number of hops	Hop1	Hops2	Hops3
Repartition	39%	46%	15 %

TABLE -01

As shown in the above table 1, there is decreased percentage in number of hops this proves network reliability, connectivity and forwarding reduction of PLC in a hybrid network.

4.3 Latency

Latency is the delay in the network, how much time it takes for a data packet to travel from one point on the network to another. Latency performances in figure 3 show that real PLC links induce many more link layer retries on real PLC networks.it uses an exponential computation, resulting in possibly high latency value in the case of MAC layer retries.



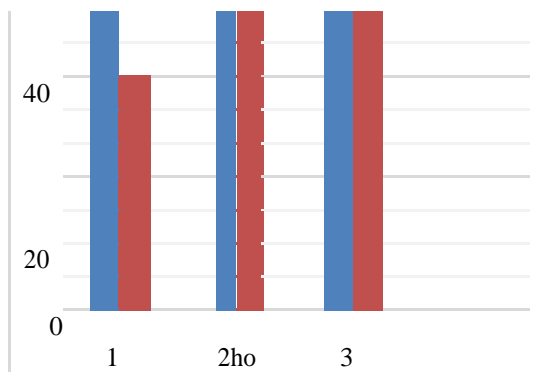


Fig03

RF systems using duty cycling mechanisms for energy efficiency and lifetime.

4.4 Lifetime

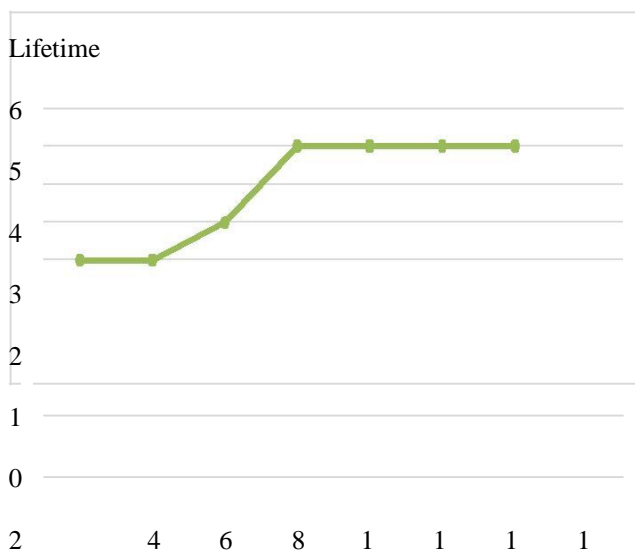


FIG-04

Many RF-PLC gateways results in the average length of routes decreases, leads to decrease in latencies.

CONCLUSION

The desire to reduce electricity consumption, add renewable energy sources to the mix of supply options, and better control the entire electrical system, a new smart grid is being proposed and implemented. This paper briefs about an architecture of smart grid, standard protocol, technologies and influence of heterogeneous infrastructure on improvising the latency, number of hops and life time.

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