

Survey on Communication Technologies for Home Area Network (HAN) in Smart Grids

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Abstract

Smart Grid (SG) becoming popular over traditional electrical power systems due its efficiently and controllability. SG network can be divided in different subsystems such as transmission network, distribution network, and substation local area network, Neighborhood Area Network (NAN), Wide-Area Network (WAN) and Home Area Network (HAN) for its accurate functionality. For all these subsystems applicable communication technologies has been defined and its plays vital role for real-time data communication and sharing between devices and systems connected in SG domain. In this paper we present network requirement and challenges in implementing networks in HAN and also survey potential communication technologies can be apply for HAN in SGs.

Keywords: *Smart Grid (SG), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide-Area Network (WAN).*

Introduction

Smart Grids generally refers to an intelligent electrical network with integration of Information and Communication Technology (ICT) to enable the observability and controllability of the electrical grids in 21st century. Over the past decades ICT based systems were entered in many industries to enable communication between machine to machine . In good old days labour force were used to get information on electrical loads by taking the meter readings as well as to monitoring power systems. After computerized and automated power distribution system introduces many advatages came across over the legacy power sytem in term of

demand side management, facilitates for renewable energy sources and micro-generation , storage, improved reliability and security of the distribution [1]. The SG technology applications can be included in to different application such as smart home appliances, electrical vehicles, real time information on electricity usage for consumers and intelgent electronic devices (IED). And the total SG network can be divided in parts. For each and every network, communication technologies have been defined. In this paper we survey available communication technologies for HAN in SG and discuss the network requirement and finally the challenges.

Network Requirements and Challenges in Smart Grid Communications

The electricity network equipped with sensors and actuators uses a communication network for their communication. These sensors and actuators enables the smart grid applications by sensing and controlling the SG devices. The integrated network supported for different application of data transfer, multimedia and voice communication and control applications through substation controller to the distribution network. To ensure continous grid supply the electrical network need to connect other SG entities such as Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) with the help of the communication network. [1] [2].

SG is an interactive and integrated platform which consists of generation, transmission, distribution, customers, service providers, operations and market with different applications and services. The

electrical power generation feed electrical power from large central generators which powered by hydropower, nuclear power, fossil fuel and other renewable power sources such as solar, wind, geothermal and etc. The transmission grid used to transport the electrical power from generation systems to distribution systems over considerable distances through multiple substations. The customer get the service as the consumer of electrical power system. The customer can be a residential, commercial or industrial which based on their power consumption and different services. In between customer and the utility the service provider manages their services. In operations manages the electrical distribution and the operation of the electrical power system. The market allows pricing and balancing of supply with the demand in electrical power system. Each system in smart grid needs to interconnect with each other in different communication area networks which enables various applications and services. The communication infrastructure in different area networks can be classified into Home Area Network (HAN) covers consumer area, Neighbourhood Area Network (NAN) covers local area network, and Wide Area Network (WAN). The area networks classified

according to their coverage area, bandwidth, applications and services [3].

Networking Connections and Home Area Network (HAN) Architecture

The architecture of smart Grid communication network was discussed in this section for logical and physical connections. Later will discuss the physical connections in smart grid communication network.

Physical Connections

The networking architecture and connections to smart grid devices shown in figure 1. The Internet Protocol (IP) is the main protocol used in this integrated network architecture. In smart grid networked devices for far-sightedness is the use of Multiprotocol Label Switching (MPLS) as the transport technology. Point-point direct connections to the core network is an essential to have the reliability and the load sharing over multiple data in control centers. For this connectivity the ISO, RTO and corporate service providers are partners of the utility.

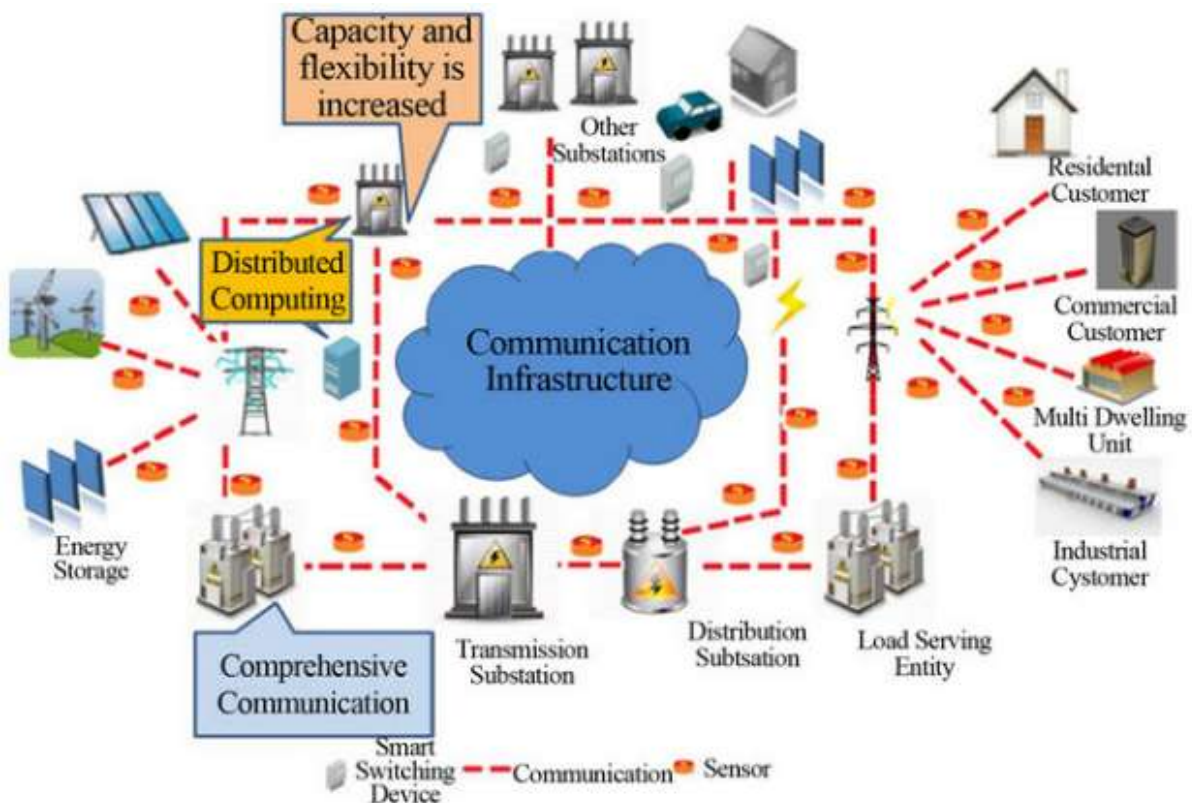


Figure 1: Smart grid network

Each and every consumer connects to the networked grid using their smart grid device located in their premises. The Distributed Energy Resource (DER) located in consumer premises which closer to the building area, energy storage elements or plug-in electric vehicles (PEV). The DER's devices connected to the communication network over Home Area Network (HAN) or Local Area Network (LAN). The distribution system, standalone and large scale renewable energy sources and energy storage systems connected to the network using one or more wireless or wire line connections. In micro grid power distribution system uses dedicated

communication network technology of Voice over Internet Protocol (VoIP) in peer-to-peer (P2P) voice or push-to-talk (PTT) communication. There is a necessity to have a wireless mobile broadband network for the VoIP communication. The legacy voice communication system needs to exist as a redundant. [3] In smart grid network there are large number of various devices connected in different technologies and architectures. In interconnection of those devices in HAN the utility is able to control the consumer appliances partially or completely to better manage the grid system. [4]

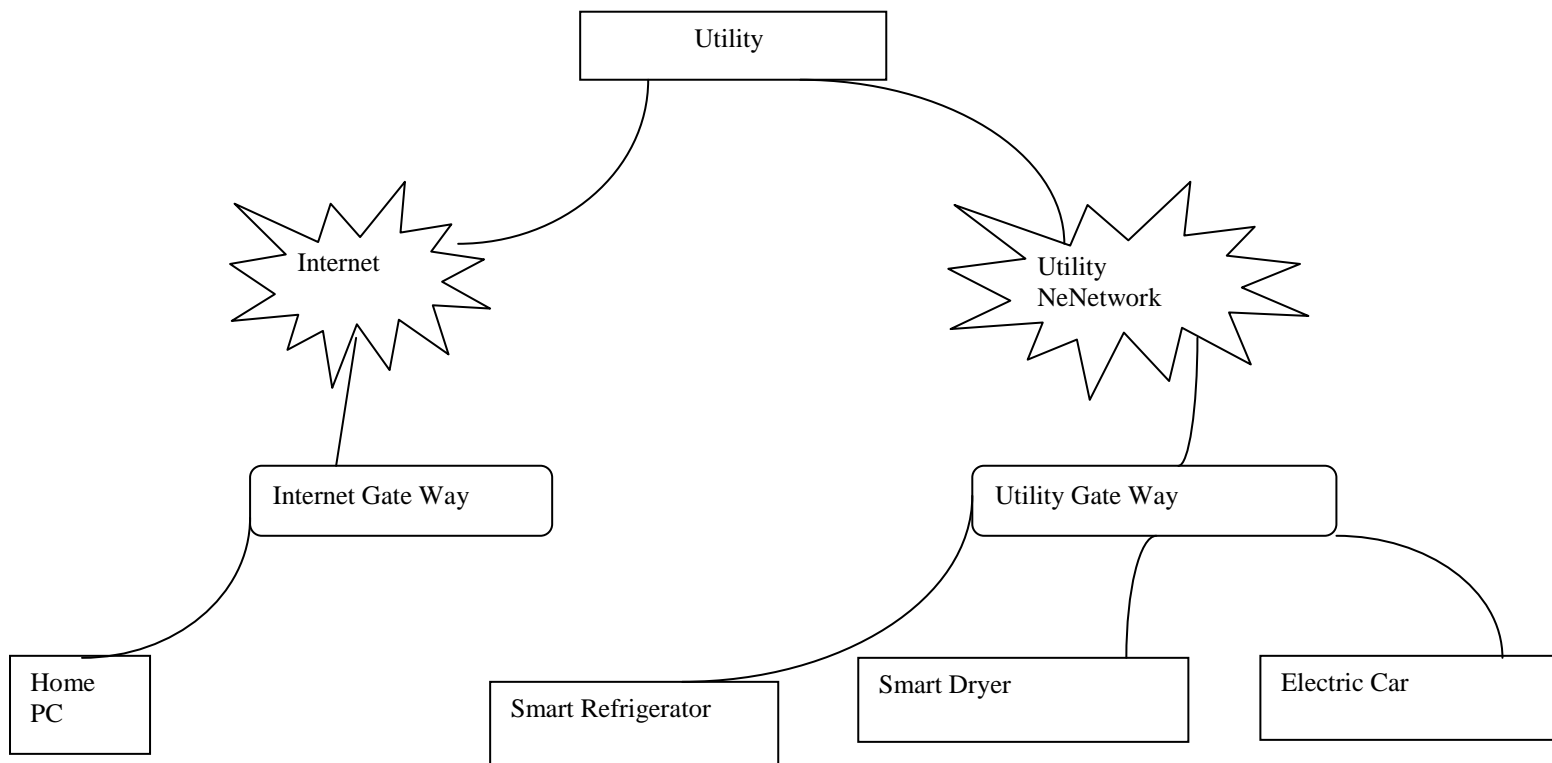


Figure 2: Architecture for HAN

As shown in figure 2, all the electrical appliances to be connected to SG network via a utility gateway as proposed and SG network can control and monitor the appliances through the network. Communication between electric appliances and utility gate way to be discussed in later part of this paper.

Home Area Networking Technologies

The major technological requirement of Smart grid communication network is two way communication. It enables to monitor and control of the electrical in

real time. All the smart grid devices communicate with each other and share their real time energy consumption control information. Different vendors and manufacturers need to be integrated with the utilities, such that to have a common interface for smart grid devices and services. For this integration it needs to have international, regional and national standards.

ZigBee

Zigbee is an open standard IEEE 802.15.4 based protocol which develops as a communication technology with low power and low cost in wireless

sensor networks. It suits for high level communication protocols with digital radio in wireless personal area networks. In figure 3 shows the zigbee layered architecture which specifically

recommended for HAN. Zigbee devices can be found as three devices and supports in multiple network topologies of star, tree and mesh [4].

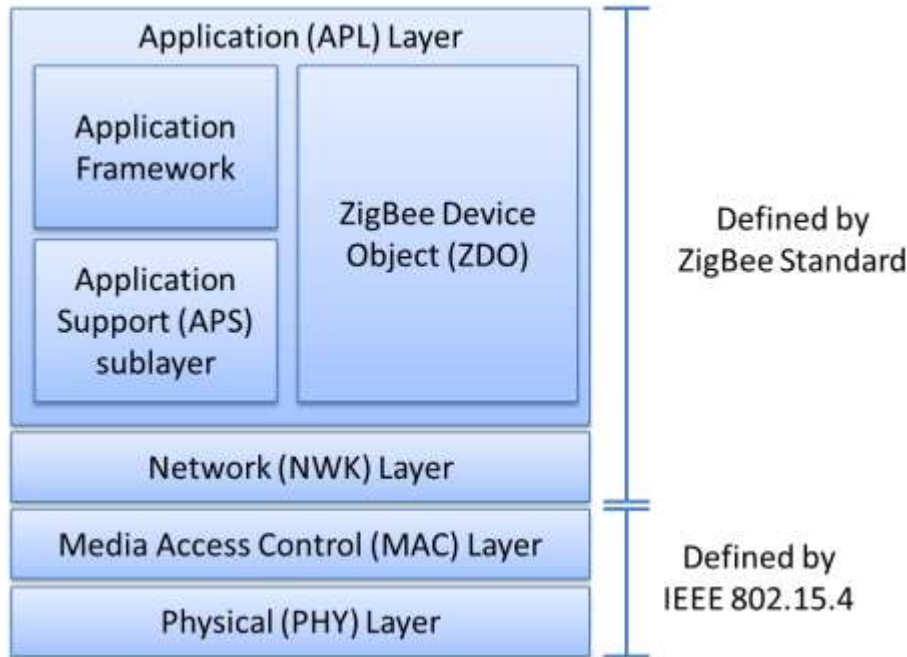


Figure 3: Zigbee Layered Architecture

1. The ZigBee Coordinator (ZC) is a full function device operates as the root of the network and manages rest of the connections in the network. The ZigBee network will have only one ZigBee Coordinator which serves as the network's trust center and provide authentication and security to the devices connected to the network.
2. The ZigBee Router (ZR) routes data between the Zigbee devices within the network and does not communicate with the devices in the network
3. Zigbee End Device (ZED) used to communicate with their parent nodes (coordinator and router) and not relay data from other devices. ZED operates with minimum hardware recourses compared with ZC and ZR [4].

Zigbee can be use in applications where you needs low bandwidth, low power and close proximity. The protocol is widely used in embedded system applications of home automation, industrial automation, health care, smart grid, smart energy and in the areas of wireless sensor networking. Against

the advantages of this protocol there are some disadvantages. It cannot be used in applications for higher bandwidth needs. Zigbee uses the frequency in the ISM band which interferes with other devices operating in the same band. For the best use of the protocol, the network needs to be secure, which security is an optional in Zigbee [4].

HomePlug

HomePlug is a non-standardized family name for power line communications defined by HomePlug Powerline Alliance Association. The specifications of HomePlug define the networking of the existing home electrical system as a unique. The applications are based on Programmable Logic Controller (PLC) or Broadband-Over-Power line (BPL) technology, which is supported by Smart Grid Technology. Orthogonal Frequency Division Multiplexing (OFDM) is used as the transmission technology over powerline and it uses frequency bands between 4.5MHz and 21MHz with equally spaced 84 subcarriers. The HomePlug has improved efficiency with noise suppressing techniques using forward

error correction and interleaving of data in transmission. HomePlug can be implemented using the existing electrical system which is an added advantage. But with the limited device availability in the market and expensive error correction techniques the HomePlug is not wide spread technology in Smart Grid Environment [5].

6LoWPAN

IPv6 over Low Power wireless Area Network (acronym 6LoWPAN) is an IPv6 based open standard technology which communicates using IEEE 802.15.4 devices. 6LoWPAN is low power with limited processing capability mainly used for Internet of Things application and smart grid devices. The newest competitor for Zigbee is the 6LoWPAN especially in smart grid applications [6].

OpenHAN

OpenHAN is Home network or home grid standard for power line communication in the utility point of view. It ensures the reliability of the communication of socket outlets. OpenHAN linked the customer's smart meter with their appliance will get knowledge of the energy consumption [7].

Bluetooth

Bluetooth is standardized by IEEE 802.15.1. It uses ISM band frequency of 2.4 GHz. Bluetooth is widely used in mobile and fixed personal area networks with effective coverage up to hundred meters [8].

Conclusion

For HAN in SGs required a low bandwidth to communicate within the network elements in the network. Communication technologies can be applied in HAN can be categorized as wired solutions and the wireless solutions. Such as HomePlug is wired and Ethernet based and no need to set up new wires as we can use the same Ethernet network. Over wired solutions wireless solutions are competitive in terms of their ease of mobility and ease of implementation. Zigbee, WiFi and Bluetooth are capable of implementing HANs.

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