

# An Innovative Solution to Empower the WiMAX Grid Network for Smart Applications: An Innovation in Intelligent Networks Approach

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## Abstract:

WiMAX (Worldwide interoperability for microwave access) is a broadband wireless technology which provides support to higher bandwidth and multiple services. Basically, it is a topology of wireless communication which comes under 4<sup>th</sup> generation and its use in the smart grid applications is very cost effective i.e. valuable one. This technology had enormous applications with high performance, like smart metering, surveillance, mobile workforce, fleet connectivity, asset management and emergency communication, etc. This intelligent networking approach supports most of the techniques of the modulation as well as coding methodology. It has been found that the architecture and the standards which are required for the designing of smart grids i.e. intelligent networks are basically depending on the various internet protocols, and have the similarity i.e. proper correlation with the 4<sup>th</sup> generation mobile network technology. Thus, one can say that the WiMAX can be put forward as a systematic and detailed top-down approach for the design of 4G cellular systems, which are based on IEEE 802.16m and 3GPP LTE/LTE approach i.e. an advanced technology of wireless communication, that forms the basis of the development of various smart devices as per the need of the various developing industries, based on the standards like IEEE802.16 and ETSI hypeeman level of acceptance and implementation. This paper basically focuses on the brief technical overview of WiMAX (Worldwide Interoperability for Microwave Access) in the development and designing of various intelligent network applications using IEEE 802.16e standard and its specifications. Our emphasis is to maximize the use of intelligent networks efficiently by correlating it with the energy consumption during peak hours. With the increasing demands for the wireless network based applications and the quality of the data rates associated with these networks, it has become the necessity to explore the use of WiMAX as a wireless technology for large deployments say, the smart grids for the efficient monitoring of energy usage remotely and in emergency response systems.

**Keywords:** *Smart Grid, Sprint and Grid Net, CAEX, OPEX, IEEE 802.16, WIMAX, 4G, 3GPP, Intelligent Networks, Smart Network Approach.*

## I INTRODUCTION TO WIMAX & ITS ARCHITECTURE

The WiMAX topology is basically based upon the 4<sup>th</sup> generation technology that has been used for the enormous commercial use in the broadband services based applications. This intelligent networking approach fulfils the basic requirement of the smart grid based applications which ensures a simple, economical and easy to implement the intelligent network based applications with the desired level of security and reliability. The smart grid technology based on WiMAX is quite innovative approach for the beginners in the domain of wireless technology with high bandwidth. This technology can also be used to deliver various probable services like mapping information and the video tools for mobile workers that provides the video services for the facility of monitoring the various sub-modules of the intelligent applications. This approach to the wireless networks implementations also enables to be used in the smart grid topology because it provides a high bandwidth and open standard by which the participating and developing agencies gets benefited economically. The basic grid or networking topology can be considered or qualifies as a smart grid when this conventional network has been developed with the use of the telecommunication infrastructure, management of data according to telecommunication technology and control structure. In recent years of development, the broadband technology has rapidly become an established, globally accepted commodity which is required by a high percentage of the population i.e. the end users. In the present scenario of the development of the technology, the demand for the intelligent networking has risen rapidly, with a worldwide installed base of 57 million lines in 2002 rising to an estimated 80 million lines by the end of 2003 [1]. This healthy growth curve is expected to continue steadily over the next few years and reach the 200 million mark by 2006. The DSL operators, who initially focused their deployments in densely-populated urban and metropolitan areas, are now challenged to provide

broadband services in suburban and rural areas where new markets are quickly taking root. Governments are prioritizing broadband as a key political objective for all citizens to overcome the “broadband gap” also known as the “digital divide” [2].

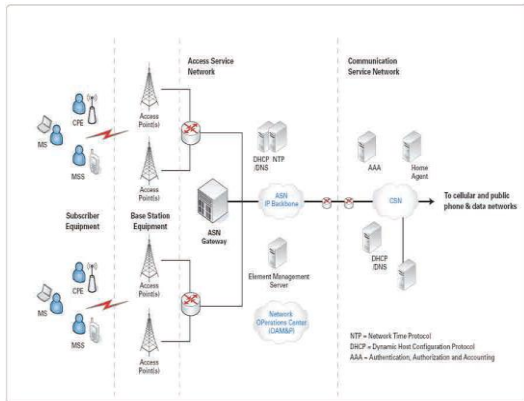


Fig.1 Basic WiMAX Architecture [U.S. Small Business Administration, 14]

The above fig 1 shows the possible architecture of the WIMAX network that has been already implemented successfully to the work level. The various sub modules of this architectural network are quite simple in the context of their explanation and are fully functioning.

## II BASICS OF THE SMART GRID TOPOLOGY

The smart grid is basically a telecommunication based networks which are used for the enhancement and growth of the community to which it serves i.e. provides the methodology so as to interact with each other. One of the cost effective utility or the application of this innovative approach is to monitor the grid for the power production to power consumption ratio using the 4<sup>th</sup> generation technology. The smart grid based applications can be easily developed economically i.e. in less than half the cost of the basic network, if we can compare it with them. This WiMAX based approach is quite easily feasible and accessible as compared to the traditional one that provides a large range of possibilities for the smart grid, which are quite easily affordable by the industries. Thus, the smart grid can be put forward as an intelligence system that monitors all the utilities related to the home/office appliances and it also helps to prevent energy leaks from these appliances i.e. provides the efficient use of energy. This networking device can be easily installed at the customers or end user’s premise/location so as to read the daily power energy used or consumed by the end load, water

consumption, and the gas consumption by each and every appliance in real time domain. These are the few probable applications where the intelligent networks can be used efficiently that help to control the routine activities in home simply by increasing or decreasing the energy consumption during the peak hours or time periods. In addition to this efficient consumption of the parameter, it also transfers this energy consumption information or data to the main controlling section by using the intelligent wireless network for monitoring and billing purposes. The biggest reason for using WIMAX for the smart grid is its high bandwidth (i.e. the amount of data it can carry), which is quite larger when compared to other wireless network topologies. This data transfer rate ranges from 1Mbps to 15Mbps which simply depends on the end user applications and on the medium through which the data has to be transmitted [3 - 5].

- Smart Grid = Utility (i.e. Application) + Communication (i.e. transmission of data)

The smart grid networking has taken the control of the applications based on the intelligent systems alongwith the utility of the end users and the medium through which the communication of the data is taking place within the network. It has enormous features which enables the end user highly conserved power energy as well as the cost saving, which is not possible on using conventional electric grid network. Thus, if the end users or subscribers can avail the maximum advantages of the smart grid intelligence based networking then the basic obstacles or the limitation of the implementation of this smart networking like the technical, financial, regulatory and behavioural aspects can be easily eliminated. It means that these networks can be established as the future prospective of the conservation or proper utilisation of the energy, which in turn set up an intelligent system which is efficiently capable of deciding that the consumers are getting the proper distribution of the energy as per their need of the system.

Thus, it has been observed that in the upcoming future applications based on the intelligent networking system in the domain of telecommunication, which is totally an IP based wireless topology and supports the possibilities of the WIMAX based smart grids. It is so because this technology supports the policy management, quality of services, manages in case of high traffic on the basis of priorities and can perform accordingly with the management of the bandwidth that utilizes the network resources. Another essential and most important feature of any networking technology is the assurance of a full proof secured transmission of the data i.e. the secure flow of the data

which is important for any application so as to utilize it properly. The WIMAX based smart grid networks has inbuilt feature of the security the data transmission i.e. a secure communication throughout the network through smart grids [6 - 8]. This network has got another inbuilt feature that it can create or establishes a temporary network in the emergency areas by moving the mobile base station and terminal devices as per the requirement of the application. In addition to this, the voice over internet protocol (i.e. VOIP) and the WIMAX can altogether make a new revolution in the telecommunication industry i.e.

- The VOIP feature of the intelligent grid provides the economic support to WIMAX, if it is without the limitation, say, the current connectivity factor.
- The WIMAX internet feature can use the different VOIP services from which it is possible to make free or cheap calls locally or worldwide.

The quality of this intelligent networking system can deliver the high quality service as voice and video successfully i.e. in case of the WIMAX network within the subscribers and the base stations, there is not occurrence of much numbers of air latency on the air link but there are large collection of latency on the wired portion [9 - 10].

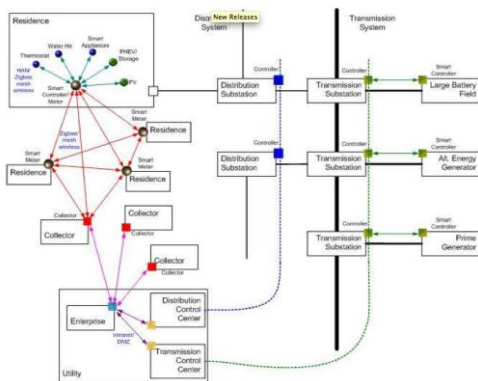


Fig. 2 Block diagram of Smart Grid connection and components [Source: U.S. Department of Energy, Smart Grid System Report (July 2009), 14].

## II FEATURES OF THE SMART GRID

The smart grid based networking generally refers to a class of technology based applications which are using the intelligent system so as to bring the consumption or utility of the electricity delivery systems in the 21<sup>st</sup> century, by using computer-based remote monitoring & control based automation system (RMCAS). This intelligent system is only feasible i.e. possible to

implement by applying a two-way communication technology and computer processing, that has been in use for the decades in various industries. This system has been started to found its basic use i.e. application on the electricity delivering networks, which are generated at the power plants and wind farms, to all the way to the end users or consumers of the electricity in homes and businesses with the benefits to the end users or consumers with mostly seen in big improvements in the energy efficiency on the electricity grid and in the energy consumption at homes and offices.

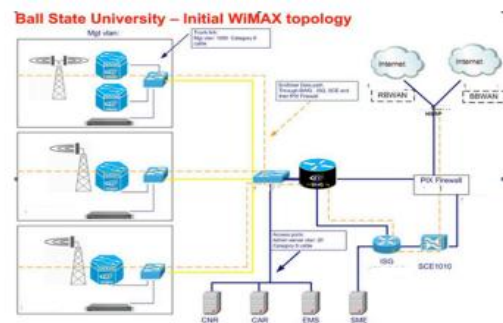


Fig. 3 WIMAX Infrastructures [Source: Bell State University, 14]

The above fig 3 shows the working model of the WIMAX networking architecture that has been implemented successfully at the Bell State University. In order to discuss this operating architecture, we can consider a working model example that has been implemented successfully. On the left side of this architecture, there are three Cisco P4 antennas, which are mounted on three buildings which are spread across the effective area of these antennas within the campus where this has been installed. Out of these four antennas, the first one is a bi-directional type; while the second and third antennas are omnidirectional, which are responsible for beaming the WIMAX signals at a 2 mile radius area, which is well enough to include the effective sites on and off the campus area, where the intelligent system has been installed. The data transmission between the various antennas installed at an exemplary campus has been managed by the dedicated switches that navigate the user data to and from these antennas through a BWG gateway router. This router in turn is connected to a switch that creates a virtual LAN's (VLAN) for the backend servers and the antenna network so that the data communication can be done effectively. The main function of this switch handles the data in turn from both the sources and hands over i.e. propagate them over to the ISG router, which is the essential feature of the Cisco IOS software complete set that

provides a structured framework in which edged devices can deliver flexible and scalable services to subscribers. The Cisco Service Control Engine (SCE) is a network element specifically designed for carrier-grade deployments requiring high-capacity and the CISCO Network Register (CNR) is a full-featured DNS/DHCP system provides scalable naming and addressing services for the large enterprise network. The Committed Access Rate (CAR) feature limits services and input or output transmission rate on an interface or sub interface based on a flexible set of criteria. The (CAR) feature performs the following functions [11 - 12]:

These two research initiatives have not only provided the faculty and students involved, ample exposure to new technologies, it has also provided a case study detailing the technology required for a viable WiMAX deployment in the mid-west region. Technological improvements in the broadband wireless arena have been rapid and significant in recent years, offering operators greater performance and flexibility in their deployments while reducing their investment risks and ongoing operating expenses. The 802.16/HiperMAN for 2-11 GHz is a wireless metropolitan area network (MAN) technology that provides broadband wireless connectivity to Fixed, Portable and Nomadic users [13 - 15]. This powerful OFDM and NLOS technology can be used to backhaul 802.11 hotspots and WLANs to the Internet, provide campus connectivity, and enable a wireless alternative to cable and DSL for last mile broadband access. It provides up to 50-kilometers of service area range, allows users to get broadband connectivity without needing direct line of sight with the base station, and provides total data rates of hundreds of Mbps per base station - a sufficient amount of bandwidth to simultaneously support hundreds of businesses with T1/E1-type connectivity and thousands of homes with DSL-type connectivity with a single base station [16]. Network accessed with WiMAX and Device Pairs-The accessed network and the device pair must use the same protocol. WiMAX devices access networks uses 802.16e WiMAX protocol using equipments accordingly WiMAX specification .900 MHz access network can only communicate with 900 MHz device which is made by the same access network. In wireless technology there are 3 basic access network technology as Wireless network- WiMAX, Cellular (2G and 3G) and proprietary (900 MHz). Wireless network has the lowest build out cost which depends on the density of consumers. Wired Communication Network- Cable, Digital Subscriber Line (DSL) and Ethernet. Wired Communication Network cost also depends on the subscribers covered. This is not suited with Smart

Grid as they exist in the period of wire line communication so still being used. Wired Power Line Communication-Broadband Over Power Line (BPL) and Data Communication Link (DCL). Wired Power Line Communication used in data transportation with the help of Electric Network. Wireless Network is truly beneficial if we consider cost and availability of the products [17 - 20].

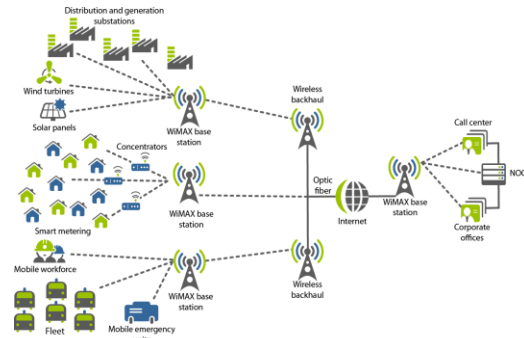


Fig. 3 Smart Grid connectivity supported WiMAX [14]

#### IV IMPLEMENTATION OF THE SMART GRID NETWORKING

WiMAX with Smart Grid application from business point of view- WiMAX technology is IP based it can be used by the operator for small area, industries and transportation. WiMAX maintain balance between cost, flexibility to the network, control on the technology and complexity. WiMAX operates under wide range of frequency as eg-3.65 GHz in US. WiMAX has a flat structure which makes it highly flexible and scalable because of these qualities it is easy to add new application with greater capacity, reduced cost and covers the wide range. By extending the utility of wireless infrastructure it can be increased coverage in rural areas and low density areas. In between service provider and vendor it is also necessary to establish a long term communication but mobile operators upgrade to new technology according to subscribers demand [21]. WiMAX is new cost effective technology because it dose not charged by the mobile operators recurrent charges per terminal device. Smart Grid CAPEX and OPEX- CAPEX (Capital Expenditure) is money which is spent with the planning of initiating cash for future to build a strong business. It is invested by a company to achieve non consumable money or property of a company. Basically CAPEX are of two types i.e. One which is invested to maintain the existing resources and assets in the company and the second one is to invest something for the growth in future in particular direction. OPEX (Operational Expenditure)- OPEX is

the counterpart of CAPEX. It is invested for the daily expenses of any organization or in any business. Sprint and Grid Net proponents of WiMAX. Grid Net provides IP based Smart Grid application for any broadband technology. On combining Grid Net with the sprint it can provide Smart Grid solution to connect Smart meters to Smart Grid routers through Sprint 4<sup>th</sup> Generation technology. Grid Net are used for the application like use of renewable energy, satisfaction of the consumer by maintaining the cost, efficient energy, management of load on electric vehicle. Advantages of Grid Net-Lowest total cost-Smart Grid technology with Grid Net software are cheaper than multi network implementation. Instant Communication- Its real time speed is less than 100 millisecond and it fully support the internet protocol. Total Security- It provides total end to end security. Scalability- It manages 10s of millions of devices from single deployment. Universal Management- It is able to manage all electric devices as fiber, 3G, 4G, ZigBee, WiFi, Ethernet and home plug. Sprint is the first Smart Grid network launched in the US. It is used to search embedded WiMAX connectivity in Smart Grid routers Smart meters with Grid Net. Grid Net and Sprint combine provides security, scalability, economic support and compatibility to the consumers. Sprint 4G network used by the consumers since 2008 [22 - 25]. To make proper utilization of Smart Grid with WiMAX it is necessary to build Smart Grid carefully within the given access technology and the minimum requirements of successful services. WiMAX provides many advantages among other technology for Smart Grid application. It provides full utility of products, Provides greatest features and functions on the lowest cost. Advantages over PLC (Programmable Logic Controller), DLC (Data Link Control) and Mesh Network are significant [26 - 32].

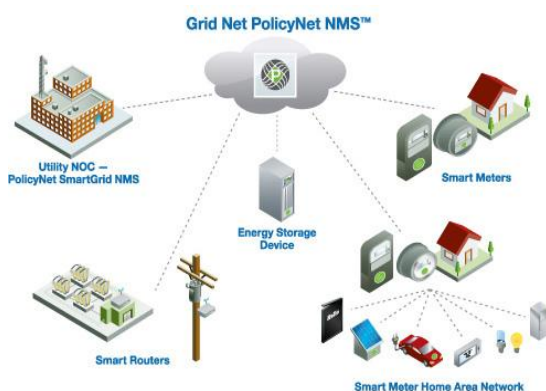


Fig.4 Grid Net with long term evolution Comparison of accessed technology [14]

## V CONCLUSIONS

The wireless network is a very important and dominant module of all the possible system that is used in the telecommunication domain for intelligence based applications. It is so because it provides the full utilization of the technology to the end users i.e. subscribers, which in turn makes it cost effective and thus, uses the fixed as well as mobile connection both for the inter-communications of the data between the users. In this present high-tech information era of the broadband services, the WIMAX based intelligent network systems are becoming the basic need or requirement which forms that bases of the communication. Thus, the smart grid applications of the intelligent WIMAX network definitely results in a revolution in the telecomm era that changes the subscriber's mindset so as to utilize the technology and set a high level of success in telecommunication. The intelligence based smart grid applications are high end effective data transfer in the 4<sup>th</sup> generation wireless broadband technology especially, using the WIMAX network. Based on this discussion, the machine to machine communication is becoming very important feature of telecom industries, and the most promising and first inter mobile applications of the wireless topology is the smart grid applications, with its prominent efficiency, security and reliability. The businesses organization, public institutions and private end users regard it as an enabling technology and it has become an alarming requirement for delivering the communications services in this current information age. In the last end of the market trends where the traditional cable or copper infrastructures are either saturated, outdated or simply out of reach, Broadband Wireless Access (BWA) technology that fills the void admirably, providing highly efficient and cost effective access services for millions of subscribers who would otherwise be left out of the loop.

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