Design of a WiMAX radio link

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***Abstract* - The telecommunication industry has been through disruptive times, but data networking service revenue has continued to rise. The telecommunication industry is expected to continue to grow as demand increases for cable and high-speed Internet in previously unserviced locations and as local telephone companies upgrade their lines in response to increasing competition. This paper presents an extended overview of the Worldwide Interoperability for Microwave Access (WiMAX) and its applications in higher generation wireless networks as a cost effective solution to answering the challenges posed by the digital divide. It looks at the technology behind WiMAX and networks design and deployment factors that impact WiMAX coverage. A cell site coverage simulation at different frequency bands using Wireless simulation tool is presented. Also the paper makes a comparison of WiMAX with two enhanced third generation (3G) technologies that are potential competitors to WiMAX. It then goes on describe the business models in WiMAX and states some of the benefits and drawbacks of a mobile WiMAX network.**

***keywords* - WiMAX,3G,ASN,GSM,ISDN,IEEE-802.16,AAS,AMS,AES,MAC,IP,VOIP**

Introduction-

Telecommunications has grown at a tremendous rate in the last ten to twenty years. Improved semiconductor and electronics manufacturing technology, and the growth of the internet and mobile telecommunications have been some of the factors which have fueled this growth in telecommunications. The least developed countries have been left in the technological dark ages with few or none of the next generation networks installed. Developed countries now boast high speed connections with a large percentage of homes having access to the internet and broadband services at an affordable fee. The underdeveloped countries are yet to enjoy such facilities. This is referred to as the digital divide [1]. During the first World Summit on the Information Society (WSIS) held in Geneva in December 2003, the Digital Divide was defined as the unequal access to Information and Communication Technologies (ICTs), where the least developed countries are separated from the developed countries because of a lack of technology particularly information and communication technology [2].

The digital divide has persisted due to the relatively high cost of putting up modern telecommunications infrastructure. This is compounded by the fact that there are a number of different services available and each service requires its own technology and network [3]. Therefore existing technologies such as Wireless Fidelity (WiFi), Digital Subscriber Line (DSL), Global System for Mobile communications (GSM), Integrated Services Digital Network (ISDN), and the relatively new 3G technologies have not been able to provide a total solution to closing the digital divide.

This process will move much faster than the deployment of cellular networks and devices for the following key reasons:

1. The manufacturing process for WiMAX devices will be quite similar to that of wireless devices and mostly the changes will be in components and software.
2. Readiness of the current wireless fixed and mobile market and waiting on new technology.
3. As carriers built out wireless networks, most of the questions in this field have been answered and can now be applied to the development of a mirror network that provides WiMAX access.

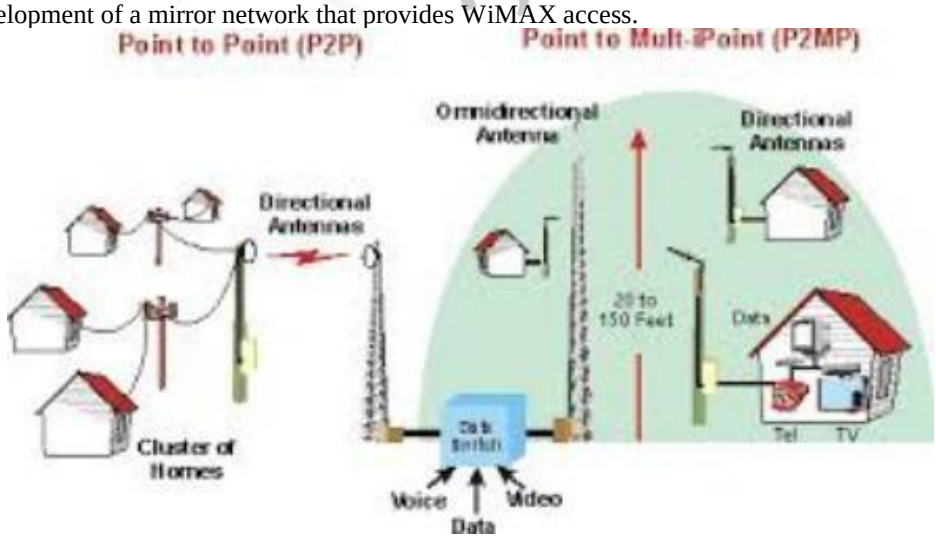

Fig2: WiMAX [9]

Network Architecture-

WiMAX has a flexible architecture. The Mobile WiMAX End-to-End network architecture is based on an All-IP platform, all packet technology and no circuit switch telephony.

The open IP architecture gives network operators great flexibility when selecting solutions that work with legacy networks or that use the most advanced technologies, and in determining what functionality they want their network to support The architecture allows modularity and flexibility to accommodate a broad range of deployment options such as small scale to large scale, urban, suburban and rural coverage, mesh topologies , flat , hierarchical and their variant, and finally, co-existance of fixed , nomadic portable and mobile usage models [4].

Mobile WiMAX adds both the mobility and Multiple Input Multiple Output (MIMO) functionalities to the IEEE 802.16- 2004 standard. It is one of two standards adopted by the WiMAX forum with the other one being the IEEE 802.16 – 2004. Mobile WiMAX network architecture mainly has three components. These include the Access Services Network (ASN), the Core Services Network (CSN) and the Application Services Network (AS). Fig. 3 illustrates the interconnection of these networks. The WiMAX network supports the following key functions:

1. All IP Access and core service networks
2. Support for fixed, nomadic and mobile access
3. Interoperability with existing networks via internetworking functions
4. Open interfaces between ASN's and between the ASN and the CSN
5. Support for differential quality of service depending on the application
6. Unbundling of the Access, core and application service networks

A. ASN-

The ASN is the access network of WiMAX and it provides the interface between the user and the core service network. Mandatory functions as defined by the WiMAX forum include the following:

1. Handover
2. Authentication through the proxy authentication, authorization and accounting (AAA) server.
3. Radio resource management
4. Interoperability with other ASN's
5. Relay of functionality between CSN and MS, e.g. IP addressallocation

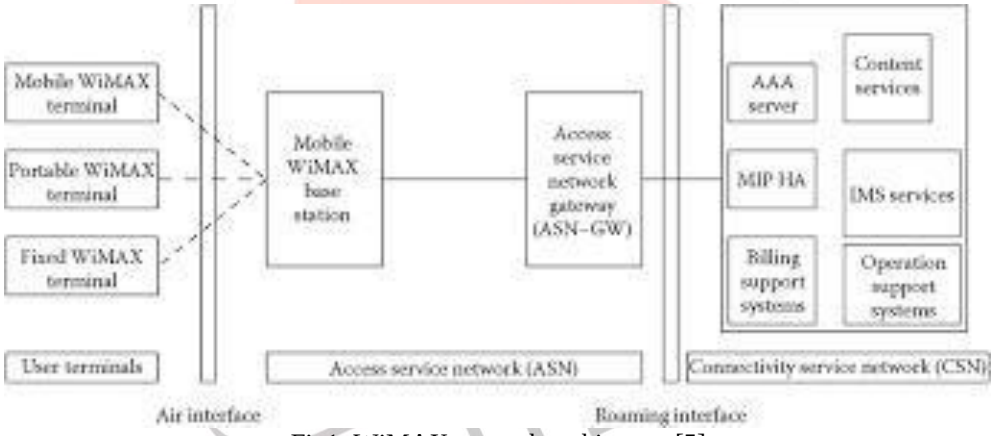

Fig1: WiMAX network architecture[5]

Base Station(BS)-

The cell equipment comprises the basic base station equipment, radio equipment and a base station link to the backbone network. The base station is what actually provides the interface between the mobile user and the WiMAX network. The coverage radius of a typical base station in urban areas is around 500 to 900 meters [6]. In rural areas the operators are planning cells with a radius of 4 kilometer (Km). This is quite a realistic number now and quite similar to the coverage areas of GSM and UMTS/HSDPA base stations today. Deployment is driven either by the bandwidth required to meet demand, or by the geographic coverage required to cover the area. Based on the cell planning of other previous technologies, urban and suburban segments cell deployment will likely be driven by capacity. Rural segment deployment will likely be driven by the cell radius.

ASN gateway-

The ASN Gateway performs functions of connection and mobility management and inter-service provider network boundaries through processing of subscriber control and bearer data traffic. It also serves as an Extensible

Authentication Protocol (EAP) authenticator for subscriber identity and acts as a Remote Authentication Dial in User Service (RADIUS) client to the operator's AAA servers.

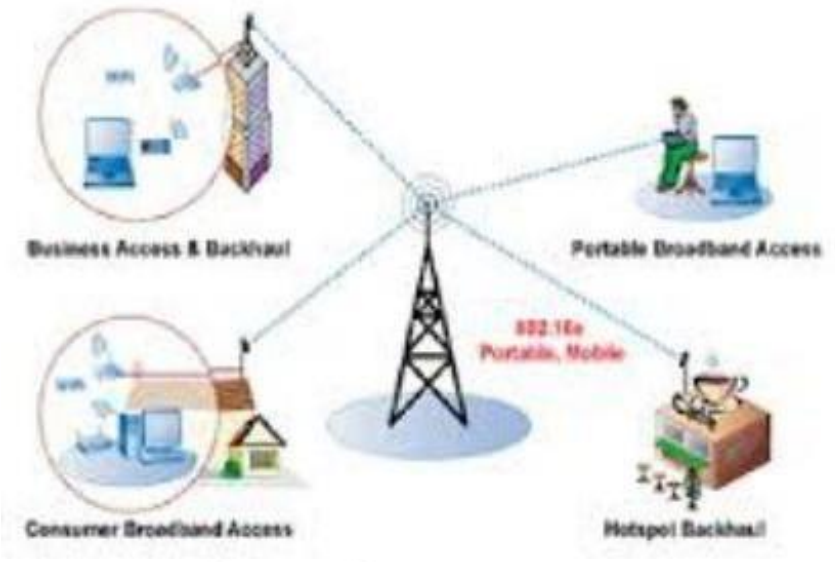

Fig3: WiMAX Base station[10]

B. Core Service network:

The CSN is the transport, authentication and switching part of the network. It represents the core network in WiMAX. It consists of the home agent (HA) and the AAA system and also contains the IP servers, gateways to other networks i.e. Public Switched Telephone Network (PSTN), and 3G. WiMAX has five main open interfaces which include; reference points R1, R2, R3, R4 and R5 interface [7]. The R1 interface interconnects the subscriber to the base station in the ASN and is the air interface defined on the physical layer and Medium Access Control (MAC) sub layer. The R2 is the logical interface between the mobile subscriber and the CSN. It is associated with authorization, IP host configuration management, services management, and mobility management. The R3 is the interface between the ASN and CSN and supports AAA, policy enforcement and mobility management capabilities. The R4 is an interface between two ASN's. It is mainly concerned with coordinating mobility of Mobile Stations (MS's) between different ASN's. The R5 is an interface between two CSN's and is concerned with internetworking between two CSN's. It is through this interface that activities such as roaming are carried out.

Technologies employed by WiMAX

Mobile WiMAX operates in licensed frequency bands in the range of 2 to 6 MHz. The technologies employed by mobile WiMAX include the following:

1. Scalable Orthogonal Frequency Division Multiple Access (SOFDMA) on the physical layer.
2. MIMO
3. IP (Internet Protocol)
4. Adaptive antenna systems (AAS)
5. Adaptive Modulation schemes (AMS)
6. Advanced Encryption Standard (AES) encryption

Environment-

The base station will be built on towers and rooftops. The deployment of the design network will be a combination of outdoor and indoor units. In the design, obstacles between two base stationswill be avoided, to enable Line of Sight (LOS) communication.The landscape should not have very high mountains and this will make the design less complex and cost effective. The subscriber station (SS) will use Non Line of sight (NLOS) in communicating with the base station.

Applications-

The WiMAX standard has been developed to address a wide range of applications. Based on its technical attributes and service classes, WiMAX is suited to supporting a large number of usage scenarios.

VOIP & IP-

Mobile WiMAX is an all IP network. The use of OFDMA on the physical layer makes it capable of supporting IP applications. It is a wireless solution that not only offers competitive internet access, but it can do the same for telephone service.

Voice over Internet Protocol (VoIP) offers a wider range of voice services at reduced cost to subscribers and service providers alike .VoIP is expected to be one of the most popular WiMAX applications. IPTV enables a WiMAX service provider to offer the same programming as cable or satellite TV service providers. IPTV, depending on compression algorithms [8], requires at least 1 Mbps of bandwidth between the WiMAX base station and the subscriber.

Benefits of WiMAX-

WiMAX is a global technology. Different countries refer to their systems by different names for example; WiBro is the name of 802.16e standard in South Korea and HIPERMAN(High Performance Radio Metropolitan Are Network) in Europe. The

Widely used international broadband spectrum range is 3.5 GHz. The followings are some of the advantages of WiMAX-

1. Wireless
2. High Bandwidth
3. Long Range
4. Multi-application
5. High Security
6. Flexible architecture
7. Interoperability
8. Low cost and quick deployment

Conclusion

Broadband wireless is a significant growth marketplace for the telecom industry to deliver a variety of applications and services to both mobile and fixed users. The combination of both advanced radio features and flexible end-to-end architecture makes WiMAX attractive solution for diverse operators. It provides many different services on one network, services which required different networks in the past. It also provides convergence of fixed and mobile networks. It provides high speed access to the subscriber at a reasonable cost, thereby enabling the service provider to make a profit from the technology, using economies of scale. It offers the advantage of reduced total cost of ownership during the lifetime of a network deployment.

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