IJITKM Volume 8 • Number 1 June-Dec 2014 pp. 5-10 (ISSN 0973-4414)

Literature review of worldwide interoperability of microwave access (WiMax) Technology

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ABSTRACT

Wimax stands for worldwide interoperability of microwave access. Along with the development of mobile communication and broadband technology, WiMax has become a hot spot for global telecom operators and manufacturers. WiMax promises to deliver the Internet throughout the globe, and connect the "last mile" of broadband wireless connectivity services. WiMAX will offer broadband wireless access at data rates of multiple Mbit/s to the end-user and within a range of several kilometers. The same radio technology will also offer high-speed data services to all nomadic terminals (laptops, PDAs, etc.) with an optimized tradeoff between throughput and coverage. Ultimately it will enable the "Portable Internet" usage replicating on the move the same user experience as at home or at the office. Given its huge benefits, WiMAX will develop as a powerful radio access solution with many integration synergies in mobile or fixed network architecture. WiMAX will also enable end-users to benefit from an "Always Best Connected" experience when accessing their applications via the best available network, at home, on the pause, or on the move.

1. Introduction

With the further development of the communication network, WiMax has major realistic significance and strategic value as a standard facing to “the last kilometre” access, especially when no globally uniform standard is established for broadband wireless access. There are two main types of such standard: the IEEE 802.16d supporting air interface of fixed broadband wireless access system, and the IEEE 802.16e in the works supporting the air interface of both fixed and mobile broadband wireless access systems.

WiMax is a Broadband Wireless Access Metropolitan Area Network (BWA-MAN) technology based on the IEEE 802.16 standard, which is also called the IEEE Wireless MAN. It is a new air interface standard in connection with the frequency ranges of microwave and millimetre wave. Its main purpose is to provide a broadband wireless access approach which can be interoperated effectively in the environment of multiple manufacturers with "one-point to multi-point" in the metropolitan area network. With the increasing market demand for WiMAX, it is now regularly compared with Wi-Fi. While both technologies have some identical technical characteristics, however they are approaching the wireless space from completely different perspectives.

2. Background

The first WiMAX standard, IEEE 802.16-2001, was published in 2002. It defines a point-to-multipoint (PMP) fixed wireless access system between a base station (BS) and its associated subscriber stations (SSs). It operates in the 10–66 GHz frequency range, which is the so-called line-of-sight (LOS) communications. The IEEE 802.16-2004 standard was published in 2004 to extend the WiMAX specification into the 2–11GHz frequency range, the so-called nonline-of-sight (NLOS) operation. It also describes the WiMAX system profiles and conformance criteria to adapt to the dynamic wireless environment. By introducing the mesh mode, IEEE 802.16-2004 is capable of forwarding traffic from a node to its neighboring nodes. The latest WiMAX standard, IEEE 802.16e-2005, was approved in December 2005. By employing scalable orthogonal frequency division multiplexing (SOFDM), IEEE 802.16e-2005 provides full mobility support for both licensed and unlicensed spectra.

3. WiMax Architecture

The WiMAX protocol architecture is structured into two major layers - the MAC layer and the PHY layer. MAC layer contains 3 sublayers. Starting from the base, the first sublayer is SS which encrypts and decrypts the data which are entering and leaving in and from PHY layer. This sublayer uses for data traffic 56bit DES (Data Encryption Standard) encryption and for Key Exchanges uses 3DES encryption . The second MAC sublayer is the CS (Service Specific Convergence Sublayer). This sublayer maps higher level data services to MAC layer service flow and connections. The third sublayer is the CPS (Common Part Sublayer). In this sublayer are constructed the MPDUs (MAC Protocol Data Units). The CPS sublayer defines rules and mechanisms for ARQ (Automatic Repeat Request 10), for connection control and for system access bandwidth allocation. It also provides centralization, channel access and duplexing. CS and CAP are communicated by MAC SAP (Service Access Point). The PHY layer it's a connection between MPDU and the PHY layer frames with the encoding of the radio frequency when sent and received through modulation. WiMAX technology architecture was created so as to allow its connection with IP networks which provide Internet services. Fig Fig fig

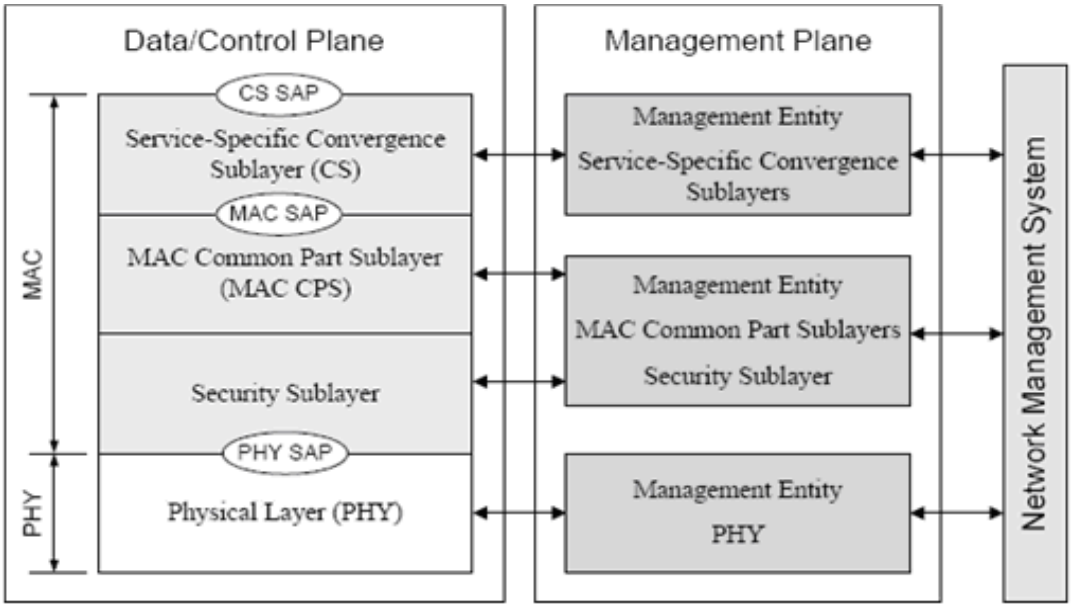

Figure 1.Wimax Architecture

3.1 Characteristics of PHY Layer

The working frequency of WiMAX ranges from 2 to 66GHz (2-11GHz for IEEE802.16 standard; 10-66GHz for IEEE802.16a standard), and the channel band width can be adjusted flexibly within the range of 1.5-20MHz, which is favorable for fully utilizing the frequency spectrum resource in the distributed channel bandwidth. WiMAX adopts macro cells with the maximum coverage up to 50km. In the 20MHz channel band width, it supports a sharing data 2sector technology can be used to expand the system capacity WiMAX adopts various advanced technologies to realize the NLOS and ONLOS transmission, such as OFDM, receiving-transmitting diversity, adaptive modulation, which greatly improve the efficiency of wireless transmission in cities. The physical layer supports two kinds of wireless duplex multiple access, i.e., TDD/DMTA and FDD/TDMA, to adapt to the requirements of telecommunication system in different or regions. It supports single carrier (SC), OFDM (256 points), and OFDMA 2048 points), which can be selected flexibly as needed. The physical layer may change subject to the performance of transmission channel. The modulation mode and parameters of physical layer (such as, modulation parameters, FEC parameter, power level, polarization method, etc.) can be adjusted dynamically to guarantee good transmission quality.

3.2 Characteristics of MAC Layer

The MAC layer is divided into three sub-layers: Service Specific Convergence Sub-layer (CS), Common Part Sub-layer (CPS), and Privacy Sub-layer (PS).

(1) The main function of CS is to convert and map the external network data received by SAP to the MAC SDU, and then transmit to the SAP of MAC layer. The protocol provides multiple CS specifications as interface to various external protocols.

(2) CPS is the hardcore of MAC, with the main functions of system access, band width allocation, connection establishment and connection maintenance. It receives the data from different CS layers via MAC SAP, and classifies them into specific MAC connections. Meanwhile, it implements QoS control to the data transmitted and dispatched on the physical layer.

(3)The main function of PS is to provide authentication, key exchange and encryption/decryption processing.

4. Structure of WiMax Network System

The WiMax network system mainly comprises of core network and access network. The core network includes the network management system, router, AAA agency or server, user database, and Intern gateway equipment. It mainly provides an IP connection to WiMax users. The access network includes base station (BS), subscriber station (SS) and mobile subscriber station (MS). It mainly provides wireless access to WiMax users. See the following figure.

4.1 Core Network

The WiMax core network is mainly responsible for the user authentication, roaming service, network administration and providing interface to other networks. Its network administration system is used to monitor and control all base stations and subscriber stations in the network, and provide the functions of inquiry, condition monitoring, software download, and system parameters configuration. The IP network connected to the WiMax system is generally a traditional switching network or the Internet or other networks. The WiMax system provides the connection interface between the IP network and base stations. However, the WiMax system does not cover these IP networks.

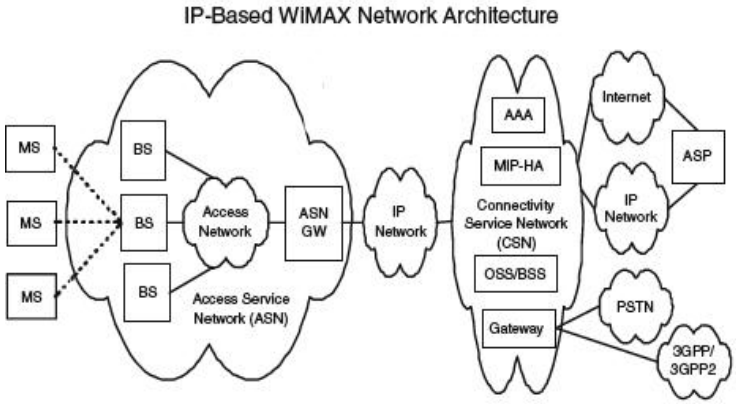

Figure 2.Wimax network architecture

4.2 Access Network

The base station provides a connection between the subscriber station and the core network. It generally uses a sector/beam antenna or umbrella antenna, which provides flexible arrangement and configuration of sub-channels, upgrades and expands the network based on the conditions of users. The subscriber station is a kind of base station, which provides the repeater connection between the base station and the equipment of user terminal. It generally uses a beam antenna installed on the roof. The dynamic adaptive modulation mode of the signal is used between base station and subscriber station. MS mainly refers to the mobile WiMax terminal and handheld devices responsible for realizing the wireless access for mobile WiMax users.

4.3 Base Station

The base station provides a connection between the subscriber station and the core network. It generally uses a sector/beam antenna or umbrella antenna, which provides flexible arrangement and configuration of sub-channels, upgrades and expands the network based on the conditions of users.

4.4 User Terminal Equipment

The WiMAX system defines the connection interface between the user terminal equipment and the base station, and provides the access of terminal equipment. However, the user terminal equipment does not belong to the WiMAX system.

5. Type of WiMax

The WiMAX family of standards concentrate on two types of usage models a fixed usage model and a mobile usage model. The basic element that differentiates these systems is the ground speed at which the systems are designed to manage. Based on mobility, wireless access systems are designed to operate on the move without any disruption of service; wireless access can be divided into three classes; stationary, pedestrian and vehicular.A mobile wireless access system is one that can address the vehicular class, whereas the fixed serves the stationary and pedestrian classes. This raises a question about the nomadic wireless access system, which is referred to as a system that works as a fixed wireless access system but can change its location.

5.1 Fixed WiMax

Service and consumer usage of WiMAX for fixed access is expected to reflect that of fixed wire-line service, with many of the standards-based requirements being confined to the air interface. Because communications takes place via wireless links from Customer Premise Equipment (CPE) to a remote Non Line-of-sight (NLOS) base station, requirements for link security are greater than those needed for a wireless service. The security mechanisms within the IEEE 802.16 standards are sufficient for fixed access service. Another challenge for the fixed access air interface is the need to set up high performance radio links capable of data rates comparable to wired broadband service, using equipment that can be self installed indoors by users, as is the case for Subscriber Line (DSL) and cable modems. IEEE 802.16 standards provide advanced physical (PHY) layer techniques to achieve link margins capable of supporting high throughput in NLOS environments.

5.2 Mobile WiMax

The 802.16a extension, refined in January 2003, uses a lower frequency of 2 to 11 GHz, enabling NLOS connections. The latest 802.16e task group is capitalizing on the new capabilities this provides by working on developing a specification to enable mobile WiMAX clients. These clients will be able to hand off between WiMAX base stations, enabling users to roam between service areas.

6. Key Technology of WiMax

6.1 MIMO

MIMO means using multiple transmitting and receiving antennae at the transmitting and receiving terminals respectively. The signals are transmitted and received by multiple antennae at the transmitting and receiving terminals, and accordingly the quality of is improved for each user.

Figure 3.MIMO

Compared with the traditional single-element system, MIMO technology greatly improves the unitization rate of frequency spectrum, which enables the system to transmit data by higher speed under limited bandwidth. The block diagram of MIMO system with N transmitting antennae and M receiving antennae is shown in Figure.

6.2 OFDM

The Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier digital modulation technology. The research on the technology is traceable to the middle of 1960s. The concept of OFDM has remained for years. However, it was recognized as a good approach for high-speed bi-directional wireless data communication until the development of media industry recently. OFDM is a high-speed transmission technology in wireless environment. Most frequency response curves of the wireless channel are not flat. The main idea of OFDM is to divide the bonded channel into many orthogonal sub-channels in the frequency range, and use a sub-carrier on each sub-channel for modulation, in which the sub-carriers are transmitted in parallel. In this way, in spite of the non-flat channel with different frequency options, every sub-channel is flat relatively, and narrow-band transmission is completed on these sub-channels, with the band width of signal less than the corresponding band width of channel. Accordingly, the interference between signal waves will be eliminated. Because the carriers on these sub-channels in OFDM are orthogonal to each other, they have overlapped frequency spectrum, which reduces the interference between sub-carriers and improves the utilization rate of frequency spectrum. The key technologies of OFDM are guard space (cyclic prefix/postfix), simultaneous techniques, training sequence/pilot frequency and channel estimation, control of PAPR (Peak to Average Power Ratio), channel coding and interleaving and equalization technique.

7.WiMax vs WiFi

As for the relation between WiMax and WiFi, they are not in the same category. WiFi is an interoperability organization related to the IEEE802.11x standard of WLAN, while WiMax is an interoperability organization related to the IEEE802.16x standard of WMAN. They are oriented to different application types. Compared with WiFi, WiMax has a better physical layer and MAC layer technology with higher speed and QoS, and the competition follows. WiFi is mainly used in the category of WLAN, and the WiMax is used in the category of WMAN, which are complementary to each other. It can be considered that WiFi is suitable for the indoor usage, and WiMax is suitable for outdoor usage in cities.

WiMax composes the network combining Wi-Fi to solve the problems in Wi-Fi. WiMax and Wi-Fi develop in a complementary trend. For a long time, they coexist and cooperate with each other, and also develop compatible to 3G. WiMax combines the WLAN to provide full-wireless solution, in which WiMax solves the “Last Kilometer”, and WLAN solves the “Last Hundred Meters”.

Table 1.Wifi vs Wimax

	Wi-Fi	WiMAX
Range	Up to 300 feet (about 91.4 meters)	Up to 30 miles (about 48.3 kilometers); cell radius of 4-6 miles
Coverage	Optimized for indoor performance, short range	Outdoor Non-Line-of-Sight (NLOS) performance; support for advanced antenna technologies
Scalability	Supporting one to dozens users, one Customer Premises Equipment (CPE) per user; fixed 20MHz channel width	Effectively supporting one to hundreds pieces of CPE; unlimited subscribers within each CPE; flexible channel sizes from 1.5MHz to 20MHz
Bit rate	2.7bits/s/Hz	5bit/s/Hz, and up to 75Mbit/s in a 20MHz channel
QoS	No QoS support	Support for QoS at the MAC level, which enables differentiated services for voice and video
Security mechanism	Wired Equivalent Privacy (WEP) authentication; pre-shared key	Extensible Authentication Protocol (EAP)-based authentication; Advanced Encryption Standard (AES); Privacy Key Management (PKM)

8. Future of WiMax

The IEEE 802.16 standard body members are working toward incremental evolution, from fixed operation to portability and mobility. The IEEE 802.16e will amend the base specification to enable not just fixed, but also portable and mobile operation. IEEE 802.16f and IEEE 802.16g task groups are addressing the management interfaces for fixed and mobile operation. Clients will be able to hand-off between 802.16 base stations, enabling users to roam between service areas. In a fully mobile scenario users may be moving while simultaneously engaging in a broadband data access or multimedia streaming session. All of these improvements will help make WiMAX an even better Internet access solution for growing economies like that of India.

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