Survey on WiMAX Technology and its protocol-A review

Amit Bhambri, Naveen Kansal

Abstract— **High data rate services, multimedia applications and, in general, high quality information streams are nowadays demanded by a larger and larger number of consumers. Wireless communications are expanding their field of action since they allow to obtain performances comparable to the cabled solutions, but with less costs in infrastructures and in the network deploying procedures. WiMAX technology is considered one of the most prominent solutions capable to provide a Broadband Wireless Access in metropolitan areas. In this paper, the technique of WiMAX is considered as well as protocol IEEE 802.16 is presented to disclose working of WiMAX technology. This paper presents study of features and characteristics of WiMAX; Various architectures and QoS features are compared for WiMAX.**

Index Terms— **WiMAX, OFDM, BLER. QoS, MAC.**

I. INTRODUCTION

WiMax stands for worldwide interoperability for microwave access**.** It is a telecommunications protocol that provides fixed and mobile Internet access. WiMAX is a wireless digital communications system, also known as IEEE 802.16 that is intended for wireless "metropolitan area networks". WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. In contrast, the WiFi/802.11 wireless local area network standard is limited in most cases to only 100 - 300 feet (30 - 100m). To understand the WiMAX technology, the term Wireless mesh network is there. Wireless mesh networks (WMNs) consist of mesh routers and mesh clients, where mesh routers have minimal mobility and form the backbone of WMNs. They provide network access for both mesh and conventional clients. WiMAX technology enables ubiquitous delivery of wireless broadband service for fixed and/or mobile users, and became a reality in 2006 when Korea Telecom started the deployment of a 2.3 GHz version of mobile WiMAX service called WiBRO.

Manuscript received Sep, 2014.

Amit Bhambri, ECE Department, PTU/RIMT-IET., Mandi Gobindgarh, India, Mobile No +91-9464948773

***Naveen Kansal**, ECE Department, PTU/RIMT-IET., Mandi Gobindgarh, India, Mobile No +91-9876792100*

II. WIMAX STANDARDS

The IEEE specifications are required to understand the family of IEEE standards. As 802.16 is one of the IEEE standard specification used for WiMAX technology, there are some factors that affects the performance of WiMAX according to bandwidth, rate, and speed etc.

A member of the IEEE802 family of specifications:

- IEEE802.16-2004 includes P2P, P2MP and mesh access networks.
- During 2005 IEEE 802.16e includes mobility.
- During 2005 MIB standardized as well.
- IEEE802.16 is supported by the industry group WiMAX.
- IEEE802.11 is supported by the industry group Wi-Fi.

The following Table 1 shows specification factors of IEEE 802.16 standard.

Table 1: IEEE 802.16 Standards

Factors	**IEEE 802.16**	**IEEE 802.16 Revs'**	**IEEE 802.16 e**
Completed	December 2001	May 2004	Est. Mid. 2005
Spectrum	10-66 GHz	2-11 GHz	2-6 GHz
Application	Backhaul	Wireless DSL and Backhaul	Mobile Internet
Channel Condition	Line of sight only	None line of sight	None line of sight
Bit Rate	32-134 Mbps	Up to 75 Mbps	Up to 15 Mbps
Modulation	QPSK, 16 QAM, 64 QAM	OFDM 256, OFDMA 2048,16 QAM,64 QAM	Same as 02.16 d
Channel Bandwidth	20,25,28 MHz	Bandwidth between 1.5 & 20 MHz	Same as 02.16 d

Advantages and Disadvantages of WiMAX as compared to 3G:

1) **Cost:** Lower equipment cost for WiMAX due to certified products but, WiMAX require new infrastructure.
2) **Coverage:** This technique has roughly the same coverage.
3) **Performance:** Almost same performance of both techniques.

ISSN: 2278 – 1323

III. MODELS OF WIMAX TECHNOLOGY

There are some basic models, from where we can understand the parts of technology and its working. The models are named as follow:

A. WiMAX architecture End-to-End Reference Model

The entire model describes how one component is connected to another from end to end. The model is drawn in fig. 1 as shown below:

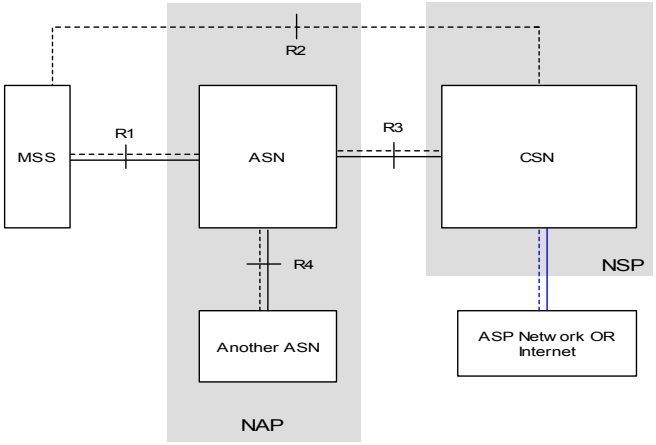

Fig. 1 End-to-End Reference Model

B. ASN reference Model

The part of end to end reference model that is shown in fig. 1 named as ASN is diagrammatically shown in fig. 2.

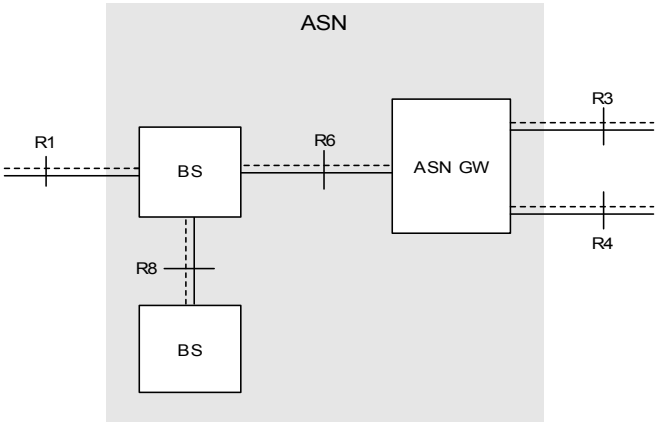

Fig. 2 ASN reference model

The figure shows how ASN model consists of, what its basic parts are and how they are connected together.

IV. MODULATION TECHNIQUES IN WIMAX

The modulation is the process to convert one side data to another side with proper communication channel and to respond the sender with signal. WiMAX technology is nowadays considered one of the most prominent solutions capable to provide a Broadband Wireless Access (BWA) in metropolitan areas with a simpler installation and lower cost than traditional wired alternatives. The work done by Romano Fantacci et al. [14] deals with the proposal of efficient adaptive modulation and coding techniques to be used in WiMAX based wireless networks, that allow to improve network performance in the case of Non Line-of-Sight communications, which are typical in urban environments. In particular, two approaches have been proposed by taking into account the channel behavior both in terms of attenuation and frame error rate. The first approach selects the most suitable MCS on the base of the estimation of the channel attenuation on the uplink. This technique has been implemented according to two different algorithms: TBLER, aiming to keep the error rate under a specified value and to employ the MCS which guarantees the highest efficiency while respecting the error target, and MT that, conversely, aims to maximize the system throughput without controlling the error rate performance. A frame error rate approach has been then considered by taking into account the effect of the errors in previous frames. After the intensive computer based simulations, that all the proposed techniques allow to satisfy different QoS constraints in terms of BLER or throughput and allow significant advantages with respect to the FMC where the modulation and coding scheme are fixed. Through the given techniques it is possible to switch the modulation order and coding rate in order to better match the channel conditions, and, hence, obtaining better performance both in terms of error probability and data throughput. Dania Mafabissi et al. [6] proposed a state model based on the state transition diagrams (STD) that are used to compare the performance of two different adaptation algorithms based on the maximization of different functional costs suitable for use in WiMAX system with an OFDMA physical structure. Two techniques have been considered by taking onto account the channel behaviour in terms of attenuation and the frame error rate. The first technique is based on the physical channel estimation on the uplink, and selects the best modulation order by using a three state model. Three algorithms such that Maximum Throughput technique, Target SER technique and Minimum SER technique have been introduced with the aim of minimizing the SER, maximize the throughput or select the best modulation order for a certain SNR value. On the other side the frame error rate technique has been considered also by taking into account the effect of the previous frames to the actual one. The proposed techniques allow viewing with a different flavor of the QoS in terms of SER or throughput, even if all of them show advantages with respect to statistical modulation schemes.

Two another adaptive modulation and coding schemes or techniques such that Target Block Error Rate Technique and Maximum Throughput Technique have proposed by Dania Marabissi [7], with the aim of improving performances in Non Line-of-Sight communications, typical of urban environments. The two proposed adaptive techniques differentiate from the procedure of the calculation of the thresholds needed to perform the adaptation. Each adaptation algorithm is basically characterized by five thresholds, representing the changing events between different transmission schemes: when a threshold is reached, the modulation order and/or the coding rate change and the state machine keeps a different state until another threshold is reached. Both of the techniques are based on the physical channel estimation on the uplink and foresee the selection of the best transmission scheme by using a finite state model. The first algorithm aims to keep the error rate under a fixed limit and to employ the MCS which guarantees the higher efficiency while respecting the error target. The second technique reflects an opposite approach and aims at maximizing the system throughput, through the use of the most efficient MCS among the available ones for each SNR. The proposed techniques allow satisfying different QoS

constraints in terms of BLER or throughput. Moreover, both of them show significant advantages with respect to statistical MCS selection technique. A performance comparison of Fixed and Mobile Frequency Division Multiplexing (OFDM) based WiMAX transmission system with adaptive modulation and coding (AMC) over different fading channels has done by Ali H. Al-Qahtani and Rabah W. Aldhaheri [3] by using MATLAB. Various modulation techniques such that BPSK, QPSK, 16-QAM and 64 QAM have considered to realize the proposed work. The simulation results show that depending on the channel conditions, an optimizing mechanism of AMC can be chosen that employ multiple modulation and coding schemes in order to instantaneously adapt spectral efficiency to the variations in the channel SNR while maintaining an acceptable BER. According to this mechanism, as the range increases, the system steps down to a lower modulation, but as closer to the base station, higher order modulations can be used for increased throughput. By setting threshold Eb/No, adaptive modulation schemes can be used to attain highest transmission speed with a target BER.

V. OFDM ADAPTIVE TECHNOLOGY

In this section, the adaptive OFDM technique is discussed with different types. The bit error probability of different OFDM subcarriers transmitted in time dispersive channels depends on the Frequency domain channel transfer function. The occurrence of bit errors is normally concentrated in a set of several faded subcarriers, while in the other subcarriers often no bit errors are observed. OFDM divides a wideband channel into narrowband sub channels to mitigate ISI. The features of OFDM in multi user system are:

- In multiuser systems these sub channels can be allocated among different users
- Orthogonal allocation: Multiuser OFDM
- Semi orthogonal allocation: Multicarrier CDMA
- Spatial techniques help to mitigate interference between users
- OFDM overlaps sub streams
- Sub streams separated in receiver
- Minimum sub stream separation is B/N, total BW is B
- Impaired by timing jitter, frequency offset, and fading
- Used by the CATV community
- Assigns a subset of available carriers to each user

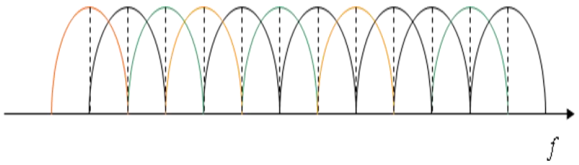

Fig. 4 Subset of individual user carriers

VI. WI-MAX PROTOCOL

WiMax has two main topologies, namely Point to Point for backhaul and Point to Multi Point Base station for Subscriber station. In each of these situations, multiple input multiple output antennas are used. IEEE 802.16 is a series of wireless broadband standards written by the Institute of Electrical and Electronics Engineers (IEEE). The IEEE Standards Board established a working group in 1999 to develop standards for broadband for wireless metropolitan area networks. The Workgroup is a unit of the IEEE 802 local area network and metropolitan area network standards committee. Although the 802.16 family of standards is officially called Wireless MAN in IEEE, it has been commercialized under the name "WiMAX" (from "Worldwide Interoperability for Microwave Access") by the WiMAX Forum industry alliance. The Forum promotes and certifies compatibility and interoperability of products based on the IEEE 802.16 standards. The 802.16e-2005 amendment version was announced as being deployed around the world in 2009.[1] The version IEEE 802.16-2009 was amended by IEEE 802.16j-2009.

Technology of 802.16e

The 802.16 standard essentially standardizes two aspects of the air interface – the physical layer (PHY) and the media access control (MAC) layer. This section provides an overview of the technology employed in these two layers in the mobile 802.16e specification.

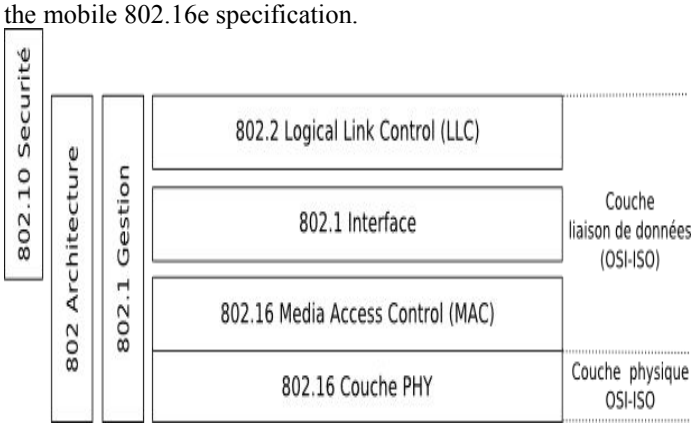

Fig. 5 Layers of IEEE 802.16

PHY: 802.16e uses scalable OFDMA to carry data, supporting channel bandwidths of between 1.25 MHz and 20 MHz, with up to 2048 subcarriers. It supports adaptive modulation and coding, so that in conditions of good signal, a highly efficient 64 QAM coding scheme is used, whereas when the signal is poorer, a more robust BPSK coding mechanism is used. In intermediate conditions, 16 QAM and QPSK can also be employed. Other PHY features include support for (MIMO) multiple-input multiple-output antennas in order to provide good non-line-of-sight propagation (NLOS) characteristics (or higher bandwidth) and hybrid automatic repeat request (HARQ) for good error correction performance. Although the standards allow operation in any band from 2 to 66 GHz, mobile operation is best in the lower bands which are also the most crowded, and therefore most expensive.[3]

MAC*:* The 802.16 MAC describes a number of Convergence Sub layers which describe how wire line technologies such as Ethernet, Asynchronous Transfer Mode (ATM) and Internet Protocol (IP) are encapsulated on the air interface, and how data is classified, etc. It also describes how secure communications are delivered, by using secure key exchange during authentication, and encryption using Advanced Encryption Standard (AES) or Data Encryption Standard (DES) during data transfer. Further features of the MAC layer include power saving mechanisms (using sleep mode and idle mode) and handover mechanisms key feature of 802.16 is that it is a connection-oriented technology. The subscriber station (SS) cannot transmit data until it has been allocated a channel by the base station (BS). This allows

802.16e to provide strong support for quality of service (QoS).

QoS: Quality of service in 802.16e is supported by allocating each connection between the SS and the BS (called a service flow in 802.16 terminologies) to a specific QoS class. In 802.16e, there are 5 QoS classes:

Table 2: 802.16e-2005 QoS classes

Service	Abbrev	Definition	Typical Applications
Unsolicited Grant Service	UGS	Real-time data streams comprising fixed-size data packets issued at periodic intervals	T1/E1 transport
Extended Real-time Polling Service	ertPS	Real-time service flows that generate variable-sized data packets on a periodic basis	VoIP
Real-time Polling Service	rtPS	Real-time data streams comprising variable-sized data packets that are issued at periodic intervals	MPEG Video
Non-real-time Polling Service	nrtPS	Delay-tolerant data streams comprising variable-sized data packets for which a minimum data rate is required	FTP with guaranteed minimum throughput
Best Effort	BE	Data streams for which no minimum service level is required and therefore may be handled on a space-available basis	HTTP

The BS and the SS use a service flow with an appropriate QoS class (plus other parameters, such as bandwidth and delay) to ensure that application data receives QoS treatment appropriate to the application.

VII. CONCLUSION

The WiMAX technology is very fast and advance technique used for mobile purposes. This technology provides various protocols and features as compared to older technologies. Wireless communications are expanding their field of action. WiMAX technology is considered one of the most prominent solutions capable to provide a Broadband Wireless Access in metropolitan areas. This paper concludes the overall features and characteristics of WiMAX and the protocol IEEE 802.16 is also described. Various architectures and QoS features are compared for WiMAX. The paper concludes survey of WiMAX technique with its protocols.

REFERENCES

[1] Daan Pareit, Bart Lannoo et al. "The History of WiMAX: A Complete Survey of the Evolution in Certification and Standardization for IEEE 802.16 and WiMAX." IEEE Communications Surveys and Tutorials, p.p. 1-29, October 2011

[2] Dania Marabissi, Daniele Tarchi, Federico Genovese, and Romano Fantacci," Adaptive Modulation in Wireless OFDMA Systems with Finite State Modeling." IEEE Global Telecommunications Conference (GLOBECOM '07), p.p. 5210-5214, November 2007..

[3] Dr. Panos Bakalis and Bello Lawal, "Performance Evaluation of CBR and TCP Traffic Models on MANET using DSR Routing Protocol." International Conference on Communications and Mobile Computing, p.p. 318-322, April 2010..

[4] Lars Berlemann, Christian Hoymann, R.G. Heirtz, S. Mangold. "Coexistence and Interworking of IEEE 802.16 and IEEE 802.11(e)." IEEE 63rd Vehicular Technology Conference, p.p. 27-31, June 2006.

[5] L.D.Malviya, A. gaiwak, Dr. P.D.Vyavhare, "Simulation based comparison of different Modulation schemes for Mobile WiMAX using TCP and its Variants."First International Conference on Emerging Trends in Engineering and Technology, p.p. 168-172.

[6] Mehmet S. Kuran, Birkan Yilmaz, Fatih Alagoz, Tuna Tugcu, "Quality of Service in Mesh Mode IEEE 802.16 Networks."International Conference on Software in Telecommunications and Computer Networks (SoftCOM 2006), p.p. 107 - 111, October 2006.

[7] Min Kim; Ilkyeun Ra; Jisang Yoo; Dongwook Kim; Hwasung Kim, " QoS Mesh Routing Protocol for IEEE 802.16 based Wireless Mesh Networks."10th International Conference on Advanced Communication Technology (ICACT 2008), p.p. 812-817, Vol. 1,February 2008.

[8] Morteza Nabipoor, "Controlling and Evaluating of IEEE 802.16 WiMAX standard."2nd International Conference on Software Technology and Engineering (ICSTE), p.p. 22-25, vol. 2, October 2010.

[9] Romano Fantacci, Dania Marabissi, Daniele Tarchi, and Ibrahim Habib, "Adaptive Modulation and Coding Techniques for OFDMA Systems." IEEE Transactions on Wireless Communications, p.p. 4876-4883, October 2009.

[10] Yajun Li, Yuhang Yang, Chengyu Cao, Liang Zhou, " QoS Issues in IEEE 802.16 Mesh Network."International Conference on Information Science and Engineering (ICISE), p.p. 2687-2690, December 2009, N.

