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A Study on Wimax Network Technology

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ABSTRACT: Interest in broadband wireless access (BWA) has been growing due to increase in user mobility and the need for data access at all times. IEEE 802.16e based WiMAX networks promise the best available quality of experience for mobile data service users. Unlike wireless LANs, WiMAX networks incorporate several quality of service (QoS) mechanisms at the Media Access Control (MAC) level for guaranteed services for data, voice and video. The problem of assuring QoS is basically that of how to allocate available resources among users in order to meet the QoS criteria such as delay, delay jitter and throughput requirements. IEEE standard does not include a standard scheduling mechanism and leaves it for implementer differentiation. Scheduling is, therefore, of special interest to all WiMAX equipment makers and service providers. So we can conclude IEEE 802.16(Broadband Wireless MAN) is fast growing wireless broadband networks of the world The combination of Multiple Input Multiple Output wireless technology with IEEE 802.16e-2005 (WiMAX) standard has been recognized as most promising technologies with advent of next generation broadband wireless communications. In this paper we provide an overview and review of WiMAX.

KEY WORDS: WiMAX, IEEE 802.16, OFDM, OFDMA, MAC LAYER, QOS, SECURITY

I. INTRODUCTION

Despite the challenges faced when transmitting data through varying wireless channels, broadband metropolitan area wireless systems are becoming a reality, partly thanks to the increasingly sophisticated designs that are being employed. Such designs have been made possible by theoretical advances and also by improvements in technology that have led to faster and cheaper implementations compared to older systems. Currently, the focus is on developing 4G systems in the framework of IMT-Advanced [1], an ITU platform on which the next generation of wireless systems will be built. Broadband Wireless technology has become life line of people of the world in recent years. The Worldwide Interoperability for Microwave Access (WiMAX) is the leading broadband wireless technology. WiMAX is the alterative and the best option in comparable to Digital Subscriber Line (DSL), which deliver broadband over twisted pair telephone wires, and cable modem technology ,which delivers over coaxial cable TV plant, are the dominant mass market broadband access technologies today[1] . Since the WiMAX technology is to be deployed as broadband wireless metropolitan area networks, IEEE 802.16 standard family is also called Wireless MAN [2].

WiMAX technology has evolved through four stages :(1) narrowband wireless local–loop system,(2) first generation line- of- sight (LOS) broadband systems, (3) second generation non-line-of–sight (NLOS) broadband systems, and (4) standards–based broadband wireless systems [1] . The standard extended its operation through different PHY specification to2-11 GHz frequency band enabling non line of Sight (NLOS) connection. WiMAX can operate in both unlicensed (typically 2.4GHz and 5.8 GHz) and licensed (typically 700 MHz, 2.3 GHz, 2.5 GHz, and 3.5 GHz) bands [3].WiMAX supports relatively high data throughput. Compared to microwave, WiMAX is less costly in terms of licensed spectrum fees [4]. Theoretically, WiMAX can provide single channel data rates up to 75 Mbit/s and up to 350 Mbit/s via multiple channel aggregation [5].

WiMAX supports a maximum range of approximately 50 km for single –hop architectures in the presence of line of sight and 25 km in non-line of sight connectivity [6]. WiMAX supports bandwidth management via centralized

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bandwidth scheduling in both uplink and downlink directions. This allows efficient resource allocation and hence higher achieved capacities [7].

II. FEATURES OF WIMAX

WiMAX [1] is a wireless network that has a high class set of features with a lot of flexibility in terms differentiates it from other metropolitan area wireless access technologies are: 1. OFDM-based physical layer, 2. Very high peak data rates, 3. Scalable bandwidth and data rate support, 4. Adaptive modulation and coding (AMC), 5. Link-layer retransmissions, 6.Support for TDD and FDD, 7. Orthogonal frequency division multiple access (OFDMA), 8. Flexible and dynamic per user resource allocation, 9. Support for advanced antenna techniques, 10. Quality-of-service support, 11. Robust security, 12. Support for mobility, 13. IP-based architecture.

The WiMAX PHY layer is based on OFDM, a scheme that uses many subcarriers, or tones, to carry a signal. OFDM signaling consists of a large set of spaced subcarriers with no mutual interface e to perform parallel data transmission in the frequency domain. The peak data rate indicates the bit-rate a user in good radio conditions can reach when not sharing the channel with other users. WiMAX is capable of supporting very high peak data rates. WiMAX has a scalable PHY layer architecture that allows for the data rate to scale easily with available channel bandwidth. This scalability is supported in the OFDMA mode, where the FFT (fast Fourier transform) size may be scaled based on the available channel bandwidth. During the time of transmission the quality of the radio link always varies. To overcome the transmission challenges, WiMAX supports a number of modulation schemes. Adaptive modulation allows the WiMAX system to adjust the signal modulation scheme depending on the signal to noise ratio (SNR) of the channel conditions. WiMAX incorporates strong error correction techniques like FEC and ARQ to improve throughput. In FEC errors are detected and corrected upon reception by adding redundancy to the transmitted signal. Reed Solomon FEC, convolutional coding and interleaving algorithms are used in WiMAX systems. Network Working Group (NWG) in the WiMAX Forum has defined a reference network architecture that is based on an all-IP platform. WiMAX has been at the forefront of the move to all-IP end-to end networks based on open systems. All end-to-end services are delivered over an IP architecture relying on IP-based protocols for end-to-end transport, radio resource management, QoS management, security, and mobility [15].

III. STANDRAD OF WIMAX

IEEE 802.16 is a series of Wireless Broadband standards written by the Institute of Electrical and Electronics Engineers (IEEE) [8]. The IEEE 802.16 group was formed in 1998 to develop wireless broadband. The group's initial focus was the development of a line- of- sight (LOS)-based point-to-multipoint wireless broadband system for operation in the 10 GHz -66GHz millimeter wave band. The following Table 1.shows the IEEE 802.16 standard [23].

TABLE I. IEEE 802.16 STANDARDS

Sl. No.	IEEE Standard	Year of Publication	Features	Status
1.	802.16	2001	Fixed Broadband wireless Access (10-66GHz)	Superseded
2.	802.16.2	2001	Recommended practice for coexistence	Superseded
3.	802.16c	2002	System profiles for 10-66 GHz	Superseded
4.	802.16a	2003	Physical layer and MAC definitions for 2-11 GHz	Superseded
5.	P802.16b		License-exempt frequencies(Project withdrawn)	Withdrawn
6.	P802.16d		Maintenance and System profiles for 2-11GHz(project merged into 802.16-2004	Merged
7.	802.16	2004	Air Interface for Fixed Broadband Wireless Access System(rollup of 802.16- 2001,802.16a,802.16c and P802.16d)	Superseded
8.	P802.16.2a		Coexistence with 2-11 GHz and 23.5-43.5GHz(project merged	Merged

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			into 802.16.2-2004	
9.	802.16.2	2004	Recommended practice for coexistence(Maintenance and rollup of 802.16.2-2001	Current
10	802. 16f	2005	Management Information Base (MIB) for 802.16-2004	Superseded
11	802.16-2004/Cor. 1	2005	Corrections for fixed operations(co-published with 802.16e-2005)	Superseded
12	802.16e	2005	Mobile Broadband Wireless Access System	Superseded
13	802.16k	2007	Bridging of 802.16(an amendment to IEEE 802.1D	Current
14	802.16g	2007	Mobile Management Information Base(Project merged into 802.16-2009	Merged
15	802.16	2009	Air Interface for Fixed and Mobile Broadband Wireless Access System	Current
16	802.16j	2009	Multihop relay	Current
17	802.16h	2010	Improved Coexistence Mechanisms for License-Exempt Operation	Current
18	802.16m	2011	Advanced Air Interface with data rates of 100Mbits/s mobile and 1Gbits/s fixed.	Current
19	P802.16n	2012	Higher Reliability Networks	In Progress
20	P802.16p	2012	Enhancements to support Machine –to-Machine Applications	In Progress
21	802.16.1b	2012	Enhancements to Support Machine-to-Machine Applications	In Progress
22	802.16.1a	2012	Higher Reliability Networks	In Progress

A. PHYSICAL LAYER

The WiMAX physical layer is based on orthogonal frequency division multiplexing (OFDM).WiMAX OFDM features multiple subcarriers ranging from a minimum of 256 up to 2048, each modulated with BPSK, QPSK, 16 QAM, or 64 QAM modulation [11]. OFDM is the transmission scheme of Choice to enable high-speed data, video, and multimedia communications and is used by variety of commercial broadband systems. OFDM is an elegant and efficient scheme for high data rate transmission in non-line-of –sight or multipath radio environment. In fact, an OFDM signal can be made from many user signals, giving the OFDMA (Orthogonal Frequency Division Multiple Access) multiple accesses. In OFDMA, the OFDMA subcarriers are divided into subsets of subcarriers, each subset representing a sub channel. In the downlink, a sub channel may be intended for different receivers or groups of receivers; in the uplink, a transmitter may be assigned one or more sub channels. The subcarriers forming one sub channel may be adjacent or not.

OFDMA multiple access is not the only specificity of OFDMA PHY. Another major difference is the fact that its OFDM transmission is scalable. Although this word does not appear in the standard, OFDMA PHY is said to have Scalable OFDMA (SOFDMA). The scalability is the change of the FFT size and then the number of subcarriers. The supported FFT sizes are 2048, 1024, 512 and 128. FFT size 256 (of the OFDM layer) is not included in the OFDMA layer. Only 1024 and 512 are mandatory for mobile WiMAX profiles. The IEEE 802.16 suite of standards (IEEE 802.16-2004/IEEE 80216e-2005) [9, 10] defines within its scope four PHY layers, any of which can be used with the media access control (MAC) layer to develop a broadband wireless system. The PHY layers defined in IEEE 802.16 are

1. Wireless MAN SC, a single-carrier PHY layer intended for frequencies beyond 11GHz requiring a LOS condition. This PHY layer is part of the original 802.16 specifications.
2. Wireless MAN SCa, a single-carrier PHY for frequencies between 2GHz and 11GHz for point-to multipoint operations. Wireless MAN SC, a single carrier PHY layer intended for frequencies beyond 11GHz requiring a LOS condition. This PHY layer is part of the original 802.16 specifications.
3. Wireless MAN SCa, a single-carrier PHY for frequencies between 2GHz and 11GHz for point-to multipoint operations.

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4. Wireless MAN OFDM, a 256-point FFT-based OFDM PHY layer for point-to-multipoint operations in non-LOS conditions at frequencies between 2GHz and 11GHz. This PHY layer, finalized in the IEEE 802.16-2004 specifications, has been accepted by WiMAX for fixed operations and is often referred to as fixed WiMAX.
5. Wireless MAN OFDMA, a 2,048-point FFT-based OFDMA PHY for point-to-multipoint operations in NLOS conditions at frequencies between 2GHz and 11GHz. In the IEEE802.16e-2005 specifications, this PHY layer has been modified to SOFDMA (scalable OFDMA), where the FFT size is variable and can take any one of the following values: 128, 512, 1,024, and 2,048. The variable FFT size allows for optimum operation/ implementation of the system over a wide range of channel bandwidths and radio conditions. This PHY layer has been accepted by WiMAX for mobile and portable operations and is also referred to as mobile WiMAX [1].

Fig.1. shows the various functional stages of a WiMAX PHY layer. The first set of functional stages is related to forward error correction (FEC), and includes channel encoding, rate Matching (puncturing or repeating), interleaving, and symbol mapping. The next set of functional stages is related to the construction of the OFDM symbol in the frequency domain. During this stage, data is mapped onto the appropriate sub channels and subcarriers. Pilot symbols are inserted into the pilot subcarrier, which allows the receiver to estimate and track the channel state information (CSI).

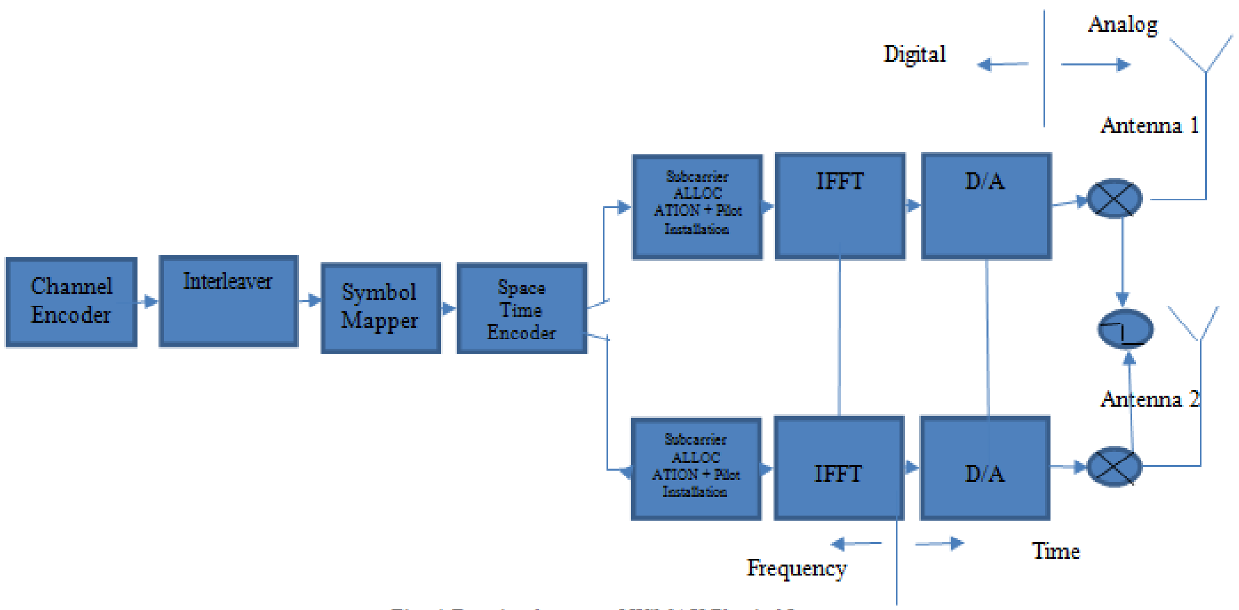

Fig. 1 Functional stages of WiMAX Physical Layer

B. MAC LAYER

WiMAX MAC [12, 13, 14] is designed for the point-to-multipoint wireless communication with the capability to support higher-layer protocols including ATM, IP, and other future protocols In a network, the purpose of the PHY layer is to reliably deliver information bits from the transmitter to the receiver, using the physical medium, such as radio frequency, light waves, or copper wires. Usually, the PHY layer is not informed of quality of service (QoS) requirements and is not aware of the nature of the application, such as VoIP, HTTP, or FTP. The PHY layer can be viewed as a pipe responsible for information exchange over a single link between a transmitter and a receiver. The Media Access Control (MAC) layer, which resides above the PHY layer as shown in Fig.2, is responsible for controlling and multiplexing various such links over the same physical medium. Some of the important functions of the MAC layer in WiMAX are to Segment or concatenate the service data units (SDUs) received from higher layers into the MAC PDU (protocol data units), the basic building block of MAC-layer payload.

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- Select the appropriate burst profile and power level to be used for the transmission of MAC PDUs Retransmission of MAC PDUs that were received erroneously by the receiver when auto-mated repeat request (ARQ) is used.
- Provide QoS control and priority handling of MAC PDUs belonging to different data and signaling bearers. Schedule MAC PDUs over the PHY resources.
- Provide support to the higher layers for mobility management.
- Provide security and key management. Provide power-saving mode and idle-mode operation.

The common-part sub layer of the MAC layer performs all the packet operations that are inde-pendent of the higher layers, such as fragmentation and concatenation of SDUs into MAC PDUs, transmission of MAC PDUs, QoS control, and ARQ. The security sub layer is responsible for encryption, authorization, and proper exchange of encryption keys between the BS and the MS.

a. QUALITY OF SERVICE SUPPORT

Support for QoS is a fundamental part of the WiMAX MAClayer design. WiMAX borrows some of the basic ideas behind its QoS design from the DOCSIS cable modem standard. Strong QoS control is achieved by using a connection-oriented MAC architecture, where all downlink and uplink connections are controlled by the serving BS. Before any data transmission happens, the BS and the MS establish a unidirectional logical link, called a connection, between the two MAC-layer peers. Each connection is identified by a connection identifier (CID), which serves as a temporary address for data transmissions over the particular link. In addition to connections for transferring user data, the WiMAX MAC defines three management connections—the basic, primary, and secondary connections—that are used for such functions as ranging [1]. Scheduling services are globally the data handling mechanisms allowing a fair distribution of resources between different WiMAX users [15] [16][17]. A service flowis a unidirectional flow of packets with a particular set of QoS parameters and is identified by a service flow identifier (SFID).The QoS parameters could include traffic priority, maximum sustained traffic rate, maximum burst rate, minimum tolerable rate, scheduling type, ARQ type, maximum delay, tolerated jitter, service data unit type and size, bandwidth request mechanism to be used, transmission PDU formation rules, and so on. Service flows may be provisioned through a network management system or created dynamically through defined signaling mechanisms in the standard. The base station is responsible for issuing the SFID and mapping it to unique CIDs. Service flows can also be mapped to DiffServ code points or MPLS flow labels to enable end-to-end IP-based QoS [1].There are five different quality of service [1] for WiMAX, as below:

- Unsolicited grant services (UGS): This is designed to support fixed-size data packets at a constant bit rate (CBR). Examples of applications that may use this service are T1/E1 emulation and VoIP without silence suppression. The mandatory service flow parameters that define this service are maximum sustained traffic rate, maximum latency, tolerated jitter, and request/transmission policy.
- Real-time polling services (rtPS): This service is designed to support real-time service flows, such as MPEG video, that generate variable-size data packets on a periodic basis. The mandatory service flow parameters that define this service are minimum reserved traffic rate, maximum sustained traffic rate, maximum latency, and request/transmission policy.
- Non-real-time polling service (nrtPS): This service is designed to support delay-tolerant data streams, such as an FTP, that require variable-size data grants at a minimum guaranteed rate. The mandatory service flow parameters to define this service are minimum reserved traffic rate, maximum sustained traffic rate, traffic priority, and request/transmission policy.
- Best-effort (BE) service: This service is designed to support data streams, such as Web browsing, that do not require a minimum service-level guarantee. The mandatory service flow parameters to define this service are maximum sustained traffic rate, traffic priority, and request/transmission policy.
- Extended real-time variable rate (ERT-VR) service: This service is designed to support realtime applications, such as VoIP with silence suppression, that have variable data rates but require guaranteed data rate and delay. This

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service is defined only in IEEE 802.16e-2005, not in IEEE 802.16-2004. This is also referred to as extended real-time polling service (ErtPS).

b. SECURITY OF WIMAX NETWORKS

There are several security concerns and development implications that arise from the varying nature of mobile communication and the fast-paced increase in usage of mobile devices for m-commerce, email, and other functionality that require secure connections. Mobile security poses an interesting problem, largely because it requires an enormous amount of compatibility over different access media, as well as a wide range of end user devices, with different capacities and capabilities. Users expect to be able to use their mobile devices spontaneously in many different environments, and sometimes continuously while going through multiple types of access points, for example, in a moving car. Despite the frequent need for even more security than is provided to their counterparts that are within a fixed network, mobile devices have much less processing ability and also need to comply with reasonable cost, size and weight restrictions as well as usability requirements. To make matters even more complicated, mobile devices are also often lost or stolen, which calls for even higher protection of sensitive information. Through more detailed discussion of the security challenges it becomes clear that there are many hurdles that engineers must consider when designing mobile communication architectures.

For secure communications, privacy and confidentiality are fundamental issues. Secured communication provides resistance to interception and eavesdropping. Message authentication provides integrity of the message and sender authentication, corresponding to the security attacks of message modification and impersonation. Anti-replay detects and disregards any message that is a replay of a previous message. Non-repudiation is against denial and fabrication. Access control prevents unauthorized access of the resources [18]. The physical layer of WiMAX is vulnerable to threats as compared to MAC layer. The attacks on physical layer are jamming and scrambling [19]. Jamming attack may be unintentional or malicious and also stated that jamming is easy to detect and when detected then it is easy to countermeasure. Scrambling attack is difficult to achieve and also difficult to detect [20]. A DDoS attack is also a major problem on this point and it is also unable to handle. It is advised, Intrusion Detection System for handling some of the threats. The doors of WiMAX are open to threats, which are the Traffic Encryption Key (TEK) and Authorization Key (AK) issues. That could be exposed and can create a problem. The issues of user authentication, the issues relating to mobility are pointed [21]. These threats are having five classes: interception attack, fabrication attack, modification, replay attack, reaction attack, interruption attack and repudiation attack [22].

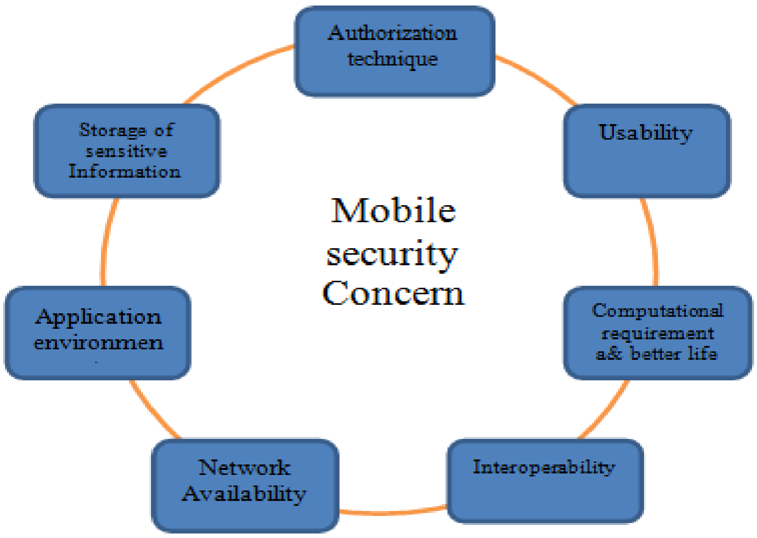

Fig. 3 Major Mobile Security Concerns

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IV. CONCLUSIONS

In this paper authors have presented a brief overview of WiMAX networks, which is the first technology to apply OFDMA as physical layer. They have many rich features as discussed in this paper .Security is the key issues for any wireless networks which includes WiMAX also. With the introduction of mobile WiMAX technology, it is expected that future work will focus on thmobility aspect and interoperability of mobile WiMAX with other wireless technologies.

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