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Review on WiMAX

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ABSTRACT:Data-rate services, multimedia applications and, in general, high-quality information streams are now being demanded by a growing number of consumers. Wireless communications has extended their scope because they provide performance comparable to wired solutions but with less cost in infrastructure and network deployment procedures. WiMAX technology is considered as one of the most prominent solutions capable of providing wireless broadband access in metropolitan areas. In this paper, we give a review of WiMAX.

KEYWORDS: WIMAX, IEEE standards, WiMAX vs Wi-Fi, WIMAX transmitter and WIMAX receiver.

I.INTRODUCTION

WiMAX is short for Worldwide Interoperability for Microwave Access. It likewise passes by the IEEE name 802.16.WiMAX is a remote industry coalition committed to the progression of IEEE 802.16 standards for broadband wireless access networks. WiMAX is a technology for point to multipoint wireless networking which supports mobile, nomadic and fixed wireless applications. A mobile user typically refers to someone in transit and nomadic user refers to a portable device on which user is connected. A fixed wireless, in this context, refers to wireless connectivity among non-mobile devices in homes and businesses.

II.FEATURES

The features of WiMAX are as follow:

- **OFDM-based physical layer:** The WiMAX physical layer (PHY) is based on orthogonal frequency division multiplexing [4]. It offers good resistance to multipath, and allows WiMAX to operate in NLOS conditions.
- **Very high peak data rates:** WiMAX is capable of supporting very high peak data rates.
- **Scalable bandwidth and data rate support:** WiMAX has a scalable physical-layer architecture that allows for the data rate to scale easily with available channel bandwidth [4]. This scalability is supported in the OFDMA mode, where the FFT (fast fourier transform) size may be scaled based on the available channel bandwidth.
- **Adaptive modulation and coding (AMC):** WiMAX supports a number of modulation and forward error correction (FEC) coding schemes and allows the scheme to be changed on per user and per frame basis, based on channel conditions. AMC is an effective mechanism to maximize throughput in a time-varying channel.
- **Link-layer retransmissions**: WiMAX supports automatic retransmission requests (ARQ) at the link layer for connections that require enhanced reliability. WiMAX also optionally supports hybrid-ARQ which is an effective hybrid between FEC and ARQ.
- **Support for TDD and FDD:** IEEE 802.16-2004 and IEEE 802.16e-2005 supports both time division duplexing and frequency division duplexing, as well as a half-duplex FDD, which allows for a low-cost system implementation [2].
- **Orthogonal frequency division multiple access (OFDMA):** Mobile WiMAX uses OFDM as a multiple-access technique, whereby different users can be allocated different subsets of the OFDM tones [4].
- **Flexible and dynamic per user resource allocation:** Both uplink and downlink resource allocation are controlled by a scheduler in the base station. Capacity is shared among multiple users on a demand basis, using a burst TDM scheme [7].

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- **Support for advanced antenna techniques:** The WiMAX solution has a number of hooks built into the physical-layer design which allows for the use of multiple-antenna techniques, such as beamforming, space-time coding, and spatial multiplexing [4]. These schemes can be used to improve the overall system capacity and spectral efficiency by deploying multiple antennas at the transmitter and/or the receiver[2].
- **Quality-of-service support:** The WiMAX MAC layer has a connection-oriented architecture that is designed to support a variety of applications, including voice and multimedia services. The system offers support for constant bit rate, variable bit rate, real-time, and non-real-time traffic flows, in addition to best-effort data traffic [7]. WiMAX MAC is designed to support a large number of users, with multiple connections per terminal, each with its own QoS requirement.
- **Robust security:** WiMAX supports strong encryption and has a robust privacy and key-management protocol.
- **Support for mobility**: The mobile variant of the WiMAX supports roaming of mobile units within coverage area at high data rate speeds and without interruption in handovers [7].
- **IP-based architecture:** The WiMAX Forum has defined a reference network architecture that is based on an all-IP platform. [2]

III. COMPARISON OF WIMAX WITH WI-FI

It turns out to be completely expected to develop conventions and frameworks which could supports vast scale networking with high data speeds as wireless networking tends to spread itself outside workplaces and houses. A few innovations for such wide gets to have been in the correspondences market, for example, 2G, 3G and 4G. There are, be that as it may, numerous tradeoffs in utilizing these advances on a bigger premise, for example, giving web or stream interactive media remotely. This is the reason another convention, named WiMAX was incepted. It is same like an extended technological term to Wi-Fi, but there are a few contrasts between these two protocols. The differences between these two protocols are as follow:

- **Shortened Term: Wi-Fi** stands for Wireless Fidelity and on the other hand **WiMAX** stands for worldwide interoperability for Microwave Access.
- **Official Release:** Wi-Fi was official released in the year 1997 and on the other hand WiMAX released in the year 2004.
- **IEEE standards:** Wi-Fi has been defined under IEEE802.11x standards where x refers to the various versions of Wi-Fi such as 802.11a, 802.11b, 802.11g and 802.11n and WiMAX has been defined under 802.16y standards where y refers to the various versions of WiMAX such as 802.16a, 802.16d and 802.16e some of the popular WiMAX versions.
- **Frequency Band:** Wi-Fi has been characterized under ISM bands where client needs to pay no additional charging for using those bands. On the differentiation, there is no bar on frequency usage in the WiMAX.
- **Range:** Wi-Fi based network can reach upto 100 meters and on the other hand WiMAX can reach upto 80-90 Kilometers.
- **Data transfer rates:** Wi-Fi has a data transfer rate upto 54mbps and WiMAX has a data transfer rate upto 75mbps. In WiMAX, Data transfer rates have more variation as larger distances are to be covered. [3]
- **Channel bandwidth:** Wi-Fi have a channel bandwidth of 20 MHz whereas WiMAX have a channel bandwidth ranges from 1.25 MHz to 20 MHz
- **Bandwidth Efficiency:** Bandwidth Efficiency of WiMAX is twice as compare to Wi-Fi.
- **Encryption Techniques:** Wi-Fi uses Advanced Encryption standard(AES) and RC4 as encryption techniques whereas WiMAX uses Triple Data Encryption Algorithm and Advanced Encryption Standards.

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IV. IEEE802.16 Standards and Amendments

Although the original 802.16 standard along with amendments a, b and c are aloof now, there are as yet many reports that are being utilized for characterizing and developing the 802.16 standard. Asummary of the major documents, including those that have been withdrawn is given below:

Table 1. Summary of the IEEE 802.16 standards [1]

STANDARD / AMENDMENT	COMMENTS
802.16	Now withdrawn. This is the basic 802.16 standard that was released in 2001. It provided for basic high data links at frequencies between 11 and 60 GHz.
802.16a	Now withdrawn. This amendment addressed certain spectrum issues and enabled the standard to be used at frequencies below the 11 GHz minimum of the original standard.
802.16b	Now withdrawn. It increased the spectrum that was specified to include frequencies between 5 and 6 GHz while also providing for Quality of Service aspects.
802.16c	Now withdrawn. This amendment to 802.16 provided a system profile for operating between 10 and 66 GHz and provided more details for operations within this range. The aim was to enable greater levels of interoperability.
802.16d (802.16-2004)	This amendment was also known as 802.16-2004 in view of the fact that it was released in 2004. It was a major revision of the 802.16 standard and upon its release, all previous documents were withdrawn. The standard / amendment provided a number of fixes and improvements to 802.16a including the use of 256 carrier OFDM. Profiles for compliance testing are also provided, and the standard was aligned with the ETSI HiperMAN standard to allow for global deployment. The standard only addressed fixed operation.
802.16e (802.16-2005)	This standard, also known as 802.16-2005 in view of its release date, provided for nomadic and mobile use. With lower data rates of 15 Mbps against to 70 Mbps of 802.16d, it enabled full nomadic and mobile use including handover.
802.16f	Management information base
802.16g	Management plane procedures and services
802.16h	Improved coexistence mechanisms for license-exempt operation
802.16j	Multi-hop relay specification
802.16k	802.16 bridging
802.16m	Advanced air interface. This amendment is looking toth e future and it is anticipated it will provide data rates of 100 Mbps for mobile applications and 1 Gbps for fixed applications. It will allow cellular, macro and micro cell coverage, with currently there are no restrictions on the RF bandwidth although it is expected to be 20 MHz or more.

V. BLOCK DIAGRAM OF WIMAX SYSTEM

The block description of WiMAX physical layer is very diverse which consists of various blocks, works in conjunction with each other. The WiMAX is divided into two parts: the WiMAX transmitter and WiMAX receiver. The block diagram of WiMAX physical layer is as:

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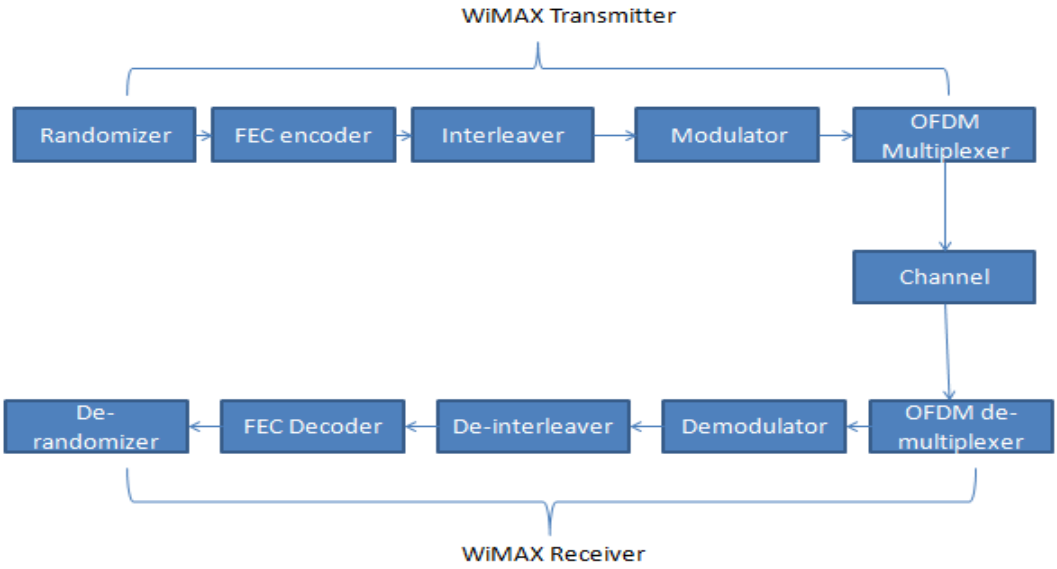

Figure 1. Block Diagram of WiMAX system

❖ **WiMAX Transmitter:**

1. **Randomizer:** Randomizer is the first block of WiMAX transmitter section where data from the source is randomized. Randomization is done to avoid long sequences of consecutive "ones" or "zeros". The randomized data are arranged in block format before passing through the encoder.The randomizer block consists of an XOR operation of the data to be randomized with a pseudo random sequence, generated by a Pseudo Random Binary Sequence (PRBS) generator [5]. The PRBS generator is reinitialized for each FEC block.Some common sequence generating polynomials are:

$$\text{PRBS7} = x^7 + x^6 + 1$$
$$\text{PRBS15} = x^{15} + x^{14} + 1$$
$$\text{PRBS23} = x^{23} + x^{18} + 1$$
$$\text{PRBS31} = x^{31} + x^{28} + 1$$

The 15 stage shift register with generator polynomial of $X^{15}+X^{14}+1$with XOR gates in feedback configuration is shown in figure as

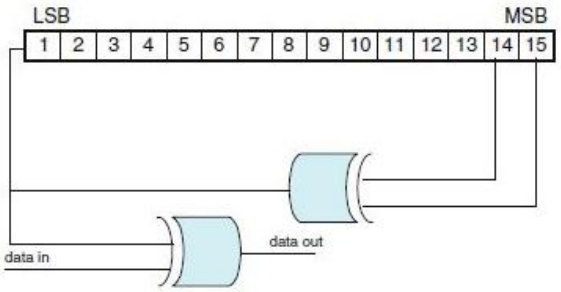

Figure 2. PRBS generator

2. **FEC Encoder:**This is the most important block of WiMAX physical layer. The function of the FEC Encoder is to add redundancy in a controlled manner. This will improve the reliability of data[1].

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Table 2.WiMAX Adaptive coding [2]

Parameter	Downlink	Uplink
Coding	Mandatory: Convolutional codes at rate 1/2, 2/3, 3/4, 5/6 Optional: Convolutional turbo codes at rate 1/2, 2/3, 3/4, 5/6;repetition codes at rate 1/2, 1/3, 1/6, LDPC, RS codes for OFDM-PHY	Mandatory: Convolutional codes at rate 1/2, 2/3, 3/4, 5/6 Optional: Convolutional turbo codes at rate 1/2, 2/3, 3/4, 5/6;repetition codes at rate 1/2, 1/3, 1/6, LDPC

3. **Interleaver:** Interleaving is done on encoded data at the output of FEC encoder. Interleaver is used to overcome very long sequences of errors or burst errors. The size of interleaving block depends upon the number of coded bits per encoded block size. The interleaving is performed using a two-step permutation process. In first permutation, the adjacent coded bits are mapped onto nonadjacent subcarriers[6] and is defined by the formula:

$$mk = (Ncbps/12)*mod(K, 12) + floor(K/12)$$

where mk= Index of coded bits after first permutation

Ncbps= number of coded bits per symbols

K= Index of coded bits before first permutation

In second permutation, the adjacent coded bits are mapped alternately onto less or more significant bits of the constellation [6]. It is defined by the formula as:

$$s=ceil(Ncpc/2)$$

$$jk = s*floor(mk/s)+(mk+Ncbps-floor(12*mk/Ncbps))mod(s)$$

where Ncpc= number of coded bits per carrier

jk= Index of coded bits after second permutation

4. **Modulator:** The next block is modulator after interleaver. WiMAX uses adaptive modulation where modulation changes depending upon the channel conditions [1].

Table 3. WiMAX Adaptive Modulation[2]

Parameter	Downlink	Uplink
Modulation	BPSK,QPSK,16-QAM,BPSK optional for OFDMA-PHY	BPSK,QPSK,16 QAM,64 QAM optional

5. **OFDM Multiplexer:**OFDM stands for orthogonal frequency division multiplexing. In this block, the modulated data which is in frequency domain is then converted into time domain by performing IFFT or IDFT on it. Cyclic prefix has been added with the time domain data to reduce inter-symbol interference (ISI). These time domain signals are then transmitted through the channel.

❖ **Channel:** Channel is the transmission medium over which the signal is transmitted.Air is the transmission medium for wireless communication. Different channels can be used in WiMAX physical layer like AWGN, Rayleigh fading channel, Rician fading channel,SUI or Nakagami channel.

❖ **WiMAX Receiver:**

1. **OFDM De-multiplexer:**At the receiver side**,** cyclic prefix which is added at the transmitter for reducing ISI is removed.The received signal is converted into frequency domain using FFT or DFT algorithm. As OFDM symbol consists of data, pilots and a zero DC subcarrier with guard bands. Pilot carriers and data values are extracted over here.

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2. **Demodulation:** This block is used to demodulate the signal waveform to digital data.
3. **De-interleaver:** This block is used to undo the changes done by interleaver and retrieve the actual information.
4. **FEC Decoder:** The redundancy that is added at the transmitter side is removed in this block. This redundancy is examined to see if there are any errors
5. **De-randomizer:** De-randomizer does the inverse process of randomizer to nullify the effect of randomizer.
6.

VI. APPLICATIONS

A WiMAX system has been utilized as a part of different Fields such as:

- **Home and broadband internet access:** The internet provided by the WiMAX can be well utilized in rural area where DSL and any wired internets devices are not available [8].The utilization of WiMAX Internet technology is to convey unwavering quality to clients, since it is basically remote, did not utilize its conspicuous media.
- **Medium and small business:** WiMAX is more suitable to address the issues of little and medium-sized business particularly in low-density zones. High-density zones will most likely be unable to completely understand it's potential. It has ghastly restrictions.There may not be sufficient data transfer capacity to give access to vast customers in high thickness zones. This may expand costs [8].
- **Backhaul networks for cellular base stations:**Strong WiMAX technology can turn into the main decision for big business backhaul, for example, hot spots and point to point backhaul access solutions
- **Wi-Fi Hotspots:** This permits users to remotely get to the Internet through wandering outer workplaces and homes [7]. There are a few hotspots and WiMAX backhaul offerings for wireless networking wireless solutions.

VII.CONCLUSION

In this paper, authors have presented a brief overview of WiMAX networks. WiMAX have many features and applications as discussed in this paper. Difference between Wi-Fi and WiMAX are discussed along with the model description of WiMAX physical layer.

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