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# Performance Improvement of WiMAX using Convolution Coding

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**Abstract: In this paper, we present the review and the focus is on the Convolution coding used in WiMAX system and the difference between WiMAX system and Wi-Fi Technology is shown. The architecture used on WiMAX to drive a service over a radius upto several kilometers is configured in the same way as a traditional cellular network with base stations.**

**Keywords: WiMAX, Coding Techniques, Wi-Fi, IEEE, etc.**

## INTRODUCTION

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communication standard that is designed to provide 30 to 40 megabit-per-second data rates, with the update of 2011 providing up to 1 Gbit/s citation required for the fixed stations. It is one of the hottest wireless technologies available now-a-days. It is based on IEEE 802.16 specification and it is expected to deliver high quality broadband services. The name "WiMAX" ,that was started in June 2001 , was created by the WiMAX Forum to promote consent and interoperability of the standard. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and Digital Subscriber Line(DSL)".

WiMAX technology is a mature , affordable solution for high speed 4G mobile broad band. WiMAX refers to the interoperable implementations of the IEEE 802.16 family of wireless-networks standards authorized by the WiMAX Forum. WiMAX Forum certification allows dealers to sell fixed or mobile products as WiMAX certified, thus ensuring a level of interoperability with other certified products, as long as they fit the same profile. WiMAX is also known as the next generation broadband wireless technology that offers high speed, secure and last mile broadband services. The evolution of WiMAX began a few years ago when the scientists and engineers felt that there is a need of broadband services which works properly everywhere ;especially in the rural areas or in those areas where it is difficult to establish the wired infrastructure and is economically not feasible. IEEE 802.16, also known as IEEE Wireless-MAN, explored both licensed and unlicensed band of 2-66 GHz which is standard of fixed wireless broadband and ialso includes the mobile broadband application. The objective of this paper is to provide the review of the WiMAX. WiIMAX transmits the data with low bit error rate even in the noisy environment and to reduce the noise , we apply Forward Error Correction method with different coding techniques. This method is useful to reduce the bit error rate (BER) and increase the efficiency of WiMAX.

### Features of WiMAX

**I) Interoperability :**The IEEE 802.16 standard is internationally accepted and the standard is maintained and certified by WiMAX forum covers the fixed, portable and mobile classifications and give the user; the freedom to choose their product from different certified sellers and use it in different fixed, portable or mobile networks.

**II) Long Range :** It covers up to 30 miles but in real practice, it covers only 6 miles. Wireless communication system enable people to be connected and reachable without any limitation of location where they are.

**III) Mobility:** WiMAX offers extremly large mobility especially IEEE 802.16e-2005 as it adopted SOFDMA (Scalable Orthogonal Frequency Division Multiple Access) as a modulation technique and MIMO (Multiple Input Multiple Output) in its physical layer. It allows users to access information beyond their desk and conduct business anywhere even without a wire connectivity.

**IV) Security :** WiMAX have a strong privacy and key management protocol because it employs Advanced Encryption Standard (AES) which provides strong encryption policy. It also supports flexible authentication architecture which allows a variety of subscriber credentials including subscriber's username and password, cards and digital certificates.

**V) New services:** Wireless communication systems supports new services like SMS and MMS.

**VI) Simplicity :** Wireless communication systems are easy and fast to deploy in comparison to cable network. Initial setup cost is a bit high but its advantages overcome that high initial setup cost.

## WIMAX v/s Wi-Fi

WiMAX is different from Wi-Fi in many respects. In fact, Wi-Fi can operate at distances as great as WiMAX. The reason is the radio operating in the unlicensed frequencies are not allowed to be as powerful as those operated with licenses; and from convention , less power means less distance. The Wi-Fi MAC layer uses contention access. This causes users to compete for data throughput to the access point. Wi-Fi even has problems with interference, and throughput and that is why triple play (voice, data, and video) technologies cannot be hosted on traditional Wi-Fi. In contrast, IEEE 802.16 use a scheduling algorithm. This algorithm allows the user to compete once for the access point. This gives WiMAX inherent advantages in throughput, latency, spectral efficiency, and advanced antenna support. From the technical point of view, it can be seen that both wireless technologies are not from the same market but are very complementary. Wi-Fi is basically an implementation of wireless local area network within a short range like a small building, a college or an institutional campus. But WiMAX is a metropolitan technology whose aim is to interconnect houses , buildings or even hot spots to allow communication between them and with their networks. WiMAX technology has several advantages as compared to Wi-Fi such as: a better reflection tolerance; a better penetration of obstacles and an increase in the number of interconnections (a few hundreds of equipment rather than some tens of equipment for Wi-Fi). It's obvious that the goal of the WiMAX standard is not to replace Wi-Fi in its applications but to supplement it to make a wireless network web. Although there is a similarity in the equipment cost, WiMAX technology needs a costly infrastructure as compared to Wi-Fi which can easily be installed using low cost access points. The two wireless technologies have many common components in their operations but a major difference is the communication range. The following table.no.1 gives the detailed comparative analysis of the two broadband wireless access networks (Wi-Fi and WiMAX).

**Table. No.1. Difference between WiMAX and Wi-Fi**

| Feature | WiMAX (802.16a) | Wi-Fi (802.11b) | Wi-Fi (802.11a/g) |
|---|---|---|---|
| Primary Application | Broadband Wireless Access | Wireless LAN | Wireless LAN |
| Frequency Band | Licensed/Unlicensed 2 G to 11 GHz | 2.4 GHz ISM | 2.4 GHz ISM (g) 5 GHz U-NII (a) |
| Channel Bandwidth | Adjustable 1.25 M to 20 MHz | 25 MHz | 20 MHz |
| Half/Full Duplex | Full | Half | Half |
| Radio Technology | OFDM (256-channels) | Direct Sequence Spread Spectrum | OFDM (64-channels) |
| Bandwidth Efficiency | <=5 bps/Hz | <=0.44 bps/Hz | <=2.7 bps/Hz |
| Modulation | BPSK, QPSK, 16-, 64-, 256-QAM | QPSK | BPSK, QPSK, 16-, 64-QAM |
| FEC | Convolution Code Reed-Solomon | None | Convolution Code |
| Encryption | Mandatory- 3DES Optional-AES | Optional- RC4 (AES in 802.11i) | Optional- RC4 (AES in 802.11i) |
| Mobility | Mobile WiMAX (802.16e) | In development | In development |
| Mesh | Yes | Vendor Proprietary | Vendor Proprietary |
| Access Protocol | Request/Grant | CSMA/CA | CSMA/CA |

## IEEE 802.16WIMAX standards

The IEEE standard committee had introduced standards for networking elements as IEEE 802.16 in 1999. The 802.16 family standard is also known as Wireless Metropolitan Area Network (MAN) ,also called WiMAX which is an industry-led, non-profit organization and responsible for testing, certificating and promoting interoperable wireless products based on IEEE 802.16 working group. The original IEEE standard have addressed 10 to 66 GHz in licensed bands and 2 to 11 GHz in unlicensed frequency range. Currently, WiMAX has two main differences: one is for fixed wireless applications (covered by IEEE 802.16-2004 standard) and another is for mobile wireless services(covered by 802.16e standard). Both

the standards have evolved from IEEE802.16 and IEEE 802.16a, the earlier versions of WMAN standards. The basic characteristics of the various IEEE 802.16 standards are summarized in Table 1(R.B. Marks et al, 2004).The 802.16 standards only specify the PHY layer and MAC layer of air interface while the upper layers are not considered. IEEE 802.16 suite of standards (IEEE 802.16-2004/IEEE 802-16e-2005) 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 are defined in IEEE 802.16 are: (i) WMANSC: a single carrier PHY layer intended for frequencies beyond 11GHz requiring a LoS condition; (ii) WMANSCa: a single carrier PHY for frequencies between 2GHz and11GHz for point–to– multipoint operations; (iii) WMAN OFDM: a 256–point FFT–based OFDM- PHY layer for point–to–multipoint operations in NLoS conditions at frequencies between 2GHz and 11GHz; (iv) WMAN 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 IEEE 802.16e–2005, this layer has been modified to scalable OFDMA, where the FFT size is variable and can take any one of the following values: 128, 512,1,024, and 2,048 (R.B. Marks et al, 2004).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( R.B. Marks et al, 2004).

| | 802.16 | 802.16-2004 | 802.16e-2005 |
|---|---|---|---|
| Date | Dec.2001 | June-04 | Dec. 2005 |
| Spectrum | 10-66GHz | 2-11 GHz | 2-6 GHz |
| Operation | LoS | LoS &NLos | NLoS |
| Bit Rate | 35-134 Mbps | Up to 75 Mbps | Up to 15 Mbps |
| Channel BW | 28 MHz | 20 MHz | 5 MHz |

**WIMAX Transmitter**

The data to be sent is taken from the source is randomized and afterwards it is coded and mapped into QAM symbols. The functional blocks that compose the transmitter of the WiMAX This PHY layer uses orthogonal frequency division multiplexing (OFDM) with 256 subcarriers. Each OFDM symbol is composed of 192 data subcarriers, 1 zero DC subcarrier, 8 pilot subcarriers, and 55 guard carriers. The signal is converted to the time domain by means of the inverse fast Fourier transform (IFFT) algorithm and finally, a cyclic prefix (CP) with the aim of preventing inter-symbol interference is added.

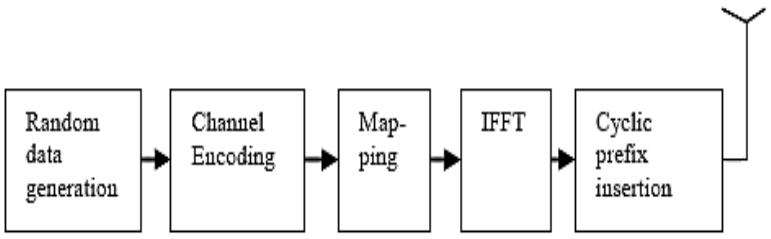


**Fig. 1: WiMAX Transmitter**

**WIMAX Receiver**

The receiver basically performs the reverse operation as the transmitter as well as channel estimation necessary to reveal the unknown channel coefficients. The block diagram for receiver is as shown in figure 2 (Prabhakar Telagarapu K. Chiranjeevi, 2011). Firstly, the CP is removed and the received signal is converted to the frequency domain using, in this case, the FFT algorithm. As we already know that an OFDM symbol is composed by data, pilots , a zero DC subcarrier, and some guard bands. Thus, a process to separate all these subcarriers is needed. First, the guard bands are removed, and then, a disassembling is performed to obtain pilots, data, and trainings. The training is used in the channel estimator, which calculates the channel coefficients. The estimated channel coefficients can be used in the demapper to perform an equalization of the data and compensate the frequency selective fading of the multipath propagation channel. Once the data has been demapped, it enters the decoder to recover the originally transmitted signal.

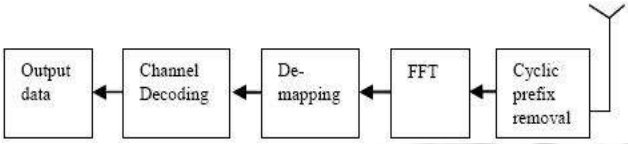


**Fig. 2 WiMAX Transmitter**

**Convolution Code (CC)**

In the telecommunication , a convolution code is a type of error-correcting code in which each m-bit information symbol (each m-bit string) to be encoded into n-bit symbol, where m/n is the code rate( greater than equal to m) and the transformation is a function of the information symbols , where k is the constraint length of the code.
To convolutionally encode data, start with k memory registers, each holding 1 input bit. Unless otherwise specified, all memory registers start with a value of 0. The encoder has n modulo-2 adders (a modulo 2 adder can be implemented with a single Boolean XOR gate, where the logic is: 0+0 = 0, 0+1 = 1, 1+0 = 1, 1+1 = 0), and n generator polynomials — one for each adder (see figure below). An input bit $m_1$ is fed into last k leftmost register. Using the generator polynomials and the existing values in the remaining registers, the encoder outputs n bits. Now bit shiftall register values to the right ($m_1$ moves to $m_0$, $m_0$ moves to$m_{-1}$) and wait for the next input bit. If there are no remaining input bits, the encoder continues output until all registers have returned to the zero state.

The figure below is a rate 1/3 (m/n) encoder with constraint length (k) of 3. Generator polynomials are $G_1$ =(1,1,1), $G_2$ = (0,1,1), and $G_3$ = (1,0,1). Therefore, output bits are calculated (modulo 2) as follows:

$n_1 = m_1 + m_0 + m_{-1}$ eq.(i)
$n_2 = m_0 + m_{-1}$ eq.(ii)
$n_3 = m_1 + m_{-1}$. eq.(iii)

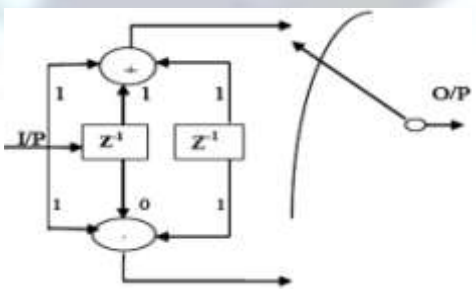


**Figure 3.Convolutional code with rate 1/2, K=1/3, generator polynomial [7,5] octal**

generator polynomial is $[7,5]_8=[111,101]_2$.The output from the $7_8 = 111_2$ arm uses the XOR of the current input, previous input and the previous two previous input. The output from the $5_8 = 101_2$ uses the XOR of the current input and the previous two previous input.
rate=1/2,constraint length, k=3
generator polynomial l$[7,5]_8$ = [111,101]

## Conclusion

WiMAX is based on a very flexible and strong air interface defined by the IEEE 802.16 group. WiMAX is similar to the wireless standard known as Wi-Fi, but on a much larger scale and at faster speeds. WiMAX physical layer is based on OFDM, which is an elegant and effective technique for overcoming multipath distortion. The physical layer supports several advanced techniques for increasing the reliability of the link layer. These techniques include powerful error correction coding, antenna arrays. WiMAX supports a number of advanced signal-processing techniques to improve overall system capacity. These techniques include adaptive modulation and coding, spatial multiplexing, and multiuser diversity. WiMAX has a very flexible MAC layer that can accommodate a variety of traffic types, including voice, video, and multimedia, and provide strong QoS.Robust security functions, such as strong encryption and mutual authentication, are built into the WiMAX standard. WiMAX defines a flexible all-IP-based network architecture that allows for the exploitation of all the benefits of IP. WiMAX offers very high spectral efficiency, particularly when using higher-order MIMO solutions.

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