Capacity Improvement of WI-MAX In presence of Different Codes

WI-MAX: Speed & Scope of future

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Abstract

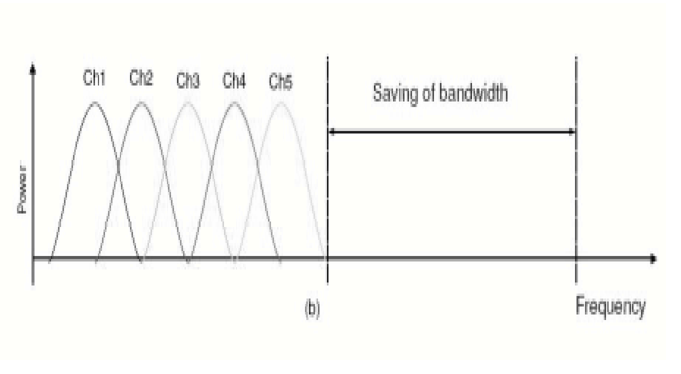
IEEE 802.16e, mobile Wi-Max, is a wireless technology used to provide very high data rate over large areas to a large number of users where broadband is unavailable. It uses OFDMA (Orthogonal Frequency Division Multiple Access) as a transmission scheme based on multicarrier modulation. The performance or capacity improvement is achieved using forward error correction codes (FEC). Two other codes, convolution code (CC) and low density parity check code (LDPC) are for achieving the high capacity. BER is also a major factor of it & performance with BER is compared using different FEC for mobile Wi-max.

Keywords: *Wi-Max, CC, FEC, BER*

1. Introduction

Wi-Max means Worldwide Interoperability for microwave access "is a telecommunications protocol that provides fixed and mobile Internet access. The current WiMAX revision provides up to 40 Mbit/s with the IEEE 802.16m update expected to offer up to 1 Gbit/s fixed speeds. The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity 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 DSL. IEEE 802.16e-2005 improves upon IEEE 802.16-2004 by:

1.1 Adding support for mobility (soft and hard handover between base stations). This is seen as one of the most important aspects of 802.16e-2005, and is the very basis of Mobile WiMAX. Scaling of the Fast Fourier transform (FFT) to the channel bandwidth in order to keep the carrier spacing constant across different channel bandwidths (typically 1.25 MHz, 5 MHz, 10 MHz or 20 MHz). Constant carrier spacing results in higher spectrum efficiency in wide channels, and a cost reduction in narrow channels. Also known as Scalable OFDMA (SOFDMA). Other bands not multiples of 1.25 MHz are defined in the standard, but because the allowed FFT subcarrier numbers are only 128, 512, 1024 and 2048, other frequency bands will not have exactly the same carrier spacing, which might not be optimal for implementations. Carrier spacing is 10.94 kHz.



2. Ease of Techniques

Physical System Layer Overview

The IEEE 802.16 standard supports multiple physical specifications due to its modular nature. The 802.16e OFDMA PHY is based on OFDMA modulation, which includes OFDM modulation and subcarriers allocation.

2.1 OFDMA

OFDM belongs to a family of transmission schemes called multicarrier modulation, which is based on the idea of dividing a given high-bit-rate data stream into several parallel lower bit-rate streams and modulating each stream on separate carriers, called subcarriers, or tones. OFDM is a spectrally efficient version of multicarrier modulation, where the subcarriers are selected such that they all are orthogonal to one another over the symbol duration, thereby avoiding the need to have non overlapping subcarrier channels to eliminate intercarrier interference.

Simulation Model

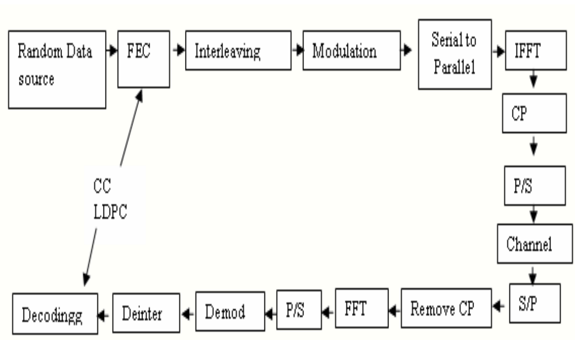


Fig. 2.1 Simulation Model

3. Forward Error Correction (FEC)

3.1 Convolution Code (CC)

In the Mobile Wi-Max OFDMA part, the CC is the only mandatory coding scheme. Its computations depend not only on the current set of input symbols but on some of the previous input symbols. A trellis description is used for convolution encoding which gives relation how each possible input to the encoder influences the output in shift register. It uses the Viterbi algorithm for decoding.

3.2 Low Density Parity Check (LDPC) Codes

Low-density parity-check (LDPC) codes are a class of linear block codes. The name comes from the characteristic of their parity-check matrix H which contains only a few 1's in comparison to the amount of 0's.Their main advantage is that LDPC is the first code to allow data transmission rate performance which is very close to the theoretical capacity maximum, the Shannon Limit and linear time complex algorithms for decoding. It is the sparseness of H which guarantees both a decoding complexity, which increases only linearly with the code length and a minimum distance, which also increases linearly with the code length

There are two different possibilities to represent LDPC code

1). Matrix Representation

2). Graphical Representation

1). Matrix representation

As LDPC is linear block code, so like in any other linear block code these can be described via matrices. Lets consider an example for low density parity check matrix, this matrix has for dimension of n X m for (8, 4) code. W is the number of ones in each row & Wc is the number of ones in each column. If W & WC=m, the matrix is called as lower density matrix.

$$\begin{array}{cc} & \begin{array}{ccccccc} x_1 & x_2 & & \cdots & & & x_7 \end{array} \\ \mathbf{H} = \begin{array}{c} c_1 \\ c_2 \\ c_3 \end{array} & \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix} \end{array}$$

2). Graphical Representation:- Tanner introduced an effective graphical representation of LDPC codes, these graphs are bipartite graphs which means that the graphs are separated into two distinctive sets and edges are only connecting nodes of 2 types which are v nodes or variable nodes, c nodes or check nodes

Regular and irregular codes: From these matrices and graphs we can check which code is regular and which is irregular. A LDPC code is called regular if Wc is constant for every column and Wc=Wc(n/m) also constant for every row and in case of a graph if there is same number of incoming edges for every v nodes and also for c nodes. H is of low density but the numbers of ones in each row or column are not constant then the code is called irregular LDPC code. An interesting fact is that high performance codes are irregular.

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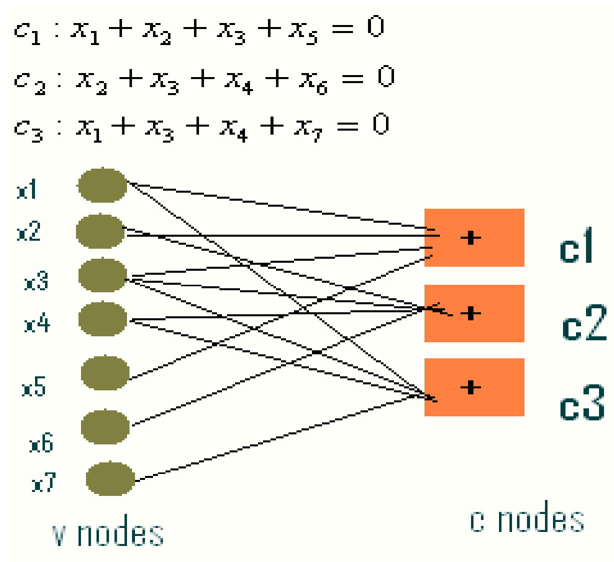

Fig. 3.1 Graphical representation

4. LDPC IN 3G

The IEEE 802.16 LDPC code is based on a set of one or more fundamental LDPC codes, each of which is systematic linear block code. Using the described methods, the fundamental codes can accommodate various code rates and packet sizes. There are six different LDPC code rates (1/22/3A, 2/3B, 3/4A, 3/4B, and 5/6) defined in IEEE Std 802.16e the standard also defines the Block Size for each code. Block Size controls the length of the output packet, and the code rate determines the ratio of the input Packet length to the output packet length.

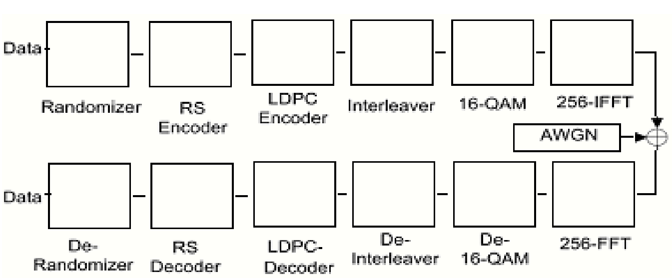

Fig. 4.1Graphical representation

4.1 LDPC Encoder/ Decoder

Feature of LDPC is to perform near Shannon's limit even for large block length. If we consider binary symmetric channel; large block length results in large parity check and generator matrix.

Complexity of multiplying a codeword with a matrix depends on the amount of 1's in the matrix. Now if the sparse matrix H is made in the form (p^t) where P is the sub-matrix which is generally not sparse via Gaussian elimination and the generator matrix G can be calculated as G= [IP].

Complexity increases with large block length; therefore iterative decoding/encoding algorithms are used. Those algorithms perform local calculations and pass those local results via messages. This is repeated several times and decisions are made. For decoding algorithms like belief propagation algorithms, the message passing algorithm and sum product algorithm are used. In all these first hard decision are made and then extended to work with soft decision leading to better decoding results

5. SIMULATION Parameter & Result

The assumed OFDM parameters are listed in Table I. The nominal bandwidth BW is assumed to be 20 MHz. Applying a sampling factor of n = 8/7, yields a sampling frequency Fs =22.856 MHz. Denoting the useful symbol time by Tb and the length of the cyclic prefix by Tg, the fraction of G = Tg/Tb was assumed to be G = 1/8. Bit rate is taken 15Mbps

In this paper physical layer Simulation of Mobile Wi-Max is done under AWGN condition. CC and LDPC FECs are used for simulation and their comparison is made

TABLE 1
SIMULATION PARAMETER

Type	Parameters	Value
	Nominal Channel Bandwidth	25MHz
P R I M I T I V E	NFFT (smallest power of 2 greater than N used	2052
	Number of Used Subcarrier N used	1704
	Sampling Factor, n 8/7	
	Ratio of Guard time to useful symbol time, G	1/6
	Sampling Frequency, Fs (N*bw/8000)*8000	24.456MHz

	Subcarrier Spacing, f = Fs/NFFT	12.10 KHz
D E R	Useful Symbol Time, Tb =1/ f	79.26μs
I	CP Time, Tg = G.Tb	12.42μs
V E D	OFDM Symbol Time Ts = Tb+Tg	128.8μs

Fig.5.1 presents SNR vs. BER performance of Wi-Max without FEC Using QPSK and 16-QAM.
Fig.5.2 presents SNR vs. BER performance of CC Using QPSK and 16-QAM. It improves performance as compared to Fig.5.1 As it shows at BER value of 10 -3, QPSK Gives 2 db gain and 16QAM gives 3 db gain and 16QAM gives 3 db gain.

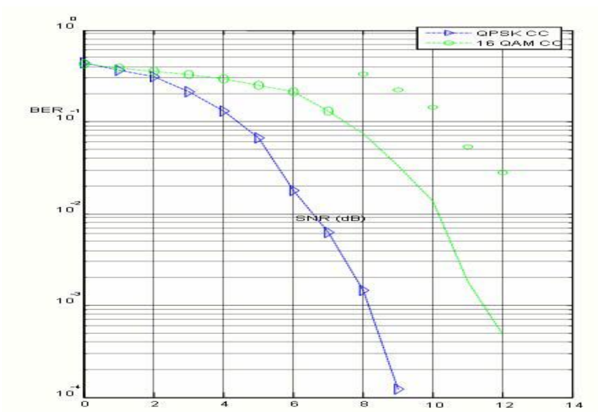

Fig.5.1 presents SNR vs. BER performance of Wi-Max without FEC Using QPSK and 16-QAM

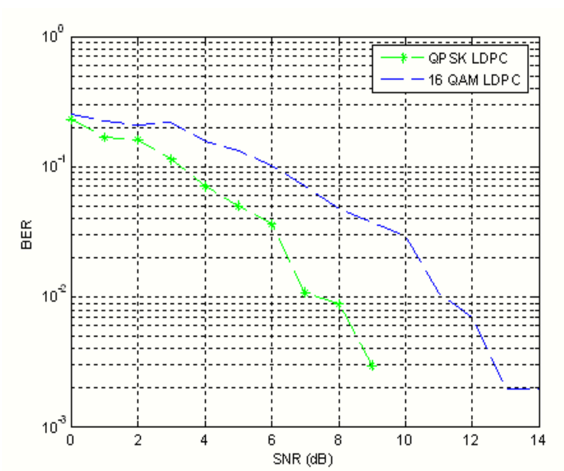

Fig.5.2 presents SNR vs. BER performance of CC Using QPSK and 16-QAM

10	QPSK 14 QAM
10^{-1}	OQPSK 14 QAM
10^{-2}	-DO-
10^{-3}	-DO-
10^{-4}	-DO-

SNR (dB)

6. Conclusion

IEEE 802.16e PHY. layer is simulated and performance curves are concluded. Physical layer performance with QPSK and 16-QAM for CC and LDPC are given for AWGN channel. It is concluded that LDPC gives noticeable performance improvement to mandatory CC. Same simulation can be carried out for fading channel for future work.

REFERENCES

[1] IEEE Std 802.16-2004, “Standard for Local and Metropolitan area networks”, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October2004.

[2] IEEE 802.16e/D7, “Draft IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands” April 2005.

[3] Richard van Nee, Ramjee Prasad“OFDM for Wireless Multimedia Communication” Artech House Publishers, 2000.

[4] Wen-an Zhou; Bing Xie; Jun-de Song“Link-level Simulation and Performance Estimation of WiMAX IEEE802.16e”, 2nd International Conference on Pervasive Computing and Applications, Page(s):667 –671, July 2007.

[5] R. G. Gallager,“Low-Density Parity-Check Codes” , Cambridge, MA: MIT Press, 1963.