OFDM UMTS Based LTE System

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Abstract – For wireless communication system high bit rate and low bit error rate is required. Research towards the growing demands and to fulfill the requirements of high data rates, multiple channel bandwidths (1.25-20MHz) and spectral efficiency, Long Term Evolution (LTE) is an area of research interest for next generation of wireless communication. Orthogonal Frequency Division Multiplexing (OFDM) is selected as the basis of LTE physical layer. This paper presents the performance of OFDM UMTS based LTE system where minimum BER is measured for different modulators. The proposed model is compared with OFDM-IDMA system in terms of BER. This paper concludes that it is quiet efficient and is applicable for next generation wireless communication system.

Keywords - LTE, OFDM, OFDM-IDMA, BER, Eb/N0, Cyclic Prefix(CP)

I. INTRODUCTION

A rapid increase of mobile data usage and to fulfill the growing demands of new applications such as Multimedia Online Gaming, mobile TV, Web 2.0, streaming contents have motivated the Third Generation Partnership Project (3GPP)[13] to work on the Long-Term Evolution (LTE)[16] on the way towards fourth-generation mobile. The aim of LTE is to provide a high data rate, low latency and packet optimized radio access technology supporting wider spectrum. The network architecture has been designed to support packet-switched traffic with seamless mobility and great quality of service. LTE evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System (UMTS), which in turn evolved from the Global System for Mobile Communications (GSM). LTE introduced to get higher data rates, 300Mbps peak downlink and 75 Mbps peak uplink. In a 20MHz carrier, data rates beyond 300Mbps can be achieved under very good signal conditions.

Orthogonal frequency-division multiplexing (OFDM), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. OFDM meets the LTE requirement for spectrum flexibility and enables cost-efficient solutions for very wide carriers with high peak rates. OFDM has been adopted for several of transmission systems such as Wireless Fidelity (WiFi), Worldwide Interoperability for Microwave Access (WIMAX), Digital Video Broadcasting (DVB), and Long Term Evolution (LTE) [3].

In this paper basic principle of OFDM and different subcarrier mapping for OFDM UMTS-LTE is discussed.

The paper is organized as follows: Section II briefly describes the LTE system. In Section III discussed the OFDMA principle. Section IV presents the proposed model. Section V presents the experimental results and minimum BER of the proposed model and OFDM-IDMA is compared. Section VI concludes the paper.

II. UMTS LONG TERM EVOLUTION - LTE

Release 8 deliberations focus on the Long Term Evolution (LTE). In the Radio Access Network (RAN), the LTE goals are data rates “up to 100 Mbps in full mobility wide area deployments and up to 1 Gaps in low mobility, local area deployments”. For best effort packet communication, the long term spectral efficiency targets are 5–10 b/s/Hz in a single (isolated) cell; and up to 2–3 b/s/Hz in a multi-cellular case [4]. The LTE release 8 (Rel. 8) introduces a completely new radio access network, known as evolved universal terrestrial radio access network (E-UTRAN), with major differences compared to general UMTS protocol architecture concepts, where the target is to significantly reduce system complexity [5]. LTE is an orthogonal frequency division multiplexing (OFDM)-based radio access technology. The LTE Rel. 8 supports scalable multiple transmission bandwidths including 1.4, 3, 5, 10, 15, and 20MHz [6].

III. OFDMA PRINCIPLE

Orthogonal frequency division multiplexing (OFDM) technique is a multicarrier modulation technique with a rather simple implementation performed using FFT/IFFT algorithms, and robust against frequency-selective fading channels which is obtained by converting the channel into flat fading subchannels [7]. In OFDM each subcarrier has an integer number of cycles within a given time interval T, and the number of cycles by which each adjacent subcarrier differs is exactly one [8]. The Fig.1. shows the spectrum of four orthogonal signals with minimum frequency separation. Each signal is constant over one symbol period and the spectrum has a sin(x)/x shape and so the spectral efficiency is very high conventional frequency division multiplexing (FDM).
To overcome the effect of multi path fading problem available in UMTS, LTE uses Orthogonal Frequency Division Multiplexing (OFDM) for the downlink to transmit the data over many narrow band carriers of 180 KHz each instead of spreading one signal over the complete 5MHz career bandwidth. The OFDM symbols are grouped into resource blocks. The resource blocks have a total size of 180 kHz in the frequency domain and 0.5ms in the time domain. Each 1ms Transmission Time Interval (TTI) consists of two slots (Tslot). Each user is allocated a number of so-called resource blocks in the time frequency grid. The more resource blocks a user gets, the higher the modulation used in the resource elements, and higher is the bit-rate. Which resource blocks and how many the user gets at a given point in time depend on advanced scheduling mechanisms in the frequency and time dimensions.

The basic LTE downlink physical resource can be seen as a time-frequency grid is shown in Fig.2 below:

Combining OFDM with multiple input multiple output (MIMO) technique increases spectral efficiency to attain throughput of 1 Gbit/sec and beyond, and improves link reliability [9]. OFDM faces one drawback, that the transmitted signal shows a Gaussian like time domain waveform with some relatively high peaks and so it does not guarantee a linear behavior of the system over its large dynamic range. To know the performance or effect of nonlinearities in OFDM signal, measurement of the peak-to-average power ratio (PAPR) is done [10, 14].

They are also sensitive to cross-cell interference and frame synchronzation is usually necessary to maintain orthogonality [11].

IV. PROPOSED MODEL

The investigation of BER performance of different subcarrier mapping schemes for UMTS-LTE is done in Matlab which follows the standard according to UMTS-LTE physical layer transmission scheme.

LTE is an orthogonal frequency division multiplexing (OFDM)-based radio access technology, with conventional OFDM on the downlink and discrete Fourier transform spread OFDM (DFTS-OFDM) [12] on the uplink. One of the key elements of any OFDM system is the existence of the Fast Fourier transform (FFT). The generated streams from the OFDM modulation are carried out on different sub-carriers. Hence, the transmitter complexity is reduced by the use of the inverse Fast Fourier Transform (IFFT). Similarly, the receiver is implemented as the low-complexity Fast Fourier Transform (FFT) operation to demodulate the OFDM signals. The transmitted data are split into low bit rate streams. The proposed model is shown in Fig.3. The structure design is based on the conventional OFDM system structure [1]. The upper branch in Fig. 3 represents the OFDM based transmitter part, whereas the lower branch represents the receiver part.

Suppose we have Nsc sub-carriers and that the transmitted OFDM symbols are $X(1), X(2), X(3), X(4), \ldots , X(N)$.

After normalizing all the OFDM IFFT symbols, the mathematical discrete-time representation for these symbols is:

$$x(k) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X(n) e^{j2\pi kn/N} \quad k=0, \ldots , N-1 \quad (1)$$

At the receiver side, the received OFDM data symbols converted to the time domain by using the FFT:

$$Y(n) = \sum_{k=0}^{N-1} y(k) e^{-j2\pi kn/N} \quad n=0, \ldots , N-1 \quad (2)$$

The Cyclic prefix (CP) acts as a guard time between successive blocks. It is a copy of the last part of the transmitted OFDM symbol which is appended in front of the same symbol for each transmitted OFDM symbol. Inter-symbol interference and inter-carrier interference are the two major consequences of the transmission over time-varying frequency selective channels.
The cyclic prefix is used in the proposed UMTS-LTE transceiver, to reduce the influence of the inter-symbol interference and also it converts a discrete time linear convolution into a discrete time circular convolution. However, the length of the cyclic prefix must be at least the same or longer than the length of the channel impulse response, in order to prevent the occurrence of interference [1,15].

V. EXPERIMENTAL RESULTS

To present the effectiveness of OFDM UMTS LTE system, the performance evaluation for the OFDMA based UMTS-LTE model is experimented for random input signals which is being modulated for different modulators like BPSK, QPSK, 16QAM & 64QAM.

This paper presents the coded performance of the UMTS-LTE system. The frame length is taken 100, number of packets are 1000, number of transmitting and receiving antennas are 2 i.e. MIMO(2x2). The designed transceivers considered operating with a bandwidth of 20MHz. Fig.4 shows the BER performance with different iterative numbers using BPSK modulator with AWGN channel. Figure shows minimum BER at iteration 11. This shows that the performance drastically improves with the increasing of the iterative number and therefore number of iterations directly affects the performance of OFDM UMTS LTE.
Next, to present the performance, over AWGN, of the system are achieved bit error rates for different modulation formats. Fig. 5 shows the transceivers performance in terms of BER versus Eb/No for BPSK, QPSK, 16QAM and 64QAM. The figure shows that system performs better in BPSK and 16QAM modulators.

The proposed model is compared with OFDM-IDMA[2] with respect to minimum BER and Eb/N0. The comparison is tabulated in the table 1. The minimum BER values shows better performance of OFDM UMTS based LTE system using BPSK and 16QAM modulators.

The performance of the proposed model is compared with other modulators like BPSK, QPSK, 16QAM, 64QAM and also compared with wavelet based OFDM-IDMA[2] system for next generation wireless communication system. The experimental results shows better performance for BPSK and 16QAM.

Also the minimum BER comparison, between wavelet based OFDM IDMA and OFDM UMTS based LTE systems, shows better performance of OFDM UMTS based LTE system using BPSK and 16QAM modulators. This paper concludes that it is quiet efficient and is applicable for next generation wireless communication system.

VI. CONCLUSIONS

This paper concludes with the successful implementation of OFDM UMTS based LTE system. The performance is measured by BER. The proposed model is experimented for minimum bit error rate (BER) with different energy per bit to noise power spectral density ratio (Eb/N0).

The performance of the proposed model is compared with other modulators like BPSK, QPSK, 16QAM, 64QAM and also compared with wavelet based OFDM-IDMA[2] system for next generation wireless communication system. The experimental results shows better performance for BPSK and 16QAM.

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REFERENCES


