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Design and Analysis of OFDMA and SC-FDMA for LTE Uplink Enhancement

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Abstract

There is a large demand for high speed communication network, due to the fast growth in multimedia services provided by the mobile operators. SC – FDMA (Single Carrier Frequency Division Multiple Access) and OFDM (Orthogonal Frequency Division Multiplexing) are the most common communication standards prevalent in the 4th generation (LTE) mobile communication network, LTE-Advanced and Ultra Mobile Broadband (UMB). For mobile communication system high data rate and low BER (Bit Error Rate) is required. Various researches have been carried on to fulfill the demand of high data rates, multiple channel bandwidths and spectral efficiency. LTE (Long Term Evolution) is one of such area research have been carried on to fulfill the above mentioned requirement.

Keywords: LTE, OFDMA, SC-FDMA, DFT, IDFT, Error Rate, Bandwidth

I. INTRODUCTION

In the modern world, requirement of high data rate communication has become inevitable. The applications like streaming video and image transmission and browsing the internet require high speed data transmission with high mobility. In

order to accomplish this high demand of data, the 3rd Generation Partnership Project (3GPP) and introduced Long Term Evolution (LTE), in order to make available high speed data rate for mobile communication. Demand for high-volume data streams in the current market is growing at a fast pace. In order to continue up with the tendency to higher throughput requirements within unchanged bandwidth limitations, the Long Term Evolution (LTE) technology has become a solution for replacing the data transfer over 2G / 3G communication networks. It is anticipated that LTE will become the primary cellular standard in next few decades. The reason for this growth in the popularity of LTE, points to the low cost and high presentation that is provided by this technology [1].

A. Long Term Evaluation

Long Term Evolution (LTE), which was standardized by the 3GPP group, is proposed to have wider range of channels up to 20MHz, with lower delay and packet optimized radio access technology. The peak data rate for LTE forecast that it has a downlink speed of 100 Mbps and uplink speed of 50 Mbps. The 3GPP did choose the Orthogonal Frequency Division Multiple Access as the radio access technology due to its simple implementation in receiver, high performance and high spectral efficiency. In addition to OFDMA technology, different MIMO transmission methods are used to achieve data rate compliance with the LTE standards. To achieve high throughput required by the LTE system downlink, Adaptive Modulation and Coding (AMC) has to confirm a BLER value lesser than 10%. The SNR-to-CQI mapping is required to attain this goal [2].

Long Term Evolution (LTE) is commonly known as 4G —or next generation wireless communications —is the latest standard used all over the country high speed broadband. This standard will permit access to digital technologies and distribute extended capabilities to community safety practitioners in the field. LTE is the bridge stone for bringing public safety fully in a digitized ay. Various high end devices and applications are now being released on a daily basis, in competition to those that could be run only on in-office servers and desktops some years back. This network will promote further development of applications. The LTE permits faster speed and holds great future prospects for fast responders, although there are certain backdrops for the related technology in the community safety arena. The transition to LTE will not be a simple process. It will involve idea and complex build up as well as an implementation process that will take many years to come. It requires an immense work of harmonization and adjustment among the existing public safety broadband users now operating on the mixture of commercially and publicly supported networks on non-adjacent bands of spectrum [3, 4].

B. Multiplexing and De-multiplexing

It was observed that majority of the device which is used for personage data - communicating generally require reserved data rate. But, communicating media usually has very high bandwidth. As an outcome, two stations which are communicating each other don't make use of the entire capacity of a data link. Moreover, when more number of nodes competes to access the network, some proficient techniques are used to access the network. When the signal transmitted over the channel has the bandwidth greater than the medium, then the medium be able to share with more than one channel of signals.

a. Multiplexing

Multiplexing was formerly urbanized in the 1800s for telegraphy. Nowadays, multiplexing is widely used in most of the communication applications, such as telephony, video calling, digital broadcasting and wireless telephony. Multiplexing combines multiple signals (analog or digital) bound for transmission over a single communication line or communication channel. The input signals to a multiplexer will be an analog signal or a digital signal. The use of multiplexing is to transmit a signal in more efficiently through a single communication channel. A multiplexer is a devise used to combine two or more input signal into a single signal [5].

b. De-Multiplexing

Demultiplexing is the extraction of the original signal on the receiving end. Demultiplexing (DEMUX) is the turnaround of the multiplexing (MUX) process.. De-multiplexer is also a device with one input and multiple output lines. It is used to send a signal to one of the many devices. The main dissimilarity between a multiplexer and a de-multiplexer is that a multiplexer takes two or more signals and encodes them on a wire, whereas a de-multiplexer does reverse to what the multiplexer does [6, 7].

II. BACKGROUND

The background study is a collection of sufficient information base on the analysis of the proposed problem. It also includes the steps required to design and implement a feasible solutions and the results obtained.

A. OFDMA

OFDMA is a variant of orthogonal frequency division multiplexing (OFDM), a digital multi-carrier modulation scheme which is mostly used in wireless systems but moderately new to cellular system. In OFDM, a high bit rate of data is transmitted with a single carrier. OFDM makes use of a huge number of intimately spaced orthogonal subcarriers that are transmitted in parallel. Orthogonal frequency division multiplexing (OFDM) technique is a multicarrier modulation technique with a simple implementation performed using FFT/IFFT algorithms, and converts the channel into

flat fading sub channels by means of frequency-selective fading channels [8]. In OFDM for a given time interval the subcarrier has a finite number of cycles, and each adjacent subcarriers differs the number of cycles is exactly one [9].

OFDMA is a combination of modulation scheme that resembles OFDM and a multiple access scheme that combines TDMA and FDMA. Orthogonal frequency-division multiple accesses (OFDMA) have gained much consideration in the past few years since it is widely recognized as a promising technique for fourth-generation broadband wireless networks [10]. In OFDMA system, numerous users transmit their own data simultaneously by modulating a limited set of orthogonal subcarriers. Two important problems in OFDMA uplink transmissions are: frequency/timing synchronization and channel estimation. Similar to orthogonal frequency-division multiplexing (OFDM), OFDMA is particularly sensitive to carrier frequency offsets (CFOs) and timing errors.

OFDMA is a multi-user version of the orthogonal frequency-division multiplexing (OFDM) digital modulation scheme. Multiple accesses are achieved in OFDMA by allocating subsets of subcarriers to individual users as shown in the illustration below. This results in simultaneous low data rate transmission from several users [11].

OFDMA Usage

- The mobility mode of the IEEE 802.16 Wireless MAN standard commonly referred to as WiMAX.
- The IEEE 802.20 mobile Wireless MAN standard, commonly referred to as MBWA,
- MoCA 2.0,
- The downlink of the 3GPP Long Term Evolution (LTE) fourth generation mobile broadband standard. The radio interface was formerly named as High Speed OFDM Packet Access (HSOPA), now named as Evolved UMTS Terrestrial Radio Access (E-UTRA).
- The Qualcomm Flarion Technologies Mobile Flash-OFDM
- The now defunct Qualcomm/3GPP2 Ultra Mobile Broadband (UMB) project, intended as a successor of CDMA2000, but replaced by LTE

OFDMA is also a competitor access method for the IEEE 802.22 Wireless Regional Area Networks (WRAN).The project is designed as the first cognitive radio based standard, working in the VHF and low UHF spectrum [11].

B. SC-FDMA

SC-FDMA is hybrid modulation schemes that combine the low peak-to-average ratio (PAR) of traditional single-carrier formats such as GSM with the multipath resistance and in-channel frequency scheduling flexibility of orthogonal frequency-division

multiplexing (OFDM).

Similar to OFDMA, SC-FDMA divides the bandwidth of transmitted signal into multiple parallel subcarriers. The subcarriers orthogonality is maintains by the addition of the CP (cyclic prefix) as a guard interval. On the other hand, the data symbols are not assigned directly to each subcarrier independently like in OFDMA. The signal assigned to each subcarrier is a linear combination of all modulated data symbols transmitted at the same time instant. The difference of SC-FDMA transmission from the OFDMA transmission which is an additional DFT block before the subcarrier mapping can be seen in Figure 1. Following from this fact, this system is not a multi-carrier but a single-carrier system [12].

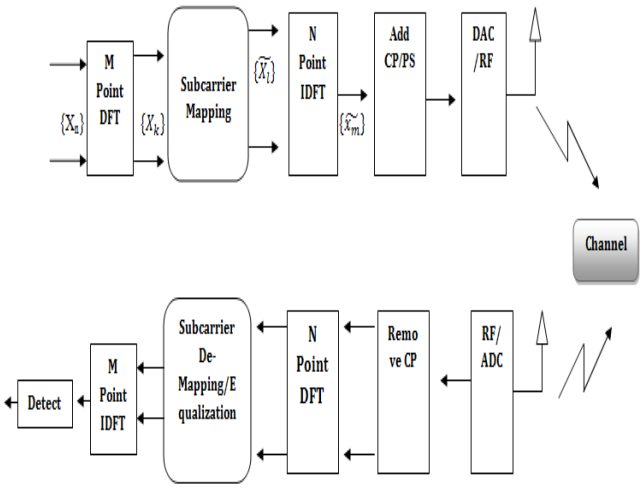

Figure 1: Transmitter and receiver structure of SC-FDMA [12]

III. EXPERIMENTAL SETUP

The stimulation of implemented both OFDMA and SC-FDMA in MATLAB environment based on some realistic parameter by using here we have define their values along with name.

IV. RESULT ANALYSIS

We have implemented OFDMA and SCFDMA in GUI MATLAB to show performance using Amplitude, Bandwidth, Speed and Error rate.

A. Amplitude

Amplitude: Amplitude Modulation is defined as a technique in which the amplitude of the carrier signal is changed in accordance with some attribute of the modulating

signal. Amplitude modulation mean the process of modifying a carrier wave which is coherent by combining it with a nonlinear device with the modulated signal to produce discrete upper and lower sidebands, which are the difference and sum frequencies of the carrier signal. In figure 2 and 3 shows the amplitude values for downlink and uplink. In both figure, X- axis shows simulation time in second and Y-axis indicates uplink downlink performance. In figure 2 and 3, blue line show the OFDMA and green line show the SC-FDMA. We are comparing both link performances as OFDMA have 29.9 mbps and SC-FDMA 32.06% mbps for Uplink while OFDMA 88.19 mbps and SC-FDMA 81.02% mbps.

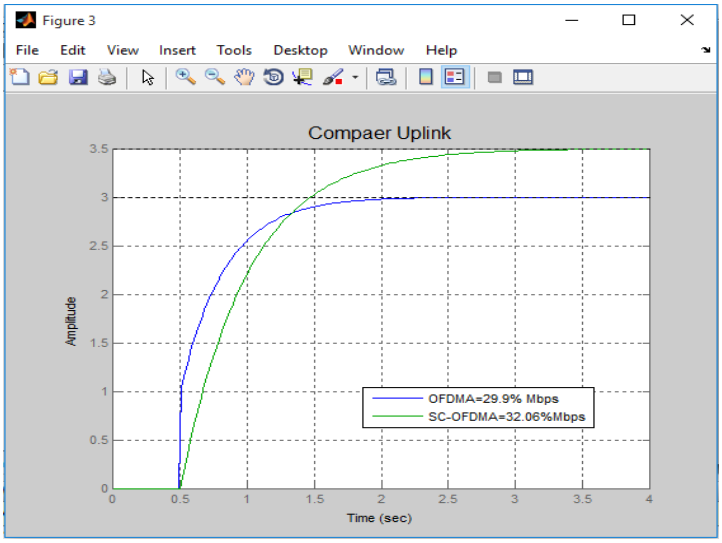

Figure 2: Amplitude for Uplink

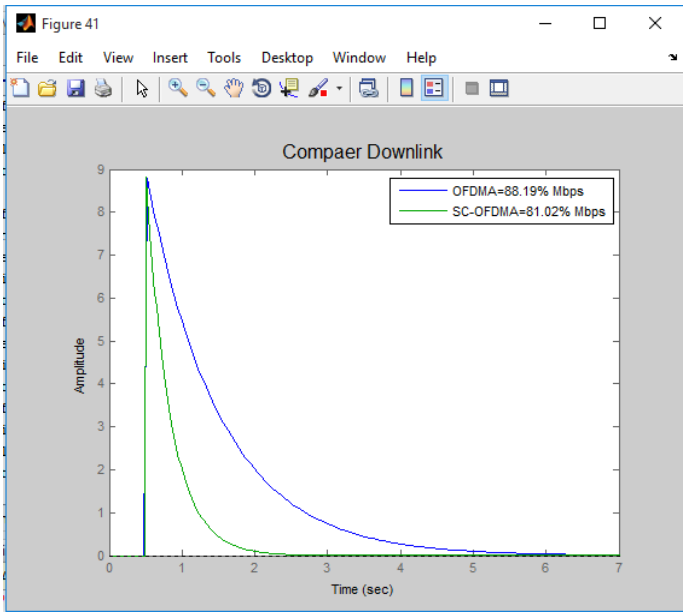

Figure 3: Amplitude for Downlink

B. Bit Error Rate

In wireless communication, the bit errors rate is defined as the number of bits received in a data stream transmitted over a communication channel that has been distorted due to noise, interference, bit synchronization errors etc. The bit error rate (BER) is the ratio of number of bit errors and the total number of bits transmitted at a stipulated time interval. BER is frequently articulated as a percentage.

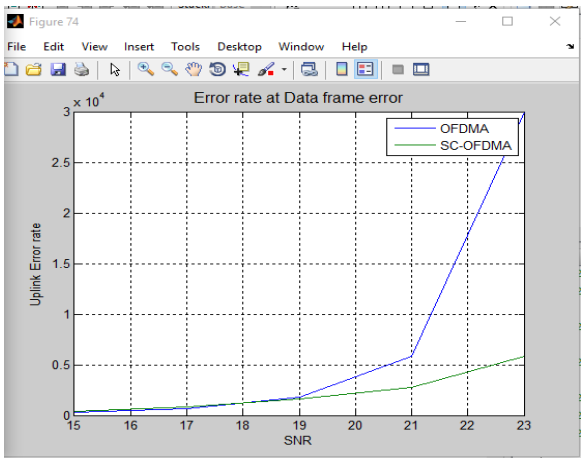

Figure 4: Error Rate for Uplink

This approximation is accurate for a lengthy time interval and a large number of bit errors. BER performance is given by figure 4 and 5 for uplink and downlink respectively. In this, X- axis show SNR (signal to noise ratio) and Y-axis shows error rate of signal which degrading the carriers as corresponding their noise ratio. In this figure OFDMA is indicated by blue line and SC-FDMA is indicated by green line.

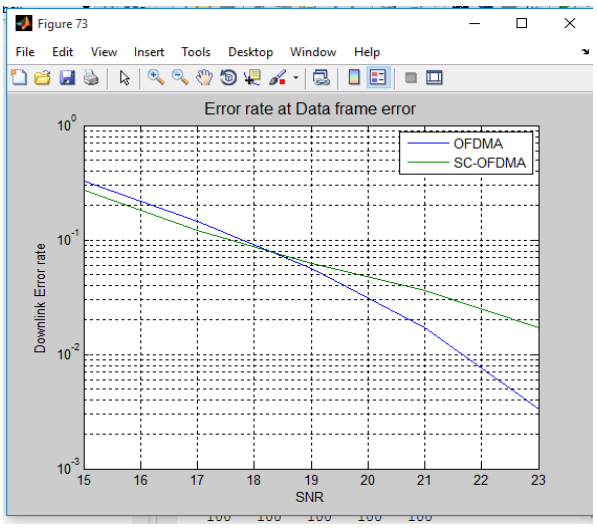

Figure 5: Error Rate fir Downlink

C. Bandwidth

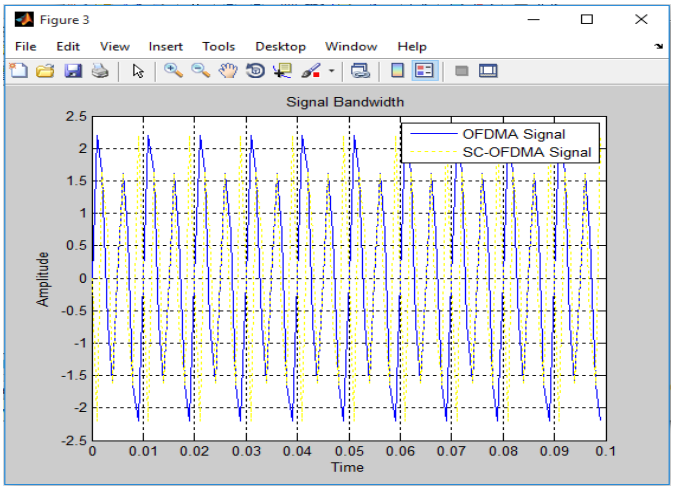

Figure 6: OFDMA /SC-OFDMA Bandwidth

Bandwidth is defined as the bit-rate measure of the transmission capacity over a network communication system. Bandwidth is also described as the carrying capability of a channel or the data transfer speed of that channel.

Figure: 6 demonstrate the bandwidth data signal rate for OFDMA and SC-FDMA where X-axis describes simulation time and Y-axis show amplitude modulation with respect to the bandwidth. So using this we can calculate both carrier signal performance. Here yellow line shows SC-FDMA and blue line for OFDMA in which bandwidth output in zigzag form.

D. Speed

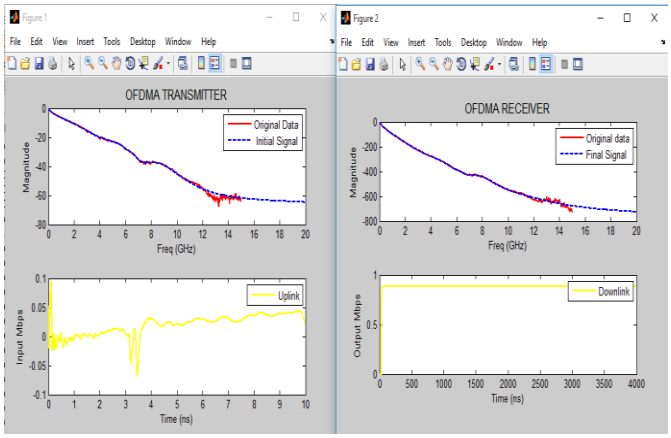

Figure 7: Speed for OFDMA

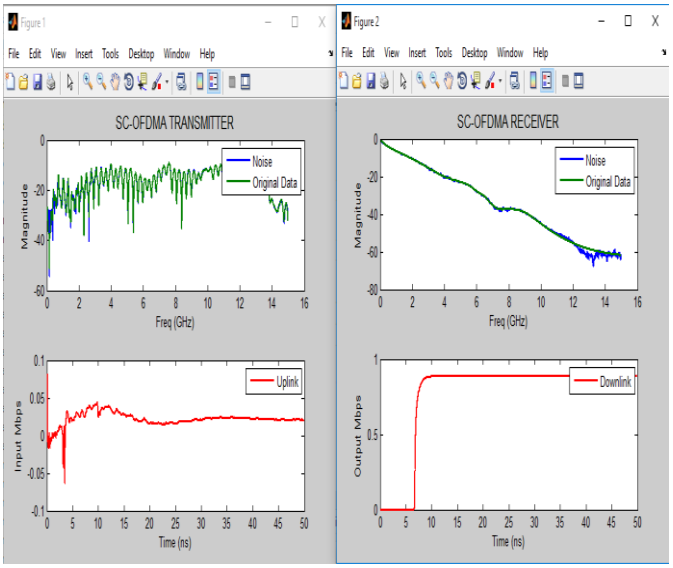

Figure 8: Speed for SC-OFDMA

V. CONCLUSION AND FUTURE PROSPECT

This paper provides the introduction to LTE and the key components of communication. From the discussion, it is observed that OFDMA is used as downlink and SCFDMA as uplink modulation schemes; SC-FDMA is the new multiple access technique adopted in the Long Term Evaluation uplink scheme. Compared with the popular OFDMA, which is used in the LTE downlink scheme and WiMAX, SC-FDMA has a better performance in terms of Amplitude, Bandwidth, Speed and FER (Frame Error Rate) due to its coherent 'single-carrier' property and built-in frequency diversity.

FUTURE PROSPECT

For future prospect we can add more modulation scheme and also calculate more parameter such as Peak to Average Power Ratio, congestion and many more. Additionally, in future should be work on scheduling process for uplink improvement with both is technique and their comparative study.

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