International Journal of Computer Engineering and Information Technology

VOL. 8, NO. 2, February 2016, 18–22
Available online at: www.ijceit.org
E-ISSN 2412-8856 (Online)

An Evaluation on Long Term Evolution (LTE) and its PHY Layers

Engr.Farman Ali1, Engr. Noman Muslim2, Engr.Muhammad Athar Suri3, Rahmat Ullah4

[1] Electrical Engineering Department Iqra National University, Peshawar Pakistan

[2,3] Electrical Engineering Department Sarhad University of Science and IT, Peshawar Pakistan

[4] Department of Computer science University of Peshawar, Pakistan

[1]farman_pukhtun@yahoo.com, [2]noman.ee@suit.edu.pk, [3]athar_zia2001@yahoo.com, [4]rahmat.9314@gmail.com

ABSTRACT

LTE (Long Term Evolution) is a next generation communication technology. It is a standard by 3rd and 4th Generation. In this article, we give an overview the physical layer (PHY) of LTE transceiver is analyzed in downlink and uplink transmissions. A number of issues regarding the design and analysis of PDSCH and PUSCH are discussed in this paper and their link level and system level performance has been evaluated.

Keywords: *Long term Evolution (LTE), Physical Downlink Shared Channel (PDSCH) and Physical Uplink Shared Channel (PUSCH).*

1. INTRODUCTION

Now the world has become globe and these fast changing, change our business, our relations in all over the world. It is our basic requirement to communicate and to send necessary data to each other personally or mutually, accurately, safely in short amount of time. Due to these key requirements wireless technologies faces tremendous changes in very less time compare to other fields. In the field of technology time to time improvement can be seen in less time. It was a tremendous and unique change when in 1980's the wireless technology kept its first step in the field of communication technology with the name of zero generation "0G" technology also known as radio wireless transmission technology. The permission in 0G was voice only, but it was a heart touch experiment to change transmission from physical connection to free wire. As a result the wireless technology becomes a pointed focus of researchers to make it more optimize and advance. Due to increase in demand to make wireless technology more efficient the "1G" joined the journey. It was consist of analog circuit switch technology system. Then "1G" improves to digital system given name 2nd generation "2G" technology. The performance in voice and data transfer was good with a speed up to 64kbps. Then "2G" jumps to "2.5G" with just increment in speed up to 144kbps [2]. At start this speed was considered a big achievement in technology but with increase in number of users the given speed becomes limited. Due to which it's become our thrust to achieve more speed to maintain our technology according to demand, so it took us in "3G" 3rd generation. High data rate transmission and enlarge capacity for voice calling are key targets of this generation. Speed used by with high data rates than previous generations. The main significant of 3G is to provide each and any information like (video calls, high data transfer and IP etc) with a wide range services this technology is up to 2Mbps which made a clear difference in voice and data transmission from earlier technology. International mobile telephone 2000(IMT-2000) project lunched the "3G" requirements with the basic of UMTS-HSPA,CDMA-2000 EV-DO and WiMAX [3]. Due to highlights of these modern techniques in technology now the world have become a globe and researchers are doing their best to make it more and more advance. Further the wireless technology has been enhanced and "4G" is introduced, which provides better data rates and services than its predecessor technologies. Due to high bandwidth and high data rates than 3G it attained the name "MAGIC". Now "4G" is up graded to another better evolution named LTE (long term evolution). LTE is the type of 4G and its advantage is to provide more reliable wireless and internet broadband services. In this report our research criteria is consist of the analysis on LTE and their channels in detail. The different stages of evolutions in technology are shown in Fig 1:

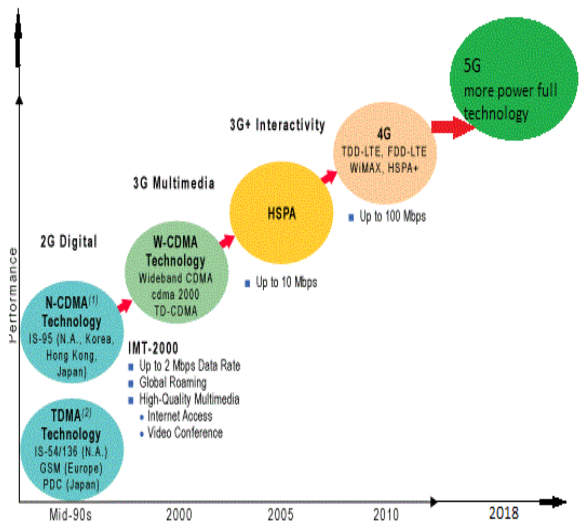

Fig. 1. Evolution in wireless technology [4]

The 3GPP Long Term Evolution (LTE) represents a major advance in cellular technology. It is designed to meet carrier needs for high-speed data, media transports including high-capacity voice support well into the next decade. It encompasses high-speed data, multimedia uni-cast and multimedia broadcast services. LTE delivers improved system capacity and coverage, improved user experience through higher data rates, reduced-latency deployment, and reduced operating costs, and seamless integration with existing systems. Further enhanced requirements, however, in 2008[14], LTE has been approved as a radio technology for International Mobile Telecommunications-Advanced (IMT-Advanced). IMT-Advanced requirements are defined by the International Telecommunication Union, which is an organization that provides globally accepted standards for telecom-munications [1]. LTE is represented by another name as well Evolved Universal Terrestrial Radio Access (E-UTRA), which is an improved jump to 4th generation technology to support highest data rate specifications. OFDM (orthogonal frequency division multiple) and SC-FDMA (single carrier frequency division multiple access) is used for uplink and down link by LTE, Which is totally change from 2G and 3G standards [5].

LTE–A (LTE advanced) which is further advance-ment of LTE has data rate speed of I Gbps in downlink and 500Mbps in the uplink with a very low latency rate. The downlink transmission model for E-UTRA consists of MIMO-OFDM [6]. In OFDM, the existing spectrum is divided into multiple mutually orthogonal carriers, called sub-carriers and Each one of these sub-carriers is modulated by a low rate data stream [7]. LTE is interoperable with widely used technologies such as GPRS, WCDMA and HSPA, and this enables mobile operators deploying LTE to provide a seamless service and multimode devices for customers [8].

LTE supports time division duplex (TDD) and frequency division duplex (FDD) schemes in the same frequency bands as those allocated to UMTS: 15 frequency bands (1 to 14 and 17) are FDD and 8 bands (33 to 40) are TDD [6]. LTE also supports three modulation schemes, which are QPSK, 16-QAM and 64-QAM and Error Vector Magnitude (EVM) is a parameter used to measure the quality of modulation [7]. The minimum requirements for the EVM are 17.5% for QPSK, 12.5% for 16-QAM and 8% for 64-QAM [7]. This paper focuses only on Physical Downlink Shared Channel (PDSCH) and Physical Uplink Shared Channel (PUSCH). The LTE PHY is a highly efficient to conveying both data and control information between an enhanced base station (eNodeB) and mobile User Equipment (UE) and it also controls coding and decoding, modulation and demodulation, and antenna mapping [9]. This paper is organized as follows: In Section II and III, the PDSCH downlink transmission and PUSCH transmission are analyzed respectively. At last, conclusions are given in Section IV.

2. LTE DOWNLINK TRANSCEIVER

It is working on the basis of OFDMA, and The LTE downlink physical resources are represented by a time-frequency resource grid [10]. Resource elements are grouped into Resource Blocks (RBs) and each RB consists of 12 subcarriers with a spacing of 15 kHz in the frequency domain and 7 consecutive OFDM symbols in the time domain. The number of available RBs in the frequency domain varies depending on the channel bandwidth, and the channel bandwidth is between 1.4 MHz and 20 MHz [11].

2.1 PDSCH Transceiver:

In Fig: 2 the structure of PDSCH on the basis of transceiv-er and receiver is shown.

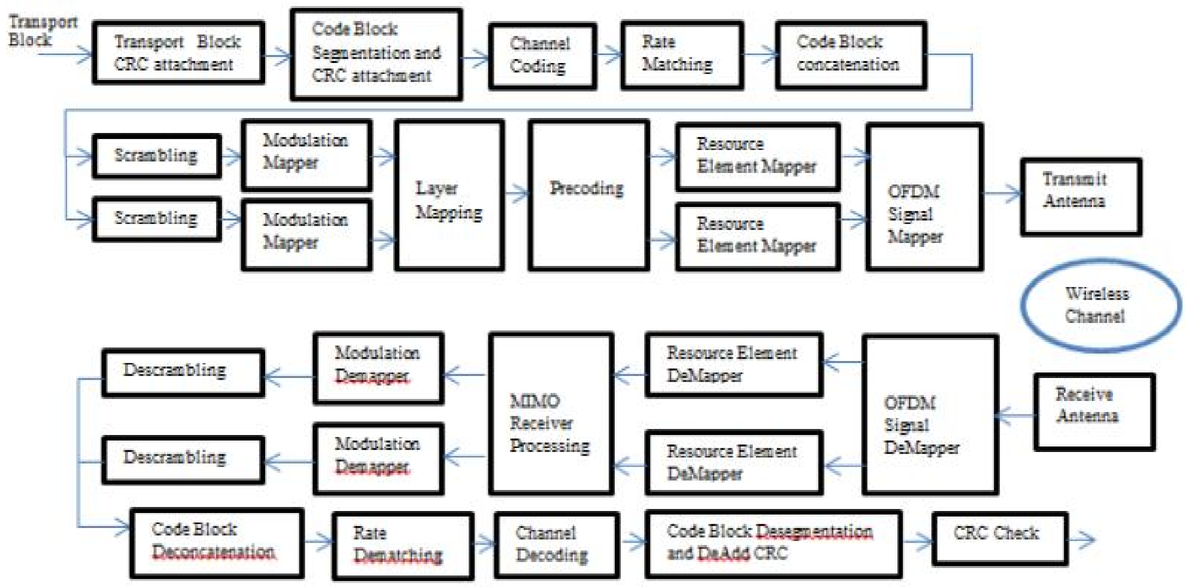

Fig. 2. PDSCH Transmitters and Receiver Structure [12]

The transmitter in the physical layer starts with the grouped resource data which are in the form of transport blocks. PDSCH is used to transmit the Downlink Shared Channel (DL-SCH). The DL-SCH is the transport channel used for transmitting downlink data (a transport block). One or two coded transport blocks (code words) can be transmitted simultaneously on the PDSCH depending on the precoding scheme used. According to [1] the processing steps of transmitting downlink data in PDSCH are given below.

Transport block CRC attachment: A cyclic redundancy check (CRC) is used for error detection in transport blocks. The entire transport block is used to calculate the CRC parity bits and these parity bits are then attach to the end of transport block [12].

Code block segmentation and CRC attachment: In LTE, a minimum and maximum code block size is specified so the blocks sizes are compatible with the block sizes supported by the turbo inter leaver. Minimum code block size is 40 bits and maximum code block size is 6144 bits [9]. The input block is segmented when the input block is greater than the maximum code block size [11].

Channel coding: The channel coding scheme for PDSCH adopts Turbo coding, which is a robust channel coding [2]. The coding rate of turbo encoder is 1/3[9].The code blocks undergo turbo coding which is a form of forward error correction that improves the channel capacity by adding redundant information. The turbo encoder scheme uses a Parallel Concatenated Convolution Code (PCCC) with two recursive convolution coders and a contention free Quadratic Permutation Polynomial (QPP) inter leaver [13].

Rate Matching: The main task of the rate matching block is to create an output bit stream to be transmitted with a desired code rate. As the number of bits available for transmission depends on the available resources the rate matching algorithm is capable of producing three bit streams from the turbo encoder are interleaved followed by bit collection to create a circular buffer. Bits are selected and pruned from the buffer to create an output bit stream with the desired code rate. The Hybrid Automatic Repeat Request (HARQ) error correction scheme is incorporated into the rate-matching algorithm of LTE [10].

Code Block Concatenation: In this stage, the rate matched code blocks are concatenated back together. This task is done by sequentially concatenating the rate-matched blocks together to create the output of the channel coding [12].

Scrambling: The codewords are bit-wise multiplied with an orthogonal sequence and a UE-specific scrambling sequence to create the following sequence of symbols for each codeword. It also helps in privacy of the data[14].

Modulation: The scrambled codewords undergo modulation using one of the PDSCH modulation schemes QPSK, 16 QAM, 64 QAM, resulting in a block of modulation symbols [9].

Layer Mapping: The modulation symbols are mapped to one, two, or four layers depending on the number of transmit antennas used. There are mainly two kinds of layer mapping, one for transmit diversity and the other for spatial multiplexing. If transmit diversity is used, the input symbols are mapped to layers based on the number of layers. In the case of spatial multiplexing, the number of layers used is always less or equal to the number of antenna ports used for transmission of the physical channel [6].

Precoding: Symbols on each layer will be pre-coded for transmission on the antenna ports according to different modes of transmission, which are spatial multiplexing, transmit diversity, and single antenna port transmission.

Mapping to Resource Elements: For each of the antenna ports used for transmission of the PDSCH, the block of complex valued symbols, are mapped in sequence to resource elements not occupied by the other physical downlink channels except PDSCH, or synchronization and reference signals. The number of resource elements mapped to is controlled by the number of resource blocks allocated to the PDSCH. The symbols are mapped by increasing the subcarrier index and mapping all available REs within allocated resource blocks for each OFDM symbol [8].

OFDM Modulation: Data stream are modulated to much orthogonal sub-carriers in parallel. A carrier will reduce each code element rate of the sub-carrier, increase the code element symbols cycle, and improve the system of anti-interference ability. OFDM modulation is mainly for Inverse Fast Fourier Transform (FFT) [9].

3. LTE UPLINK TRANSCEIVER

LTE uplink (from device to tower) transmission is based on SC-FDMA. Uplink transmission is organized in a frame structure with the frame duration of 10 ms [6]. SC–FDMA increases the capacity of the users by means of using several frequencies for carrying the data of a single user and low the BER [4].

3.1 PUSCH Transceiver

The transmitter and receiver structure of the LTE Uplink is shown in Figure 2.

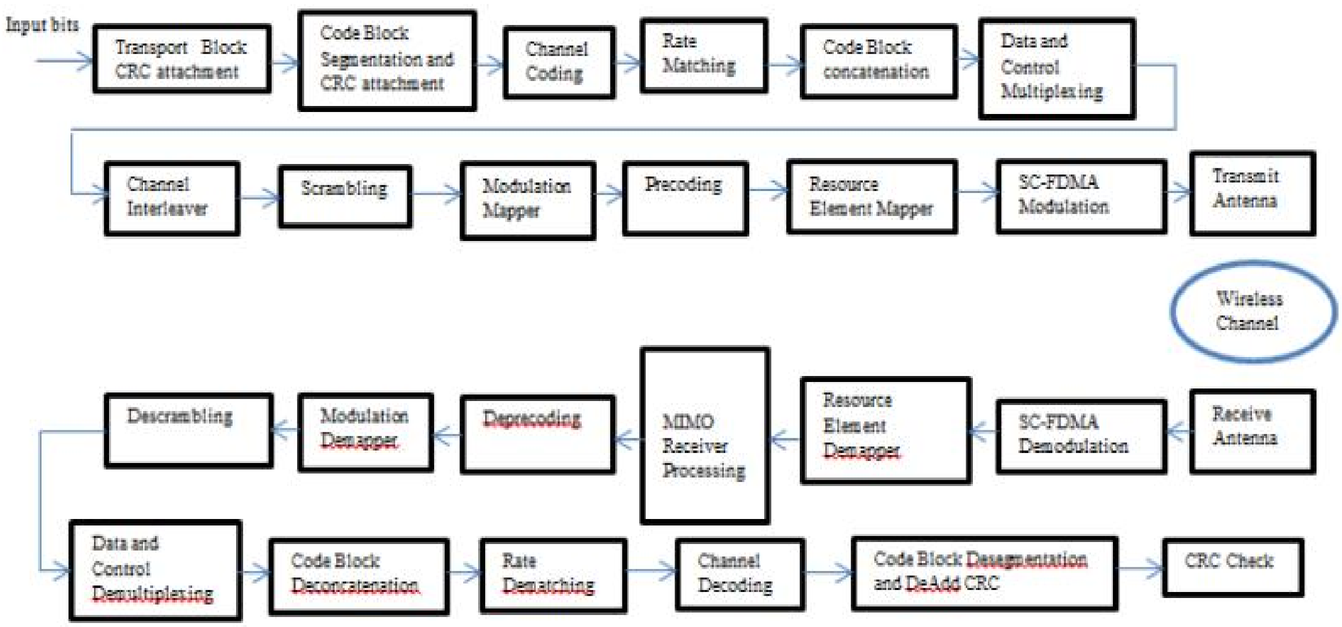

Fig. 3. PUSCH Transmitter and Receiver Structure[12]

PUSCH channel can be divided into bit level, symbol level and sample level [7]. The physical uplink shared channel is used to transmit the uplink shared channel (UL-SCH) and control informatio.

UL-SCH is the transport channel used for transmitting uplink data (transport block) which undergoes transport block coding. The encoding process includes type-24A CRC calculation, code block segmentation and type-24B CRC attachment, rate matching with and code block concatenation. The PUSCH transmission processing steps for the PUSCH as described in [1], includes:

- Transport block CRC attachment
- Code block segmentation and CRC attachment
- Channel coding
- Rate Matching
- Code Block Concatenation

Data and Control Multiplexing: The transport data and control multiplexing is performed such that HARQACK information is present in both slots and is mapped to resources around the demodulation reference signals. The mapping is important, as it assumes the channel estimation are of better quality.

Channel Interleaver: The channel interleaver implements a first time mapping of modulation symbols onto the transmit waveform while ensuring that HARQ information is present on both slots.

Precoding: The PUSCH precoding is not the same as the downlink (multi-antenna) precoding. The block of valued symbols, is divided into sets. Each set corresponds to one SC-FDMA symbol. A Discrete Fourier Transform is then applied to each set, essentially precoding part of the SC-FDMA modulation [10].

Mapping to Resource Elements.: The final stage in the PUSCH processing is to map the symbols to the allocated physical resource elements. The allocation sizes are limited to values whose prime factors are 2, 3 and 5. The symbols are mapped in increasing order beginning with subcarriers, then SC-FDMA symbols.

SC-FDMA modulation: is based on the OFDM approach, however, a Discrete Fourier Transform (DFT) precoding of the signal is employed. This operation spreads individual subcarriers which are known from the OFDM system over the assigned bandwidth and convert it to a single-carrier transmission, thus effectively reducing the PAPR [13], and improving the cell edge coverage and User Equipment (UE) battery life [14].

4. CONCLUSIONS

LTE transceiver downlink (PDSCH) and uplink (PUSCH) transmissions has been analyzed and it is concluded that LTE technology is more efficient, reliable, provides low BER and high data rates system in comparison to the other wireless communication technologies.

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