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PERFORMANCE ANALYSIS OF LTE-MIMO FOR DOWNLINK & UPLINK END-TO-END SIMULATION

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Abstract - *Third Generation Partnership Project (3GPPP) grew Long Term Evolution which is era's next standard. Examination of the physical layer (PHY) of LTE handset in downlink and uplink transmissions is performed in this paper. By utilizing LTE System Toolbox by Mathworks, recreation of the physical layer of LTE handset is gotten. The execution examination of LTE handsets end to end reproduction in Physical Downlink Shared Channel (PDSCH) and Physical Uplink Shared Channel (PUSCH) are introduced in Simulation comes about. For various re-enactment setups, throughput and Bit Error Rate (BER) estimations are acquired.*

***Key Words*: LTE, DL-SCH, PDSCH, UL-SCH, PUSCH, PHY**

1. INTRODUCTION

3GPP chosen to update the centre and radio system bringing about the advancement of Long Term Evolution (LTE) to conquer the impacts of multipath fading. 4G LTE is a rapid remote correspondence standard which builds framework's ability and information rates and created by 3GPP. It satisfies the point of accomplishing worldwide broadband portable interchanges. By expanding the transmission channel, the transmission speed is expanded, which is accomplished by expanding narrowband transporter's number without changing the parameters for the narrowband channels themselves. The band of frequencies utilized as a part of LTE gadgets depend on the range which is made accessible by the system administrators. The multipath impact is diminished in view of the more extended transmission steps. The destinations incorporate enhanced radio get to information rates, improved framework limit alongside unearthly proficiency, multi-receiving wire bolster, diminished working costs, adaptable data transmission, low inactivity. LTE varies from the prior innovations in numerous viewpoints, for example, modulation Schemes utilized, Frame structure, Channel processing.

LTE Release 8 holds facilitate HSPA Evolution elements, for example, utilizing MIMO and 64 QAM all the while. With 3GPP Release 10, new thoughts to further push the breaking points are indicated as a major aspect of the LTE-Advanced venture to follow the International Telecommunication Union's (ITU's) for 4G remote systems.

Release 9 came in December 2009 [5]. It included components, for example, Multimedia Broadcast/Multicast Services bolster, area benefits, and provisioning for base stations that bolster various benchmarks. LTE-Advanced (discharged in December 2010) is a change of the first LTE standard. It incorporates advances, for example, bearer collection, upgraded downlink MIMO, uplink MIMO, and transfers [5].

The LTE and LTE-Advanced are produced by the 3GPP. They display the properties from earlier 3GPP benchmarks. The Release 8 LTE standard later developed to LTE Release 9 with minor adjustments and afterward to Release 10, otherwise called the LTE-Advanced standard with the pinnacle information rate of 1 Gbps. Uplink is the transmission from the UE or client gear to the eNodeB or the base station in execution of physical channel downlink according to Release 8 and 9.

2. IMPLEMENTATION OF DOWNLINK PHYSICAL LAYER

Transmission and gathering of information in and from the transport blocks is the central part of physical layer (PHY). An arrangement of asset components is dispensed to each and every physical channel in the time-frequency grid which conveys data to and from higher layers. The genuine transmission of information is performed by PHY layer. Transport channel processing incorporates DL-SCH as appeared in Fig. 1.

2.1. DL-SCH (Down Link Shared Channel)

DL-SCH as appeared in the Fig. 2, comprises of taking after strides to be specific

1. Transport block CRC Attachment
2. Code Block Segmentation and CRC Attachment

3. Turbo Coding
4. Rate Matching
5. Code Block Concatenation [1, 2, 3, and 4].

2.1.1. Transport Block CRC Attachment

In the downlink, the base station adds a 24-bit CRC to every DL-SCH transport blocks, which the mobile will in the long run use for error identification. For the count of CRC parity bits, the transport blocks is utilized totally [6]. As depicted in [3], with a specific end goal to produce 24 parity bits, the total transport block is partitioned by cyclic generator polynomial. The generated parity bits are connected toward the end of the transport block.

2.1.2. Code Block Segmentation and CRC Attachment

In LTE, the turbo interleaver underpins minimum & maximum block sizes of 40 and 6144 bits separately keeping in mind the end goal to make it perfect with the block sizes of turbo interleaver. Code segmentation of the input block is done if the length surpasses the most extreme code block size [6]. For the fragmented code hinders, the 24 bit CRC is affixed toward the finish of each block and the parity bits are produced utilizing same cyclic generator polynomial [8]. For the situation when segmentation is not required just 1 code block is acquired. In the event that the code block size is not as much as the minimum size then zeros are annexed at the beginning of the code blocks.

2.1.3. Turbo Coding

Turbo coding is performed on the code blocks in DL-SCH with the code rate of 1/3. The channel limit can be improved by including the repetitive data so it is the type of forward error correction [6]. This encoding employs:

- Parallel connected convolutional code (PCCC) with 2 recursive convolutional coders.
- Interleaver in light of Quadratic change polynomial (QPP) – It is most extreme contention free which implies that when diverse parallel procedures are getting to the interleaver memory, the disentangling should be possible parallel with no hazard for contention [9].

2.1.4. Rate Matching

Turbo coders yield is given to the rate matching block which yields the bit stream with the coveted code rate. The rate matching algorithm has the ability of creating any discretionary rate, as the quantity of bits accessible for transmission relies on the resources. The 3 bit streams from the turbo encoder are interleaved trailed by bit gathering to make a circular buffer. Bits are chosen and pruned from the buffer to make output bit stream with the coveted code rate. The Hybrid Automatic Repeat Request (HARQ) error correction plan is consolidated alongside the rate- matching algorithm of LTE.

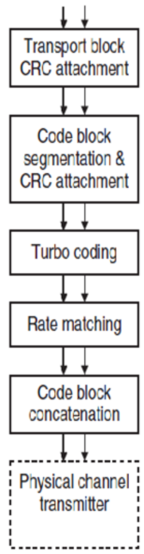

Fig-1: Downlink Shared Channel (DL-SCH) [7]

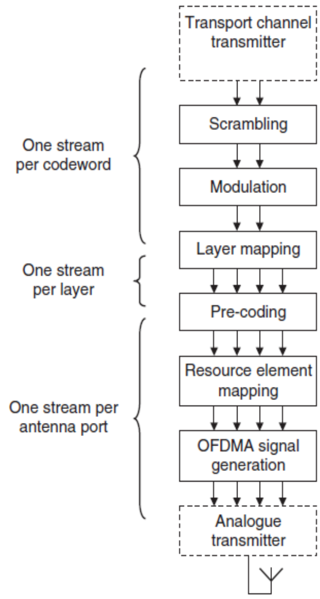

Fig-2: Physical Downlink Shared Channel (PDSCH) [7]

2.1.5. Code Block Concatenation

In this stage, the rate matched code blocks are concatenated back together. By linking the rate- matched code blocks successively this assignment is performed together keeping in mind the end goal to make the yield of the channel coding.

2.2. PDSCH (Physical Downlink Shared Channel)

Processing of the Physical layer (PHY) holds PDSCH which incorporates followings steps:

1. Scrambling
2. Modulation
3. Layer mapping
4. Precoding
5. Resource Mapping
6. OFDM Modulation

The blocks are clarified in detail individually [1, 2, 3, and 4].

2.2.1 Scrambling

The codeword delievered by the hybrid-ARQ usefulness are bit wise multiplied (exclusive-or operation) by bit- level scrambling sequence to create the symbols for the codeword.

2.2.2 Modulation

The scrambled bits are modulated by means of modulation schemes, for example, QPSK, 16QAM, and 64QAM, relating to two, four, and six bits for each modulation symbol respectively.

2.2.3 Layer Mapping

Contingent upon the number of transmit antennas the modulated symbols are mapped to 1, 2 or 4 layers. Layer mapping exists for transmit diversity and for spatial multiplexing. For

- Transmit Diversity - Based on the quantity of layers, input symbols are mapped to layers.
- Spatial Multiplexing-The quantity of layers utilized is constantly less or equivalent to the number of antenna ports utilized for transmission of the physical channel.

2.2.4 Precoding

As per diverse methods of transmission, on each layer symbols will be pre-coded for transmission on the antenna ports. The modes can be spatial multiplexing, transmit diversity, and single antenna port transmission.

2.2.5 Resource Mapping

The complex esteemed symbol blocks are mapped to resource elements successively and are not possessed by the other physical downlink channels aside from PDSCH, synchronization and reference signals for each of the antenna ports utilized for transmission of the PDSCH. The quantity of resource blocks dispensed to the PDSCH controls the quantity of resource elements mapped. By expanding the subcarrier index and mapping every single accessible RE inside allocated resource blocks for each OFDM symbol, the symbols are mapped.

2.2.6 OFDM Modulation

Modulation of information stream to much orthogonal sub-carriers in parallel is finished. A carrier will bring about

- Reduction in each code element rate of the sub-bearer
- Increase in the code element symbols cycle
- Improvement in the arrangement of anti-interference ability

OFDM modulation is primarily for Inverse Fast Fourier Transform (IFFT).

3. IMPLEMENTATION OF UPLINK PHYSICAL LAYER

LTE uplink (from gadgets to tower) transmission depends on SC-FDMA and sorted out in an frame structure with the frame length of 10 ms [7]. By utilizing a few frequencies for conveying the information of a solitary client and enlarges the BER, SC–FDMA builds the capacity of the users.

3.1. PUSCH Transceiver

The uplink shared channel (UL-SCH) and control data (L1 and L2) is transmitted by the physical uplink shared channel (PUSCH) is portrayed in fig 3 and fig 4.This channel can be separated into bit, symbol and sample level. UL-SCH is the transport channel utilized for transmitting uplink information (a transport block) which experiences transport block coding. The PUSCH transmission preparing ventures for the PUSCH incorporates:

3.1.1 CRC Insertion per Transport Block

For every uplink transport block a 24-bit CRC is ascertained for and annexed.

3.1.2 Code-Block Segmentation and per-Code-Block CRC Insertion

Code-block segmentation, including per-code-piece CRC inclusion, is same as that connected for transport blocks bigger than 6144 bits in the downlink processing.

3.1.3 Channel Coding

Much the same as downlink Rate-1/3 Turbo coding with QPP-based internal interleaving is utilized for the uplink.

3.1.4 Rate Matching and Physical-Layer Hybrid-ARQ Functionality

The physical-layer portion of the uplink rate-matching and hybrid- ARQ functionality is basically the same as the relating downlink functionality, with sub-block interleaving and inclusion into a circular buffer taken after by bit choice with four redundancy variants with some essential contrasts between the downlink and uplink hybrid-ARQ conventions, for example, asynchronous versus synchronous operation. Be that as it may, these distinctions are not unmistakable regarding the physical-layer processing.

3.1.5 Bit-level Scrambling

Randomization of the interference and guaranteeing that the processing gain given by the channel code can be completely used is the aim of uplink scrambling.

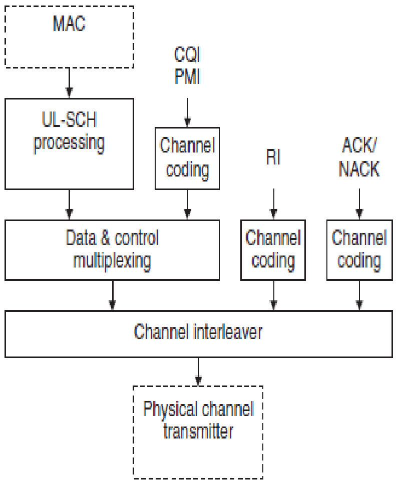

Fig-3: Uplink Shared Channel (UL-SCH)

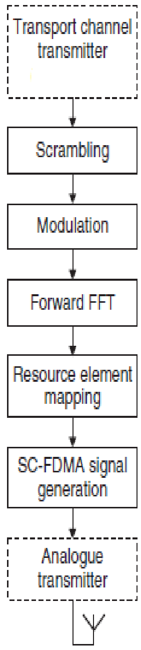

Fig-4: Physical Uplink Shared Channel (PUSCH)

3.1.6 Data Modulation

For uplink transport-channel transmission, QPSK, 16QAM, and 64QAM transmission can be utilized like the downlink.

3.1.7 DFT Precoding

The modulation symbols in blocks of M symbols, are encouraged through a size-M DFT, where "M" is the quantity of subcarriers doled out for the transmission. Precoding is done to decrease the cubic metric for the transmitted signal.

3.1.8 Layer Mapping

For resulting mapping to the physical resource (the OFDM time–frequency framework), the yield of the DFT precoder is mapped to antenna ports by layer mapping.

3.1.9 Mapping to the Physical Resource

For transmission of the PUSCH physical channel that conveys the UL-SCH transport channel, the scheduler appoints an arrangement of RB (resource block) sets to be utilized for the uplink transmission. Each such RB match traverses 14 OFDM symbols (1 subframe) in time. In any case, for uplink demodulation reference signals two of these images are utilized thus not accessible for PUSCH transmission [7]. Besides, for the transmission of sounding reference signals, one extra symbol might be reserved. Along these lines, 11 or 12 OFDM symbols are accessible for PUSCH transmission inside every RB pair.

4. SIMULATION RESULTS AND ANALYSIS

Simulations are important for testing and dissecting the development, institutionalization of LTE, and also for the usage of types of equipments. In this paper, utilizing the Mathworks LTE System Toolbox the re-enactment is being performed. Throughput and Bit Error Rate (BER) execution results are investigated for physical layer in both downlink (PDSCH) and uplink (PUSCH) end to end simulation.

4.1 PDSCH Spatial Multiplexing Throughput Simulation

LTE System Toolbox capacities are utilized to demonstrate the PDSCH throughput of a transmit & receive chain. Channel Noise is added to the received waveform which is then OFDM demodulated, bringing about a receive resource grid for each reception antenna. Channel estimation is performed to decide the channel between each transmission/reception antenna pair . PDSCH information is then extricated and decoded from this recouped resource grid [10]. PDSCH Spatial Multiplexing throughput simulation is appeared in Table 1. The recreation brings about Fig. 5 and Fig. 6 demonstrate the throughput for 4x2 and 4x4 receiving wire setup. For 4x2, the throughput is over 70% at the point when SNR is 10.5 dB or more. For 4x4 , the throughput is over 70% when SNR is under 5.5 dB or more 7.5 dB it turns out to be relentless.

TABLE-1: PDSCH Spatial Multiplexing Throughput Simulation

Transmission Scheme	Spatial Multiplexing
Number of Transmitters	4
Number of Receivers	Case 1: 2 Receivers Case 2: 4 Receivers
Multi-Antenna Correlation	Low
Propagation Channel	EVA-5(Hz)
HARQ	8
Reference Channel Measurement (RMC)	R.14

Number of Frames	10
Signal to Noise Ratio (SNR) Range	[5.5 7.5 9.5 10.5 12.5] (in dB)

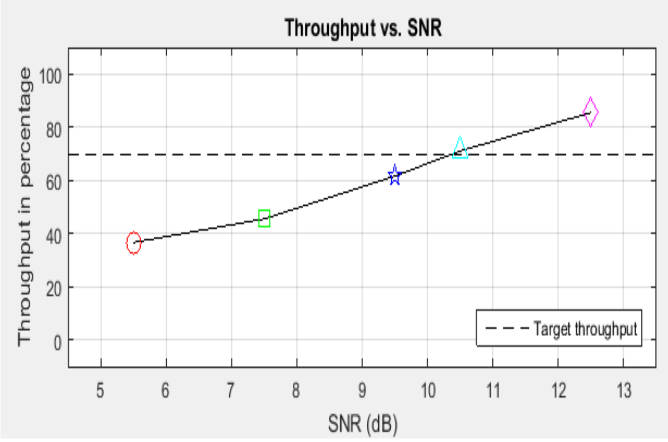

Fig-5: PDSCH Throughput against the range of SNRs for 4x2 Spatial Multiplexing.

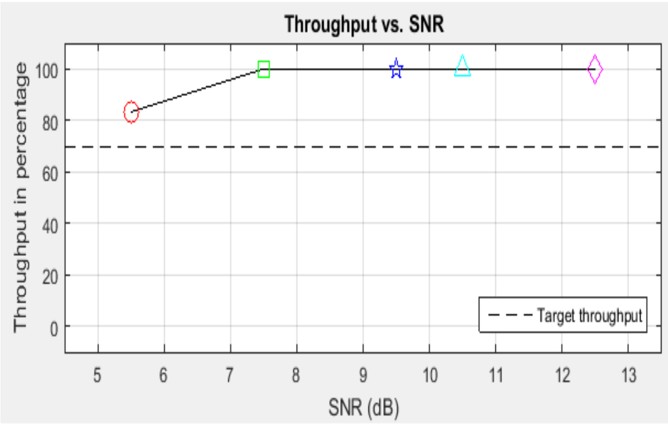

Fig-6: PDSCH Throughput against the range of SNRs for 4x4 Spatial Multiplexing

4.2 PUSCH Throughput Simulation

LTE System Toolbox capacities is utilized to demonstrate the PUSCH throughput of a transmit/receive chain. Channel noise is added to the received waveform which is then SCFDMA demodulated, bringing about a received resource grid for each receive antenna. Channel estimation is performed to decide the channel between each transmit/receive antennas. PUSCH information is then separated and decoded from this recuperated asset lattice [10]. The PUSCH throughput simulation is appeared in Table 2. The recreation brings about Fig. 7 & Fig. 8 demonstrates the throughput for two & four receiving antennas respectively. For 2 receiving antennas the throughput is over 70% when SNR is – 1.2dB or more; additionally, the throughput is steady when SNR is –0.1dB or more. For 4 receiving antennas, the throughput is above 70% when SNR is -3.0dB or more. At that point the throughput increments and turns out to be consistent when SNR is -1.6dB and above.

TABLE-2: PUSCH Throughput Simulation

Number of Receivers	Case1: 2 Receivers Case2: 4 Receivers
Propagation Channel	ETU-70(Hz)
Multi-Antenna Correlation	Low
HARQ	8
Fixed Reference Channel (FRC)	A3-1
Number of Frames	1
Signal to Noise Ratio (SNR) Range	[-5.0 -2.0 -1.6 -0.1 2]dB

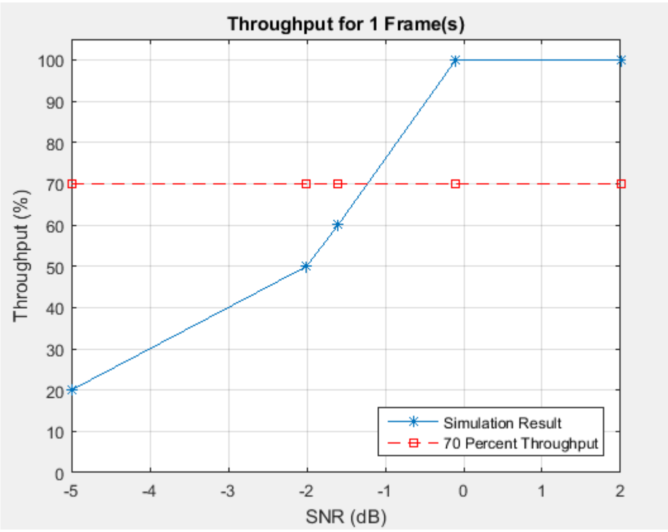

Fig-7: PUSCH Throughput against the range of SNRs of 2 Receive Antennas

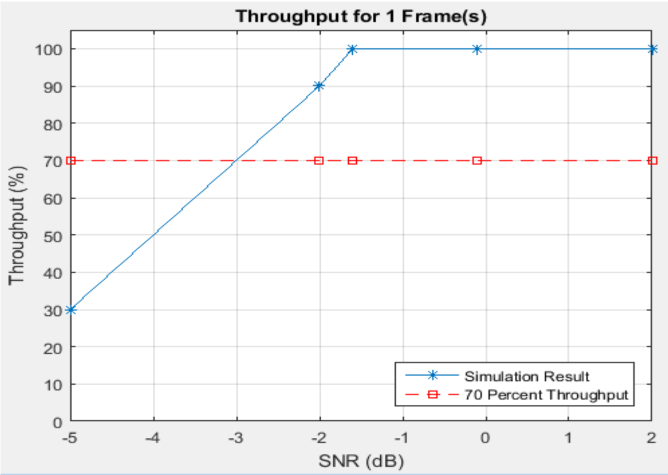

Fig-8: PUSCH Throughput against the range of SNRs of 4 Receive Antennas

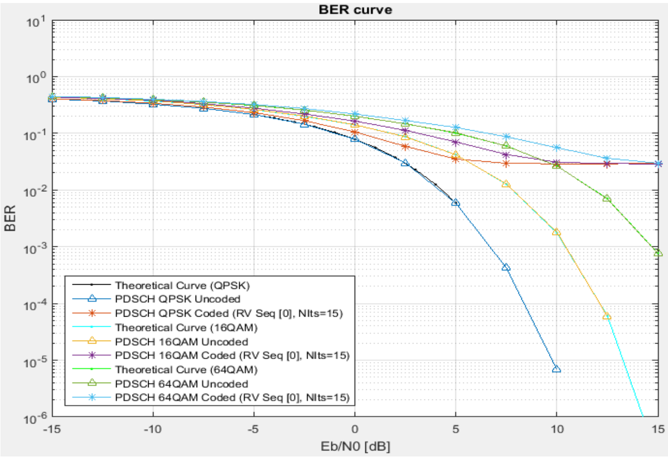

Fig-9: BER Curves for Transport Block Size of 2000

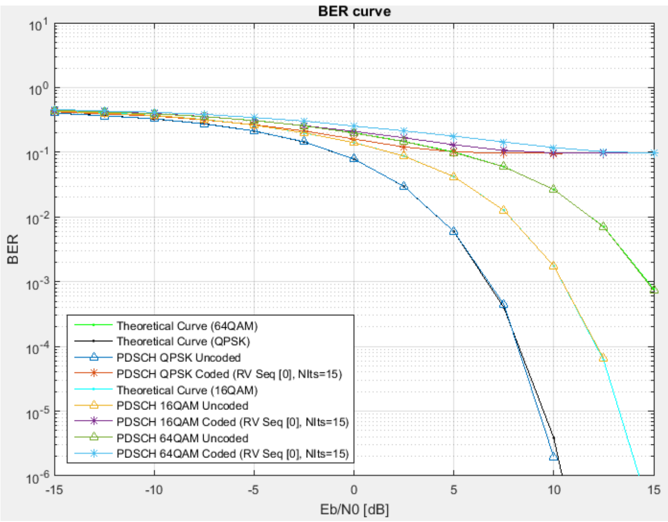

Fig-10: BER Curves for Transport Block Size of 2500

4.3 PDSCH Bit Error Rate (BER) Simulation

The LTE System Toolbox is utilized to make PDSCH BER curves under Additive White Gaussian Noise (AWGN) in a straightforward Graphical User Interface (GUI). Diverse BER bends are plotted for SNR go values (- 15 to 15), transport block Size (2000, 2500), and modulation schemes: QPSK, 16QAM, 64QAM. The BER bends in Fig. 9 and Fig. 10 demonstrate that the BER bends drop quickly with expanding SNR for the coded adjustment plans. It additionally demonstrates that when the transport block size expands the BER bends increments. Additionally, the BER bends increments with the coded adjustment plans (QPSK, 16QAM, 64QAM) separately.

5. CONCLUSIONS

This paper has dissected LTE end to end simulation in downlink (PDSCH) and uplink (PUSCH) transmissions. The reenactment are obtained from the LTE System Toolbox additionally dissected the execution of the LTE transceiver by the deliberate throughput and BER charts appeared previously. These outcomes indicate obviously the throughput and BER that can be normal for various SNR values. Additionally work can be done via doing different downlink and uplink end to end reenactments, and displaying with the LTE System Toolbox

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