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Quality of Service (QoS) by Utility Evolved Packet Core (EPC) in LTE Network

***Abstract**. LTE which stands for Long Term Evolution is one of wireless broadband technology which provides an increased on both network capacity and speed to user. As LTE network grows, LTE mobile data services becomes demanding mode of communication. From audio call to video conference, video conference to online bank transaction, user lives conveniently with LTE. The speed of LTE network is up to 300 Mbps with the coverage of 100 km. However, LTE network could not be standalone on this chain for so long as it might occur generalization of services where the quality cannot be guarantee. Here Quality of Service (QoS) play it roles in managing and design wireless services that suit every single user necessity. QoS refers to the ability of a network to accomplish maximum bandwidth and handle with another element within network performance. Not to mention, minor support that made this possible is by studying on how EPC could make a different in improving the QoS in LTE network. Evolved Packet Core (EPC) is designed to support smooth transfer for voice and data to a base station. Hence, investigation in benefit of EPC toward QoS in LTE is carry out and simulation result obtained will be evaluated throughout this paper.*

***Streszczenie.** In this place is allowed to use Google Translation tool*

Keywords: Evolved Packet Core (EPC), Long Term Evolution (LTE), Standalone, Quality of Service (QoS).
Słowa kluczowe: please use Google Translation.

Introduction

Long Term Evolution or known as LTE is one of the 4G standard for wireless communication technology which increases spectral efficiency and radio use, improves data rates in terms of capacity and throughput and then also reduces latency. LTE is developed as a packet switch, although it is an IP-based network, which really means it is an IP packet. It adopts OFDM as the transmission system for downlinks. The uplink transmission system is based on SC-FDMA to prevent a problem with synchronization [1].

The 3rd Generation Partnership Project (3GPP) designated Long Term Evolution (LTE), which also delivers GSM, GPRS, WCDMA, and HSPA. At the end of the year 1998, the GSM release 98 was completed and was followed by WCDMA release 99 at the end of the year 1999. The first Universal Mobile Telecommunication Services (UMTS) have been specified by WCDMA and offered a data rate of 2 Mbps. In March 2002 and December 2004, the UMTS was upgraded to HSDPA and HSUPA, respectively. In 2007, the evolution resumed to HSPA+ version 7. By the end of the year 2007, LTE of version 8 was approved, and its underdeveloped compatibility started in 2009 [1].

In release 8, LTE was introduced. It had been pure based on a flat architecture on all IPs and introduced new structure, elements which has been reduced with simplicity and low in latency that will be more discussed detail later. The 2600 MHz frequency band is considered capable for interacting with already-existing UMTS, but under different circumstances other frequency with low bands are also considered for LTE [2]. LTE promises the theoretically high data rates ranges from 85 Mbps up to 170 Mbps. LTE offers many sensitive services delays, such as VoIP and applications in real-time. Latency is an essential issue for wireless service performance and proficiency evaluation. Lower than 15ms can be achieved with pre-allocated resources. Round trip delay can be 20ms with scheduling delay. These round-trip delays are sufficiently low to support sensitive applications in real time. LTE can interact with 3G systems. Additional LTE improvements are introduced in Advanced version of LTE (LTE Advanced), which is reverse compatible with LTE and version 10 was introduced [3, 5].

Quality of Service (QoS) is defined as the ability of a network to accomplish optimum bandwidth and handle with another element of network performance such as latency, error rate, and uptime. It also role the parts in controlling and managing network resources by priorities setting for fixed types of applications (video conferencing, VOIP, and file transfer) on the network. Therefore, many of QoS of Radio Access Network (RAN) current studies are adapted to LTE infrastructure [6, 7].

Most essential features in EPC are the voice service in circuit-based and data service packet-based of initial 2G and 3G networks where every single mobile IP is under unified domain, an evolution of the packet-based domain of the earlier GPRS / UMTS network. In addition, network digitalized organizer in the EPC have division in term of the control plane and data plane. This feature gives carriers operators flexibility to optimize their signalling and traffic of data capacity independently [8].

QoS Parameter of LTE

Quality of Service in LTE have a several parameters that have a promising performance which is equivalent or much better than others wireless network such as Wi-Fi. Although the technical limitations are high, there is following aspect that should be considered which due to the complexity existed in mobile networks data and services of multimedia which are namely as VoIP, Voice over Internet Protocol VoIP on Mobile Phone, Video/Audio Streaming, Content

Downloading, and multiple kind of Services and Application [9].

The capacity of the telecommunications network to accommodate traffic is throughput and actual bandwidth. The real volumes that are measured as bit/s was define as throughput [10]. Increasing the network bandwidth can aid to improve service quality, but to fix this issue by adding bandwidth alone, additional cost of operating can be unfairly generated as efficiency of service can be evolved and achieved by many other means, and the throughput ratio or actual bandwidth and theoretical bandwidth can be determined by referring to Table 1 [11].

Table 1. Throughput Standard [3]

	Rate	Throughput
Throughput Quality	Very Fine	100%
	Fine	75%
	Average	50%
	Bad	<25%

Next, is the packet loss which defines as failure to accomplish packets transmissions due to several factors. The capacity of the network are overthrow by the immoderately high number of needs for already existing bandwidth. The packets loss calculates the failure of packet in percentage of the actual packets traffic. If the packet outdated exceed 15%, it can be less as shown in Table 2 [11].

Table 2. Packet Loss Percentage [3]

	Rate	Packet Loss Percentage
Packet Loss Quality	Very Fine	0%
	Fine	3%
	Average	15%
	Bad	25%

Furthermore, the delay in the transfer of point-to-point data is known as delay or latency, which may depend on the paths or distances involved, certain service networks speeds, for example. The VoIP service for prompt, fast transfers of data that are very essential because any present of delay could slow down the flows of conversation. Measurement of delay can be determined through the ratio packet length in bit or bandwidth link (bit/s) due to different factors. When the delay is more than 400 milliseconds (ms), the standard of network is less the standard as mentioned in Table 3 [12].

Table 3. Standard of Delay [3]

	Rate	Delay (ms)
Delay Quality	Fine	0-5
	Average	150-400
	Bad	>400

Jitter is defined as the phase of channel instability in a network which means different degrees of delay in each packet. The unstable data rate transfer delays are known as jitter, where it is mostly occurs during switching in packet. However, the corresponding jitter level must not overreach 50 ms as shown in Table 4 [13].

Table 4. Jitter Value [3]

	Rate	Jitter (ms)
Jitter Quality	Fine	0-20
	Average	20-50
	Bad	>50

Result and Discussion

MATLAB was used as the simulation software to model the LTE quality PHY and to give a future perception into its requirements for develop a better simulation and accomplishment. MATLAB environment has a commonly used language and a high-level development especially when it comes to execute for math and modeling for numerical. Simulink was also used, where there are various MATLAB toolboxes application to allow the task of MATLAB modeling applications. For example, the function that embedded in the simulation software can be obtained from the Communication System Toolbox to model desired communications systems. The toolbox offers tools for designing, prototyping, simulating, and verifying communications systems [14, 15].

The simulations are conducted by using the LTE Toolbox. Performance results for Throughput, BER and Packet Loss were analyzed for Physical Downlink Shared Channel (PDSCH) transceiver [16]. The PDSCH throughput of a transmitting or receiving chain is presented with LTE System Toolbox functions. Channel noise is included in the simulation but later is demodulated by OFDM technique [17].

The parameters used throughout the simulations is presented in Table 5. Fig. 1 shows the throughput for 10 frames. Based on the results obtained, the throughput for 10 frames is above 70% when only the SNR is above 0.5dB. As for 100 frames, the result is different. Fig. 2 demonstrates that the throughput for 100 frames dropped under 70% within the same SNR range. Therefore, we expand the SNR range in order to understand more about this behavior. The throughput is above 70% when SNR is 3.5dB and above as shown in Fig. 3. Later, with the SNR range of -6 to 10dB, the throughput is also above the margin of 70% as described in Fig. 4.

Table 5. Simulation Parameter [18]

Codeword	Single
Transmission Scheme	Transmit Diversity
Number of Transmitters	4
Number of Receivers	2
Multi-antenna Correlation	Medium
Propagation Channel	Extended Pedestrian A (EPA 5)
HARQ	8 HARQ retransmission processes
Reference Measurement Channel (RMC).	R.12
Number of Frames	10 (1st simulation), 100 (2nd simulation), 100 (3rd simulation), 100 (4th simulation), 1000 (5th simulation).
Signal to Noise Ratio (SNR) Range	[-2,2] (1st simulation), [-2,2] (2nd simulation), [-6,6] (3rd simulation), [-6,10] (4th simulation) and [-6,10] (5th simulation).

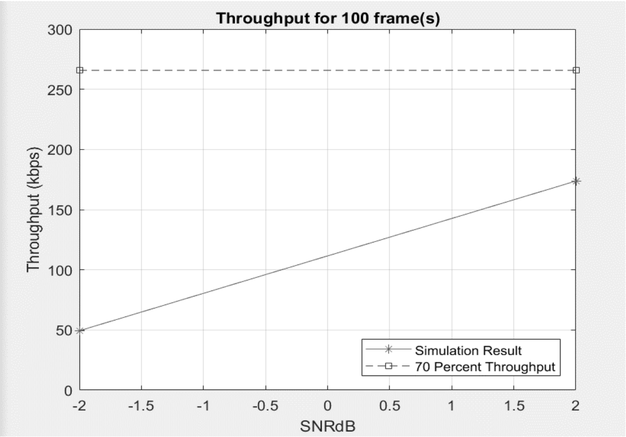


Fig. 1. Throughput for 100 frames against the range of SNR -2 and 2 dB

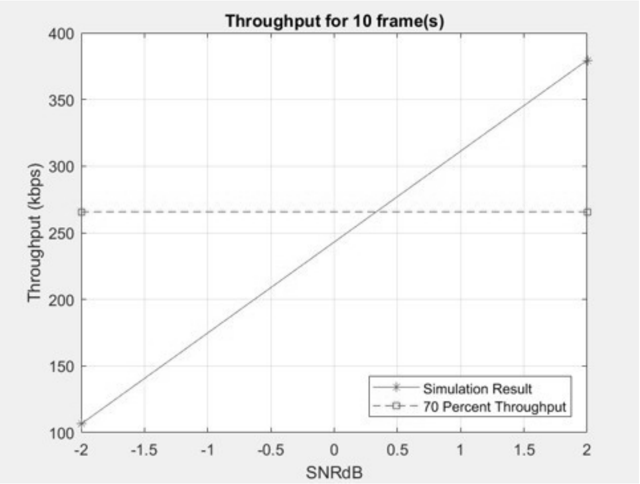


Fig. 2. Throughput for 10 frames against the range of SNR -2 and 2 dB

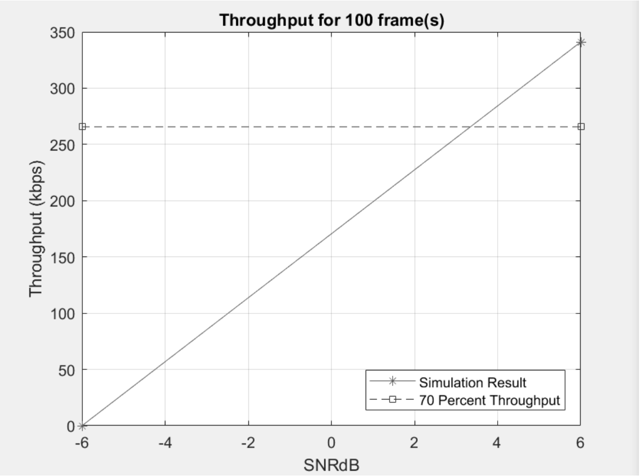


Fig.3. The throughput for 100 frames against the range of SNR -6 and 6 dB

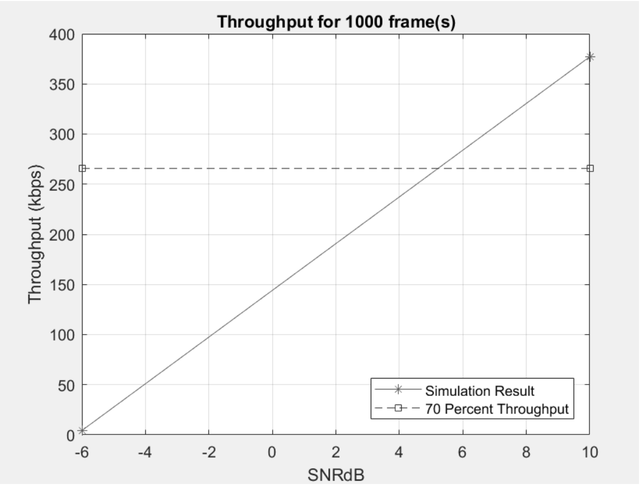


Fig. 4. The throughput for 1000 frames against the range of SNR -6 and 10 dB

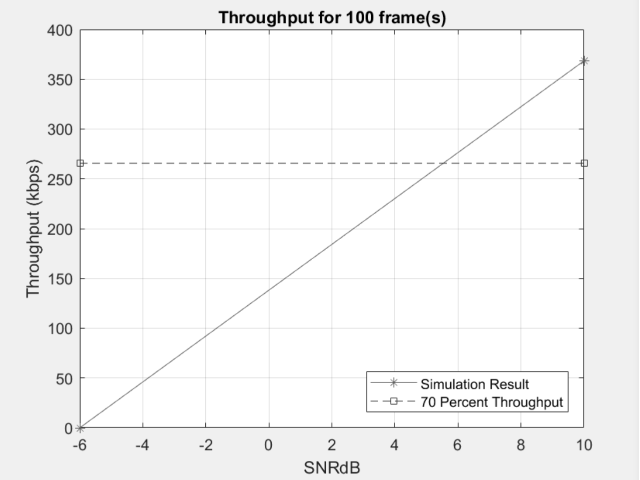


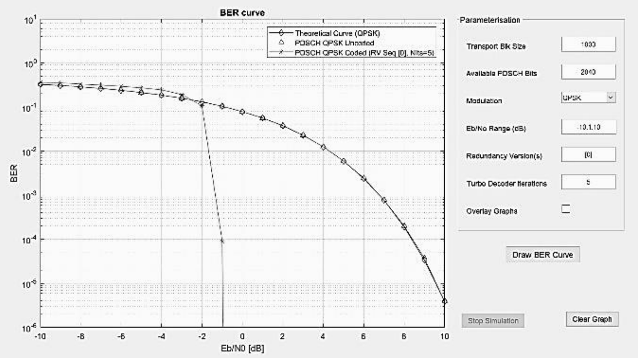
Fig. 5. The throughput 100 frames against the range of SNR -6 and 10 dB

Any communication system critical goal is to transmit and receive data without error. Regarding to this matter, during the transmission and reception process, the communication system has as little BER as possible. BER is therefore a very important pointer for showing how well a communication system is designed. To prove that a communication system is well desired, the estimated (theoretically calculated BER) is lower than a certain level of acceptance and the measured BER is lower than a certain level of acceptance after building the device [19, 20].

The PDSCH BER Curve Generation simulation parameter is shown in Table 6. The analysis covers the SNR range values of -10 to 10dB, the transport block size of 1000 and 1200, and multiple modulation schemes; QPSK, 16QAM, 64QAM. Results obtained are explained below. Fig.6, 7 and 8 shows the graphs of BER for the size of 1000 block size with three different modulation schemes. The optimum result is obtained for the 64QAM modulation scheme which performing the highest similarity with the theoretical BER graph when it starts to drop at the highest distant of the SNR range. Next, we increase the size of the block size to analyse the outcome on the BER graphs as in Fig.9, 10,11. As the summarization, the graphs show that the BER curves for the coded modulation schemes are decreasing rapidly with increasing SNR. It also shows that the BER curves increase when the size of the transport block increases.

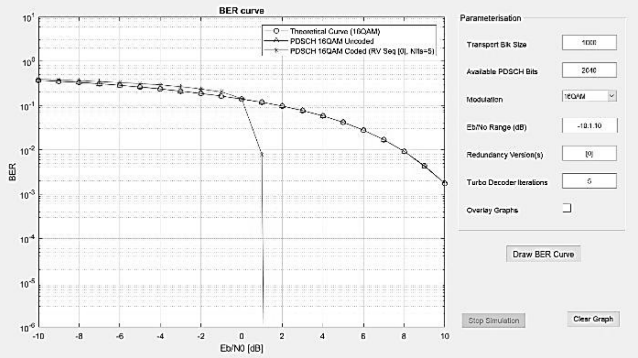
Table 6. Simulation Parameter [18]

Parameter Name	Description
Transport No. Block Size	Size of transport block
PDSCH Bits Available	Size of coded transport block after rate matching (codeword size)
Modulation	QPSK,16QAM, 32-QAM, 64 QAM
SNR Range	Eb/No range in dB
RV Seq	Redundancy version indicators sequence
Number turbo Deceits	Number of turbo decoder iteration cycles
Overlay Graphs	Holds the previous graphs when checked, thus overlays new curve on previously drawn curves



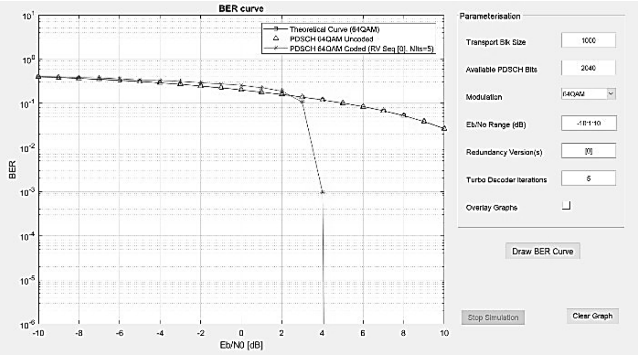
Transport Blk Size 1000
Available PDSCH Bits 2040
Modulation QPSK
Eb/No Range (dB) -10:1:10
Redundancy Version(s) [0]
Turbo Decoder Iterations 5
Overlay Graphs ☐

Fig. 6. The BER Curve for Transport Block size of 1000 (QPSK)



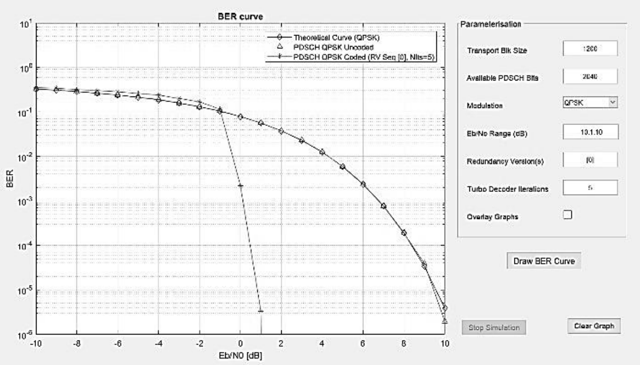
Transport Blk Size 1000
Available PDSCH Bits 2040
Modulation 16QAM
Eb/No Range (dB) -10:1:10
Redundancy Version(s) [0]
Turbo Decoder Iterations 5
Overlay Graphs ☐

Fig. 7. BER Curve for Transport Block size of 1000 (16QAM)



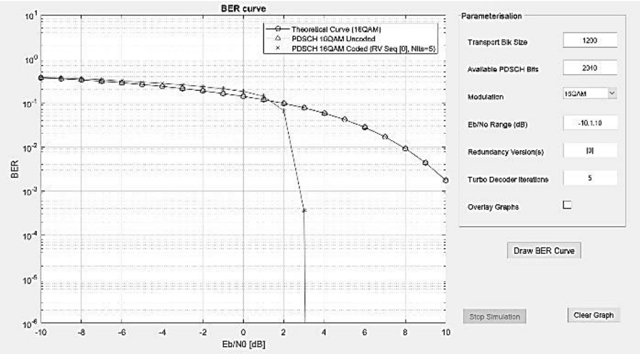
Transport Blk Size 1000
Available PDSCH Bits 2040
Modulation 64QAM
Eb/No Range (dB) -10:1:10
Redundancy Version(s) [0]
Turbo Decoder Iterations 5
Overlay Graphs ☐

Fig. 8. The BER Curve for Transport Block size of 1000 (64QAM)



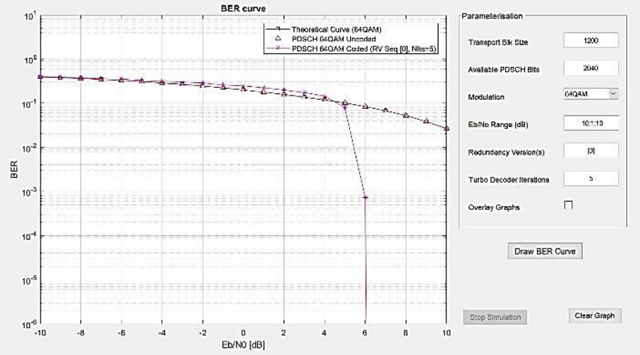
Transport Blk Size 1200
Available PDSCH Bits 2040
Modulation QPSK
Eb/No Range (dB) 10.1.10
Redundancy Version(s) [0]
Turbo Decoder Iterations 5
Overlay Graphs ☐

Fig. 9. The BER Curve for Transport Block size of 1200 (QPSK)



Transport Blk Size 1200
Available PDSCH Bits 2040
Modulation 16QAM
Eb/No Range (dB) -10:1:10
Redundancy Version(s) [0]
Turbo Decoder Iterations 5
Overlay Graphs ☐

Fig. 10. The BER Curve for Transport Block size of 1200 (16QAM)



Transport Blk Size 1200
Available PDSCH Bits 2040
Modulation 64QAM
Eb/No Range (dB) 10:1:10
Redundancy Version(s) [0]
Turbo Decoder Iterations 5
Overlay Graphs ☐

Fig. 11. The BER Curve for Transport Block size of 1200 (64QAM)

Conclusion

Throughout the research, LTE downlink transceiver (PDSCH) has been analyzed. The LTE module in MATLAB really helps our investigation through the LTE performance based on the obtained throughput and graphical analysis. Throughout the simulations, it shows that, results for throughput and BER yield a different plot for different values of SNR. The Throughput is also analyzed for the configure consideration of three eNB, where one eNB can be set as service and another two becomes as eNB interfering for distinct number of simulated frames calculated the result. If the number of frames increases, the result will remain in constant state.

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