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# Long Term Evolution Simulator - A Survey

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## Abstract

**Objectives:** Long Term Evolution(LTE) can be defined as a 4G wireless broadband technology developed by the 3GPP. It becomes the hopeful broadband ubiquitous Internet access technology. **Methods:** To maximize its working and performance many research works are going on in this field.It requires a flexible, more realistic and standard simulation environment is required to check its performance. LTE simulator is of different kinds system-level simulator and link-level simulator, hence there is a need to study in detail about this simulators. **Findings:** In this paper different simulators are discussed. The different simulators include physical-layer simulator, system-level simulator, link-level simulator. All simulator are analyzed with the BER (Bit Error Rate) and throughput results. **Applications:** This paper help to analyze the different types of simulators. Which helps to increase the performance of the LTE.

**Keywords:** Long Term Evolution (LTE), Link Level Simulator, Physical Layer Simulator, System Level Simulator, Uplink Connections and Downlink Connections

## 1. Introduction:

In the Third Generation Partnership Project (3GPP)[1] a telecommunication body developed the LTE (LONG TERM EVOLUTION)[2] a new project as the advancement of the 3G. The first development of the GPRS/3G packet core net- work was the System Architecture Evolution(SAE) and then it developed to all other. But the LTE and SAE is represented by the term LTE in common. Initially there is GSM form it the UMTS is developed then form it only the LTE evolved. The E-UTRA and E-UTRAN are the relevant stipulation which is a information[3]. The Release 8 of the 3GPP specifications is the First version of LTE document. To the way towards fourth generation mobile LTE, 3GPP is motivated by the more increasing in the internet usages and also the other thing like the Multimedia, Online Gaming, more and more web streaming and live TV shows and all others. The ultimate aim of this LTE technology is to give a more data rated mobiles, less delay and more packet switched radio access network which supports more flexible bandwidth deployments. Its network architecture has been organized with the main idea to support the packet switched trace with endless mobility and valuable quality of service. The layers are separated into Access Stratum and Non Access Stratum. The Access Stratum holds the Layer1, MAC, RLC and PDCP and the Non Access Stratum holds the RRC. In LTE development and standardization process for implementation of the manufactures, to optimize procedures and algorithms and for test the simulations are necessary. This is achieved in both link-level which is physical layer and the system-level which is network context. The LTE simulators, which are commercially available are developed along with the standard process. The vendors are also proposed their patent solutions for this. Some universities and research academy are also develop the simulators but some only have publically available source code.

### 1.2 Simulator Overview

Usually the simulator are using as a tool for the studying signal processing, MUI effects, multiple access schemes, channel estimation, MIMO transmissions and channel coding. There will be some challenges in scheduling of the downlink also for that also some novel algorithms are there to improve it performance. The various simulator are discussed here. The link-level simulations can be used for the checking of the MIMO gains issues and also includes the AMC, channel modeling of decoding and encoding Modeling of channels[4], or system-level

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modeling for the physical layer[5]. It is also more suitable for receiver structures developing[6], the strategies of the feedback[7], the issues like the interference, scheduling or cell selection will not affect. The simulation of totality of radio links is not possible in between the eNBs and the UEs in the system-level simulators since there is large value of computational power[8]. The system-level simulator concentrate more on the management of interference or handling of mobiles[9], and also it concentrates more on the scheduling issues related to the network[10].

With the advancement of the LTE technology, the performance measure of the LTE is required in which it needs more realistic, flexible and standard environment. There are more simulators are also available to check its performance. Out of many research academy discussions and many ideas the different simulators based on link-level and system-level are proposed. But all of that are not available in public to be used by all. In that some of the simulators are discussed here.In[11] proposed an LTE-Sim an open source framework, to check the LTE networks performances. It can able to simulate the uplink scheduling strategies and also for the downlink in the multicell and multiuser environments. It also consider the adaptive coding module and modulation scheme, user mobility, other aspects related to the scientific and the industrial communities. We can able to test new PHY functionalities, scheduling strategies and network protocols and architectures. The framework performance and scalability are also done to check the effectiveness of the simulator, includes software scalability test to both of the time memory requirements of the simulation and also it includes the scheduling strategies comparison. In[12] proposed a LTE simulator which is Matlab-based. This simulator implements a standard LTE physical layer with the more no of users and MIMO (multiple-input multiple-output) transmission and AMC in downlink. And also it includes thea scheduler. In this everything will be in the downlink flow. But unfortunately, even though it is freely available and an open source it does not have any LTE simulation with uplink flows such as the protocol stack, multicell environment.In[13] developed a simulator of system-level for LTE networks. This is developed as the enhancement of the pervious Matlab-based LTE simulator. Since it does not support any cell selection /planning, interference and of scheduling. This thing supports all of the scheduling schemes, interference and cell planning. Even though it rectifies this it does not support the uplink flows, bearer management and the complete LTE protocol stack unit. In[14], the Vienna LTE Simulators was proposed. Here the simulation environment of both system level and the link level based on the MATLAB where introduced. In this it shows how the system level and link level simulators are together connected. Further it also explains how the simulator of the link level acts as the layout to implement the system level simulator. Because of its open source nature, it enables researchers of reproducibility in the field of wireless communications and algorithms novelity. By this, the link level simulation in bit-accurate and PHY-model the PHY modeling at system level accuracy of system level simulatior can be compared. In[15] proposed a simulator of physical layer for both uplink and downlink connection named as LTE-LPS. The performance of the simulator are achieved by standardized environments. It is used for the educational purpose allows to check the signal processing performance, MIMO transmission, MUI effects channel estimation and coding, multiple access schemes and equalization. We can evaluate the performance of the uplink and downlink connections. This can also used as an auxiliary tool. In[16], proposed a simulator which use the LTE System Toolbox by Mathworks. The downlink and uplink transmission of the LTE transceivers physical layer is analyzed. In PUSCH and PDSCH the simulation results shows the LTE transceivers performance. For different simulation configuration the BER and throughput is obtained. In[17] proposed the comprehensive analysis of LTE DL physical layer performance using the MIMO. The work consists in modeling LTE PDSCH. It is based on the functional blocks of signal processing results and to evaluate physical layer DL. After that it is integrated to the simulator. It is illustrated with digital modulation and MIMO scheme. BER and throughput results are considered. In[18] proposed a physical-layer simulator which includes both Matlab and Simulink-based in LTE downlink. Among the UE and eNB the simulation will be taken place. This focus mainly on the PHY layer alone and also only considered the PDSCH and FDD. The performance is measured based on the BER and the throughput of the system. In[19] to check the working of the technologies in the mobile network, the simulation of system level is important. In this LTE system level simulator based on MATLAB computational is proposed. The performance of downlink shared channel of LTE SISO and MIMO by the multiplexing and transmission diversity is obtained. It can reduce the computational complexity by fading parameters at run-time. The network performance can also be increased for some new scheduling algorithms.

In[20] LTE system-level simulator was implemented in which it provides a elevated level of flexibility. It uses OOP capabilities of MATLAB. Since it having the clear structure based on objects, it gives more organized and good simulator. In[21] MATLAB based LTE physical layer simulator is proposed in which the simulation gains in execution time when parallelizing. It implement in LTE downlink with important features includes AMC, scheduling and multi users. In[22,23] proposed a simulator based on the C++ which is based on WM-SIM platform. It offers better performance. The flexibility is every less than the MATLAB implementation. And the source code is also not publicly available.

## 2. Comparison of Simulators: (Table 1)

**Table 1.** Discussion of Various Simulators

| Title | Reference | Year | Description | Drawback |
|---|---|---|---|---|
| "Simulating LTE Cellular Systems: An Open-Source Framework" | (11) | 2011 | LTE-Simcomplete performance verification of LTE networks. | HARQ and more Complicated channel and PHY models, which have not been included in the current version of the software. |
| "Simulating the long term evolution physical layer," | (12) | 2009 | Matlab-based LTE simulator | It does not consider practical applications, a complete LTE protocol stack, and multicell environments with uplink flows. |
| "System level simulation of LTE networks," | (13) | 2010 | system-level simulator | It does not holds a complete LTE protocol stack, uplink flows, and bearer management . |
| «The Vienna LTE Simulators - Enabling Reproducibility in Wireless Communications Research» | (14) | 2011. | Includes both MATLAB-based link and also the system level simulation | Wants to advances to each and every other layers. |
| "Open-Source Physical-Layer Simulator For Lte Systems" | (15) | 2011 | Used for both uplink and downlink connection, uses standradized environment | Wants further improvement |
| "Analysis and Simulation of LTE Downlink and Uplink Transceiver" | (16) | 2014 | Used for both uplink and downlink performance analysing | Accuracy of this is not appropriately known |
| "Simulating the Long Term Evolution (LTE) Downlink Physical Layer" | (17) | 2014 | To the analysis of LTE DL physical layer performance using the MIMO. | It considers only the downlink channel |
| "Long Term Evolution Downlink Physical Layer Simulation in Matlab and Simulink" | (18) | 2012 | Includes both Matlab and Simulink-based in LTE downlink. | This concentrates mainly on the PHY layer and also the PDSCH and FDD alone. |
| "System level simulation of LTE networks" | (19) | 2010 | Performance of downlink shared channel of LTE SISO and MIMO by the multiplexing and transmission diversity is obtained. | Only concentrates on the downlink |

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|---|---|---|---|---|
| "Available: http://www.nt.tuwien.ac.at/ltesimulator/" | (20) | 2010 | it provides a high degree of flexibility. | flexibility is not that much good |
| "Available: http://www.mathworks.com/products/matlab/" | (21) | 2011 | implement in LTE downlink with important features includes AMC, scheduling and multi users | flexibility is not that much good |
| "Performance evaluation of OFDMA wireless systems using WM-SIM platform" | (22) | 2006 | Based on the C++ which is based on WM-SIM platform & offers better performance. | Flexibility is not that much good and the source code is not available publically. |

## 3. Conclusion

This paper discusses various LTE simulators. With the literature review of the LTE simulators, where various simulators such as system-level, link-level, physical-layer are discussed. So the main focus in this is the system-level and link-level in the literature. And whole thing is summarized in the tabular form. Thus it is concluded that the LTE simulator are useful in checking the system performance and its optimization.

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