

# System level simulation of LTE networks

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**Abstract**—In order to evaluate the performance of new mobile network technologies, system level simulations are crucial. They aim at determining whether, and at which level predicted link level gains impact network performance. In this paper we present a MATLAB computationally efficient LTE system level simulator. The simulator is offered for free under an academic, non-commercial use license, a first to the authors' knowledge. The simulator is capable of evaluating the performance of the Downlink Shared Channel of LTE SISO and MIMO networks using Open Loop Spatial Multiplexing and Transmission Diversity transmit modes. The physical layer model is based on the post-equalization SINR and provides the simulation pre-calculated "fading parameters" representing each of the individual interference terms. This structure allows the fading parameters to be pregenerated offline, vastly reducing computational complexity at run-time.

## I. INTRODUCTION

The Long Term Evolution (LTE) standard, specified by the 3rd Generation Partnership Project (3GPP) in Release 8, defines the next evolutionary step in 3G technology. LTE offers significant improvements over previous technologies such as Universal Mobile Telecommunications System (UMTS) and High-Speed Packet Access (HSPA) by introducing a novel physical layer and reforming the core network. The main reasons for these changes in the Radio Access Network (RAN) system design are the need to provide higher spectral efficiency, lower delay, and more multi-user flexibility than the currently deployed networks [2].

In the development and standardization of LTE, as well as the implementation process of equipment manufacturers, simulations are necessary to test and optimize algorithms and procedures. This has to be performed on both, the physical layer (link-level) and in the network (system-level) context.

While link-level simulations allow for the investigation of issues such as Multiple-Input Multiple-Output (MIMO) gains, Adaptive Modulation and Coding (AMC) feedback, modeling of channel encoding and decoding [3] or physical layer modeling for system-level [4], system-level simulations focus more on network-related issues such as scheduling [5], mobility handling or interference management [6].

Along with the standardization process, commercially available LTE simulators have been developed. Equipment vendors, to this effect, have also implemented their own, proprietary solutions. Some universities and research centers have also developed such simulators, but to the authors' knowledge none with publicly available source code.

The LTE system-level simulator [1] supplements an already freely-available LTE link-level simulator [7]. This combination allows for detailed simulation of both the physical layer procedures to analyze link-level related issues and system-level simulations where the physical layer is abstracted from link level results and network performance is investigated.

The license under which the simulators are published allows for academic research and a closer cooperation between different universities and research facilities. In addition, developed algorithms can be shared under the same license again, facilitating the comparison and cross validation of algorithms and results and making them more credible.

The LTE system-level simulator implementation offers a high degree of flexibility. For the implementation, extensive use of the Object-oriented programming (OOP) capabilities of MATLAB, introduced with the 2008a Release have been made.

Having a modular code with a clear structure based in objects results in a much more organized, understandable and maintainable simulator structure in which new functionalities and algorithms can be easily added and tested.

This paper is organized as follows: in Section II we describe the overall structure of the LTE system-level simulator. In Section III we show how the physical layer has been abstracted in the link measurement model. Afterwards, we present the link performance model in Section IV, and Section V presents the main uses of the simulator as well as some conclusions.

## II. SIMULATOR OVERVIEW

While link-level simulations are suitable for developing receiver structures [8], coding schemes or feedback strategies [9], it is not possible to reflect the effects of issues such as cell planning, scheduling, or interference using this type of simulations. Simulating the totality of the radio links between the User Equipments (UEs) and eNodeBs is an impractical way of performing system level simulations due to the vast amount of computational power that would be required [10]. Thus, in system-level simulations the physical layer is abstracted by simplified models that capture its essential characteristics with high accuracy and simultaneously low complexity.

Figure 1 depicts a schematic block diagram of the LTE system-level simulator. Similarly to other system-level simulators, the core part consists of: (i) a link measurement model [11] and (ii) a link performance model [12].

# Lte System Level Simulator Documentation Tu Wien

**Albert Muñoz López**



## **Lte System Level Simulator Documentation Tu Wien:**

**The Vienna LTE-Advanced Simulators** Markus Rupp, Stefan Schwarz, Martin Taranetz, 2016-03-23 This book introduces the Vienna Simulator Suite for 3rd Generation Partnership Project 3GPP compatible Long Term Evolution Advanced LTE A simulators and presents applications to demonstrate their uses for describing designing and optimizing wireless cellular LTE A networks Part One addresses LTE and LTE A link level techniques As there has been high demand for the downlink DL simulator it constitutes the central focus of the majority of the chapters This part of the book reports on relevant highlights including single user SU multi user MU and single input single output SISO as well as multiple input multiple output MIMO transmissions Furthermore it summarizes the optimal pilot pattern for high speed communications as well as different synchronization issues One chapter is devoted to experiments that show how the link level simulator can provide input to a testbed This section also uses measurements to present and validate fundamental results on orthogonal frequency division multiplexing OFDM transmissions that are not limited to LTE A One chapter exclusively deals with the newest tool the uplink UL link level simulator and presents cutting edge results In turn Part Two focuses on system level simulations From early on system level simulations have been in high demand as people are naturally seeking answers when scenarios with numerous base stations and hundreds of users are investigated This part not only explains how mathematical abstraction can be employed to speed up simulations by several hundred times without sacrificing precision but also illustrates new theories on how to abstract large urban heterogeneous networks with indoor small cells It also reports on advanced applications such as train and car transmissions to demonstrate the tools capabilities     Development of a LTE System-level Simulator for Aircraft Cabins Albert Muñoz López, 2012 ANGL S Mobile broadband has changed the way we live and work The way we communicate is becoming enriched with higher speeds and exciting new services both at home on the road and on aircraft Nowadays a growing number of aircraft count with on board Global System for Mobile Communications GSM that enables the use of mobile phones during flight This is a result of the recent evolution of In Flight Entertainment and Connectivity IFEC systems which have experimented significant growth in the air transport industry In order to be commercially attractive such new communication services need high data rates high power efficiency low latency and a better quality of service Within this context the 3GPP Long Term Evolution LTE can make this happen However such systems require some Radio Frequency planning efforts to integrate them into the desired aircraft In these preliminary stages performance studies are commonly undertaken The current document specifies the design and implementation of a tool that aims to be useful for such studies This tool a simulator of on board LTE networks is able to simulate the in cabin LTE installations and to provide reliable results of LTE performance The LTE simulator described in this Thesis is a RESTful web application made of three parts 1 The processing unit CORE which carries out the simulations 2 The Application Programming Interface API as an abstraction layer between the processing unit and the Graphical User Interface 3 The

Graphical User Interface GUI which eases the user interaction with the system This document is structured as follows  
chapter 1 summarizes the objectives the project background and scope Chapter 2 provides a theoretical background of 3GPP  
LTE Chapter 3 describes the system at a high level through its requirements and gives an overview of the system design  
Chapter 4 describes the various subsystems of the LTE system level simulator Chapter 5 illustrates the usefulness of the  
developed LTE simulator by describing the simulation of a sample in cabin network installation Finally chapter 6 contains a  
conclusions summary of the simulator and suggestions for future work

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