International Journal of Engineering Research and General Science Volume 7, Issue 1, January-February, 2019
ISSN 2091-2730

SIMULATION OF CONTROL CHANNELS FOR LTE NETWORKS

Vineesh.P, Thushara.T, Dechakka.M.P

Coorg Institute of Technology, Ponnampet, Coorg-District, Karnataka, vineesh.pala@gmail.com

Abstract-There has been evolution of mobile technologies from 3G to 4G in the past few years.System level simulations is crucial in the evaluation of performance of new mobile technologies. . They aim at determining at what level predicted link level gains impact the network performance. This paper presents a MATLAB computationally efficient LTE (Long Term Evaluation) control channel simulator. LTE is a standard specified by the 3rd Generation Partnership Project.(3GPP).LTE offers improvement over UMTS and HSPA. In LTE, physical layer conveys data and control information b/w eNodeB & UE (User Equipment).Simulator is used to simulate the physical broadcast channel (PBCH) of LTE system. This physical channel carries information for UEs requiring to access the network.

Keywords: 3G, 4G, LTE, Controlchannel, PBCH, enodeB, UE

INTRODUCTION

With the advent of Internet and wireless communication mobile data services are undergoing a tremendous growth. First generation (1G) mobile phones had only voice facility. These were replaced by second generation (2G) digital phones with added fax, data and messaging services. The third generation (3G) technology has added multimedia facilities to 2G phones.3G has paved way to 4G with more advanced features.In order to evaluate the performance of new mobile technologies system level simulations are required. The main objective of the paper is to simulate the physical broadcast channel (PBCH) for LTE (Long term evaluation networks) networks.

LTE SIMULATION

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 or physical layer modeling for system-level, system-level simulations focus more on network-related issues such as scheduling, mobility handling or interference management. The LTE system-level simulator supplements an already freely-available LTE link-level simulator. 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 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 2010a Release has 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

OVERVIEW OF SIMULATOR

While link-level simulations are suitable for developing receiver structures, coding schemes or feedback strategies, 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. 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.Fig 1 depicts a schematic block diagram of the LTE system-level simulator. Similar to other system-level simulators, the core part consists of a link measurement model and a link performance model

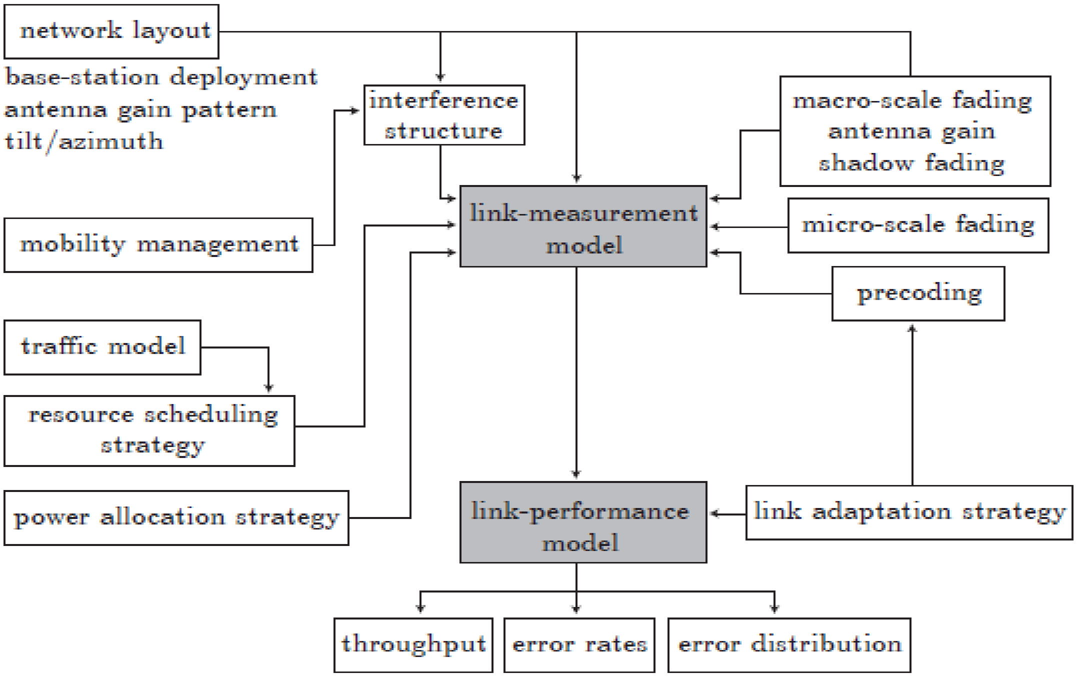


Fig 1: Schematic block diagram of LTE Simulator

The link measurement model abstracts the measured link quality used for link adaptation and resource allocation. On the other hand the link performance model determines the link Block Error Ratio (BLER) at reduced complexity's figures of merit, the simulator outputs traces containing throughput and error rates, from which their distributions can be computed. Implementation-wise, the simulator flow follows the pseudo-code below. The simulation is performed by defining a Region Of Interest (ROI) in which the enodeBs and UEs are positioned and a simulation length in Transmission Time Intervals (TTIs). It is only in this area where UE movement and transmission of the Downlink Shared Channel (DLSCH) are simulated.

RUNNING A SIMULATION

The main file of the LTE Link Level Simulator is LTE_sim_main.m, though you may normally run the simulation through a batch file such as LTE_sim_launcher.m, which performs the following tasks:

- Loading a configuration file of choice
- Executing the LTE_sim_main.m main simulation file.

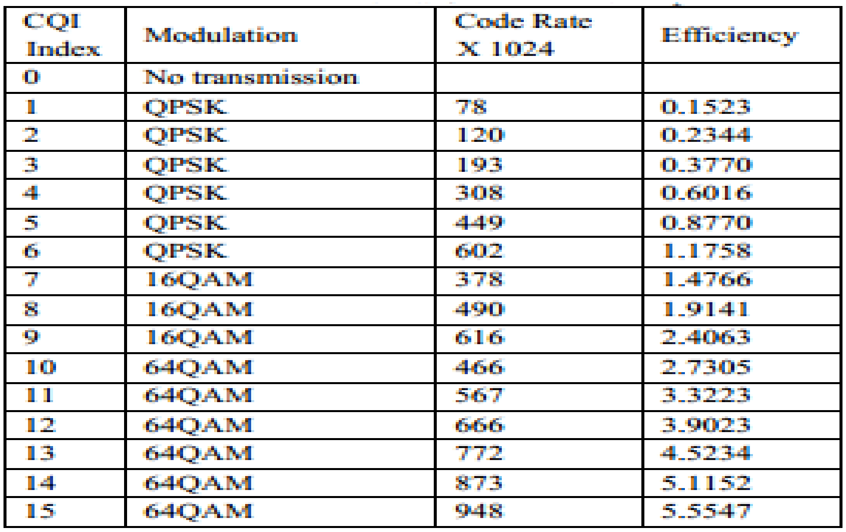
SIMULATION RESULTS

BLER V/S SNR CURVES

Block Error Rate (BLER) is used in LTE/4G technology to know the in-sync or out-of-sync indication during radio link monitoring (RLM).BLER (in LTE) = No of erroneous blocks / Total no of Received Blocks. Normal in-sync condition is 2% of BLER and for out-of-sync 10%.SNR refers to the signal to noise ratio.

The UE sends CQI feedback as an indication of the data rate which can be supported by the downlink channel. This helps the eNodeB to select appropriate modulation scheme and code rate for downlink transmission. The UE determines CQI to be reported based on measurements of the downlink reference signals. The UE determines CQI such that it corresponds to the highest Modulation and Coding Scheme (MCS) allowing the UE to decode the transport block with error rate probability not exceeding 10%.The CQI report not only indicates the downlink channel quality but also takes the capabilities of the UE's receiver into account. A UE with receiver of better quality can report better CQI for the same downlink channel quality and thus can receive downlink data with higher MCS. Table 1 shows modulation scheme, code rate along with efficiency for various CQI index

Table 1:CQI INDEX



CQI Index	Modulation	Code Rate X 1024	Efficiency
0	No transmission		
1	QPSK	78	0.1523
2	QPSK	120	0.2344
3	QPSK	193	0.3770
4	QPSK	308	0.6016
5	QPSK	449	0.8770
6	QPSK	602	1.1758
7	16QAM	378	1.4766
8	16QAM	490	1.9141
9	16QAM	616	2.4063
10	64QAM	466	2.7305
11	64QAM	567	3.3223
12	64QAM	666	3.9023
13	64QAM	772	4.5234
14	64QAM	873	5.1152
15	64QAM	948	5.5547

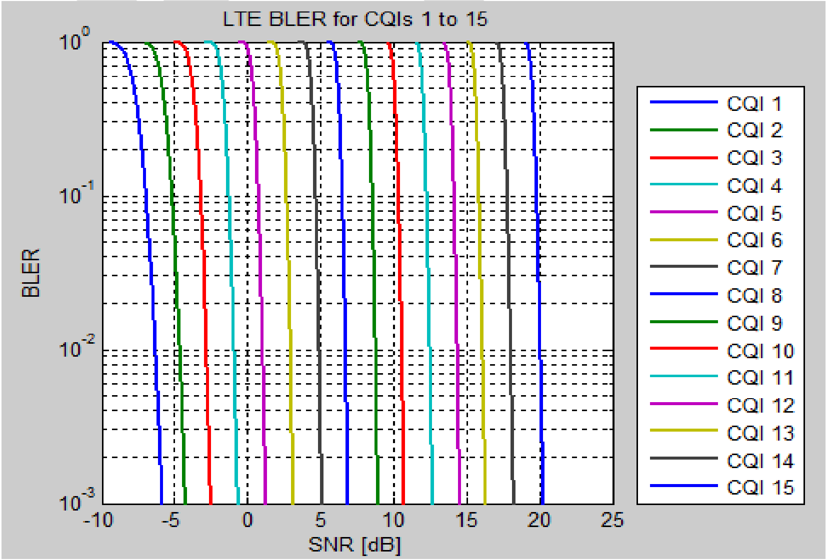


Fig 2: Fig 2 shows the BLER v/s SNR plots for the 15LTE CQI indices

SNR-CQI MAPPING PLOT

Before full commercial deployment of LTE, downlink SNR to CQI mapping for different multiple antenna techniques can be of enormous significance for the operators. Such vital RF parameters should be tuned before full-fledged commercial launch. In LTE, Adaptive Modulation and Coding (AMC) has to ensure a BLER value smaller than 10%. The SNR-to-CQI mapping is required to achieve this goal. Fig 3 shows SNR-CQI mapping plot for 10% BLER.

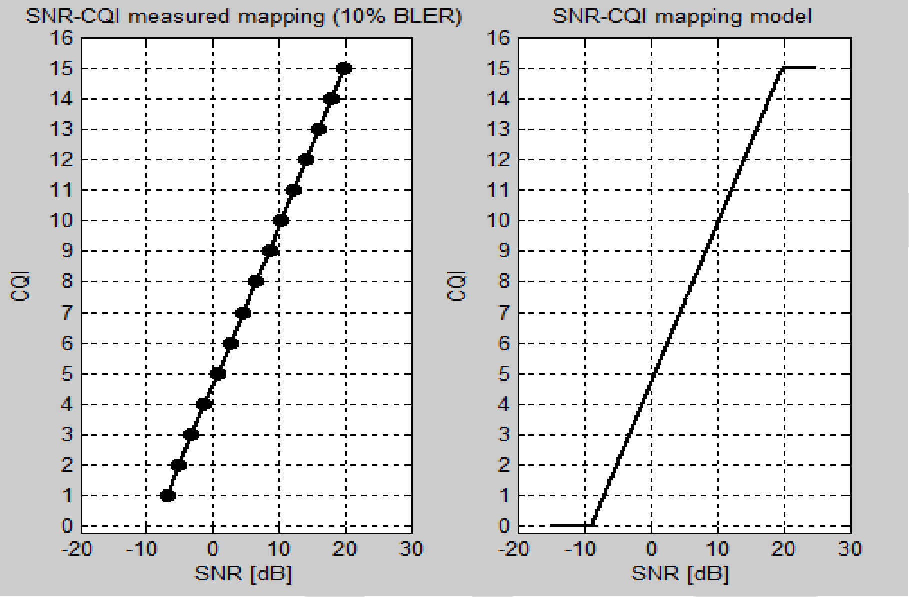


Fig 3: SNR-CQI mapping plot

ANTENNA GAIN PLOT

Antenna gain is usually defined as the ratio of the power produced by the antenna from a far-field source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna, which is equally sensitive to signals from all directions. Usually this ratio is expressed in decibels, and these units are referred to as "decibels-isotropic" (dBi). An alternate definition compares the antenna to the power received by a lossless half-wave dipole antenna, in which case the units are written as dBd. Since a lossless dipole antenna has a gain of 2.15 dBi, the relation between these units is: gain in dBd = gain in dBi - 2.15 dB . For a given frequency the antenna's effective area is proportional to the power gain. An antenna's effective length is proportional to the square root of the antenna's gain for a particular frequency and radiation resistance. Due to reciprocity, the gain of any antenna when receiving is equal to its gain when transmitting. Directive or directivity is a different measure which does not take an antenna's electrical efficiency into account. This term is sometimes more relevant in the case of a receiving antenna where one is concerned mainly with the ability of an antenna to receive signals from one direction while rejecting interfering signals coming from a different direction.The antenna gain is always maximum when $\theta=0^0$.Fig 4 shows antenna gain versus the angular position in degrees.

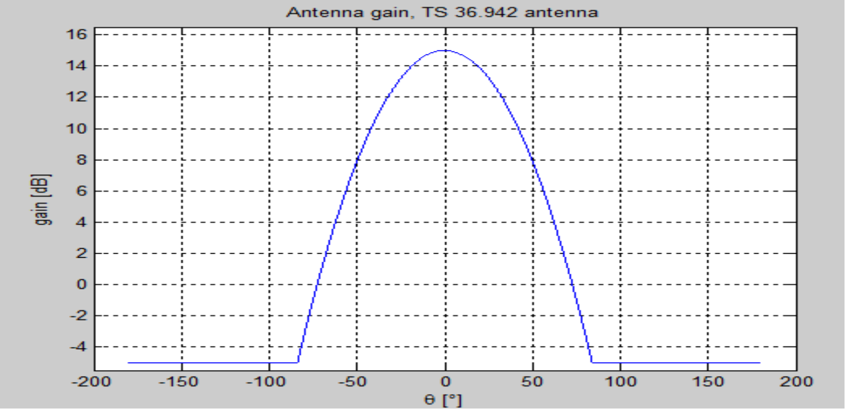


Fig 4: Antenna gain plot

MACROSCOPIC PATHLOSS V/S DISTANCE PLOT

The purposes of macroscopic modeling provide a means for predicting path loss for a particular application environment.

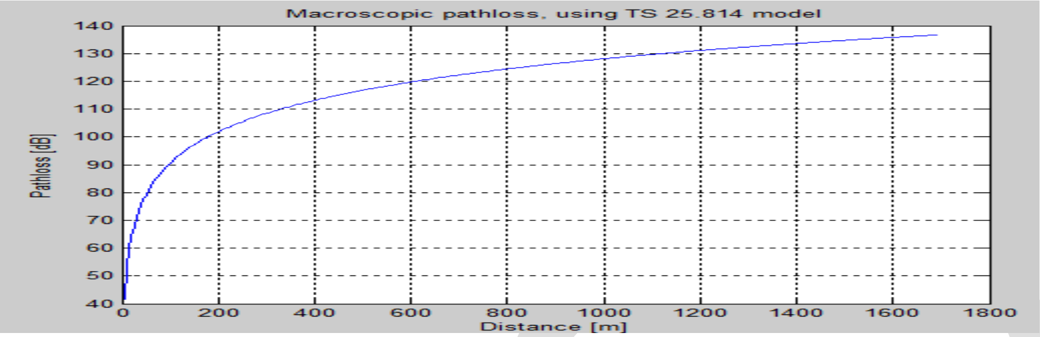


Fig 5 Macroscopic path loss v/s distance

Any individual path-loss model has a limited range of applicability and will provide only an approximate characterization for a specific propagation environment. Fig 9.4 shows the plot for macroscopic path loss versus distance. Path loss increases with distance as shown in Fig 5.

MACROSCOPIC PATHLOSS FOR DIFFERENT ENODEBS

Fig 6 shows the macroscopic path loss in dB for 3 eNodeBs in sector 1.The path loss is indicated in various colors on a scale starting from 70 with different x and y positions

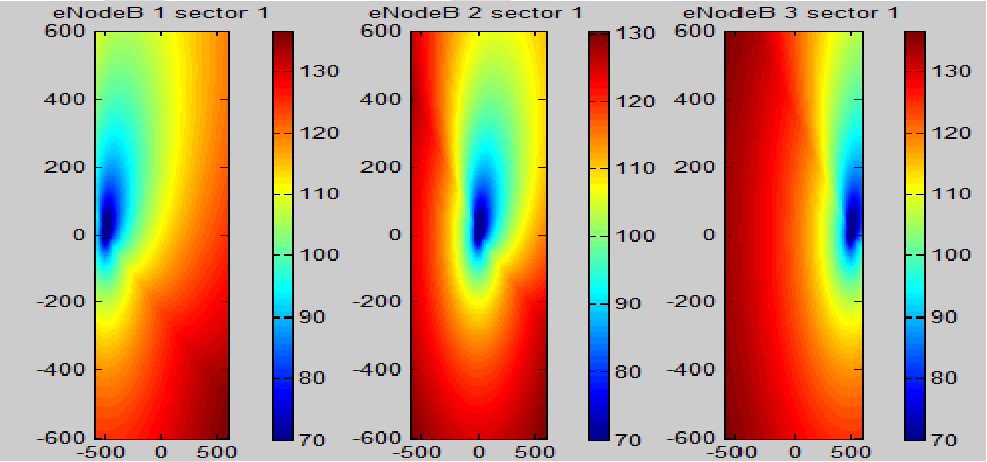


Fig 6: Macroscopic path loss for enodeBs in sector1

Fig 7 shows the macroscopic path loss in dB for 3 enodeBs in sector 2.The path loss is indicated in various colors on a scale starting from 70 with different x and y positions

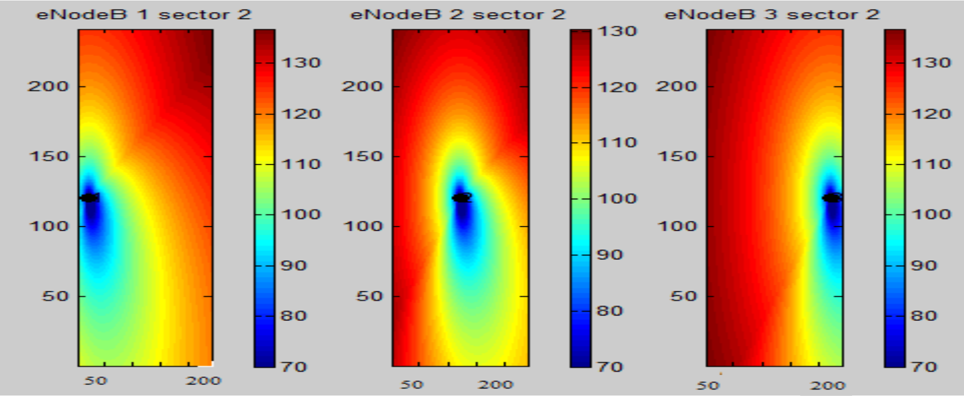


Fig 7: Macroscopic path loss for enodeBs in sector2

Fig 8 shows the macroscopic path loss in dB for 3 enodeBs in sector 3.The path loss is indicated in various colors on a scale starting from 70 with different x and y positions.

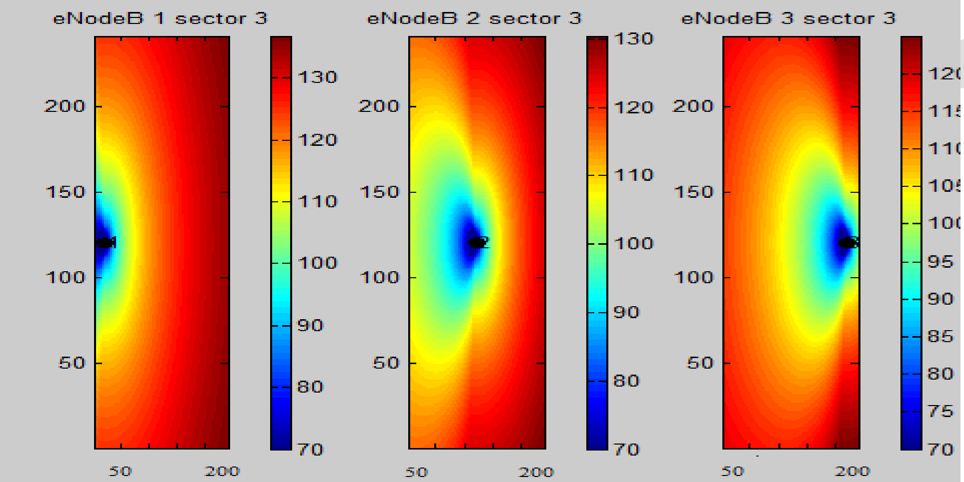


Fig 8: Macroscopic path loss for enodeBs in sector3

SHADOW FADING FOR DIFFERENT ENODEB'S

Shadow fading is a phenomenon that occurs when a mobile moves behind an obstruction and experiences a significant reduction in signal power. Path loss is a function only of parameters such as antenna heights, environment and distance. In practice, the particular clutter (buildings, trees) along a path at a given distance will be different for every path. Some paths will suffer increased loss; whereas others will be less obstructed and have increased signal strength. Fig 9 shows shadow fading for the 3 enodeBs.

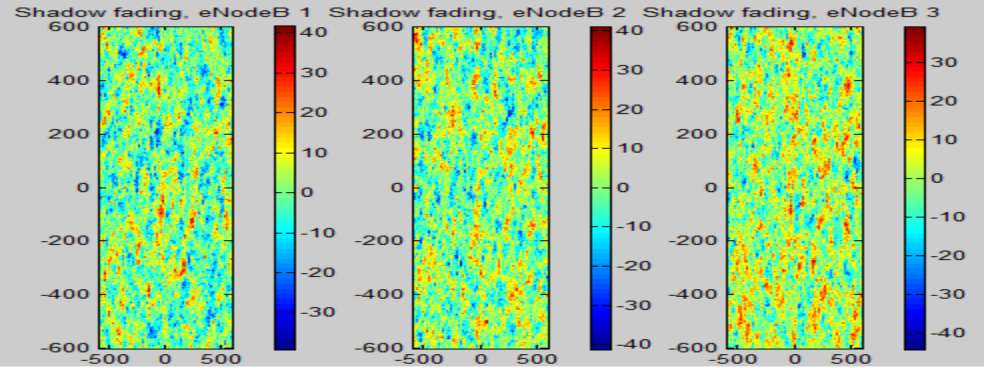


Fig 9: Shadow fading for enodeBs

UE AND ENODEB POSITIONS

Fig 10 shows the UE positions with respect to eNodeBs.The 3 enodeBs are indicated in red color. The UE's move from enodeB2 in different directions. The handoff occurs between different UE's and enodeBs as they move.

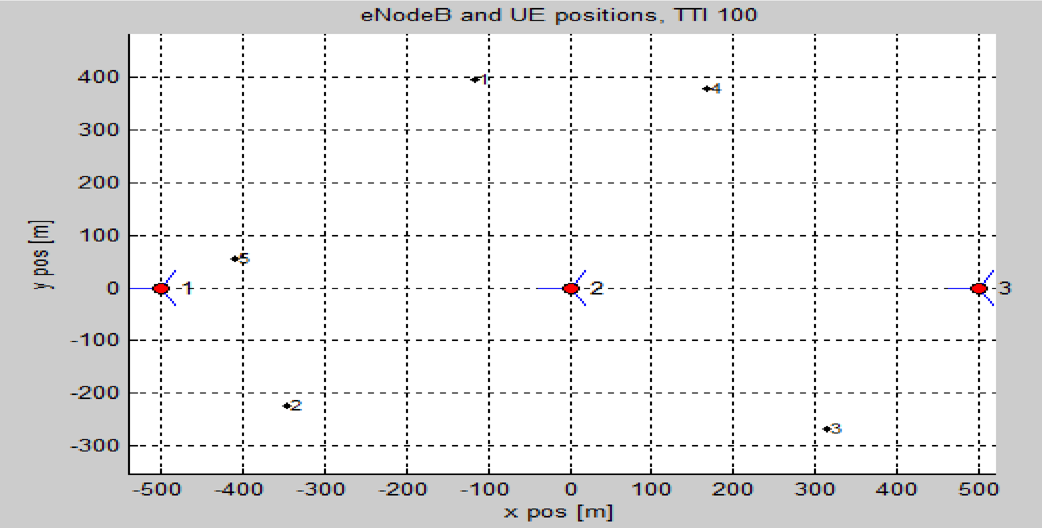


Fig 10: enodeBs and UE positions

UE INITIAL POSITION

Fig 11 shows the initial UE position, the 3 enodeBs in 3 sectors.

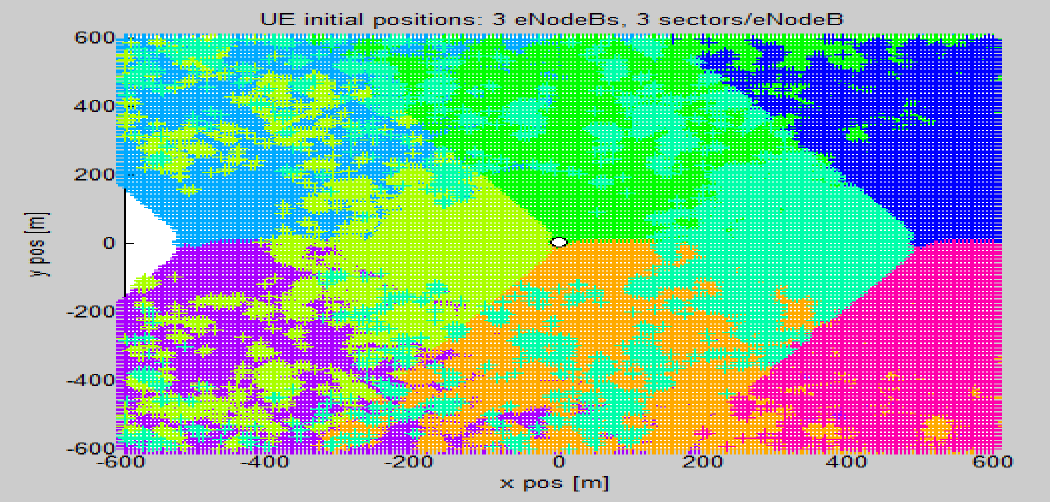


Fig 11: UE positions

MACROSCOPIC AND SHADOW FADING

The simulation is performed by defining a Region Of Interest (ROI) in which the enodeBs and UEs are positioned and a simulation length in Transmission Time Intervals (TTIs). It is only in this area where UE movement and transmission of the Downlink Shared Channel (DLSCH) are simulated. Sector SINR, calculated with distance dependent macro scale path loss and additional lognormal-distributed space-correlated shadow fading is shown in Fig 12

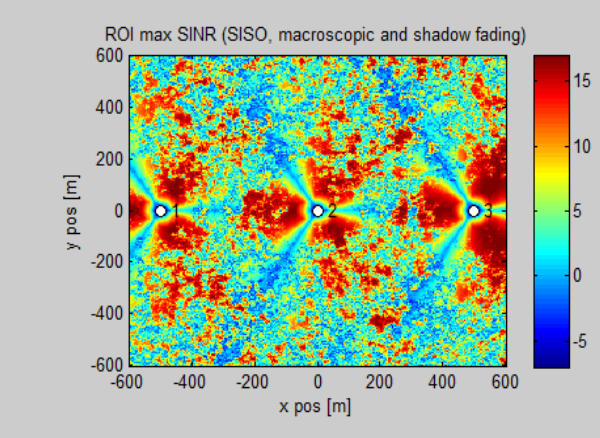


Fig `12: ROI max SINR (macroscopic and shadow fading)

Target sector CQIs calculated with distance dependent macro scale path loss and additional lognormal-distributed space-correlated shadow fading is shown in Fig 13

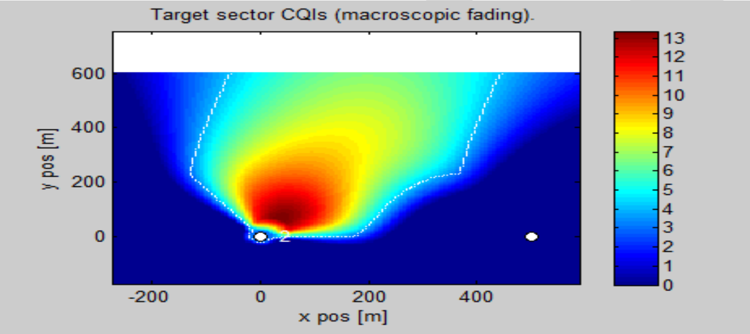


Fig 13: Target sector CQI (macroscopic and shadow fading)

SINR difference calculated with distance dependent macro scale path loss and additional lognormal-distributed space-correlated shadow fading is shown in Fig 14

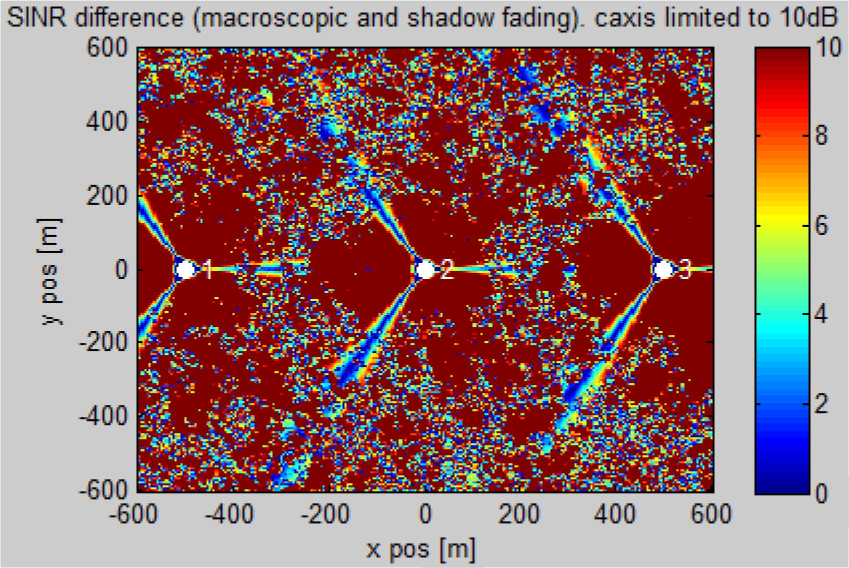


Fig 14: SINR difference (macroscopic and shadow fading)

The cell and sector assignment distance dependent macro scale path loss and additional lognormal-distributed space-correlated shadow fading is shown in Fig 15

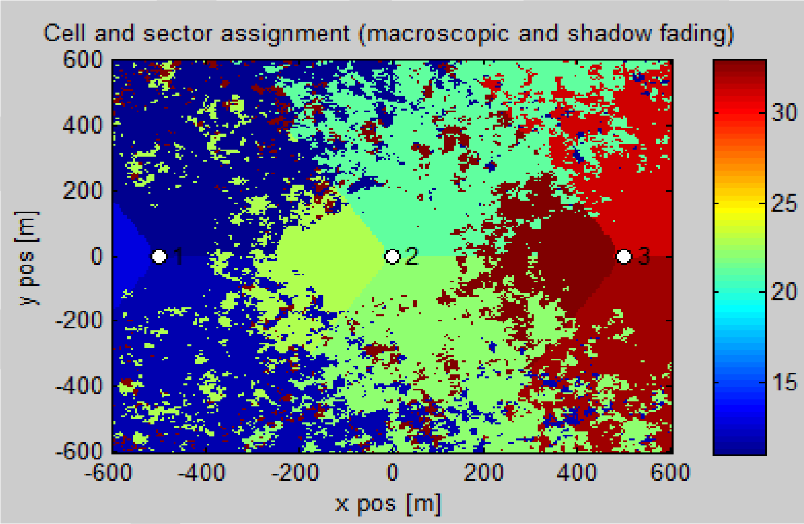


Fig 15: Cell and sector assignment (macroscopic and shadow fading)

Sector SINR, calculated with distance dependent macro scale path loss is shown in Fig 16

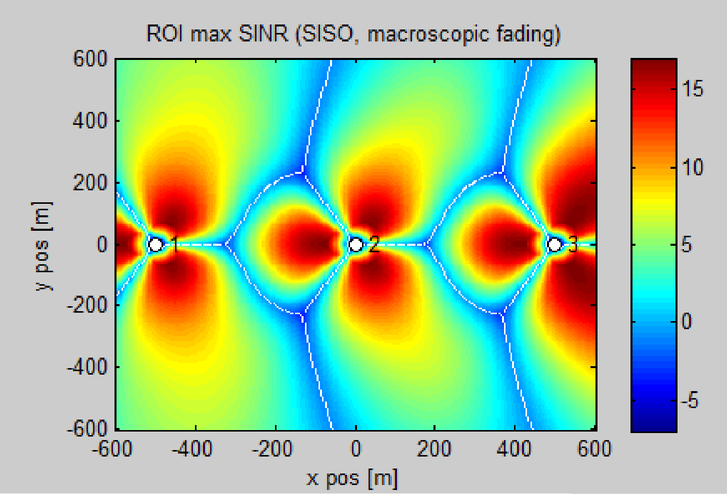


Fig 16 ROI max SINR (macroscopic fading)

TARGET SECTOR SINR CDF

Target sector CQIs calculated with distance dependent macro scale path loss is shown in Fig 17

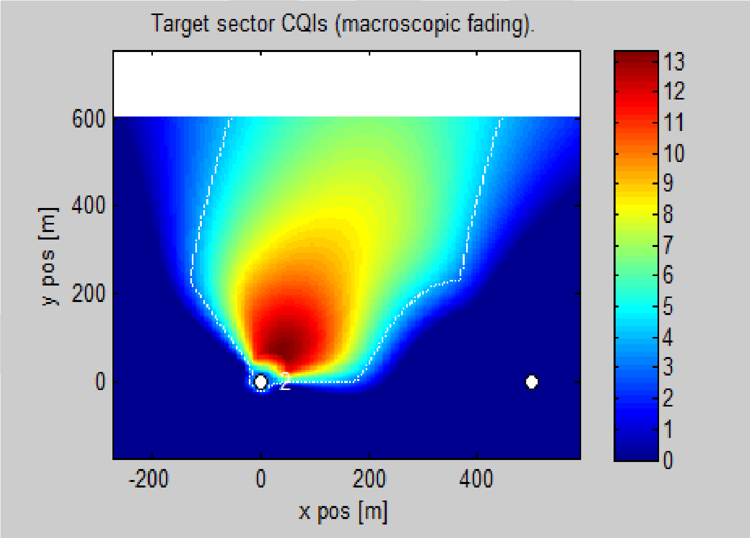


Fig 17 Target sector CQIs (macroscopic fading)

SINR difference calculated with distance dependent macro scale path loss is shown in Fig 18

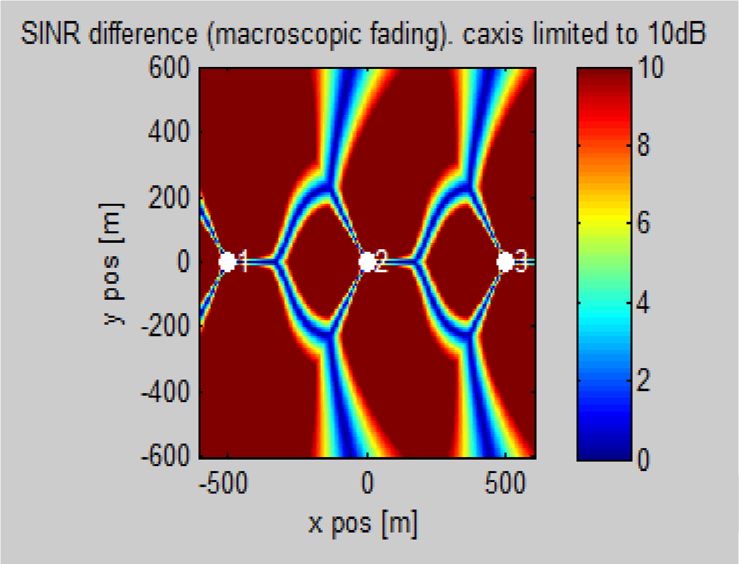


Fig 18 SINR difference (macroscopic fading)

Cell and sector assignment calculated with distance dependent macro scale path loss is shown in Fig 19

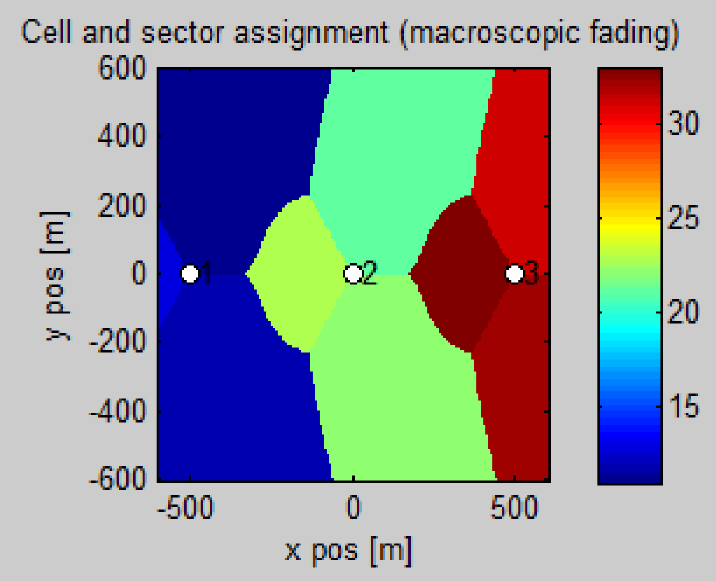


Fig 19: Cell and sector assignment (macroscopic fading)

TARGET SECTOR SINR CDF

Fig 20 shows a plot of target sector SINR as a cumulative distributive function. The continuous line shows SINR CDF for macro and shadow fading. The dotted lines show the SINR CDF of macro fading only.

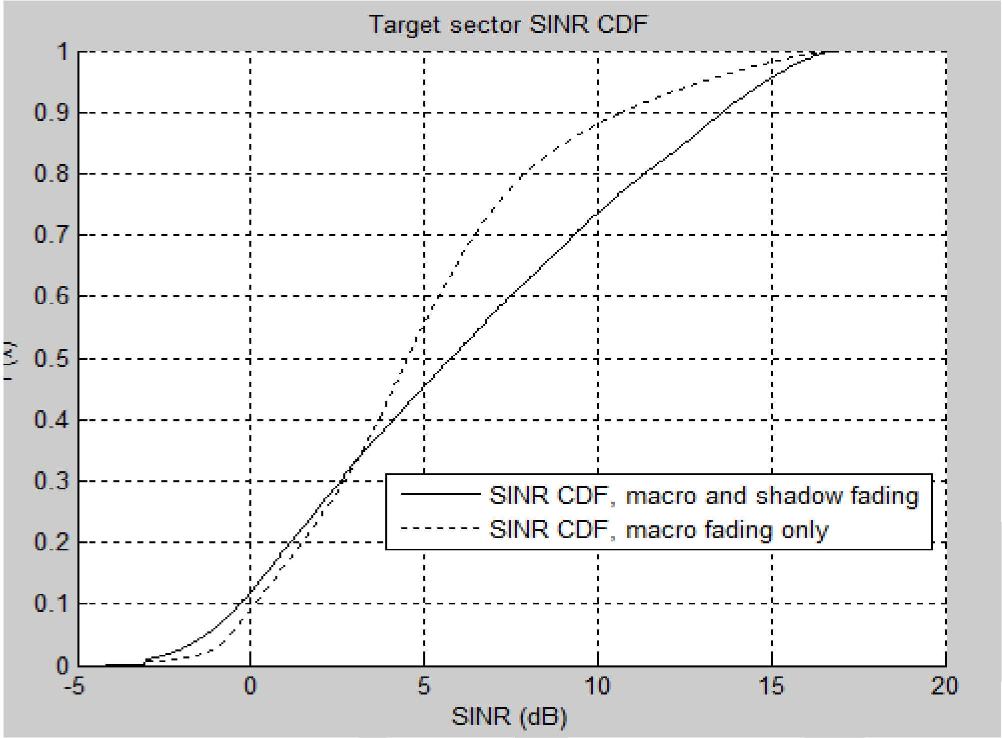


Fig 20: Target sector SINR CDF

CONCLUSION

The LTE Simulator has been used to simulate control channels of LTE network. The main purpose of this tool is to assess the network performance. Testing Fractional Frequency Reuse (FFR) strategies implemented at the scheduler level, as well as the network impact of different receiver types and channel quality feedback strategies, provided accurate modeling of those, can also be tested. These simulations focus more on network-related issues such as scheduling mobility handling or interference management .The simulator supplements a link level simulator. 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 simulator for LTE networks need to be developed for investigating the interference behaviour of femtocells placed within microcells. Thus it is necessary to simulate a multi-cell, multi-user and multi-carrier system in the downlink for Single-Input, Single-Output (SISO) and Multiple-Input, Multiple-Output (MIMO) antenna configurations.

REFERENCES:

[1] Josep Colom Ikuno, Martin Wrulich, Markus Rupp "System level simulation of LTE networks", Institute of Communications and Radio-Frequency Engineering Vienna University of Technology, Austria Gusshausstrasse 25/389, A-1040 Vienna, Austria,May 2010

[2] C. Mehlf¨uhrer, M. Wrulich, J. C. Ikuno, D. Bosanska, and M. Rupp,"Simulating the long term evolution physical layer," in Proc. of the 17th European Signal Processing Conference (EUSIPCO 2009), Glasgow,Scotland, Aug. 2009.

[3] C. Shuping, L. Huibinu, Z. Dong, and K. Asimakis, "Generalized scheduler providing multimedia services over HSDPA," in Proc. IEEE International Conference on Multimedia and Expo, 2007, pp. 927–930.

[4]E. Dahlman, S. Parkvall, J. Skold, and P. Beming, "3G Evolution: HSDPA and LTE for Mobile Broadband." Academic Press, Jul. 2007.

[5] H. Claussen, "Efficient modelling of channel maps with correlated shadow fading in mobile radio systems," Sept. 2005.

[6] J. Colom Ikuno, M. Wrulich, and M. Rupp, "Performance and modeling of LTE H-ARQ," in Proc. ITG International Workshop on Smart Antennas (WSA), Berlin, Germany, Feb. 2009.

[7] K. Brueninghaus, D. Astely, T. Salzer, S. Visuri, A. Alexiou, S. Karger, and G.-A. Seraji, "Link performance models for system level simulations of broadband radio access systems," Sept. 2005.

[8] M. ˇSimko, C. Mehlf¨uhrer, M. Wrulich, and M. Rupp, "Doubly Dispersive Channel Estimation with Scalable Complexity," in Proc. ITG International Workshop on Smart Antennas (WSA), Bremen, Germany, Feb. 2010.

[9] M. Castaneda, M. Ivrlac, J. Nossek, I. Viering, and A. Klein, "On downlink intercell interference in a cellular system," in Proc. IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 2007, pp. 1–5.

[10] M. Wrulich, W. Weiler, and M.Rupp, "HSDPA performance in a mixed traffic network," in Proc. IEEE Vehicular Technology Conference (VTC) Spring 2008, May 2008, pp. 2056–2060.

[11] M. Wrulich, S. Eder, I. Viering, and M. Rupp, "Efficient link-to-system level model for MIMO HSDPA," in Proc. of the 4th IEEE BroadbandWireless Access Workshop, 2008.

[12] S. Schwarz, M. Wrulich, and M. Rupp, "Mutual information based calculation of the precoding matrix indicator for 3GPP UMTS/LTE," in Proc. ITG International Workshop on Smart Antennas (WSA), Bremen,Germany, Feb. 2010.

[13] Technical Specification Group RAN, "E-UTRA; LTE RF system scenarios," 3rd Generation Partnership Project (3GPP), Tech. Rep. TS 36.942, 2008-2009.

[14] W. C. Lee, Mobile Communications Engineering. McGraw-Hill Professional,1982.

[15] W. C. Jakes and D. C. Cox, Microwave Mobile Communications. Wiley-IEEE Press, 1994.

[16] X. Cai and G. Giannakis, "A two-dimensional channel simulation modelfor shadowing processes," Vehicular Technology, IEEE Transactions on,Nov. 2003.