

Design and Analysis of LTE Wireless System using Various Advanced Techniques

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Abstract

The LTE infrastructure is currently under development. In this paper Long Term Evolution (LTE) system is implemented by using advanced techniques like MIMO, scheduling algorithms etc. on both uplink and downlink to achieve high peak data rates and higher system throughput. This paper evaluates the LTE key performance indicators like throughput, end to end delay and jitter after employing advanced techniques. The LTE simulation has been carried out using the licensed network simulator QUALNET Developer 6.1.

Keywords

LTE, Performance Evaluation, Scheduling, Mobility, QUALNET 6.1

I. Introduction

With recent growth in the use of mobile technology applications, the extraordinary demand in the use of voice and data services has created an increase for other solutions to mobile broadband services. There has been substantial increase in the use of mobile devices for browsing the internet (web trending applications and websites, for examples, Facebook, and Twitter), video streaming (Russia Today, Al-Jazeera and Cable News Network (CNN) live broadcasts), Voice-over Internet Protocol (VoIP) applications for internet calls (Mobile VoIP and Skype), medical applications that run on real-time data loggings, video and voice calls and a number of new applications that has greater demands for high data traffic [11].

The most significant factor involved in this technology is that the service providers have been struggling to provide the demanded rates their customers want. Achieving a higher data rate with significant wider but better coverage has posed a bigger discussion in what could be the threat in meeting the subscriber's demands.

The evolution towards the 4th generation of mobile communications (4G) has enabled the development and deployment of networks implementing the Long Term Evolution (LTE) technology [1].

The Long Term Evolution (LTE) is the standard name given by the mobile technology project of the 3rd Generation Partnership Project (3GPP) to meet up with the set of requirements for present and future needs of mobile communications. The 3GPP LTE project started in 2004. The introduction of the LTE is aimed at enhancing the Universal Terrestrial Radio Access Network (UTRAN). Its evolution is aimed towards achieving the fourth generation (4G) mobile technologies.

LTE technology is a founded on a 3GPP standard that offers a downlink speed of up to 150 megabits per second (Mbps) and an uplink speed of up to 50 Mbps. In LTE, Fixed wireless and wired standards are already approaching or achieving 100 Mbps or faster, and LTE is a way for cellular communications to be work at that high data rate [11].

In this paper, the evaluation of all performance parameters of LTE system is carried out using QUALNET Developer 6.1. The simulation model of MIMO-LTE gives efficient results in terms

of throughput, end to end delay and jitter. All the performance parameters are varied with different simulation parameters like bandwidth, application bit rate, speed etc.

The remainder of the paper is organized as follows. Section II provides an overview of the LTE architecture and its theoretical performances, outlining the major improvements introduced by the Long Term Evolution of Universal Mobile Telecommunications System (UMTS). Section III describes various advanced techniques used in LTE system. Section IV consists of Simulation scenarios and corresponding results. Section V concludes the paper.

II. LTE Architecture

The LTE architecture is of two type's i.e. Radio access type and non-radio access type with Enhanced UTRAN (E-UTRAN). The radio access basically is the evolution of the LTE Physical Layer, while the non-radio access grouped under the System Architecture Evolution (SAE), is the development of the network architecture of the LTE [8].

The major components of the LTE System Architecture are:

1. User Equipment (UE)
2. Radio Access Network (RAN)
3. Evolved Packet Core (EPC)

The LTE network is composed of the Core Network (CN), also called the EPC while there is the Access Network also, which is referred to as E-UTRAN. The Evolved Packet System (EPS) is comprised of the LTE Radio Access Network and Evolved Packet Core (EPC \Rightarrow RAN + EPS).

The LTE SAE (System Architecture Evolution) consists of UE, eNB and EPC (evolved packet core). The Particular device shows the eNB is like as the base station and UE has another name is mobile station. The LTE is also called as E-UTRAN (Enhanced-UTRAN) The figure 1 shows the system architecture with corresponding interfaces of E-UTRAN and UE.

Various interfaces are designed between various components which include Uu between UE and eNB, X2 between two eNBs and S1 between EPC and eNB. The eNB has been worked as both RNC and eNB.

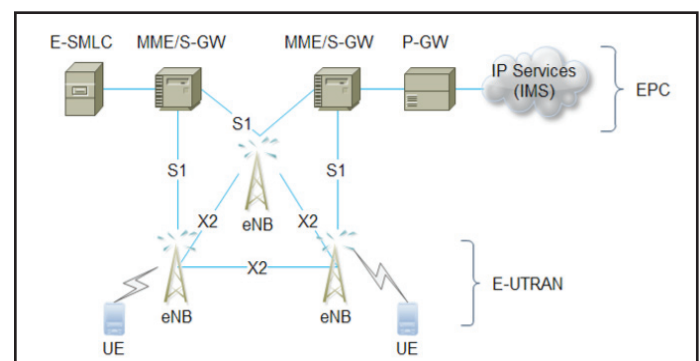


Fig. 1: LTE Architecture Overview [9]

LTE is completely IP based network [1]. In LTE, to achieve the high transmit rates and excellent spectral efficiency in the downlink (DL) and uplink (UL), a number of technological variations in

the architecture are incorporated particularly in the Multi-Carrier and Multi-Antenna (MC-MA) transmission techniques, Hybrid Automatic Repeat Request (HARQ) etc.

In the LTE E-UTRAN transmission schemes, the Orthogonal Frequency Division Multiple Access (OFDMA) is designed for Downlink (eNB to UE), while the Single Carrier-Frequency Division Multiple Access (SC-FDMA) for Uplink (UE to eNB).

III. Advanced Techniques

LTE network provides high data rate, high mobility and higher system throughput due to the various advanced techniques like MIMO, mobility effects and eNB scheduling algorithms etc.

A. Multiple Input Multiple Output (MIMO) Antenna Techniques

Multi-antenna techniques are employed in LTE systems to achieve high data rates, spectral efficiency, system capacity (number of users), and coverage. Multi-antenna systems can be realized by using multiple antennas at the transmitter and receivers with an appropriate channel coding/ decoding scheme. By increasing the number of transmit and receive antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system [7]. MIMO operation is an important feature of E-UTRAN PHY.

QUALNET currently supports:

1. Single antenna transmission (SIMO).
2. Multiple antenna transmission (MIMO)
 - Transmit diversity (SFBC).
 - Open loop spatial multiplexing (OLSM).

For the transmission scheme, uplink can only use SIMO because the maximum number of transmission antennas is 1. For downlink, various transmission schemes are available. The various transmission schemes depend on the transmission mode number shown in Table 1.

Table 1: Transmission Mode and Transmission Scheme

Mode Number	Transmission Scheme
1	Single Antenna transmission
2	Transmit diversity(SFBC)
3	RI=2: open loop spatial multiplexing(without CDD) RI=1: Transmit diversity(SFBC) (switched dynamically depending in RI)

B. For eNB Scheduling Algorithms

Scheduling is the process of dynamically allocating physical resources to User Equipment's (UEs) based on scheduling algorithms implemented at the LTE base station. Various algorithms have been proposed by network designers as the implementation of scheduling algorithm is an open issue in LTE standard. The choice of scheduling algorithm critically impacts resource utilization and the overall performance of LTE network [3].

Two type of scheduling algorithm has been explored i.e. Round Robin (RR) and Proportional Fair (PF) scheduling algorithms for Constant Bit Rate (CBR) traffic scenario.

C. By Using Mobility on UE Node

In this paper, we use the Waypoint Mobility. The Random Waypoint

Mobility Model is a variation of Random Walk model. It includes pause times between changes in direction and/or speed. A UE stays in one location for a certain period of time.

In LTE, the Mobility Management Entity (MME) is responsible for the mobility management function. The MME is connected to a large number of evolved Node (cells) that are grouped into the Tracking Areas (TAs). The TAs is further grouped into TA Lists (TALs). When a User Equipment (UE) moves out of the current TA, it reports its new location to the MME [8].

IV. Simulation and Results

In QUALNET, a specific network topology is referred to as a scenario. A scenario allows the user to specify all the network components and conditions under which the network will operate. This includes: terrain details, channel propagation, fading, and shadowing, wired and wireless subnets, network devices such as switches, hubs and routers, the entire protocol stack of a variety of standard or user-configured network components, and applications running on the network [6].

A. Simulation Parameters

For LTE network simulation, various key parameters are required like terrain details, number of channels used, bandwidth etc. Simulation parameters are shown in Table 2.

Table 2: Simulation Parameters

SIMULATOR	QUALNET 6.1
Terrain Size	1500x1500 m ²
Antenna	Omni directional
Application Rates	Mbps
Radio Type	LTE
Propagation Model	Two Ray Ground
Channel Frequency	2.4GHz
Traffic Source	CBR application
Performance parameters	Average Jitter, Average Delay, Throughput

B. Simulation Scenario

Figure 2 shows that the simulation scenario of LTE network which has 5 nodes, 1 hub and 1 wireless LTE centered network.

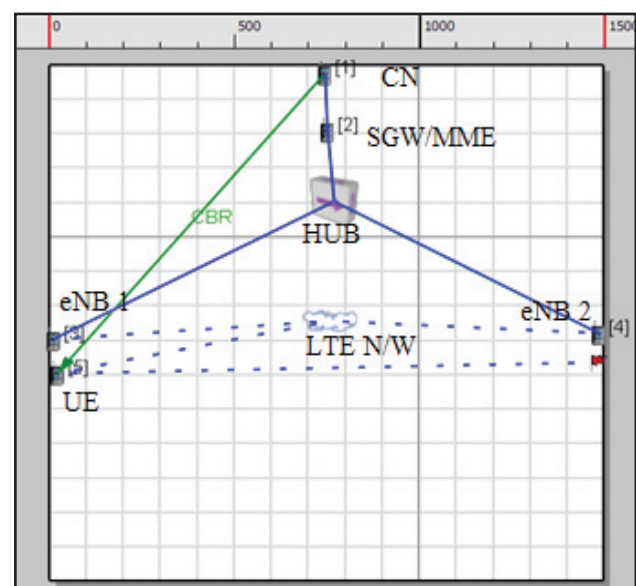


Fig. 2: Simulation Scenario of LTE Wireless Network

C. Scenario Description

In this section, detailed overview of LTE scenario is being provided. Various step followed for creating the simulation scenario of LTE system are describe below:

- Place five nodes of the default device type on the canvas. Node 1 is the CN, node 2 is the SGW/ MME, node 3 is eNB 1, node 4 is eNB 2, and node 5 is the UE.
- Create a point-to-point link between Nodes 1 and 2.
- Place a wired subnet and connect nodes 2, 3, and 4 to it.
- Place a wireless subnet and connect nodes 3, 4, and 5 to it.
- Place a waypoint for node 5 close to node 3.
- Default BER table files are included.
- Select the wireless subnet and set the LTE properties as follows:
 - Go to Wireless Subnet Properties > Physical Layer and set Radio Type to LTE PHY. Use default values for all PHY parameters.
 - Go to Wireless Subnet Properties > MAC Layer and set MAC Protocol to LTE MAC. Use default values for all MAC parameters.
 - Go to Scenario Properties Editor > General > LTE Configuration > Measurement > Mask of Events. Set Events for RSRP Metric Handover Report to Observe A3 Events.
 - Go to Scenario Properties Editor > Channel Properties. Set Number of Channels to 4.
 - For node 3 (eNB 1), go to Default Device Properties > Interfaces > Interface 1. (Make sure that Interface 1 corresponds to the wireless interface of node 3.)
 - Select the Physical Layer group.
 - Set Station Type to evolved Node B.
 - Set Listenable Channel Mask and Listening Channel Mask to 1100.
 - Select the MAC Layer group and set Station Type to evolved Node B.
 - For node 4 (eNB 2), go to Default Device Properties > Interfaces > Interface 1. (Make sure that Interface 1 corresponds to the wireless interface of node 4.)
 - Select the Physical Layer group.
 - Set Station Type to evolved Node B.
 - Set DL Channel Index to 2 and UL Channel Index to 3.
 - Set Listenable Channel Mask and Listening Channel Mask to 0011.
 - Select the MAC Layer group and set Station Type to evolved Node B.
 - For node 5 (UE node), go to Default Device Properties > Interfaces > Interface 0 > Physical Layer and set Listenable Channel Mask and Listening Channel Mask to 1111.
 - Select the wired subnet and go to Wired Subnet Properties > General
 - Set EPC Subnet to Yes.
 - Set EPC SGWMME Node ID to 2.
 - Set SGWMME Interface Index to 0.
 - Set up a CBR session between node 5 and node 1.

1. CBR Parameters

The CBR service category is used for connections that transport traffic at a constant bit rate, where there is an inherent reliance on time synchronization between the traffic source and destination. In figure 3 shows CBR parameters in which item size, interval and end time are shown. These values describe the application bit rate for LTE system.

In this paper, we use various application bit rates i.e. 2, 4, 8, 16 Mbps. In fig. 3, interval is 1ms and item size is 500 bytes. 4 Mbps application bit rate are shown in fig. 3.

Property	Value
Source	1
Destination	5
Items to Send	0
Item Size (bytes)	500
Interval	1 (milli-seconds)
Start Time	1 (seconds)
End Time	25 (seconds)
Priority	Precedence
Precedence Value	0
Enable RSVP-TE	No
Enable MDP	No
Session Name	[Optional]

Fig. 3: CBR Parameters Used in Simulation

D. Simulation Result

In this paper simulation has been done in two parts. Firstly simulation is done by consideration of MIMO techniques and then simulation is done using mobility effects.

By using the simulation model described the performance parameters has been evaluated in terms of throughput, end to end delay and jitter.

1. Simulation Results Using MIMO Technique

(i). Throughput

Network throughput is the average rate of successful message delivery over a communication channel. These data may be delivered over a physical or logical link, or pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps).

The throughput results obtained using MIMO are shown in fig. 4. In this figure, throughput results corresponding to SIMO, SFBC and OLSM are present.

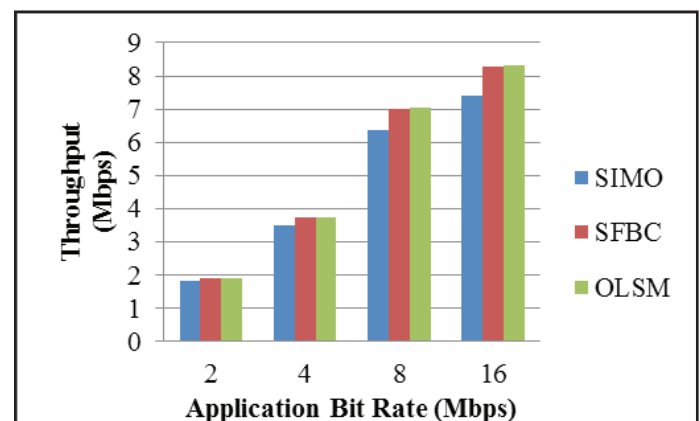


Fig. 4: Throughput Analysis of LTE Network Using MIMO

The performance of SIMO, SFBC and OLSM antenna techniques are analyzed for different application bit rate. It has been observed from the figure 4, the performance of OLSM scheme is better than

SIMO and SFBC antenna scheme. Thus use of OLSM enables LTE support multimedia applications beyond web browsing and voice, which demands higher bandwidth configurations.

(ii). End to End Delay

End-to-end delay indicates the length of time taken for a packet to travel from the CBR (Constant Bit Rate) source to the destination.

The End-to-end delay results obtained using MIMO are shown in figure 5. In this figure shows End-to-end delay results corresponding to SIMO, SFBC and OLSM are present.

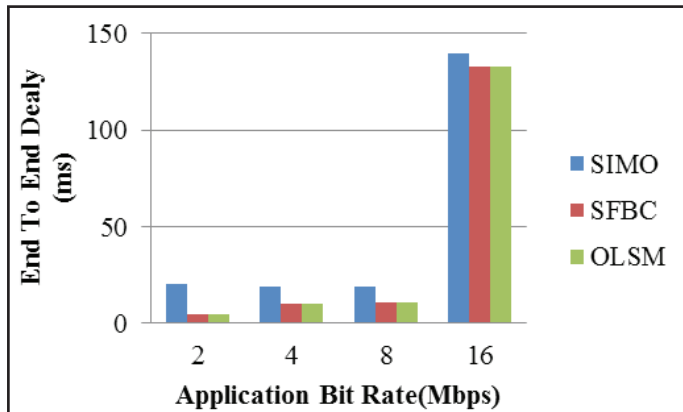


Fig. 5: End To End Delay Analysis of LTE Network Using MIMO

It has been observed from the fig. 5 that the End To End Delay over different application bit rate. In Fig. 5, end to end delay is lesser in the case of OLSM than SIMO and SFBC. Because of the multiplexing gain can easily be observed in the case of OLSM scheme.

(iii). Jitter

The variation in the latency of packets at the destination is termed as Jitter which is caused due to congestion, topology change etc. in a network. It occurs when in a transmission scenario different packets take different amount of time in reaching from source to destination. The jitter results obtained using MIMO are shown in fig. 6.

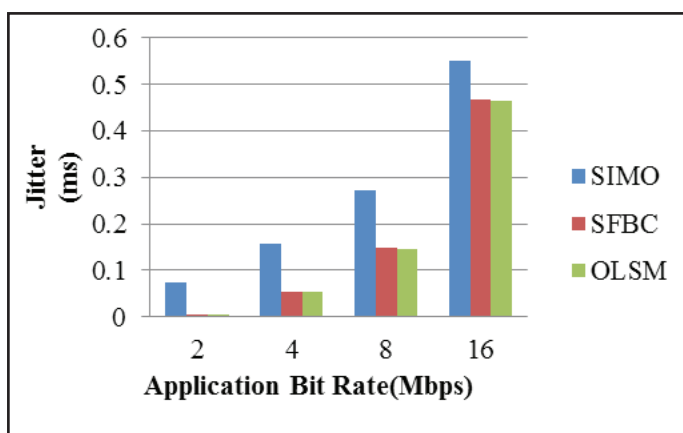


Fig. 6: Jitter Analysis of LTE Network Using MIMO

2. Simulation Results Using Mobility Effects

(i). Throughput

It is observed from the figure7 that throughput of LTE system corresponding to mobility on UE (mobile station).

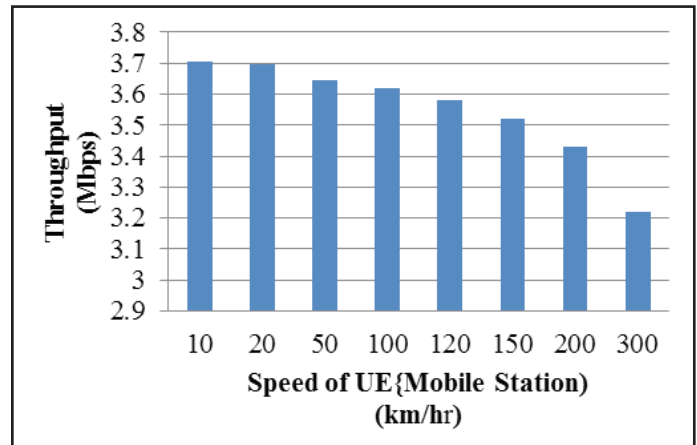


Fig. 7: Throughput Analysis of LTE Network Using Mobility

From fig. 7, we can say when the speed of mobile station is increase then throughput decrease because interference increase with increase in speed, so number of packets loss increase then throughput decrease.

(ii). End-To-End Delay and Jitter

The end to end delay results obtained using MIMO are shown in fig. 8.

It is also observed that the delay and jitter performances of LTE system is also vary with speed. Higher mobility causes more links broken and frequent re-routing and thus causes larger end-to-end delay.

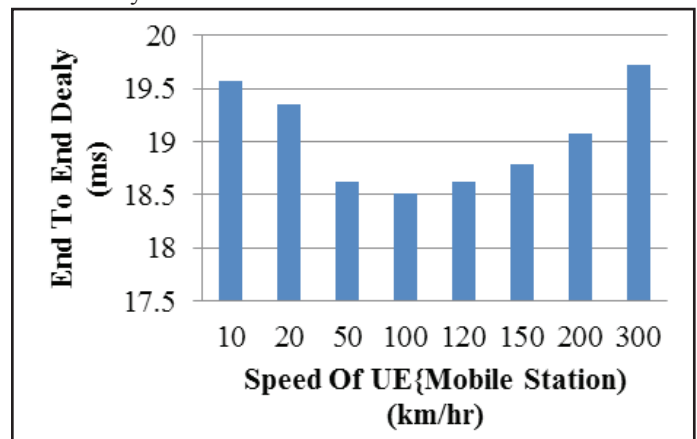


Fig. 8: End To End Delay Analysis of LTE Network Using Mobility

As, speed of mobile station is increased, jitter and delay are also increased.

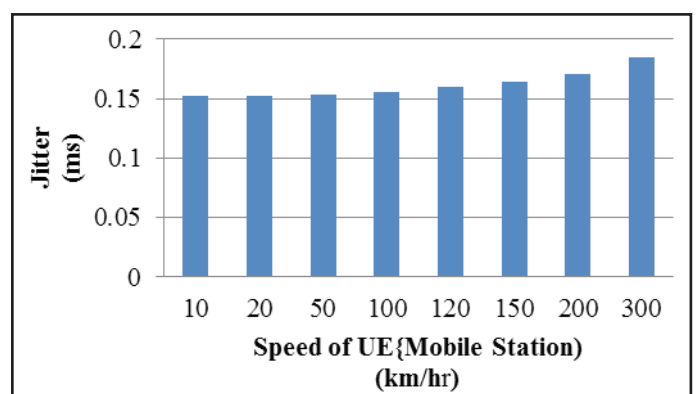


Fig. 9: Jitter Analysis of LTE Network Using Mobility

Fig. 8 and fig. 9 gives optimized speed is 100kmph because at this speed end to end is minimum and jitter is also low.

V. Conclusion

In this paper, the performance of LTE network is analyzed by using advanced techniques such as MIMO and Scheduling algorithms in terms of throughput, end to end delay and jitter.

The simulation has been carried out by varying CBR application bit rate. Simulation results concluded that the performance of OLSM is better than SFBC and SIMO. In this paper, mobility effects are also considered in LTE. As we increase the speed of mobile station then throughput decrease and losses are increased. LTE supports the optimized performance for low speeds (< 15 km/hr), high performance for speeds up to 100 km/hr and maintained performance for speeds up to 300 km/hr.

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