Performance Analysis of Long Term Evolution Wireless Network

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Abstract: Long term evolution is a prominent 4G technology with prolonged advancements and further releases facilitating a fast, efficient and reliable communication with advanced techniques. In-built model libraries in Qualnet6.1 provide platform for LTE release 9 Network designing and simulation. Qualnet supports MIMO downlink transmission modes 1, 2 and 3 with Round robin and Proportional fair Scheduling algorithms and related features. The service provided by LTE network will be efficient and reliable at the maximum rate of uplink and downlink transmissions with minimum delay, variations and packet loss so that the communication is incessant. Therefore, the Performance of LTE wireless network by considering different MIMO techniques for variable data rates, Scheduling algorithms, different Channel bandwidths, Hysteresis values and effects of mobility of users and noise factor at the network is evaluated and analyzed graphically in terms of Throughput, Average End to End delay, Average Jitter and total messages sent and received (Packet Delivery Ratio) using Qualnet Network Simulator 6.1.

***Index Terms* – Qualnet, Scenario, MIMO, Hysteresis**

I. INTRODUCTION

Long Term Evolution (LTE) is an International Telecommunication Union (ITU) approved 4G Technology used for fast and efficient Wireless Communication. LTE is a Global and Compatible Standard for accessing high speed data, high spectral efficiency and better multimedia quality and streaming. In this Context the Performance of LTE wireless network by considering different MIMO techniques (MIMO downlink transmission modes) for variable data rates, Scheduling algorithms, different Channel bandwidths, Hysteresis values and effects of noise factor at the network is evaluated and analyzed graphically from throughput, end to end delay, jitter and total messages sent and received using Qualnet Network Simulator. Presently, Qualnet 6.1 supports multiple antenna Transmission, space frequency block coding transmit diversity (SFBC) and open loop spatial multiplexing (OLSM), Round robin and Proportional fair Scheduling algorithms. . Qualnet simulator is opted because of its Graphical user interface (GUI) and debugging support. In-built model libraries in Qualnet provide platform for LTE release 9 Network designing and simulation.

II. METHODOLOGY

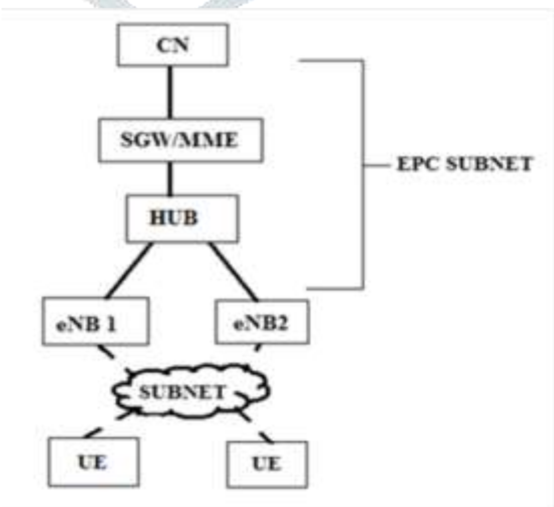

Fig. 1 LTE Network Model in Qualnet

LTE network scenario consists of Nodes representing user equipment's (Mobile stations), enodeB(Base stations) and Evolved packet core (EPC) subnet. Connection of Base station to core network is wired connection and to the subnet is wireless. Click Drag and Drop operation is performed to place nodes of default device type and to create LTE network topology on the canvas using Qualnet Graphical user interface and configuration tools as shown in Fig.1. The LTE EPC model is configured as follows:

1. Place a Hub and enodeB's on the canvas.
2. Create a link between the enodeB's and the Hub.
3. Go to Wired Subnet Properties Editor > General
4. Set Is EPC Subnet to Yes and set the EPC SGWMME Node ID and Index.

III. CASE STUDY

To analyze the Performance of LTE network two network scenario's are created using Qualnet simulator. The other network parameters under consideration are listed in Table 1.

3.1 LTE Network Scenario for Analyzing MIMO Techniques, Scheduling Algorithms, Effect of Noise Factor And Different Bandwidth.

In scenario1 (Fig.2) CBR traffic application is applied between node 5 and node 6 and Mobility is flagged. SIMO, SFBC, OLSM LTE MIMO Transmission modes and Round robin, Proportional fair scheduling algorithms are considered for analyzing MIMO techniques with 20MHz Channel bandwidth. Four channels are considered for uplink and downlink transmission. Noise factor is varied by 10,20,30,40 and 50 dB with 20MHz Channel bandwidth, Round robin scheduling, and OLSM Transmission mode for analyzing LTE network performance for different Noise factors. Channel Bandwidth is varied by 1.4, 3, 5, 10, 15, 20MHz with noise factor of 10dB, Round robin scheduling, and OLSM Transmission mode for analyzing LTE network performance for different Bandwidths.

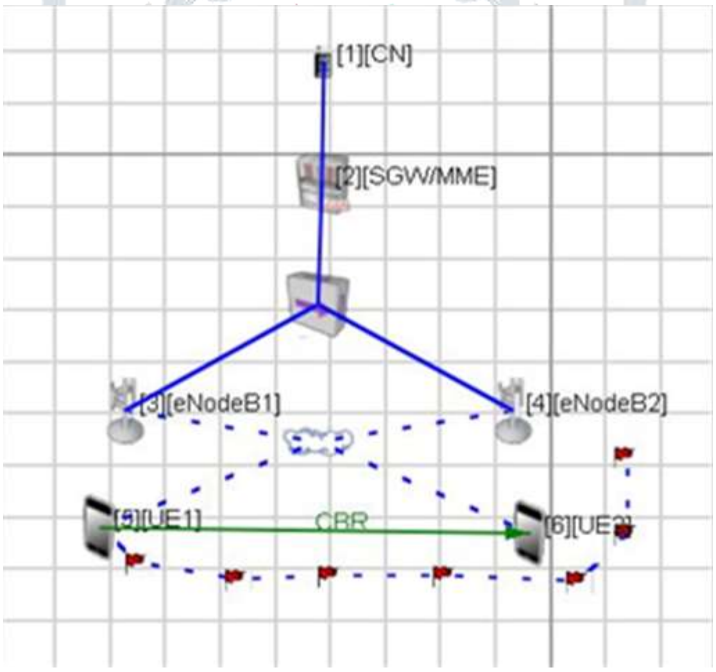

Fig. 2 LTE network scenario 1

3.2 LTE Network Scenario for Analyzing Effects of Mobility and Handover Hysteresis

In scenario 2(Fig. 3) CBR Traffic Application is applied between node 5 and node 6(between UE1 and UE2) and Random way point mobility is considered. Mobility speed of a node (UE) is varied by 1, 2, 5, 15, 20and 30 Km/s and Event A3(RSRP) hysteresis of 0,1,2,3,4,5 dB with noise factor of 10dB, Round robin scheduling, and OLSM Transmission mode is considered for analyzing LTE network performance under different mobility speed.

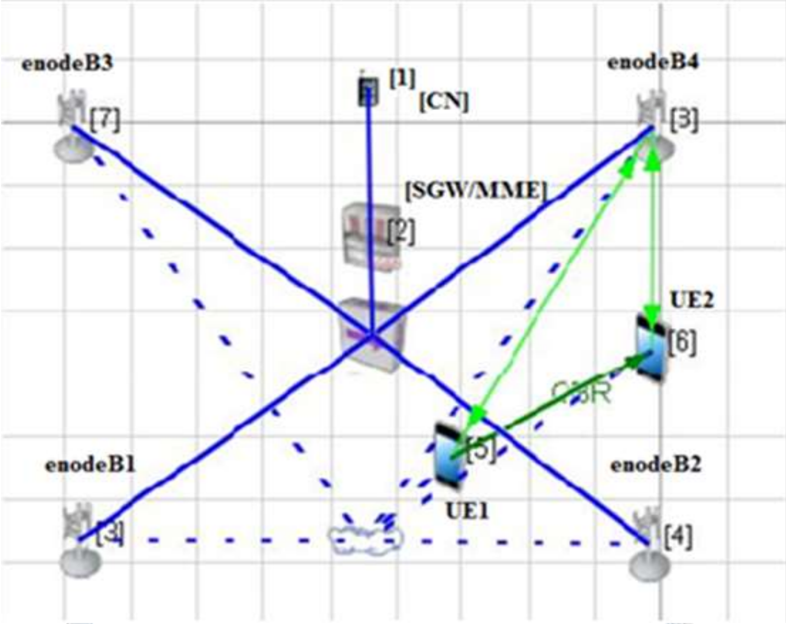

Fig. 3 LTE network scenario 2

Parameter		Value
Simulator		Qualnet 6.1
Physical and MAC model		LTE Phy and LTE MAC
Terrain		1300*1300 sq.mt
Simulation time		100 Sec
Propagation-Channel-Frequency		2.4 GHz
Traffic Type		CBR
Antenna-Model		Omni directional
enodeB Parameters	PHY-LTE-Transmission-Power	46dBm
	Number of PHY-LTE-Receiver-Antennas	2
	Antenna Height	15m
	Antenna Gain	14Db
UE Parameter	MAC-LTE-Scheduler-Type	Simple Scheduler
	PHY-LTE-Transmission-Power	23 dBm
	Number of PHY-LTE-Receiver-Antennas	1
	Antenna Height	1.5m

Table1. LTE Network Simulation parameter

IV. RESULTS AND DISCUSSION

Traffic flow through the network and the performance of the network can be analyzed from the dynamic graphs.

4.1 Results for MIMO downlink Transmission modes

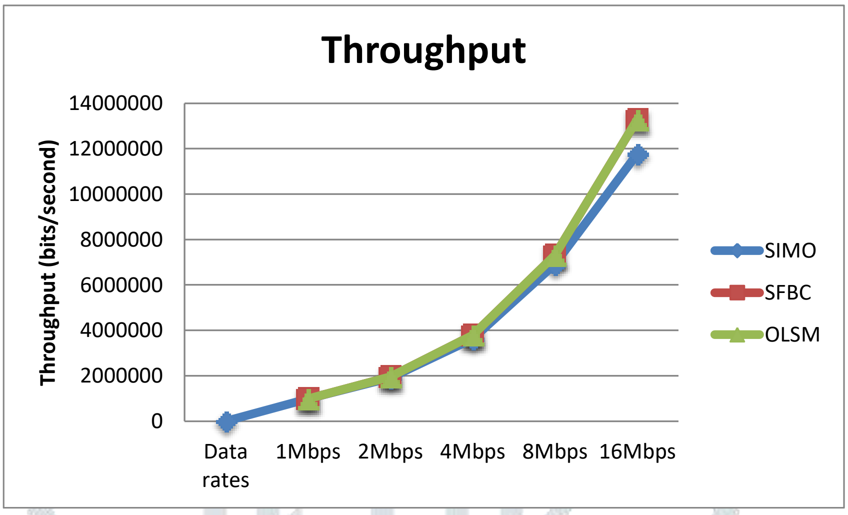

Fig. 4 Throughput for MIMO transmission modes

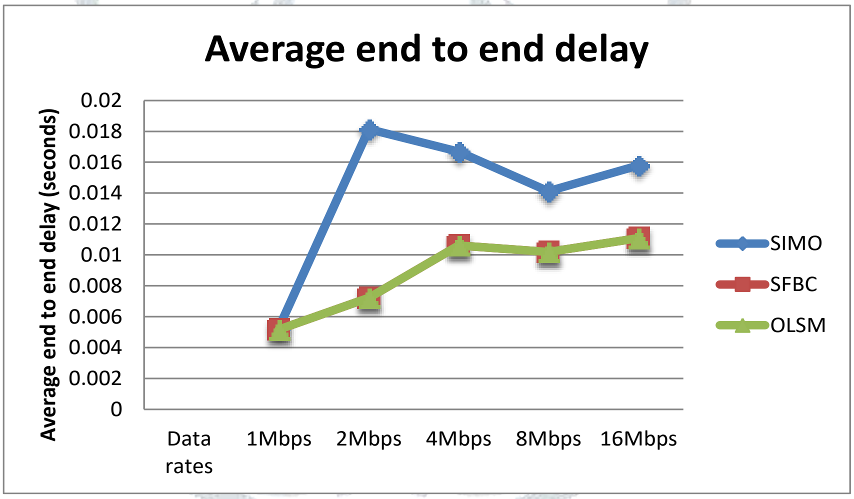

Fig. 4 Average end to end delay for MIMO transmission modes

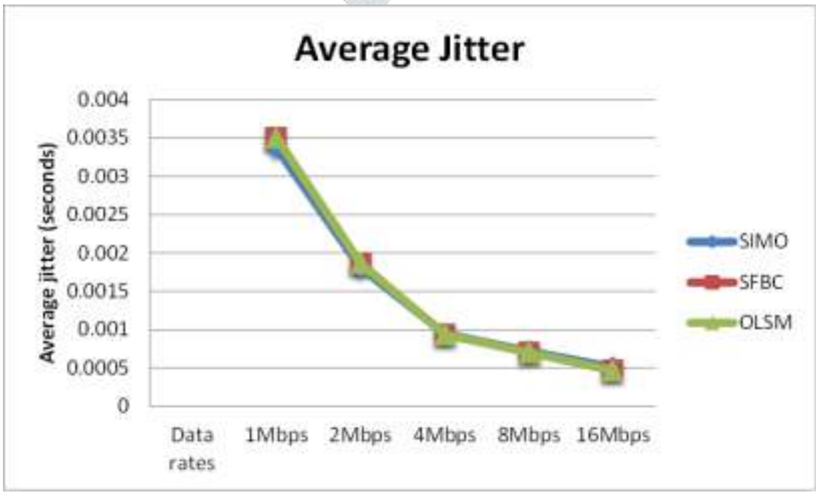

Fig. 5 Average Jitter for MIMO transmission modes

Packet delivery ratio(PDR) for SIMO= 81.08%, Packet delivery ratio(PDR) for SFBC= 87.88%, Packet delivery ratio(PDR) for OLSM=87.88%.

From the graph of Throughput, end to end delay, jitter and estimation of packet delivery ratio for SIMO,SFBC and OLSM at different data rates SFBC and OLSM are more efficient Multiple antenna techniques for downlink transmissions.However SIMO provides receive diversity and can perform well for Uplink transmission.

4.2 Results for Scheduling algorithms

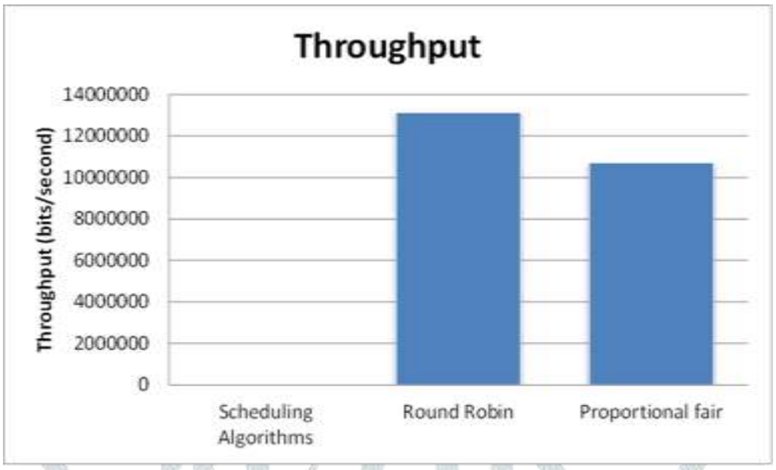

Fig. 6 Throughput for scheduling algorithms

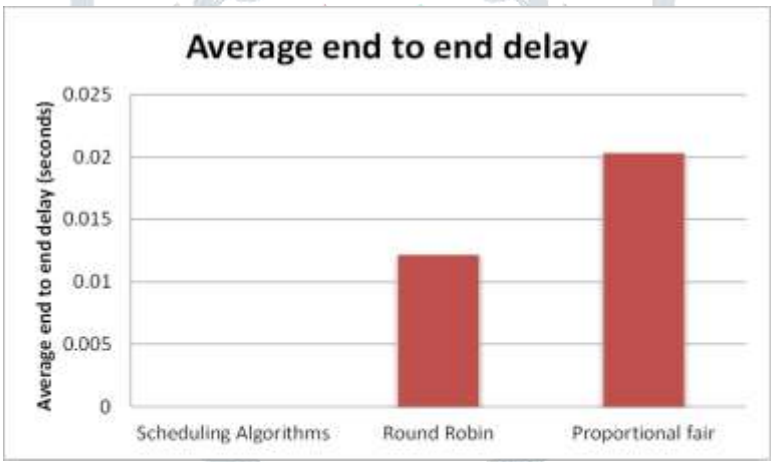

Fig. 7 Average end to end delay for Scheduling algorithms

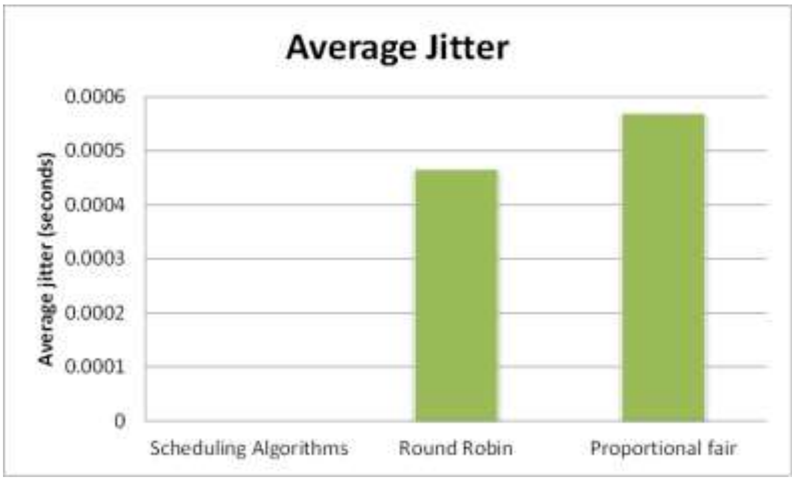

Fig. 8 Average Jitter for scheduling algorithms

Packet delivery ratio for round robin scheduling = 81.87% , Packet delivery ratio for proportional fair scheduling= 66.75%.

From the above Statistics, it is observed performance of Round robin(RR) scheduling algorithm is better interms of throughput and packet delivery ratio with less end to end delay and jitter than compared to Proportional Fair(PF) algorithm for downlink resource scheduling. The proportional fair scheduling does not assure any QoS requirement such as delay, jitter and latency. However PF performs better compared to RR when channel conditions are considered.

4.3 Results for different Noise factors

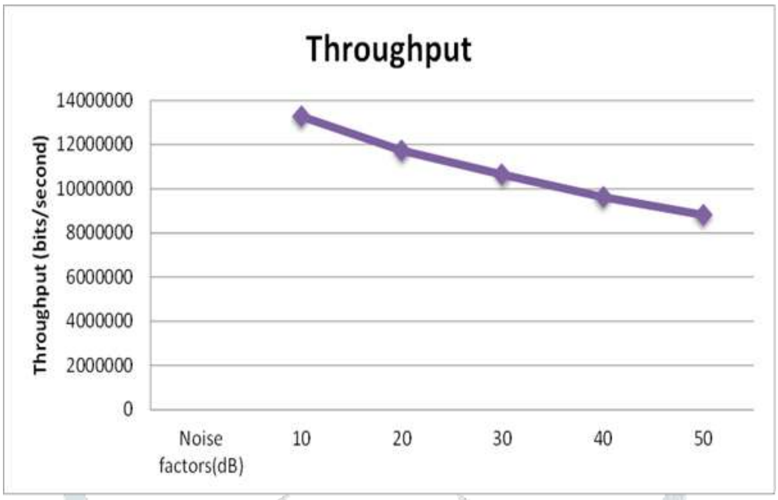

Fig. 9 Throughput for different Noise factors

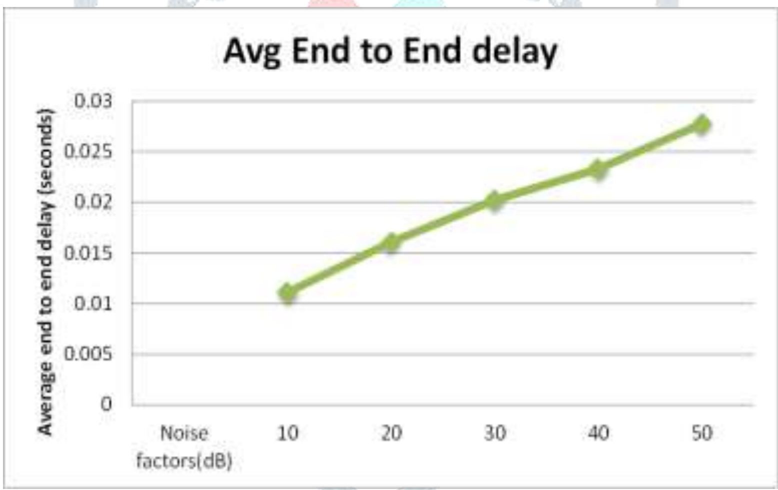

Fig. 10 Average end to end delay for different Noise factors

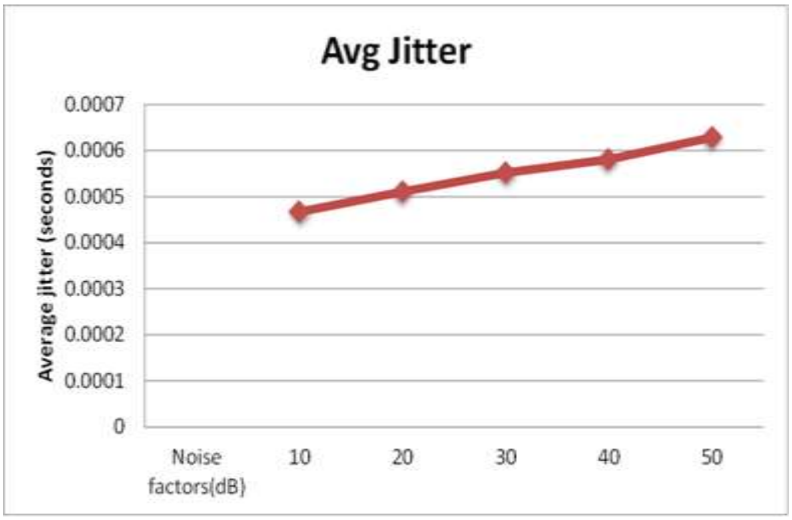

Fig. 11 Average Jitter for different Noise factors

Packet delivered ratio for 10dB Noise factor = 82.80%, Packet delivered ratio for 20dB Noise factor = 73.15%, Packet delivered ratio for 30dB Noise factor = 66.39%, Packet delivered ratio for 40dB Noise factor = 60%, Packet delivered ratio for 50dB Noise factor = 54.99%. LTE network gives better performance for low noise factors.

4.4 Results for different Bandwidths

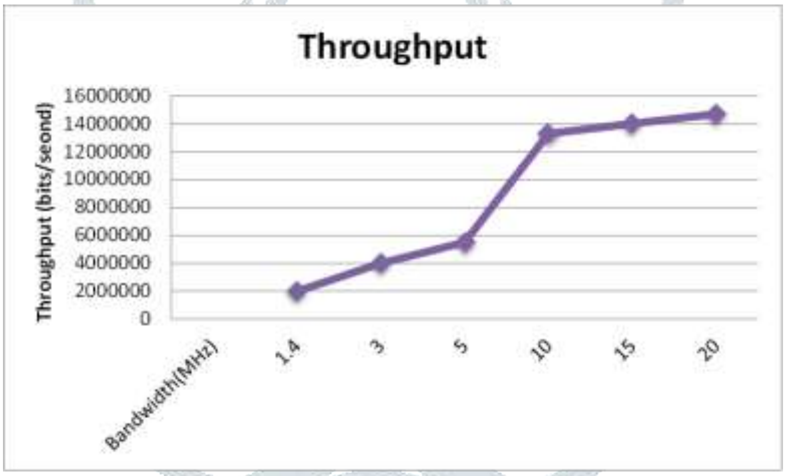

Fig. 12 Throughput for Channel Bandwidths

Fig. 13 Average end to end delay for Channel Bandwidths

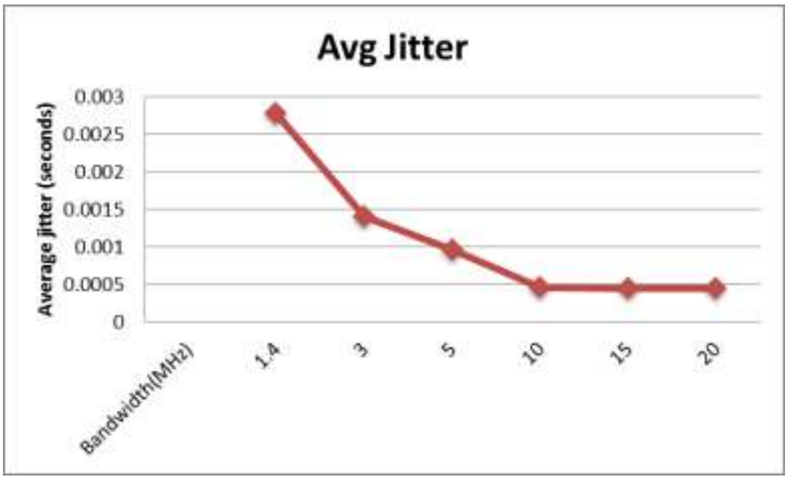

Fig. 14 Average Jitter for different Channel Bandwidths

Packet delivered ratio for 1.4MHz Channel bandwidth = 12.3%, Packet delivered ratio for 3MHz Channel bandwidth = 24.9%, Packet delivered ratio for 5MHz Channel bandwidth = 34.23%, Packet delivered ratio for 10MHz Channel bandwidth = 82.80% , Packet delivered ratio for 15MHz Channel bandwidth = 87.37%, Packet delivered ratio for 20MHz Channel bandwidth = 91.66%.

Larger Channel bandwidth,results in increased throughput and packet delivery ratio with decreased end to end delay and Jitter.PDR is above 90% for 20MHz Channel bandwidth.

4.5 Results for different Mobility speeds

Fig. 15 Throughput for Mobility speeds

Fig. 16 Average end to end delay for mobility speeds

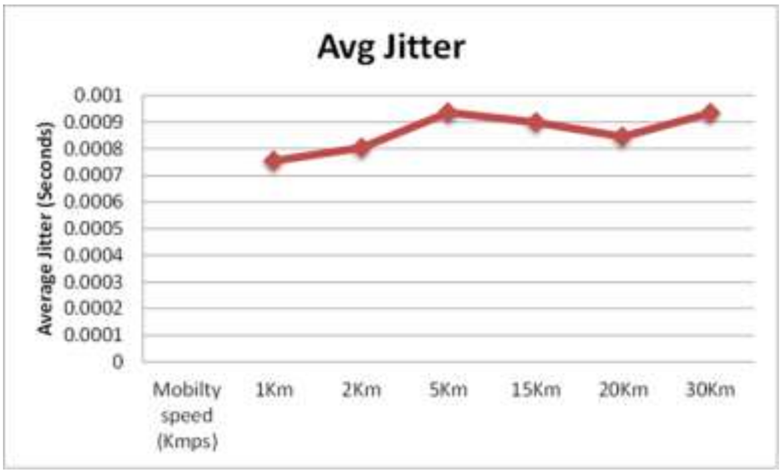

Fig. 17 Average Jitter for mobility speeds

Packet delivery ratio for 1kmps speed = 29.03%, Packet delivery ratio for 2kmps speed = 28.76%, Packet delivery ratio for 5kmps speed = 28%, Packet delivery ratio for 15kmps speed = 23.87%, Packet delivery ratio for 20kmps speed = 23.78%, Packet delivery ratio for 30kmps speed = 23.36%

Due to mobilty of users the packet delivery ratio is almost decreased by 70% for the LTE network scenario considered for analysis.Thus high speed mobility results in loss of packets during transmissions between the nodes(users) and degradation quality of service provided for users

4.6 Results for different Hysteresis values

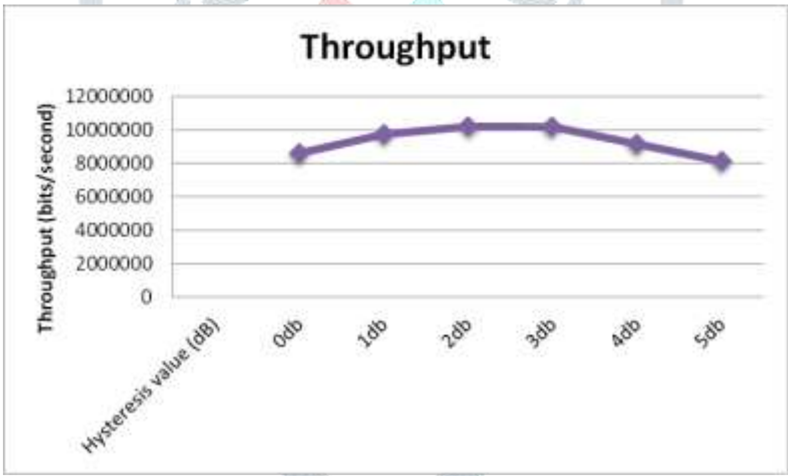

Fig. 18 Throughput for Hysteresis values

Fig. 19 Average end to end delay for hysteresis values

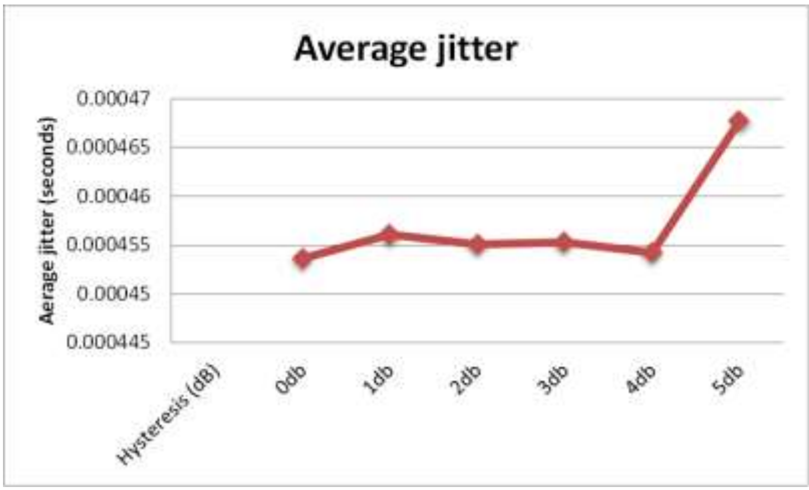

Fig. 21 Average Jitter for hysteresis values

Packet delivery ratio for 0dB Hysteresis = 53.58% , Packet delivery ratio for 1dB Hysteresis = 60.65%, Packet delivery ratio for 2dB Hysteresis = 63.62%, Packet delivery ratio for 3dB Hysteresis = 63.53%, Packet delivery ratio for 4dB Hysteresis = 57.05%, Packet delivery ratio for 5dB Hysteresis = 50.73%

The graphs reveal that between the hysteresis value of 2dB and 3dB the throughput packet delivery ratio is high with less delay and Jitter. This indicates that the handover will be efficient between the hysteresis of 2dB and 3dB for the particular LTE network scenario.

V. CONCLUSION

Simulation of two different LTE release 9 wireless network scenarios using Qualnet 6.1 simulation tool outlines the following results: Analysis of MIMO techniques(SIMO, SFBC and OLSM)with different data rates used in LTE reveals SFBC and OLSM gives better performance than SIMO. However, SIMO is suitable mode for uplink transmission, SFBC is appropriate for transmissions requiring reliability in communication and OLSM is appropriate mode of transmission for achieving high datarates.Out of two downlink resource scheduling algorithms used in LTE analysis show Round robin scheduling performs better than Proportional fair scheduling incase of Channel independent scheduling. Performance of LTE network is efficient and reliable for low noise factor at base station(enodeB)and Mobility speed of users.Increase in the channel bandwidth increase the spectrum avalaibilityand improves the LTE network performance.For 2.4GHz channel frequency, 20MHz channel bandwidth provides availability number of channels for reuse and transmission bandwidth is 90% of Channel bandwidth. Results of analysis of hysteresis values(0,1,2,3,4,and 5dB) for intra-frequency handover depicts the margin at which handover can be done without any interruption in communication.For LTE network scenario in this context, performance of network is better if the handover takes places between 2dB and 3dB hysteresis values.

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