LTE Access Network Simulation

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Abstract- The overall objective for LTE is to provide an extremely high performance radio-access technology that offers full vehicular speed mobility and that can readily coexist with HSPA and earlier networks. OFDM/OFDMA technology is introduced for the LTE downlink, supporting very high data rates of up to 300Mbps while Single-Carrier FDMA (SC-FDMA) is used in the uplink with data rates of 80Mbps possible. Additionally, LTE supports operation both in paired and unpaired spectrum (FDD and TDD) using channel bandwidths of approximately 1.4MHz up to 20MHz. The frequency domain scheduling can be done in OFDMA. One of the main challenges in OFDMA is the high peak-to-average radio of the transmitted signal, which requires linearity in the transmitter. The linear amplifiers have low efficiency. Therefore, OFDMA is not an optimized solution for a mobile uplink where the target is to minimize the terminal power consumption. An LTE uplink uses SC-FDMA, which clearly enables better power- amplifier efficiency. LTE is based on simpler multi-antenna operation. Higher bit rates can generally be obtained by using larger bandwidth and multiple antennas. Multiple input multiple output (MIMO) antenna technologies are required to achieve the LTE bit-rate targets. MIMO is simpler to implement with OFDMA.

Key words: long term evolution, technology, GSM, switching.

I. INTRODUCTION

Today cell phones have everything ranging from the smallest size, largest phone memory, speed dialing, video player, audio player, and camera and so on. Recently with the development of Pico nets and Blue tooth technology data sharing has become a child's play. Earlier with the infrared feature allows to share data within a line of sight that means the two devices has to be aligned properly to transfer data, but in case of blue tooth allows transfer of data even have the cell phone is in pocket up to a range of 50 meters.

Long Term Evolution (LTE) is a radio platform technology that will allow operators to achieve even higher peak throughputs than HSPA+ in higher spectrum bandwidth. Work on LTE began at 3GPP in 2006, with an official LTE work item started in 2009 and a completed 3GPP Release 8 specification in March 2011. Initial deployments of LTE began in late 2009[1-8].

LTE is part of the GSM evolutionary path for mobile broadband, following EDGE, UMTS, HSPA (HSDPA and HSUPA combined) and HSPA Evolution (HSPA+)[9]. Although HSPA and its evolution are strongly positioned to be the dominant mobile data technology for the next decade, the 3GPP family of standards must evolve toward the future. HSPA+ will provide the stepping-stone to LTE for many operators[12].

The overall objective for LTE is to provide an extremely high performance radio-access technology that offers full vehicular speed mobility and that can readily coexist with HSPA and earlier networks. Because of scalable bandwidth, operators will be able to easily migrate their networks and users from HSPA to LTE over time.

II. METHODOLOGY

LTE is a new technology, largely in the state of standardization. This means that it is very difficult to find the references and previous works on this subject. Mostly, 3GPP standardization documents and drafts have to be relied up on.

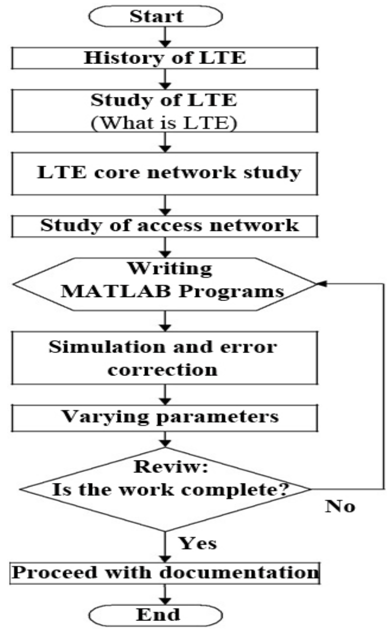

Figure 1. Methodology

A. Existing method :3G WCDMA network

Today's mobile networks are rarely ramped up from scratch. Most of the networks have evolved through time and that makes the variation of networks vast. The network has two parts; Radio access net work (RAN) and core network (CN)[16-20]. Core network is usually divided to packet core network (PS) and circuit switched network (CS). Radio access network handless all radio related functionalities and the core networks is responsible of switching and routing calls and data connections to external networks.

In a GSM network base (transreceiver) stations (BTS) and base station controllers (BSC) are the functional units of the radio access network. WCDMA radio access network includes same kinds of elements than GSM RAN. UMTS base stations are called node Bs and base station controllers are called Radio Network Controllers (RNC).

The base station and node B are used to facilitate wireless communication between user equipment (UE) and a network. Node B also takes part in radio resource management. The base station controller (BSC) and radio network controller (RNC) are the brains behind the base stations[21-23]. Normally a base station controller or a radio network controller has tens or even hundreds of base stations under its control. The BSC and RNC have many different responsibilities and functions, that are the handling of radio resources and controlling of handovers between BSC to BSC or RNC to RNC.

Main network elements in the circuit switched core network are mobile services switching center/visitor location register (MSC/VLR), home location register (HLR) and media gateway (MGW). These network elements provide circuit switched connections like PSTN and ISDN. Serving GPRS support node (SGSN) and gateway GPRS support node (GGSN), network elements provide the packet data services in the networks[24].

Home location register (HLR) is a database located in the subscriber's home system. HLR stores the master copy of user's service profile. Information about the subscriber and all allowed services, forbidden roaming areas and supplementary service information like call forwarding status are stored to service profile. The service profile is created when a new user joins to the system for example by purchasing a new Elisa SIM card.

Mobile services switching center/visitor location register (MSC/VLR) is the brains in the core networks. It is the switch (MSC) and database (VLR) which serves the user equipment (UE) in its current location for circuit switched services like speech. Visitor location register holds a copy of visiting user's service profile and the location of the user equipment inside of the serving system[25]. Media gateway (MGW) is a network element which resides at the boundary between radio access network and core networks. The MGW can be used for transmitting and converting the user plane traffic in both circuit-switched core networks and IP multimedia core network as a border element between different kinds of networks[26-30]. The MGW provides a number of configurations for different purposes depending on the network environment in which the MGW is located and on the needed interface types.

Serving GPRS support node (SGSN) functionality is very similar to the functionality of MSC/VLR but SGSN is used for packet switched services. Serving GPRS support node (SGSN), main responsibilities are the delivery of data packets from and to the user equipments (UE) within its geographical service area. Its other tasks include packet routing and transfer, mobility management, logical link management and authentication and charging functions. Location information and user profiles are stored in the location register of the SGSN. All GPRS users registered with this SGSN. The gateway GPRS support node (GGSN) is another main component of the packet network. The GGSN main responsibility is to handle the interworking between the GPRS network and external packet switched networks, like the Internet

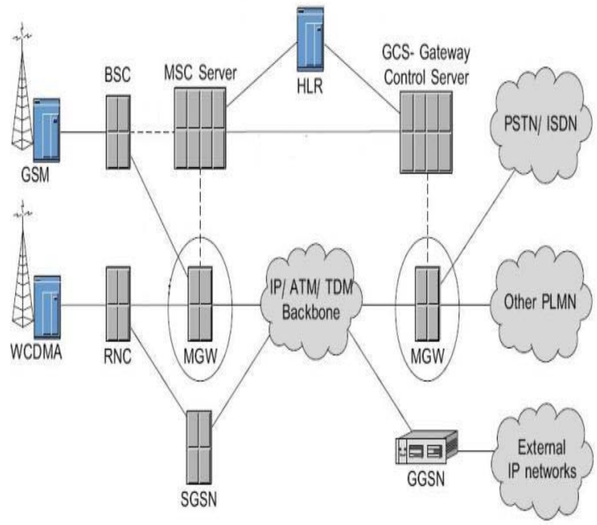

Figure 2. WCDMA Architecture

B. LTE Network

The overall objective for LTE is to provide an extremely high performance radio-access technology that offers full vehicular speed mobility and that can readily coexist with HSPA and earlier networks [13]. Moreover, the 3GPP technologies continued to evolve, future releases by the 3GPP will see both combinations of dual carriers and MIMO as well as combinations of up to 4 carriers with both alternatives capable of supporting up to 84Mbps. Also higher bit rates are possible if combinations of MIMO and 4 carriers will be supported in the future. OFDM/OFDMA technology is introduced for the LTE downlink, supporting very high data rates of up to 300Mbps while Single-Carrier FDMA (SC-FDMA) is used in the uplink with data rates of 80Mbps possible[4]. Additionally, LTE supports operation both in paired and unpaired spectrum (FDD and TDD) using channel bandwidths of approximately 1.4MHz up to 20MHz.

Now a days it is possible to browse the Internet or send e-mails using HSPA-enabled notebooks. Fixed DSL modems can be replaced conveniently with HSPA modems or USB dongles and we can also send and receive video or music using 3G phones. LTE will make the user experience even better by enhancing more demanding applications such as interactive TV, mobile video blogging, advanced games and professional services[14].

On the core network side, additional elements, like registers, are needed as well for a fully functioning system. While discussions in 3GPP are still ongoing as to whether all the interfaces will be standardized[15]. For the purposes of handover there is also an interface between the eNode Bs called X2. The interface between core and radio access networks is called S1, where S1 is defined in such a way that implementation in the core network side would be possible with having control- (S1_MME) and user-plane (S1_U) traffic processing in separate physical elements[16]. Implementation may then choose either to have an integrated core network element or to have separated ones between user-plane and control-plane handling.

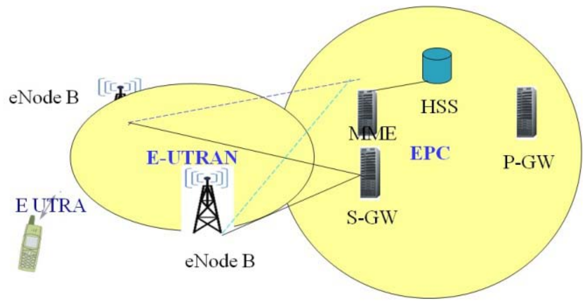

Figure 3. LTE Architecture

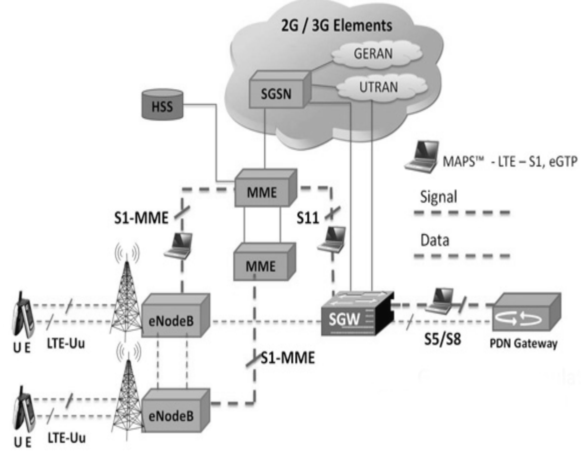

Figure 4. LTE Architecture overview

In the core network side the following entities have been defined:

1. **Serving SAE Gateway** and Public Data Network (PDN) SAE Gateway for processing the user-plane data. These handle tasks related to the mobility management inside LTE, as well as between other 3GPP radio technologies. Serving GPRS Support Node for WCDMA (as well as for GSM) could connect to the gateways defined, thus handling the Gateway GPRS Support Node (GGSN) functionalities of the GSM/WCDMA network.
2. **Mobility Management Entity (MME)** handles the control plane signaling, and especially for mobility management and idle-mode handling. The S11 interface then connects MME to SAE/PDN gateways if implemented in separate physical elements.
3. **Home Subscriber Server (HSS)** presents the registers, covering functionalities like the Home Location Register (HLR) and contains user-specific information on service priorities, data rates, etc.
4. **Policy and Charging Rules Function (PCRF)** is related to quality of service policy as well as on the charging policy applied. The use of a flat network architecture means good scalability for increased data volumes with low dependency for the data volume itself, rather adding network capacity mainly due to the increased number of users. This enables cost efficiency for both network rollout and capacity extension as the traffic increases.

III. EXPERIMENT AND RESULT

A. OFDMA- Simulation

3GPP needed to make quite radical changes to LTE radio interface because enhancements to WCDMA technology could cause major problems with power consumption. Also the processing capability required in LTE would have made the resulting technology unsuitable for handheld mobile devices. OFDM-based technology was chosen because it can achieve the targeted high data rates with simpler implementations involving relatively low cost and power-efficient hardware.

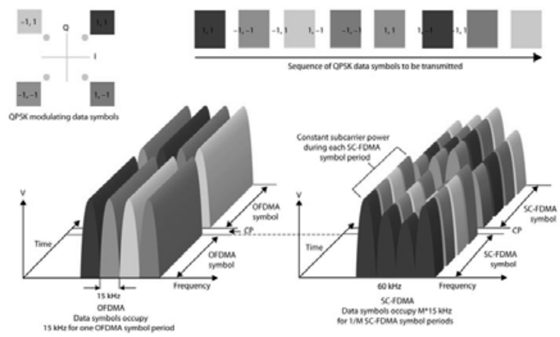

Figure 5. OFDMA used in LTE

B. OFDMA Transmitter And Receiver

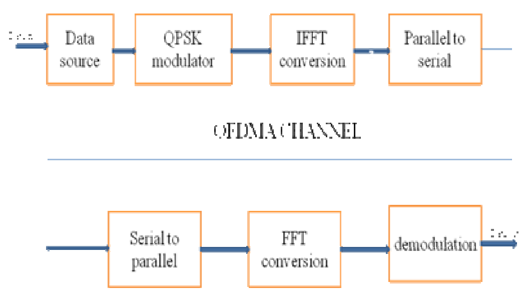

Figure 6. OFDMA simulation steps for LTE

It is good to notice that OFDMA is used in the downlink of LTE but for the uplink Single Carrier – Frequency Division Multiple Access (SC-FDMA) technology is used. SC-FDMA is technically similar to OFDMA but it suits better for handheld devices because it is less demanding on battery power. 5 MHz channel width causes constrains in data rates of WCDMA networks. To overcome these limitations in LTE networks bandwidths up to 20 MHz are deployed. If wider RF band such as 20 MHz would be used in WCDMA it could cause a group of delay problems which limits the achievable data rates in WCDM

LTE removes these limitations by deploying OFDM technology to split the 20 MHz channel into many narrow sub-channels. Total data throughput is generated by combining these sub-channels together. In Orthogonal Frequency Division Multiple Access (OFDMA) system different sub-channels are assigned to different users. Thousands of these narrow sub-channels are deployed to send many messages simultaneously. Then those are combined at the receiver to make up one high speed message.

C. MIMO

Todays mobile networks are very noisy environments. Noise in the mobile networks is created by other users, neighboring cell sites and thermal background noise. Without noise, an infinite amount of information could be transmitted over a finite amount of spectrum. Shannon's Law formulated by mathematician Claude.

Shannon’s channel capacity theorm

Shannon states that there is a fundamental limit to the amount of information that can be transmitted over a communications link. The volume of error-free data that can be transmitted over a channel of any given bandwidth is limited by noise .

1. MIMO systems use multiple antennas at the transmitting and receiver ends
2. 2 X 2 MIMO doubles the data throughput
3. 4 X 4 quadruples the data throughput

D. LTE MIMO System

To minimize the effects of noise and to increase the spectrum utilization and link reliability LTE uses MIMO technique to send the data. The basic idea of MIMO is to use multiple antennas at receiver end and use multiple transmitters when sending the data.

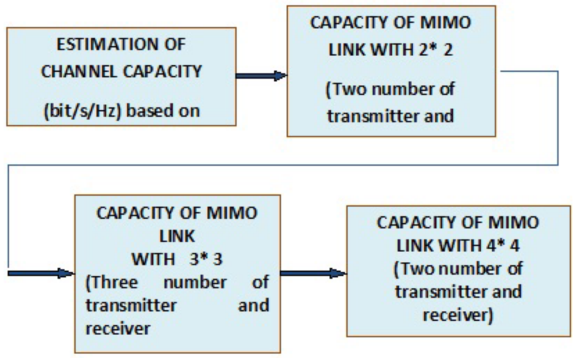

Figure 7. MIMO Valuation system in LTE

Before sending the data transmitter converts serial bit streams output by the source into multiple parallel sub streams. Then transmitter sends them via different transmit antennas using the same time slot and the same frequency band.

After receiving data receiver separates out the original sub streams from the mixed signals using the non-correlation of signals on multiple receive antennas caused by multipath in the transmission. This leads to significant increases in achievable data rates and throughput. Shannon's Law applies to a single radio link between a transmitter and a receiver.

By using MIMO technique Shannon's law can be bended a little bit. In MIMO each individual radio link is limited by Shannon's Law but collectively they can exceed it.

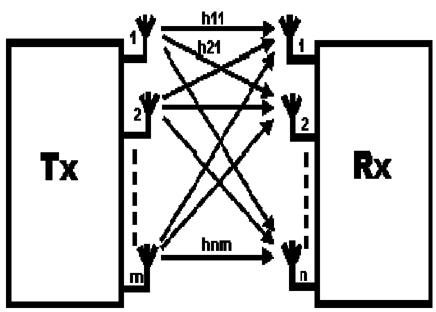

Figure 8. MIMO System

An important component in meeting the goals of LTE-Advanced is multi-antenna technology. These include things like beam forming and spatial multiplexing, which are already playing major roles in LTE.

Enhancements of MIMO technologies for LTE-Advanced are driven by the need for increased peak rates, improvement of system level performance and support of various transmission schemes with a universal structure. The scope of MIMO in LTE-Advanced will include the following:

1. Downlink (DL) higher-order MIMO.
2. Enhanced DL multi-user MIMO (MU-MIMO).
3. Uplink spatial multiplexing.

4. Uplink transmit diversity with multiple transmit (Tx) antennas

E. Propagation (Path Loss) Model

A propagation model describes the average signal propagation and it converts the maximum allowed propagation loss to the maximum cell range. It depends on:

1. Environment: urban, rural, dense urban, suburban, open, forest, sea…
2. Distance
3. Frequency
4. atmospheric conditions
5. Indoor/outdoor

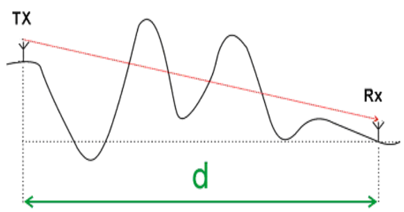

Figure 9. Microwave Propagation

Common examples include free space, Walfish–Ikegami, Okumura–Hata, Longley–Rice, Lee and Young's models. The most commonly used model in urban environments is the Okumura-Hata model as described below:

For Urban Areas:

$$Lu = 69.55 + 26.16 * \log(f) - 13.82 * \log(h_B) - C_H + [44.9 - 6.55 * \log(h_B)] * \log(d)$$

For Small and Medium-sized cities:

$$C_H = 0.8 + (1.1 * \log(f) - 0.7) * h_M - 1.56 * \log(f)$$

For Large cities:

$$C_H = \begin{cases} 8.29 * (\log(1.54 * h_M))2 - 1.1, if\ 150 \leq f \leq 200 \\ 3.2 * (\log(11.75 * h_M))2 - 4.97, if\ 200 \prec f \leq 1500 \end{cases}$$

Where,

Table 1: Parameters of Okumura-Hata Model

Parameters	Unit	Significance
Lu	dB	Path loss in Urban Areas
h_B	m	Height of base station Antenna
h_M	m	Height of mobile station Antenna
f	MHz	Frequency of Transmission
C_H	dB	Antenna height correction factor
d	km	Distance between Base station and MS

Multiple antennas can be used either at the transmitter or receiver or at both. These various configurations are referred to as multiple input single outputs MISO, Single Input Multiple Output SIMO or Multiple Input Multiple Output MIMO. The SIMO and MISO architectures are a form of receive and transmit diversity schemes respectively. On the other hand, MIMO architectures can be used for combined transmit and receive diversity, as well as for the parallel transmission of data or spatial multiplexing. When used for spatial multiplexing MIMO technology promises high bit rates in a narrow bandwidth and as such it is of high significance to spectrum

1. The LTE link budget for uplink is presented for a 64 kbps data rate.
2. Two resource block allocation, giving 360 kHz transmission bandwidth. The terminal power is assumed 24 dBm and nobody loss is included for the data connection.
3. The base station receiver assumes a radio-frequency (RF) noise Fig. of 2.0 dB. The required signal-to interference-and-noise ratio (SINR) value is taken from link.

F. OUTPUTS

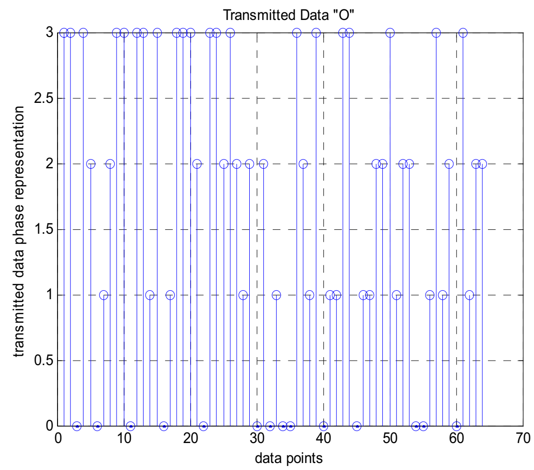

Figure 10. Transmitted data

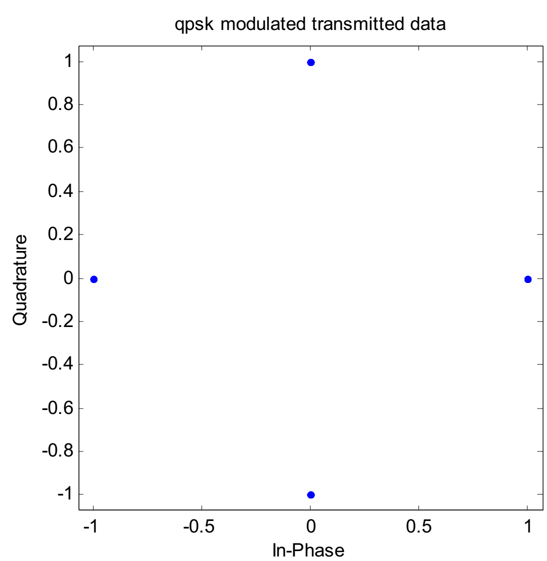

Figure 11. QPSK modulated transmitted data

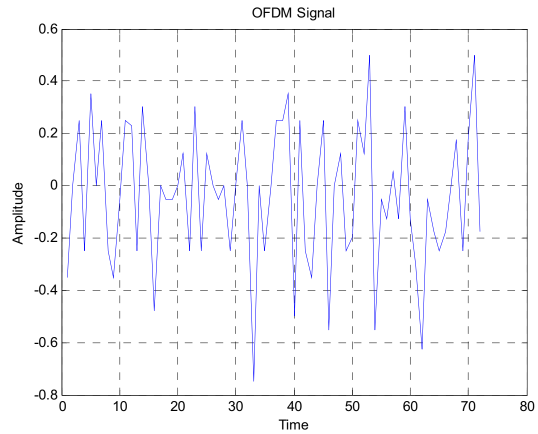

Figure 12. OFDM signal

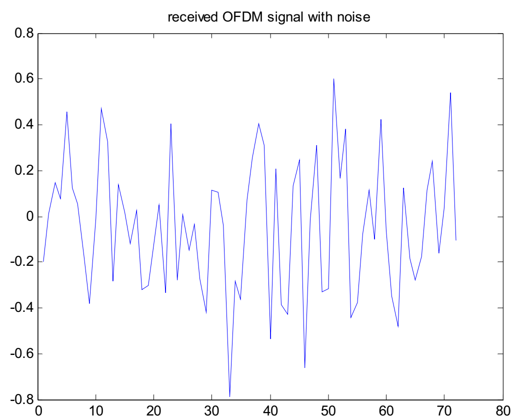

Figure 13. Received OFDM signal with noise

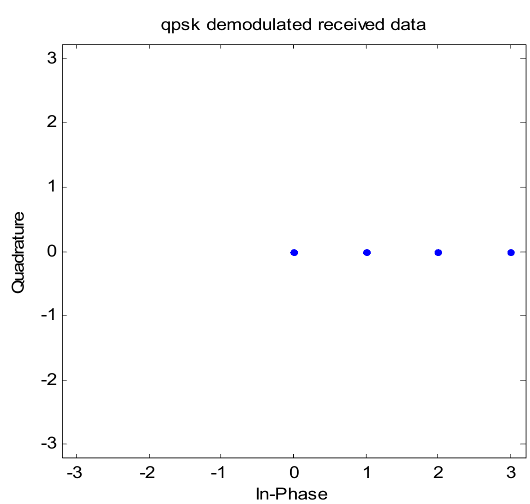

Figure 14. QPSK demodulated received data

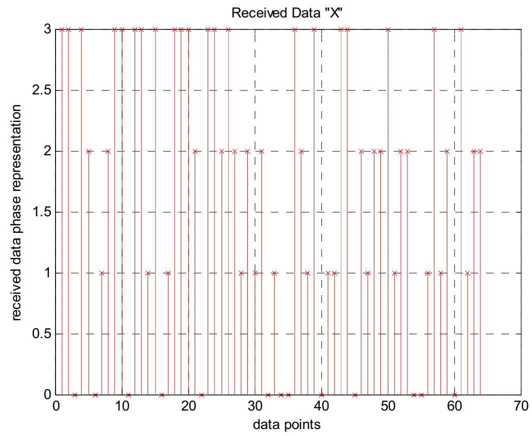

Figure 15. Received data

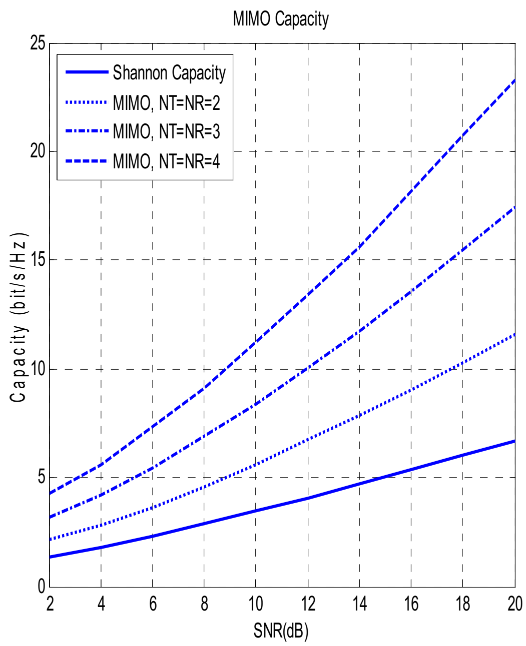

Figure 16. MIMO capacity

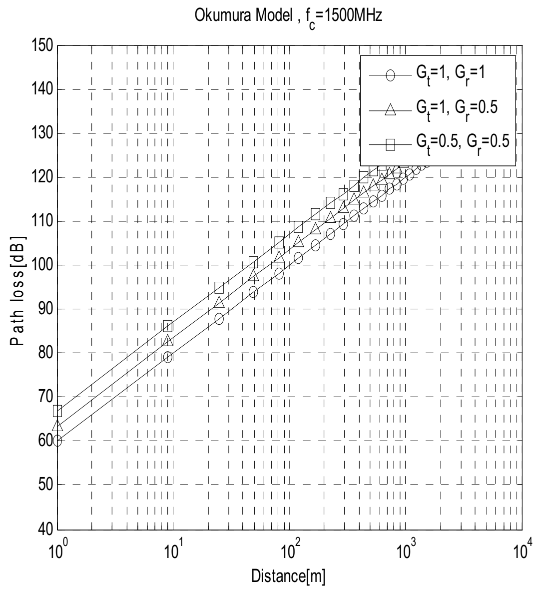

Figure 17. Okumura model

IV. CONCLUSION

Long Term Evolution (LTE) is a radio platform technology that will allow operators to achieve even higher peak throughputs than HSPA+ in higher spectrum bandwidth. LTE is part of the GSM evolutionary path for mobile-broadband, following EDGE, UMTS, HSPA (HSDPA and HSUPA combined) and HSPA Evolution (HSPA+). The overall objective for LTE is to provide an extremely high performance radio-access technology that offers full vehicular speed mobility and that can readily coexist with HSPA and earlier networks. Because of scalable bandwidth, operators will be able to easily migrate their networks and users from HSPA to LTE over time. The simulation of air interface is carried out and the simulation of core network can be simulated. It will lead to better performance evaluation as well as implementation. The next generation LTE will be known as ADVANCED LTE. Hence the simulation of Air interface of ADVANCED LTE have a widened in mobile communication performance evaluation and also in the implementation of ADVANCED LTE. In MIMO of LTE till 4x4 system is implemented, as a future scope it can be upgraded to 8x8 or further. In this project HSPA+ is considered as the existing system and it is taken as the basic block for comparison with LTE. WCDMA+ is an advanced technology, which give access to high speed mobile telephony. Hence WCDMA+ can be taken as a basic comparing element to LTE, which may leads to better implementation of LTE.

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