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# Performance Evaluation of LTE Network with Different Modulation Schemes

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## ABSTRACT

Long Term Evolution (LTE) is the latest step towards the 4th generation of cellular networks. This revolution is necessitated by the increase in demand for high-speed connection on LTE networks .The speed of any network depends of its throughput. In this paper we described how the throughput calculated and how the throughput affected by parameter such as bandwidth of channel, types of modulation used for transmission, and transmitting and receiving modes used. In the paper we show the relation between peak data rates and bandwidth for various modulation techniques.
**Keywords :** LTE, FDD,MIMO, QAM, QPSK.

## I. INTRODUCTION

The Long Term Evolution (LTE), the 4th Generation (4G) network technology release 8 specifications are being finalized in 3GPP have developed and planning to globalize compared to 3rd Generation (3G) and 2nd Generation (2G) networks [2]. LTE determines goals peak data rate for Downlink 100 Mbps and Uplink data rate for 50 Mbps, increased throughput, improved spectral efficiency and scalable bandwidth 1.4 MHz to 20 MHz [6]. VoIP capacity of LTE has to show better performance as Circuit Switch voice of UMTS. LTE should be at least as good as the High Speed Packet Access (HSPA) evolution track also in voice traffic. The core network of LTE is purely packet switched and optimized for packet data transfer, thus speech is also transmitted purely with VoIP protocols. concurrently, demand for the higher quality of wireless communications has increased as well. Use of demand driven applications and services have been growing rapidly to satisfy users. Meeting such demand poses a challenge for the researchers to solve till now. Among such demands, enhance quality of voice and data transfer rates are one of the main aspects to improve. Graham Bell invented the conventional telephone system in 1876 and contributed to the development of inter-city telephone lines in the United States by the end of the 1880s[3]. The first wireless telephone call between Bell and Charles took place via modulated light beam in 1880. G. Marconi confirmed the capabilities of radio transmission by transmission of Morse code via electromagnetic waves over 3 kilometers of distance. This invention caused an vast development in telecommunications. This application highly used in military and during the Anglo-Boer war in 1899. In the early 1900s, the modern radio was invented and the first commercial radio station was established by 1920 in Pittsburgh . By 1934, municipal police radio systems were using Amplitude Modulation mobile communication systems in the U.S. Frequency Modulation was introduced by Edwin Armstrong and was widely used in mobile communication systems until the late 1930s[5]. World War II increased the application and capabilities of wireless communications.

## II. METHODS AND MATERIAL

### 1. Revolution toward 4G LTE

The first generations of mobile communication networks were analog cellular systems that used Frequency Modulation (FM) for radio transmission. AMPS and ETACS were the most popular first generation mobile communication systems employed around 1983[2]. The $2^{nd}$ generations(2G) of mobile communication standards were developed around 1995; these standards used digital modulation and provided three times more spectrum efficiency compared to the first generation.

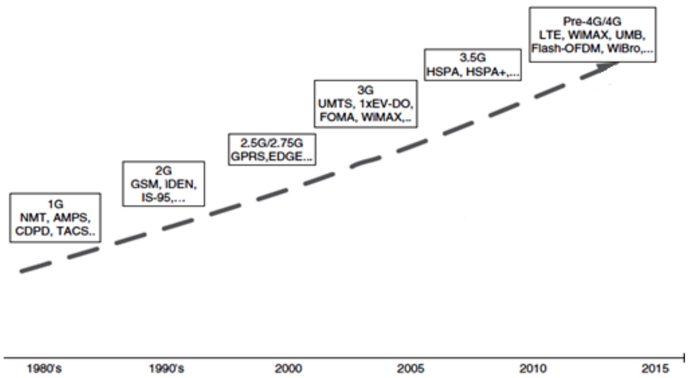



**Figure 1 :** Revolution toward 4G LTE[6]

GSM and CDMA 2000 are two well known 2nd generation(2G) standards that were introduced by 3GPP standard development groups. GSM is based on Time Division Multiple Access while CDMA- 2000 uses Code Division Multiple Access. The 2nd generation was the beginning of the evolution toward 3G and 4G standards. 3GPP, IEEE and 3GPP2 are three major standard development groups that are in tight competition to satisfy 4th generation requirements[4]. LTE, also called EUTRA, introduced by 3GPP is a 3rd generation of mobile communication standard that uses Orthogonal Frequency Division Multiplexing in downlink and Single Carrier-Frequency Division Multiple Access (SC-FDMA) in uplink, whereas previous 3rd generation standards were using CDMA. Another adaptation of LTE is in packet-switched networks, which do not follow the circuit switching of preceding standards. The evolution was important for the improvements in data rate, spectral efficiency, power consumption of the terminal, reductions in transmission latency, and cost [2]. The first release of 3G provided by 3GPP in 2000 was called Release 99' for defining W-CDMA and UMTS standards[2]. This evolution was followed by Release 4 in 2001, which added uplink, whereas previous 3rd generation standards were using CDMA. Another adaptation of LTE is in packet-switched networks, which do not follow the circuit switching of Preceding standard[5].

## 2. LTE Architecture

EPS Architecture

System Architecture Evolution (SAE) is associated with the evolution of core network along with the radio access technology, indicated as LTE. SAE has to developed for the fullfill the requirements of LTE and provide improved data capacity, reduced latency, cost and support for packet switch configuration. Thus LTE architecture consists of two main parts: E-UTRAN and EPC (Evolved Packet Core). These two nodes collectively cover an Evolved Packet System (EPS). EPS routes the IP packet with a given Quality of Service (QoS) called an EPS bearer, from the Packet Data Network Gateway (P-GW) to User Equipment (UE). Figure.2 illustrates the overall architecture of EPS [16].

### Evolved Packet Node (EPC)

EPC consist of Packet Data Network Gateway (P-GW), Serving Gateway (S-GW), Mobility Management Entity (MME), Home Subscriber Service (HSS), Policy Control and Charging Rules Function (PCRF).

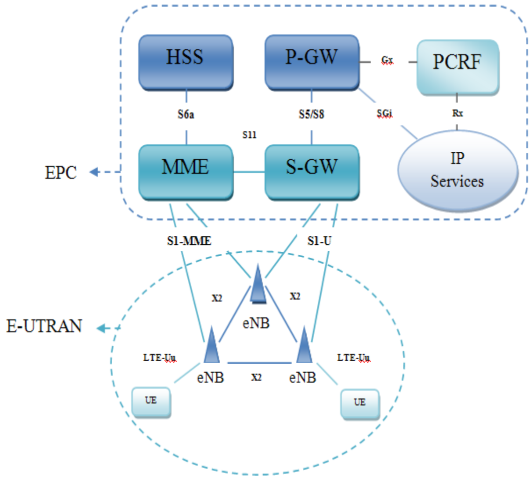


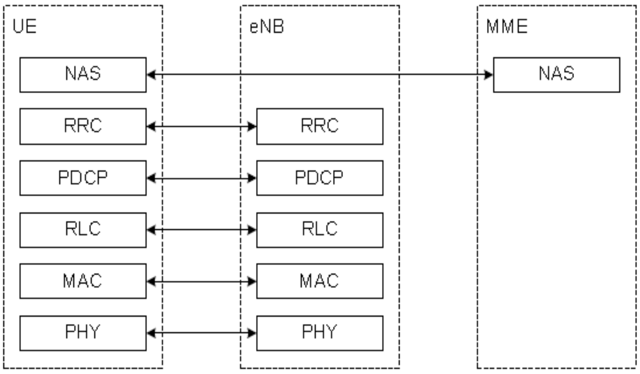

**Figure 2 :** LTE- architecture[16]

P-GW can be considered as an IP anchor which connects UE to the external packet data network. P-GW also filters the downlink user IP packets and performs Policy enforcements. Besides it can operate as a mobility secure between 3GPP and non- 3GPP technologies such as WiMAX or CDMA2000. S-GW is a mobility secure for the user plane when UE moves between eNodeBs. Further, user packets are transferred via S-GW; when UE is in its ideal state, bearer information is saved and maintained by S-GW[16]. It also performs as mobility anchor between LTE and other 3GPP standards like UMTS. MME is responsible for user authentication by interacting with HSS, bearer management, ideal mode UE tracking, and choosing the S-GW when Core Network reallocation is needed. These functionalities are taking place by Non-Access

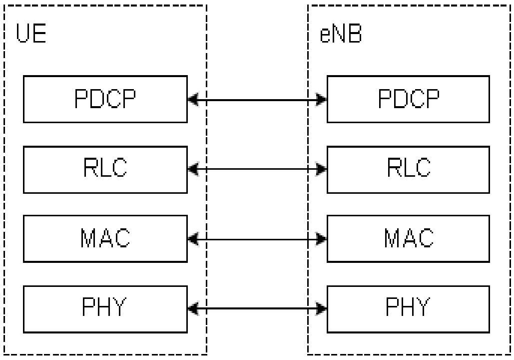
Stratum (NAS) protocols that are running between UE and CN. the information of HSS are contained on the Packet Data Networks (PDNs) to which the UE can connect, such as Access Point Name (APN) . It also includes the users' SAE subscription data and information on the MME with which the UE is interacting. PCRF performs policy control and manages charging functionalities in the Policy Control Enforcement Function of P-GW and authorizes QoS.[16]

**Access Network (E-UTRAN)**

E-UTRAN essentially includes one node: the evolved Node B (eNodeB). eNodeB is basically the base station(use in GSM) that is connected to UE which provides network air interface. One of the responsibilities of eNodeB is radio resource management relating to radio bearer control, radio admission, mobility control, and assignment of resources to UEs. In order to most capably use the radio interface, eNB is responsible for compressing the IP packet header to shrink the overhead. Security and encryption of data sent over the radio interface is another task performed by eNB. E-UTRAN architecture is flat since there is no centralized controller in E-UTRAN [2]. The network components of EPS and E-UTRAN are connected to each other via standard interfaces. Figure-2 shows the functional split between E-UTRAN and EPC [16]. In the Figure 3-B, shows the user plane consists of PDCP (Packet Data Coverage Protocol), RLC (Radio Link Control), and MAC (Medium Access Control) sublayers that are terminated in eNB [16]. The operation associated with these layers will be discussed later. In Figure-3, part-B shows the control plane that is similar to a user plane, instead of the compression header function that does not exist in control plane. The Access Strum protocol refers to the protocol between layers below the Non-Access Protocol (NAS), which is another protocol of the control plane [16].




A. control plane




B. user plane

**Figure 3 :** E-UTRAN user and control plane protocol stacks [17]

### 3. LTE Frame Structure

let us describe the LTE-FDD structure .In this the duration of one LTE radio frame is 10 ms. One frame is divided into 10 sub-frames of 1ms each and each sub-frame is divided into two slots of 0.5 ms each. Each slot contains either 6 or 7 OFDM symbol, depending on the Cyclic Prefix (CP) length.[8]

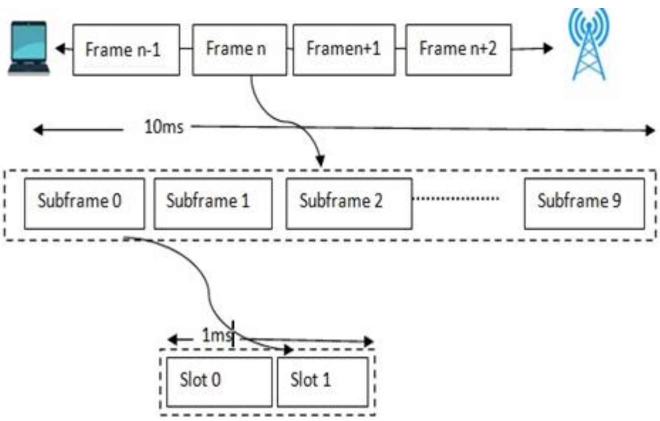



**Figure 4 :** FDD frame structure in LTE[8]

In LTE ,radio resource are allocatedin units of Physical Resource Block (PRBs).Each PRB contains 12 subcarrier and one slot.if extended CP is used ,the PRB contains only six symbols. The UE is specified allocation for the first slot of the sub frame. there ie implecit allocation for the second slot of the sub-frame. As shown is figure 3.

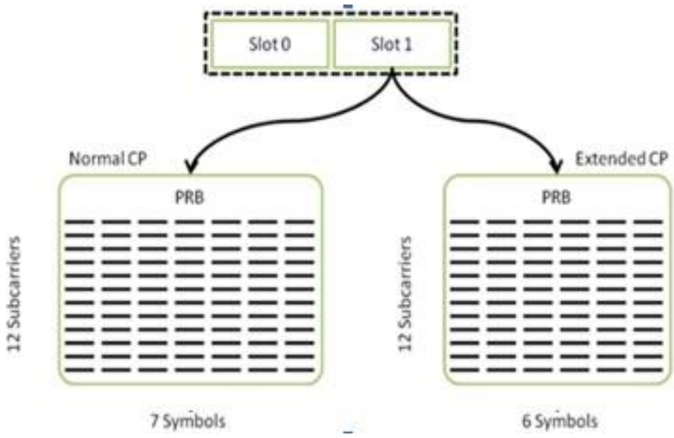



**Figure 5 :** The number of Physical Resource Block (PRBs) in one slot[8]

## 4. LTE Throughput

From the 3GPP specification:

- ✓ 1 Radio Frame (10ms) = 10 Sub-frame.
- ✓ 1 Sub-frame = 2 Time slots.
- ✓ 1 Time-slot = 0.5 ms (i.e. 1 Sub-frame = 1 ms).
- ✓ 1 Time-slot = 7 Modulation Symbols (when normal CP length is used).
- ✓ 1 Modulation Symbols = 6 bits; if 64 QAM is used as the modulation scheme.
- ✓ 1 modulation symbols= 4 bits; if 16 QAM is used as the modulation scheme.
- ✓ 1 modulation symbol =2 bits; if QPSK is used as the modulation scheme
- ✓ 1 Resource Block (RB) = 12 Sub-carriers.
- ✓ If we assume 20 MHz channel bandwidth (100 RBs), in the normal CP.

Therefore number of bits in a sub-frame = 100RBs x 12 sub-carriers x 2 slots x 7 modulation symbols x 6 bit = 100800 bits.
Hence, data rate = 100800 bits / 1 ms = 100.8 Mbps; if 64 QAM is used.
Number of bits in a sub-frame = 100RBs x 12 sub-carriers x 2 slots x 7 modulation symbols x 4 bit = 67200 bits.
Hence, data rate = 67200 bits / 1 ms = 67.2 Mbps; if 16 QAM is used.
And max bit rate 33.6 Mbps; QPSK is used.

- ✓ If 4x4 MIMO is used, then the peak data rate would be 4 x 100.8 Mbps = 403 Mbps.

## III. RESULTS AND DISCUSSION

Simulation Results

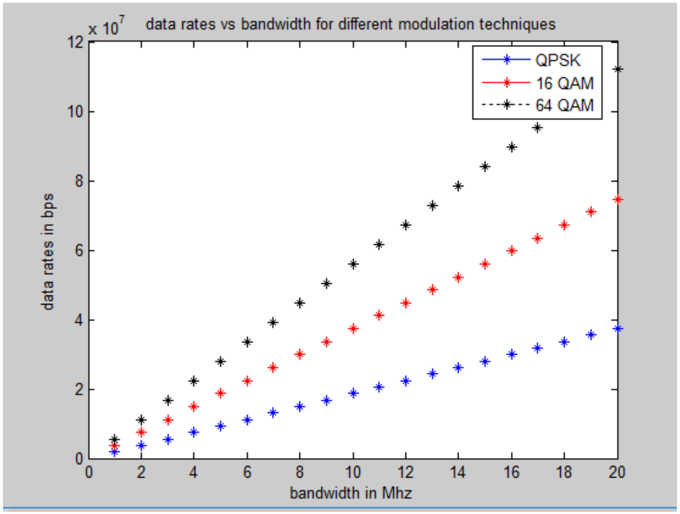



**Figure 6:** Simulation Result

The above simulation graph shows the variation of data rates with increased in bandwidth for different modulation technique,the blue points shows the data rates for QPSK modulation,red points variation of data rates for 16 QAM and black points shows for 64 QAM.

Table-1

| S. No. | BW in MHz | Data Rate in Mbps | | |
|---|---|---|---|---|
| | | QPSK | 16 QAM | 64 QAM |
| 1. | 5 | 8.4 | 16.8 | 25.2 |
| 2. | 10 | 16.8 | 33.6 | 50.4 |
| 3. | 15 | 25.2 | 50.4 | 75.6 |
| 4. | 20 | 33.6 | 67.2 | 100.8 |

In the above table we use some standard Bandwith which is used by LTE and create the table to calculate the data rates for different modulation technique it is seen that peak data is obtained in 20Mhz for 64 QAM modulation technique.

## IV. CONCLUSION

The LTE is the latest version to full fill the requrerment for the high data rates such as 4G. In the simulation result it is clearly seen that data rates highly propotional to bandwidth and also depends on the types of modulation and coding technique. The 3rd Generation Partnership Project (3GPP) introduced Long Term Evolution (LTE) as the 4th generation of mobile communication standards. which supports up to 300 Mbps of data transmission in downlink using the OFDM scheme as well as up to 75 Mbps throughput for uplink using the SC-FDMA modulation .In the 4G LTE peak deta rates is achieved at 20Mhz by using 64 QAM modulation technique.

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