PERFORMANCE ANALYSIS OF VARIOUS FADING PROPAGATION MODELS USED IN LONG TERM EVOLUTION

Farzana Alam[1,*] and Md. Asif Hossain[2]

***Abstract*—** The Long Term Evolution (LTE) or 4G Network is being developed quite promptly. To satisfy the growing demand for high-quality multimedia services, LTE represents a significant advancement in wireless communication networks. 4G is currently in its phase of enhancing QOS, or quality of service. The throughput analysis of several fading propagation models utilized in LTE's PDSCH (Physical Downlink Shared Channel) is presented in this research. This research examines three fading propagation channel models: Extended Vehicular A (EVA), Extended Pedestrian A (EPA), and Extended Typical Urban (ETU) models.

***Keywords*—** Long Term Evolution (LTE), Extended pedestrian A model, Extended vehicular A model, Extended Typical Urban Model, fading propagation models.

I. INTRODUCTION

The 3rd Generation Partnership Project (3GPP) created the 4G wireless communications standard known as Long Term Evolution (LTE), which is intended to give mobile devices up to 10 times the speed of 3G networks. The GSM/EDGE and UMTS/HSPA technologies form the foundation of LTE. LTE provides significantly increased peak data rates and increases the capacity and speed.

Fading is a variation of attenuation of a signal with various variables such as time, geographical position and radio frequency. It occurs when the two copies of the signal get combined the resulting signal can be attenuated signal. The attenuated signal is poorer than the original signal.

For simulating a delay line with many taps can be used to represent the effects of multipath fading. A tap is just the delay line point that corresponds to a certain delay. When the received signal is subject to multipath fading, the composite signal and summed signals from each tap represents a real radio wave.

In [1], the authors have compared various fading models like EPA, ETU and EVA. They have compared the performances of those parameters under LTE network. The authors in [2] have presented a throughput analysis on of a LTE System for Static Environment. They have considered various modulation models and fading models.

In [3], there has been given a lot of information about different propagation channel models and their benefits for communication. In [4], the authors give comparisons among different fading models and their statistical result. Similar works have been done in [5-10], the authors have discussed about different channel models and different fading models.

a) Long Term Evolution (LTE)

An upcoming standard for extremely fast wireless communication for mobile devices and data terminals is called Long Term Evolution (LTE). The GSM/EDGE and UMTS/HSPA technologies form the foundation of LTE. LTE improves the capacity and speed of networks by combining upgrades to the core network with various radio interfaces.

The Third Generation Partnership Project (3GPP) created the LTE 4G wireless communications standard, which is intended to give mobile devices—such as

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smartphones, tablets, laptops, and wireless hotspots—up to 10 times the speeds of 3G networks.

The technology is called "Long Term Evolution" by 3GPP engineers because it is the next generation (4G) of 3G technologies that follow GSM, a 2G standard, and UMTS, a 3G technology built on top of GSM. With the potential to reach speeds of up to 30 Mbps upstream and 100 Mbps downstream, LTE offers far higher peak data rates, lower latency, expandable bandwidth, and backwards compatibility with current GSM and UMTS technology. Future advancements might result in peak throughput of about 300 Mbps.

Because the upper layers of LTE are built on TCP/IP, an all-IP network that resembles wired communications as it exists now is probably what will happen. Mixed data, audio, video, and messaging traffic will all be supported by LTE. Orthogonal frequency division multiplexing, or OFDM, and multiple input/multiple output (MIMO) antenna technology—which is akin to that of the IEEE 802.11n wireless local area network (WLAN) standard—are employed by LTE in its later iterations. When combined with OFDM, MIMO's increased signal to noise ratio (SNR) at the receiver results in better throughput and coverage, particularly in crowded urban locations.

Verizon Wireless and AT&T Wireless plan to commercially introduce LTE in 2010. Additionally, plans to bring out 4G capabilities based on LTE have been revealed by T-Mobile and Alltel. These networks will go up against WiMAX from Clearwire in the market for business and residential broadband wireless users. More over 80% of mobile phone customers worldwide utilize GSM, making it the most widely used mobile standard outside of the US telecom sector. Therefore, the majority of customers' preferred wireless broadband technologies are probably HSDPA and LTE. To satisfy the anticipated demand, Nortel and other infrastructure vendors are devoting a large portion of their research and development resources to the development of LTE base stations. When deployed, LTE has the ability to provide ubiquitous computing to a worldwide user base, giving mobile users everywhere a wired experience.

b) Doppler Effect

The movement of both the sender and the recipient affects the frequency of a wave-like signal, such as sound or light. We call this the Doppler Effect. In Prague in 1842, the Austrian physicist Christian Doppler brought out the idea.

The relative motion difference between the source and observer is called Doppler Effect. The relative speed of an object and the shift of the frequency of wave can be measured by using the Doppler Effect. The Doppler Effect is also known as Doppler shift. The received frequency is higher if the receiver is traveling in the direction of the source because the zero crossing of the signal appears faster. if the receiver is traveling away from the source, the opposite result. Doppler shift is the term used to describe the ensuing frequency shift.

II. VARIOUS FADING MODELS

Fading is a term used to describe variations in a signal's attenuation with different factors in wireless communications. These variables consist of radio frequency, location, and time. A common model for fading is a random process. Any communication channel that fades is considered a fading channel.

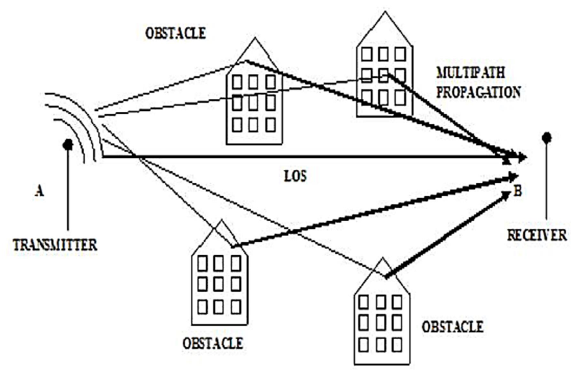

Fig. 1 Mobile Users In The Presence Of Multipath And Interference

There are various types of fading such as (a) Slow fading, (b) Fast fading, (c) Block fading, (d) Selective fading or frequency selective fading. They are discussed below:

(a) Slow fading:

When the channel's coherence time exceeds the application's relative delay requirement, slow fading takes place. the channel's enforced amplitude and phase shift. Over the period of use, this channel can be considered roughly constant. Slow fading can be caused by events such as shadowing. Shadowing occurs where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. Shadowing changes the received power. With a standard deviation according to the long-distance path loss model, Shadowing is often modeled using a log- normal distribution.

(b) Fast fading:

When the channel's coherence time is less than the application's required delay, fast fading takes place. The channel imposes amplitude and phase changes that vary significantly over the course of use.

(c) Block fading:

For a number of symbol intervals, the fading process is approximately constant in block fading.

(d) Selective fading or frequency selective fading:

Selective fadingor frequencyselective fadingis radio propagation. It is brought on by a radio signal's partial cancelation on its own.There are two ways the signal gets to the receiver. One or more of the pathways is altering; it can be getting longer or shorter. Fading models:

- Nakagami fading
- log- normal shadow fading
- Rayleigh fading
- Rician fading
- Two-wave with diffuse power(TWDP)fading
- Weibull

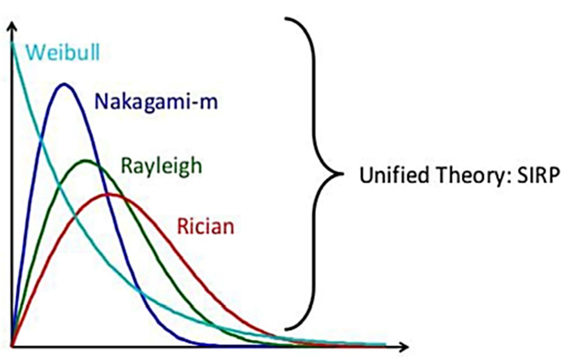

Fig. 2 Fading Distribution

Let's discuss the Fading Models (EPA, EVA & ETU).

EPA:

EPA stands for Extended pedestrian A model. It is a model which is used to generate channel models for wireless applications. This model has been based on International Telecommunication Union (ITU) Pedestrian A model and has been modified by extending the ITU Pedestrian A model. It has maximum Doppler frequency of 5 Hz. This model has number of seven channel taps and the maximum delay is 410ns. The pedestrian channel model has wider bandwidth of 20 MHz. The UE of this channel model has a speed of 3 Km/hour.

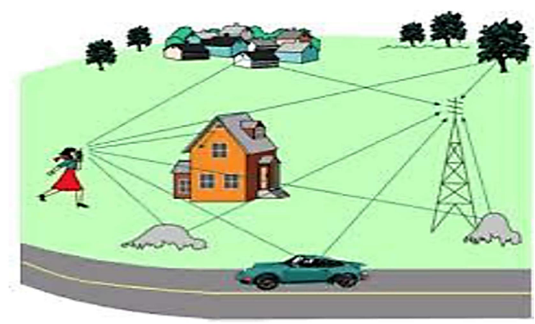

Fig. 3 The concept of fading channel EPA

Table 1: EPA Delay Profile

Excess tap delay (ns)	Relative power (dB)
0	0.0
30	−1.0
70	−2.0
90	−3.0
110	−8.0
190	−17.2
410	−20.8

EVA:

Extended vehicular A model (EVA) is a propagation channel model. This model has also been based on International Telecommunication Union (ITU)

Pedestrian A model. Its Doppler frequency maximum is 70 Hz.

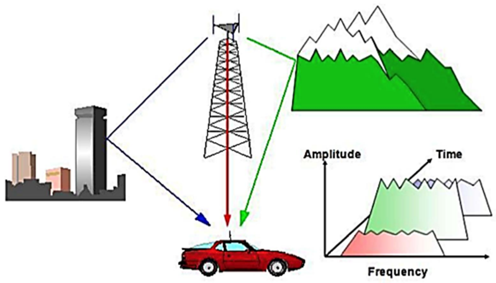

Fig. 4 The concept of EVA

This type has a maximum delay of 2510 ns and nine channel taps. The pedestrian channel model features a 20 MHz larger bandwidth. This channel model's UE can travel at speeds of up to 30 km/h or 120 km/h.

Table 2: EVA Delay Profile

Excess tap delay (ns)	Relative power (dB)
0	0.0
30	-1.5
150	-1.4
310	-3.6
370	-0.6
710	-9.1
1090	-7.0
1730	-12.0
2510	-16.9

ETU:

For wireless applications such as EPA and EVA, channel models are generated using the Extended Typical Urban Model (ETU). The GSM Typical Urban Model is the foundation for this. Its Doppler frequency maximum is 300 Hz. This type has a maximum delay of 5000 ns and nine channel taps. The bandwidth of this channel model is restricted to 20 MHz. This channel model's UE travels at a speed of either 350 or 120 km/h. This model can be used in ordinary cities.

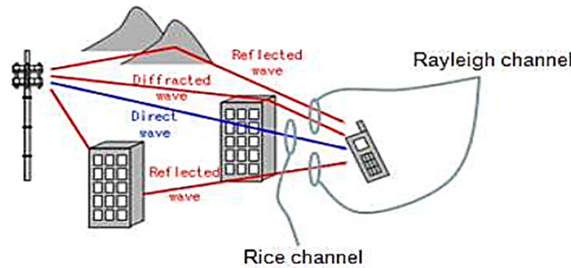

Fig. 5 The concept of ETU

Table 3: ETU Delay Profile

Excess tap delay (ns)	Relative power (dB)
0	-1.0
50	-1.0
120	-1.0
200	0.0
230	0.0
500	0.0
1600	-3.0
2300	-5.0
5000	-7.0

III. Simulations and Parameters

For the simulation purpose, MATLAB has been used. Below are the parameters that were utilized to replicate the LTE PDSCH in this instance.

Table. 4: Parameters to simulate

Parameters	Value
Reference channel	R.12
Duplex mode	FDD
Transmission scheme	TxDiversity
PDSCH Rho (dB)	-3
Propagation model	EPA, EVA, ETU
Doppler (Hz)	5, 70, 300
Antenna correlation	Medium
No. of receive antennas	2
SNR	[-2.0, -1.0, 1.0, 2.0]

Throughput is frequently normalized and quantified in percentages, however this can lead to confusion about what the % represents. Channel usage, channel efficiency, and packet loss rate in percentage are less unclear concepts. Channel efficiency, also known as bandwidth usage efficiency, is the proportion of a digital communication channel's net bitrate (in bit/s) that corresponds to the actual realized throughput. For example, if the throughput is 70 Mbit/s on a 100 Mbit/s Ethernet connection, the channel efficiency is 70%. In this case, 70 Mbit of data are transferred every second.

When a single terminal is transmitting over a point-to-point or point-to-multipoint communication link, the maximum throughput is frequently equal to or nearly equal to the physical data rate, or channel capacity, because in these types of networks, channel utilization can approach 100% with the exception of a tiny inter-frame gap.

A metric used in science and engineering to compare the strength of a desired signal to the strength of background noise is called the signal-to-noise ratio, or SNR or S/N. It is defined as the signal-to-noise power ratio, which is commonly given in decibels. More signal than noise is indicated by a ratio larger than 1:1 (more than 0 dB). The Shannon Hartley theorem connects a communication channel's bandwidth, channel capacity, and signal-to-noise ratio.

The power of a signal (meaningful information) divided by the power of background noise (unwanted signal) is known as the signal-to-noise ratio.

$$SNR = \frac{P_{Signal}}{P_{noise}}$$

P indicates average power. Within the same system bandwidth, and at comparable points in the system, the measurement of both signal and noise power is required.

IV. Results and Discussions

The outcomes of the simulation in Matlab 2016a with the different parameters that were covered in the preceding section will be covered in this section. The target throughput in all simulations has been set at 70% of the throughput ratio.

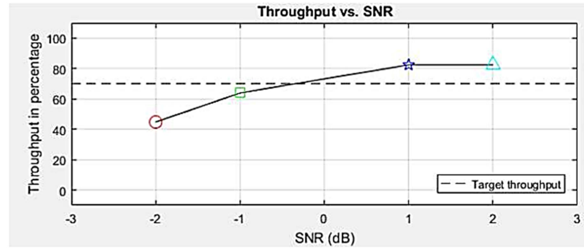

Fig.6 Viability vs SNR for EPA Using a 5 Hz Doppler Effect

Throughput vs. SNR for EPA with 5 Hz Doppler Effect is shown in Figure 6. Here, it has been noted that the throughput crosses the goal throughput of 80% when the SNR value is -2dB, 65% when it is -1dB, and 45% when it is -1dB. The outcome for 2dB SNR is the same.

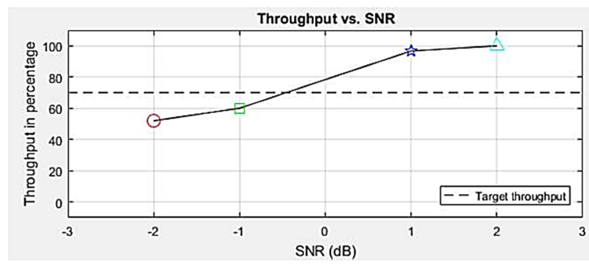

Fig. 7 Throughput vs SNR for EVA with 5 Hz Doppler Effect

The plot of the throughput versus SNR for EVA with same Doppler Effect has been found in Fig. 7. Here, for 1 dB SNR, around 98% throughput has been achieved while for 2 dB it touches 100%. Now, in Fig. 8, the poor throughput has been found. For -2 dB & -1 dB SNR, throughput is 47%, for 1 dB, it is 75% and for 2 dB it reaches 100%.

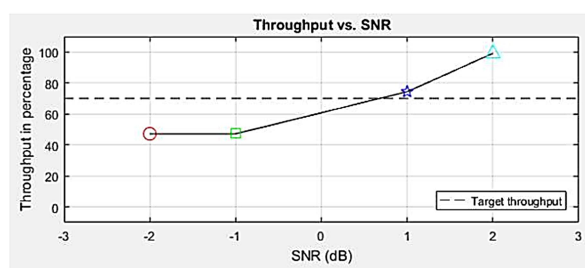

Fig. 8 Throughput vs SNR for ETU with 5 Hz Doppler Effect

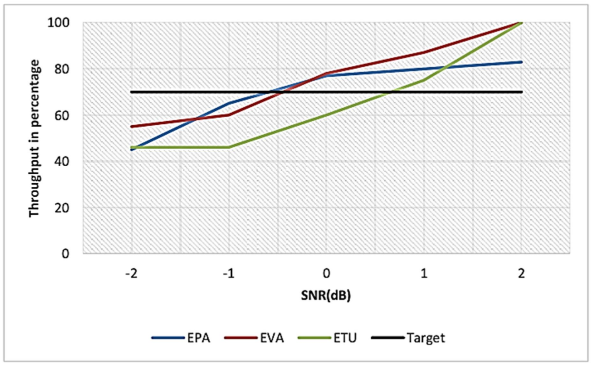

Fig. 9 Combined Throughput vs SNR for EPA, EVA &ETU with 5 Hz Doppler Effect

The throughputs for 5 Hz Doppler Effect for the all the models have been plotted in Fig. 9. From this figure, it has been observed that EVA gives the better results compare to others while ETU gives the worst. Individual plots of the throughput vs SNR for EPA, EVA and ETU with 70 Hz Doppler Effect have been shown in Fig.10-12.

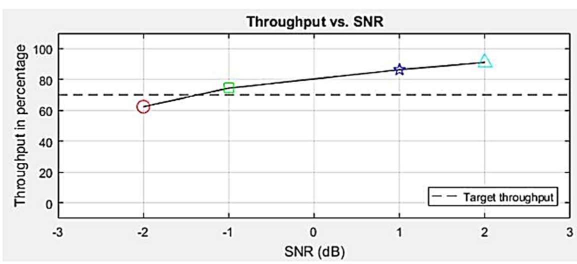

Fig. 10 Throughput vs SNR for EPA with 70 Hz Doppler Effect

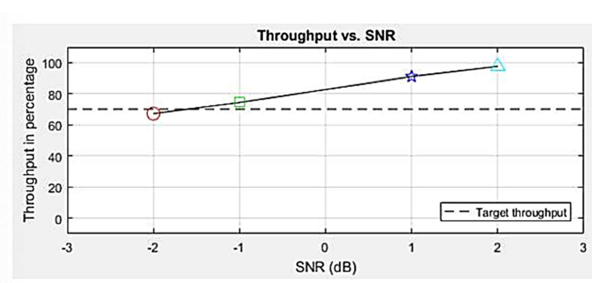

Fig. 11 Throughput vs SNR for EVA with 70 Hz Doppler Effect

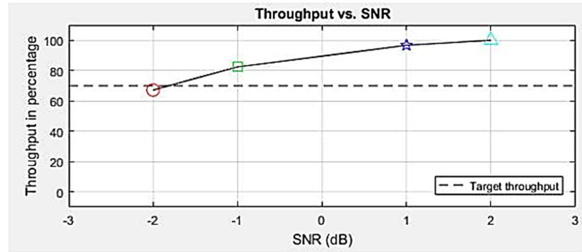

Fig. 12 Throughput vs SNR for ETU with 70 Hz Doppler Effect

Individual plots of the throughput vs SNR for EPA, EVA and ETU with 300 Hz Doppler Effect have been shown in Fig.13-15 In all the cases, the for all the SNR values, throughput has been crossed the target.

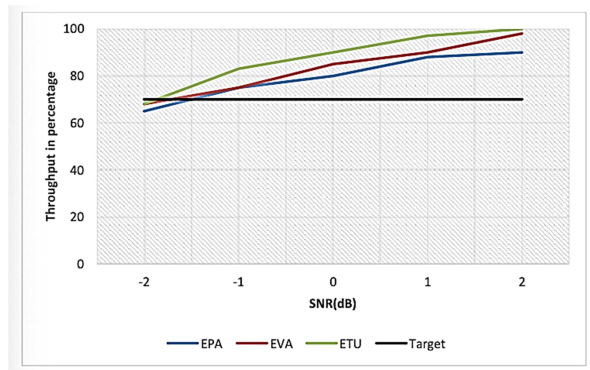

Fig. 13 Combined Throughput vs SNR for EPA, EVA & ETU with 70 Hz Doppler Effect

From Fig.13, it is found that ETU gives the best result while EPA gives the worst. So, 70 Hz Doppler Effect, the performance of ETU is the best though it was worst for the case of 5Hz.

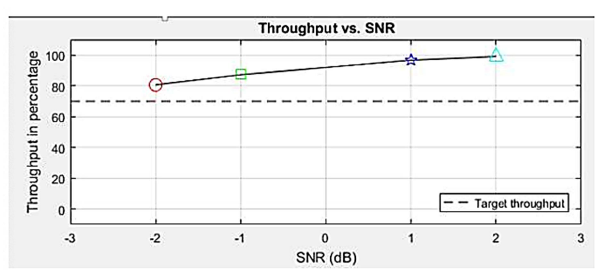

Fig. 14 Throughput vs SNR for EPA with 300 Hz Doppler Effect

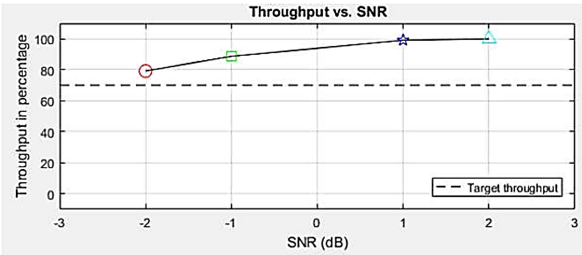

Fig. 15 Throughput vs SNR for EVA with 300 Hz Doppler Effect

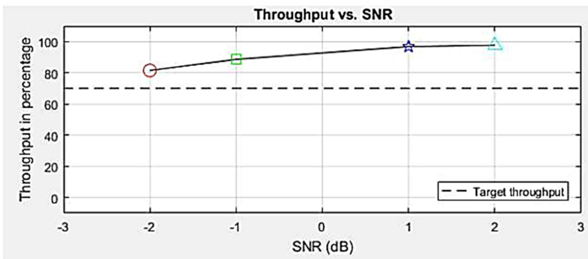

Fig. 16 Throughput vs SNR for ETU with 300 Hz Doppler Effect

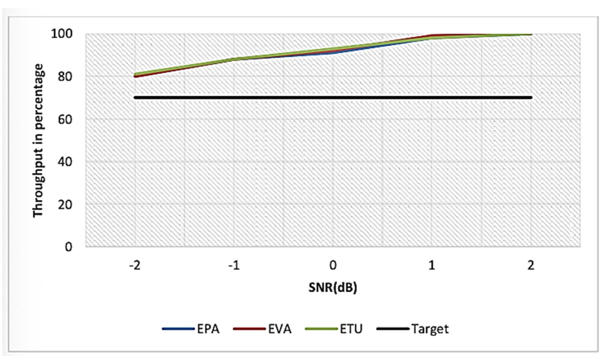

Fig. 17 Combined Throughput vs SNR for EPA, EVA & ETU with 300 Hz Doppler Effect

From Fig.17, it has been observed that all the models give the same results. That means in case of 300 Hz Doppler Effect, the results of the entire propagation model is quite identical.

In summary, a greater SNR value corresponds to a better throughput, and a stronger Doppler Effect also results in a higher throughput based on all the figures. The best results are obtained by EVA at 5 Hz, ETU at 70 Hz, and all models are the same at 300 Hz.

V. CONCLUSION

The performance of three LTE propagation models (EPA, EVA, and ETU) has been examined in this project. Value in a number of Doppler effects has been taken into consideration in the investigation. It has been discovered that EVA performs the best and ETU performs the worst for the 5 Hz Doppler Effect. ETU is the best and EPA is the worst when it comes to 70 Hz. However, for 300 Hz, every model is the same. Additionally, it has been discovered that throughput increases as SNR increases. In the future, real-world values will be analyzed rather than simulation values while taking into account additional factors.

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