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QoS Analysis for 5G Networks

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Abstract

Fifth generation (5G) is the wireless network technologies, which is designed to provide efficient quality of service in mind. The performance seen by the users of the network will primarily depend on QoS elements. Thus, by managing QoS – Bit rate, Throughput, Transmission delay, packet loss, and Jitter parameters can improve to manage the network resource efficiently. The 5G system is a combination of many different modulation techniques; this is done to ensure improvement in performance and further to result in greater-efficiency in the output. The author has made an attempt to analyze different modulation techniques with the coding scheme and compare the QoS performances between them. The performances have been analyzed for two schemes QPSK and QAM using Viterbi coding scheme. Thus for both the modulation technique with Viterbi coding scheme excellent performances were recorded, thereby providing an optimum solution to maintain QoS.

Keywords:*QPSK, QAM, Viterbi coding scheme, QoS*

INTRODUCTION

Fifth generation (5G) is next upcoming wireless broadband technologybased on IEEE802.11ac standard. It is expecting to focus on WWWW (Wireless World Wide Web), to provide high data rate of 10Gbps at peak and 100Mbps at cell edge, latency of less than 1ms, high throughput in Giga bit per seconds, low battery power consumption of 10x times lesser than 4G for efficient performance compared to 4G[1]. Thus 5G system in future includes 10 key enabling technologies like D2D communication, Millimeter wave spectrum, scalable IOT, Green communication, Network function virtualization, Massive-MIMO, Current radio-access techniques, Mobile cloud computing and Big data, Wireless software-defined network, Network ultra-densification[2].

5G spectrum requires any one of the three frequency ranges Viz., Sub 1-GHz, 1GHz - 6GHz and >6GHz to provide widespread coverage[3].

The performance of any network is determined by managing the QoS parameter i.e. delay, bandwidth, jitter (delay variation), and packet loss in a network, thus 5G involves various modulation techniques and coding schemes for excellent performance and efficient output. Performance of modulation scheme is obtained by probability of error generated in channel by the interference and noise. Thus a modulation scheme depends on SNR, BER, Bandwidth efficiency, QoS, and spectral efficiency. Performance seen by the user can be increased by decreasing BER, i.e. by incorporating proper coding scheme[4].

Thus the performances have been analyzed for two schemes QPSK and QAM using Viterbi coding scheme, which consists of Convolutional Encoding and Viterbi Decoding. The comparison proves that the efficient performances are seen by both QPSK and QAM using Viterbi coding scheme. In addition, Latency, Jitter, Throughput performances are also analyzed along with BER for different modulation techniques. Thus both the modulation techniques can be used for 5G to provide optimum solution to maintain QoS.

RELATED STUDY

Evolution of 5G[5]

In 1980s, mobilecellular era started and since then made a considerable changes. Wireless mobile technologies have made the remarkable changes in last few decades. The mobile wireless generation (G) directs to change in frequency, data rate, latency, capacity of data, technologies etc. First generation (1G) wireless mobile communication was analog and it was only for voice calls. Second generation (2G) wireless mobile communication was digital and support messaging. Third generation (3G) wireless mobile communication provided multimedia support, increased capacity, and high data rate transmission. Fourth generation (4G) wireless mobile communication integrates 3G to support mobile internet with fixed internet, to overcome the 3G limitations. Fifth generation (5G) wireless mobile communication is going to be revolution in market with very high bandwidth.
The main features of 5G are as follows:

- Better coverage and connectivity
- Provide data rate in Gbps
- Complete clarity in video/audio
- Better QoS in terms of latency, throughput, jitter
- WWWW is highly supported

Architecture of 5G[6]

All 5G mobile are IP-based systems for interoperability of mobile and Wireless networks. Fig1 shows the proposed system model of 5G network architecture for mobiles. The system comprises of RAT (Radio Access Technologies) and user terminals. To the outside world of internet, each RAT is considered as IP link within each terminal. However, for every RAT in mobile terminal there should be different radio interface. For instances, we have N number of different RATs and to have access to all N numbers there is need of N different access specific interfaces in terminal. In order to have all N numbers RATs to be active at the same time, the architecture proposed should be functional.

The two levels of OSI i.e. data-link level and physical level defines RATs through which it provide internet access with less or more mechanisms to QoS support and also further dependent on access technologies i.e. WIMAX, 3G have explicit support to QoS whereas WLAN has not. Network layer is above the OSI-1 and OSI-2 layers, where network layer is IP in present communication world which will be either IPV6 or IPV4, regardless of RATs. For proper routing of IP packets, IP ensures sufficient control data for certain application connection i.e. the session of server and client applications on the internet. According to the policies of the user, routing of packets should takes place.

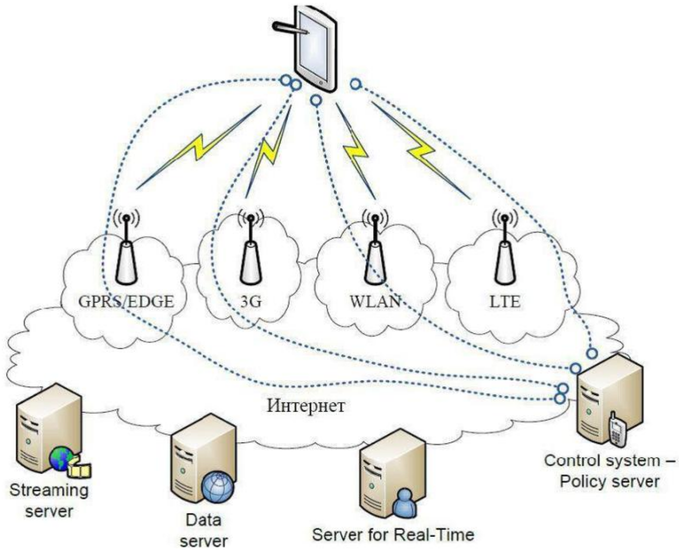

Fig1: *5G Mobile Networks – Architecture[6]*

5G Spectrum[3]
5G is awaited to support significantly fast mobile-broadband speeds and high data rate. It also enables to provide complete potentialof IOT (internet of things). 5G requires a wide mobile spectrum to provide widespread coverage and meet all use cases. Thus the 5G spectrum requires any one of the three frequency ranges Viz., Sub 1GHz, 1GHz to 6GHz and >6GHz.

Sub 1-GHz provides wide coverage across all areas like urban, rural and suburban and support IOT. 1GHz to 6GHz provides benefits of both coverage and capacity. This comprises spectrum within which the 3.3GHz to 3.8 GHz range is expected to form basis for many beginning services of 5G. The frequency above 6GHz is required to encounter ultra-high broadband speeds.

5G Modulation Schemes
The modulation schemes play a very important role when considering the performance at users. Modulation schemes performances include PAPR, spectral efficiency, and also performances in presence of interferences and noise, as it is included to make any decisions. The 3G and 4G used PSK and QAM modulation schemes respectively. These schemes provide excellent spectral efficiency and very high data rate, but falls in terms of PAPR. The suggested modulation schemes for 5G are QAM and QPSK.

QAM is used near to Base Transceiver Station (BTS), because SNR is high at BTS wherein at high SNR, it provides high data rate. Similarly QPSK is used near to border of cell, because SNR is low at cell border wherein at low SNR, it provides high data rate. Data rate can be increased by decreasing BER by choosing proper coding scheme.

5G QOS (Quality of Service)[1]
5G technology should significantly improve quality of service in context of data volume in network and variety of services. It is expected that mobile communication built on 5G will provide data rate in Gbps.

Bit Error Rate
When data is transmitted over link, errors are introduced into the system. These errors degrade the system performance. Therefore, errors are calculated by BER. It is the rate at which errors occurred during transmission. BER and signal to noise ratio (SNR) is inversely proportional to each other. Lower the value of SNR, high

will be the value of BER and vice versa.

Latency
Latency is delay (time interval) between the sources transmitting the packets to the destination receiving it. Latency is measured either by round trip time or one way. In one way, latency is calculated by considering the time taken from source to destination. In round trip delay time, latency is calculated by considering the time taken from source to destination plus the time taken from destination back to the source. Lower the latency higher will be the network efficiency.

Throughput
Throughput is the, measure of average rate of correct data delivered over logical or physical link, communication channel or specific network nodes. Higher the uncorrected data delivered, lower will be the throughput and gradually decreases the performances. Higher throughput depends on sending data in large packets than sending the same data in small packets.

Jitter
Jitter is also called as delay Jitter. It is defined as variation in delay or latency of receiving packets. At the transmitter side, when continuous stream of packets are sent, which are spaced apart evenly. Jitter is mainly affected by congestion, timing drift, and improper queuing. Jitter increases as the variation increases, i.e. packets are getting bunchedup and are spreading out. It is better to have low jitter level to maintain steady data stream.

SIMULATION AND RESULTS
In this work theperformances analysis of QoS parameters like BER, Throughput, Jitter and Latency of different modulation techniques along with coding scheme is simulated. Here two modulation techniques like QPSK and QAM along with Viterbi coding schemes are considered. The performances are analyzed with respect to SNR i.e. from negative SNR value to positive SNR. As it is possible in reality scenario of communication system i.e. negative SNR means that Signal power is lower than the noise power and positive SNR means that Signal power is Greater than the noise power [7].

QPSK modulation scheme
The result in Fig 2 shows the QoS performance of QPSK modulation techniques. The Bit Error Rate will take 1.5 dB SNR to become zero under AWGN channel, where BER decreases with increase in SNR. Throughput will range the data rate greater than Gbps from 0 dB SNR, where throughput increases with increases in SNR but decreases with increase in BER. The latency i.e. the delay is about 1ms (0.0011 Sec) for all value of SNR to transmit the data from transmitter to receiver. Similarly Jitter is null i.e. zero for all value of SNR. Thus the QPSK performance displayed in Fig 2 is considerable as it is meeting the requirement specified for 5G wrt QoS[1].

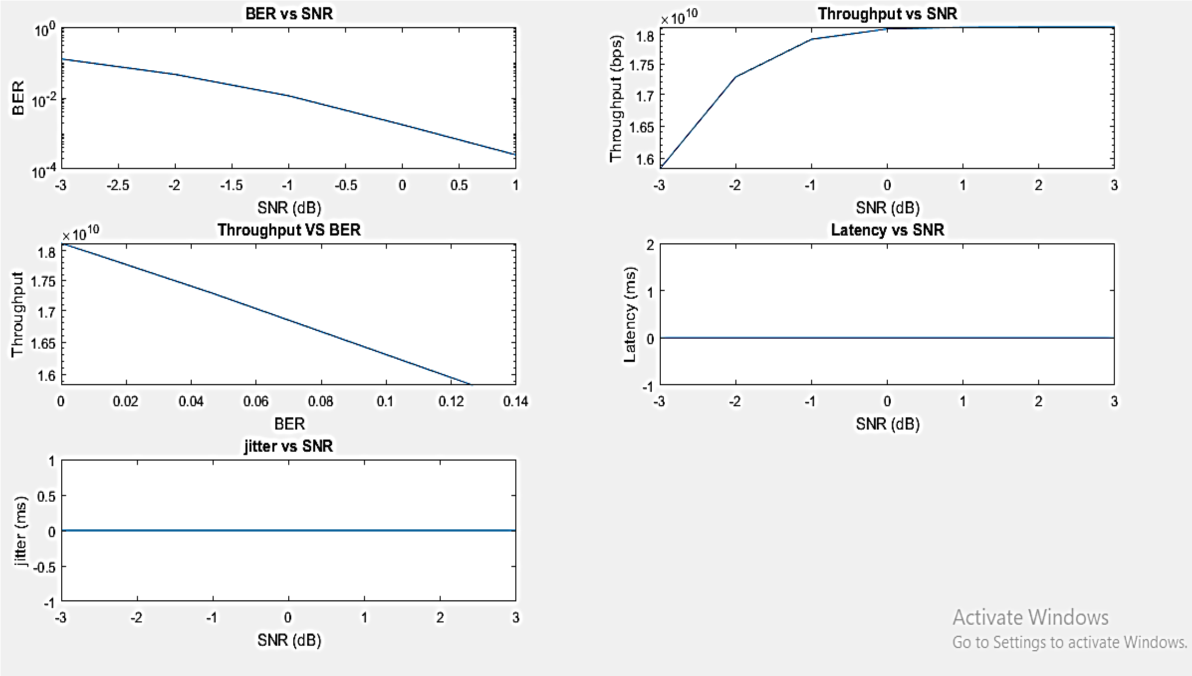

Fig 2:*QPSK performance of BER, Throughput, Jitter and Latency for π/4 phase offset*

QAM modulation scheme

The results in Fig 3 show the QoS performance of QAM modulation techniques. The Bit Error Rate will take greater than 4.5 dB SNR to become zero under AWGN channel, where BER decreases with increases with SNR. Throughput will range the data rate greater than Gbps from 0 dB SNR, where throughput increases with increases in SNR but decreases with increase in BER. The latency i.e. the delay is about 1ms (0.00108 Sec) for all value of SNR to transmit the data from transmitter to receiver. Jitter is null i.e. zero for all value of SNR. Thus the QAM performance displayed in Fig 3 is considerable as it is meeting the requirement specified for 5G wrt QoS[1].

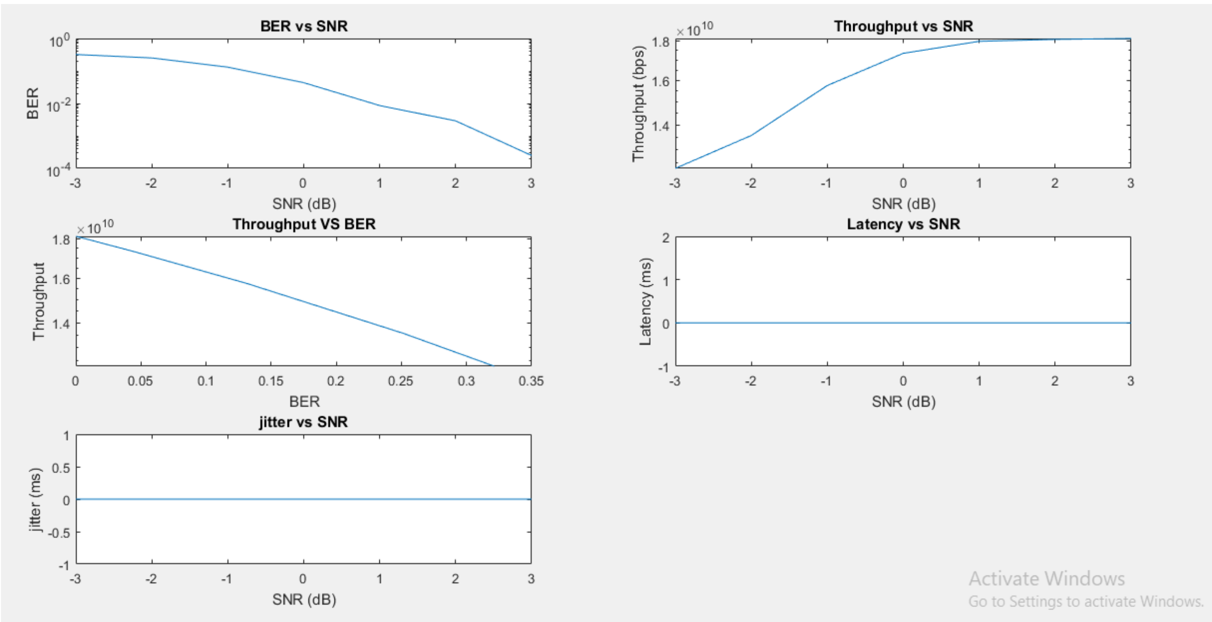

Fig 3:*QAM performance of BER, Throughput, Jitter and Latency for M-ary number of 4*

Combined Plot
Here we will combine all two proposed modulation techniques QPSK and QAM with four QoS parameters BER, Throughput, Jitter and Latency under AWGN channel and under single simulation model and simulate it.

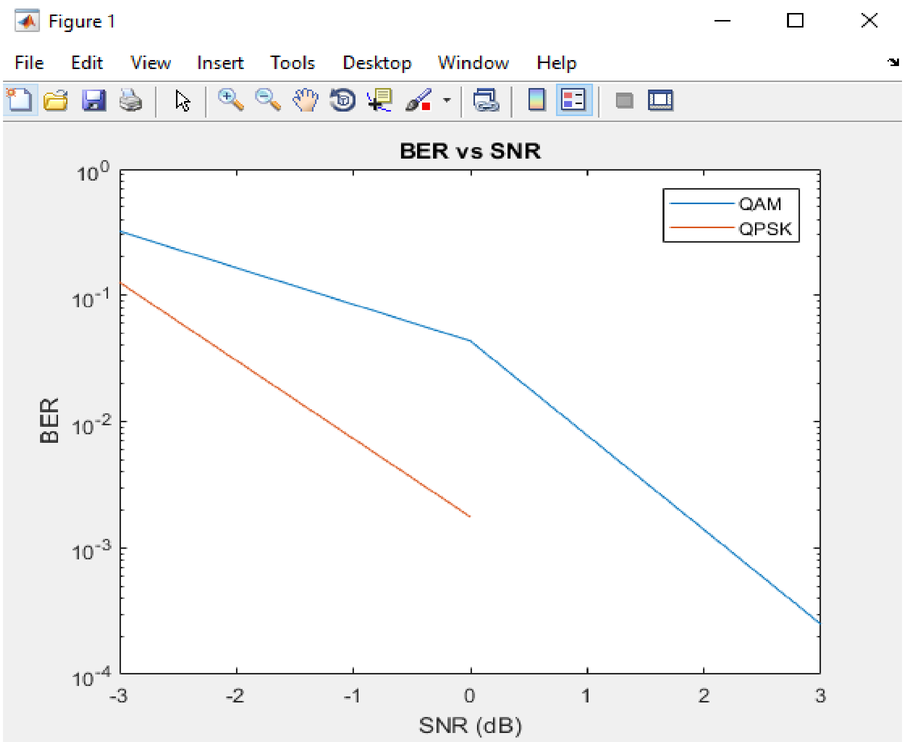

Fig 4:*Combined BER Plot*

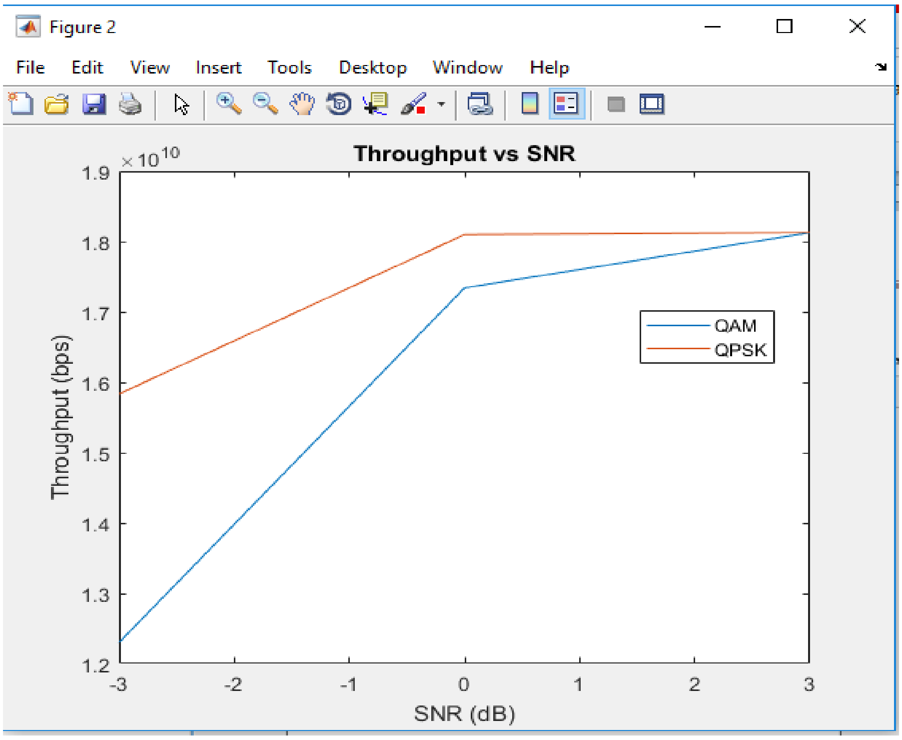

Fig 5:*Combined Throughput Plot*

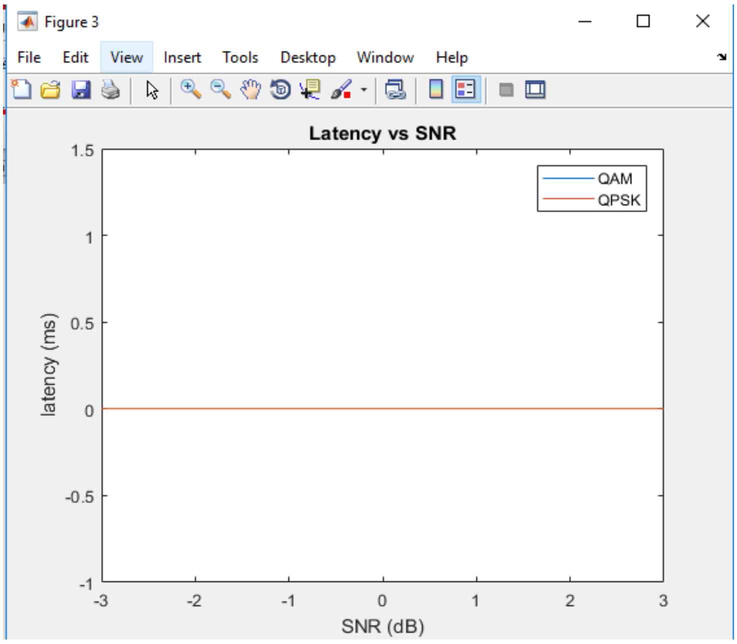

Fig 6: *Combined Latency plot*

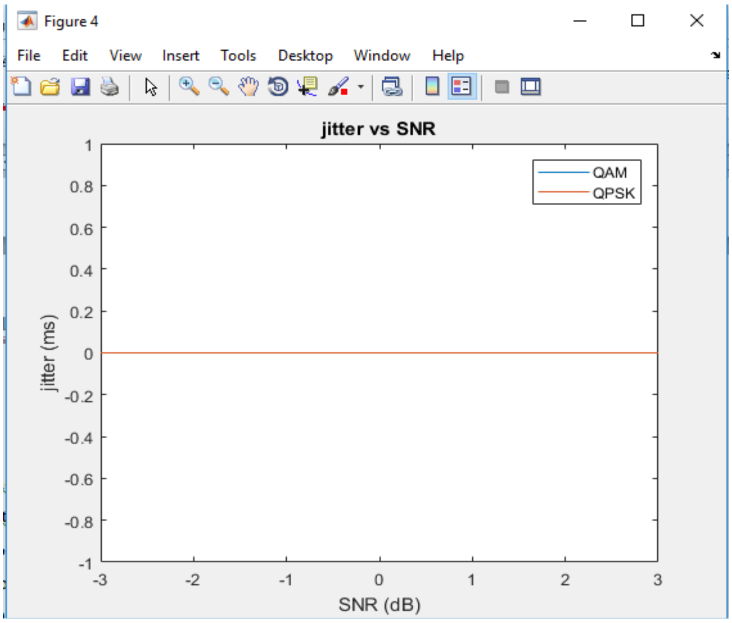

Fig 7: *Combined Jitter plot*

The above four figures shows the combined plot of BER, Throughput, Latency and Jitter for two modulation techniques QPSK and QAM. Fig 4 shows that BER will reach zero with very less SNR value of order 1.5 for QPSK modulation, which shows the best performance than QAM. Similarly Throughput reaches greater than Gbps for less value of SNR in QPSK than QAM as shown in Fig 5. Latency and jitter for both modulation schemes is 1ms and null (0) respectively for all value of SNR as shown in Fig 6 and Fig 7. The BER and throughput performance of QPSK and QAM has very minute differences in performances as shown in table 1. Thus, both the modulation techniques can be considered for 5G, as it is providing efficient performance when simulated. Thus, providing an optimum solution to maintain QoS.

Table 1: *QoS parameters comparisons between QPSK and QAM*

Modulation Techniques	Quadrature Phase Shift Keying (QPSK)			Quadrature Amplitude Modulation (QAM)		
SNR (dB)	-3	0	3	-3	0	3
BER	0.1266	0.0018	0	0.312	0.043	0.00024
Throughput (bps)	$1.58e^{+10}$	$1.80e^{+10}$	$1.81e^{+10}$	$1.23e^{+10}$	$1.73e^{+10}$	$1.81e^{+10}$
Latency (Sec)	0.0011	0.0011	0.0011	0.00108	0.00108	0.00108
Jitter (Sec)	0	0	0	0	0	0

CONCLUSION

The primary concern for both user and service provider is network performance. QoS is predominant element in any cellular network, particularly when the performance is being evaluated by the users. Thus, the work focuses to provide the QoS performances of 5G by employing two modulation techniques namely QPSK and QAM. This is accomplished by developing a communication model in Simulink at 5G frequency range. QoS is calculated, analysed and compared between two modulation techniques with respect to BER, Throughput, Jitter and Latency. It was inferred that as we go for higher SNR, Bit Error Rate decreases, throughput increases, latency and jitter remains same. BER, Throughput, Latency and Jitter analysis is made for QAM and QPSK modulation techniques and it showed that QPSK has better performance than QAM. Thus, meeting the 5G requirement

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