Performance Evaluation of WiMAX Network under Various Modulation techniques using various versions of TCP

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***Abstract*— Worldwide interoperability for Microwave Access (WiMAX) is based on 802.16d/e Orthogonal Frequency Division Multiplexing (OFDM) based adaptive Physical Layer (PHY) layer. It provides wireless broadband to fixed and mobile terminals. Modulation techniques enable WiMAX to optimize. WiMAX supports BPSK, DPSK, 16-QAM and 64-QAM. This paper parents the evaluation of various modulation techniques to increase the reliability of WiMAX based networks using various versions of Transmission Control Protocol (TCP) The proposed model helps to investigate how delay and throughput vary in terms of network parameters in order to optimize the system**

***Index Terms*— TCP Tahoe, TCP Reno, TCP New Reno, TCP Sack, Throughput, OPNET**

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX) is an emerging global broadband wireless system based on IEEE 802.16 standard. It is a new wireless OFDM (Orthogonal Frequency Division Multiplexing) based technology that provides high quality broadband services long distances based on IEEE.802.16 wireless MAN (Metropolitan Area Network) air interface standard to fixed, portable and mobile users [1, 2]. WiMAX is a wireless broadband technology it has several improvement then Wi-Fi and UMTS (Universal Mobile Telecommunication Services) / HSDPA (High Speed Downlink Packet Access). Wi-Fi (Wireless Fidelity) provides wireless high speed internet and network connections [7]. UMTS is based on 3G GSM standard. HSDPA is an enhanced 3G (Third Generation) communication protocol that supports high data transfer speed and capacity.

WiMAX uses a special type of modulation technique which is a mixture of ASK and PSK with a new name called QAM (amplitude and phase changes at the same time). In OFDM smaller data stream is then mapped to individual data sub-carrier and modulated using some sorts of PSK or QAM such as QPSK, 16-QAM, 64-QAM. OFDM needs less bandwidth than Frequency Division Multiplexing (FDM).The effect of Inter Symbol Interference (ISI) is suppressed by virtue of a longer symbol period of the parallel OFDM sub-carriers than a single carrier system and the use of a cyclic prefix (CP) [3]. This makes an OFDM ideal to handle the mobile wireless environment. OFDM is the one of the solutions to combat Inter Symbol Interference (ISI) are multi carrier modulation for data transmission. OFDM is better than Code Division Multiple Access (CDMA) which is mostly incorporated in existing 3G systems [6]. The TCP and UDP widely used transport layer protocols in internet. To achieve both reliability and congestion control TCP uses a closed feedback loop, data packets and acknowledgements are exchanged between the two end hosts of the connection. The goal of this paper is evaluating various modulation techniques to increase the reliability of WiMAX based networks using various versions of TCP. All modulation techniques tested with different performance metrics. We find TCP degrades network performance, which may be an obstacle for users running applications such as file-sharing or video conferencing applications.

In the rest of the paper, Section 2 briefly introduces the TCP variants. Section 3 describes the simulation model and different parameters used in this work. Section 4 describes various performance metrics used for performance evaluation. Section 5 presents the simulation results and discussions and finally, Section 6 concludes the paper and suggests future work.

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II. TCP VARIANTS

TCP guarantees that all data is delivered in sequence and without loss, unless the connection is broken; reliability is achieved by assigning a sequence number to each packet and acknowledging every packet received. If this acknowledgment is not received within certain timer duration, the segment is assumed to be lost and it is retransmitted [5].

A. TCP Tahoe: Follows a basic go-back-n model using slow start, congestion avoidance and Fast Retransmit algorithm. .With Fast Retransmit, after receiving small number of ACKs for the same segment, the sender infers that the packet has been lost and retransmits the packet without waiting for the retransmission timer to expire [5]

B. TCP Reno: TCP-Reno is the most widely used TCP variant with three functions: Slow Start, Congestion Avoidance and Fast Recovery. Slow Start is activated at the start of TCP connection or when a timeout event occurs. During Slow Start phase, the congestion window size (called CWND) increases exponentially until a Slow Start threshold from which CWND increases linearly. The period during which CWND increases linearly is called Congestion Avoidance phase. In TCP-Reno, a lost packet is detected and retransmitted when triple duplicate ACKs are received (called Fast Retransmit) or a timeout event occurs at the sender. With multiple losses, Reno typically timeouts because it does not see duplicate acknowledgements [5].

C. ***TCP New Reno***: Deal with multiple losses within a single window. New Reno use partial ACKs to improve loss recovery. Use retransmits one lost packet per one RTT until all the lost packets from the same window are recovered. [5].

D. ***TCP Sack***: Deal with the same problem as New Reno. It is quite different from other TCP variants. Instead of using cumulative ACK it uses selective acknowledgement. A SACK block provides the sender with all the necessary information needed to retransmit the exact packets that are missing. It is able to thus efficiently cope with packet losses in the wireless channel and retransmit all the missing packets in one RTT, reducing TCP timeouts

III. Simulation Model

This section present the system model used in our investigation. Fig. 1 shows a sample network. In the study, different networks are designed corresponding to each modulation techniques along with various versions of TCP.

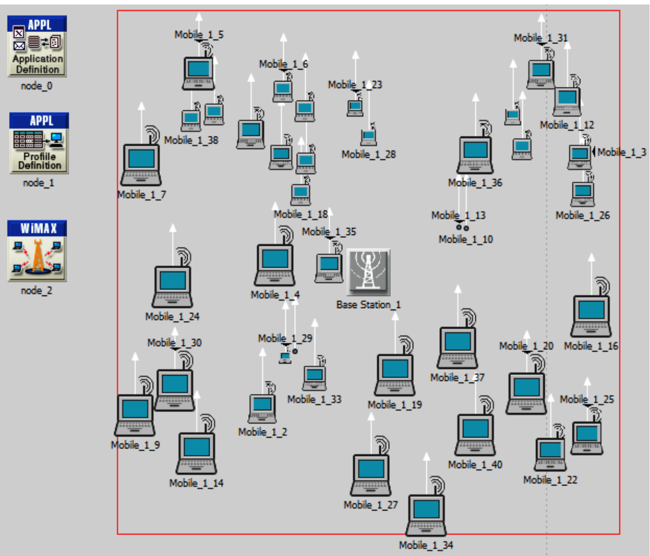

Fig. 1 Sample Network

Network consists of 40 nodes. The nodes are randomly placed within certain gap from each other in 1000x1000 m campus. The constant video conferencing was generated in the network explicitly i.e. user defined via Application and Profile Configuration.

a) Application Configuration: Video Conferencing.

b) Profile Configuration: The profile configuration for application was defined as, Operation Mode: video application start time was set at constant 600 seconds.

DES Configuration Parameter: The DES simulation parameters are configured similar to [4]. All the DES parameters are:
• Duration: 600 seconds
• Seed: 256
• Update Interval 500000 events

Using the OPNET Simulation, some common parameters are listed in Table I

TABLE I: PARAMETERS IN SIMULATION

Attribute	Values
Trajectory (Mobility Model)	Random Waypoint
Size of the Network (meters)	1000 x 1000
Antenna Gain (dBi)	-1dBi
Maximum Transmission Power (watts)	.5

IV. Performance Metrics

To increase the reliability of system under the various TCP variants, different metrics have been chosen:

Delay (sec): Represents end-to-end delay for all the data packets that are successfully received by the WiMAX MAC layer and forwarded to the higher layer.

Throughput (bits/sec): Throughput is defined as the ratio of the total data reaches at a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput.

V. Simulation Result

In this section the evaluation of various modulation techniques to increase the reliability of WiMAX based networks using various versions of TCP results are presented using Discrete Event Simulator OPNET

A. Delay: Average BPSK delay (Fig. 2). It has been concluded that the network using TCP default shows the maximum delay such that increased by 22 % from the network using TCP Reno.Fig.3 parents Average DPSK delay. Here the network using TCP New Reno shows the maximum delay such that increased by 9 % from the network using TCP Tahoe. Fig.4 parents Average QAM 16_34 BLER delay. So it is concluded that the network using TCP default shows the maximum delay such that increased by 4 % from the network using TCP New Reno.Fig.5 parents Average QAM 64_34 BLER delay. It has been observed that the network using TCP New Reno shows the maximum delay such that increased by 3 % from the network using TCP default.

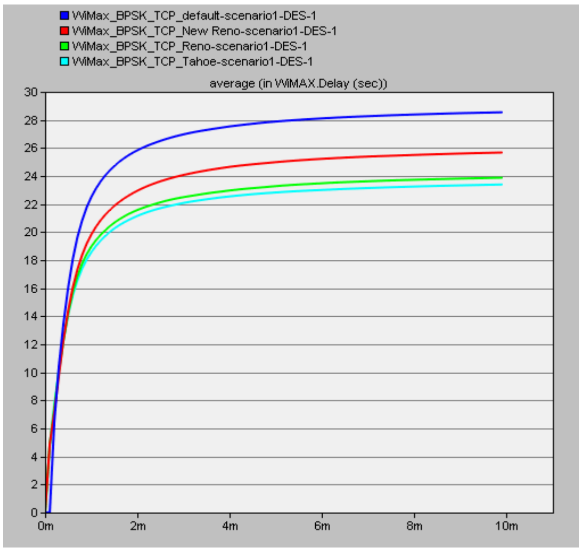

Fig. 2 Average BPSK delay

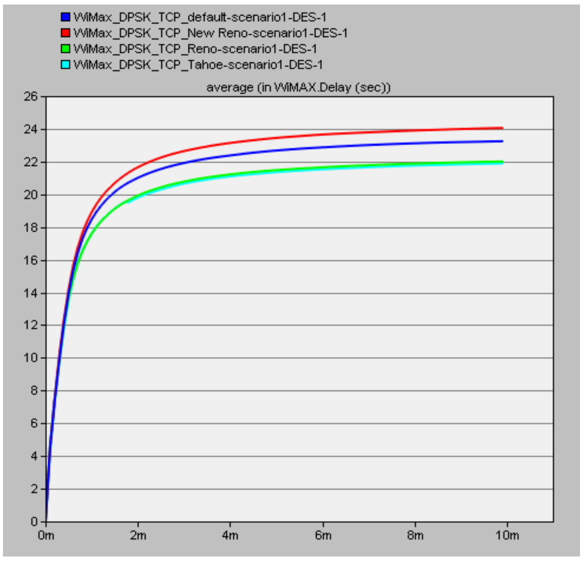

Fig. 3 Average DPSK delay

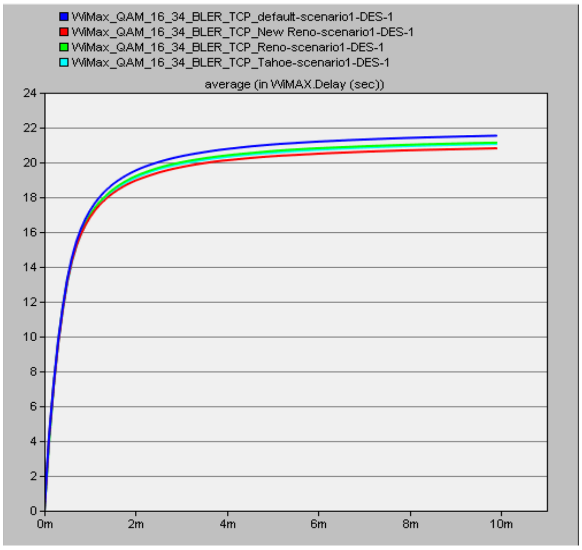

Fig. 4 Average QAM 16_34 BLER delay

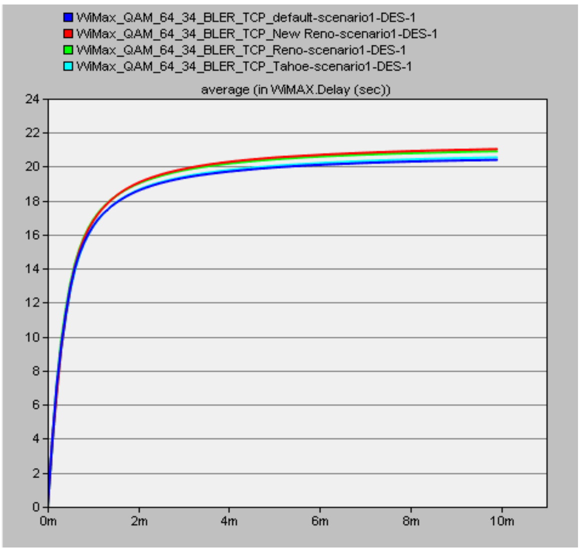

Fig. 5 Average QAM 64_34 BLER delay

B. Throughput: Fig. 6 shows Average BPSK throughput, the network using TCP Tahoe shows the maximum throughput such that increased by 36 % from the network using TCP Reno. Fig. 7 shows Average DPSK throughput, the network using TCP New Reno shows the maximum throughput such that increased by 55% from the network using TCP Tahoe. Fig. 8 shows Average QAM 16_34 BLER throughput. In this case, the network using TCP Tahoe shows the maximum throughput such that increased by 27 % from the network using TCP default. Fig. 9 shows Ave rage QAM 64_34 BLER throughput. It has been observed that the network using TCP Reno shows the maximum throughput such that increased by 44 % from the network using TCP default.

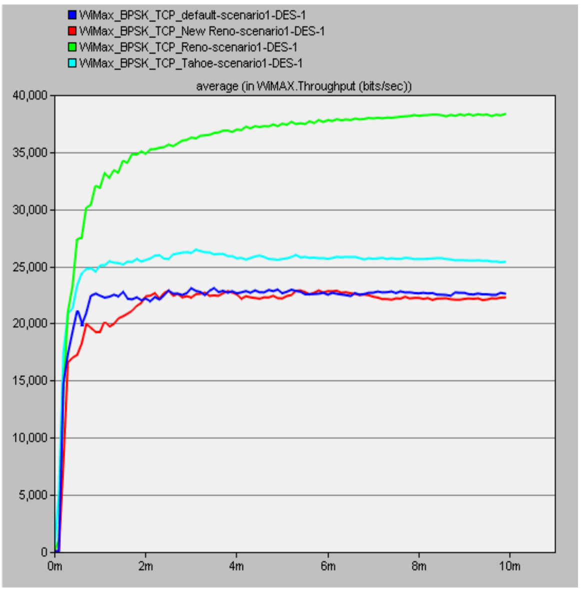

Fig. 6 Average BPSK throughput

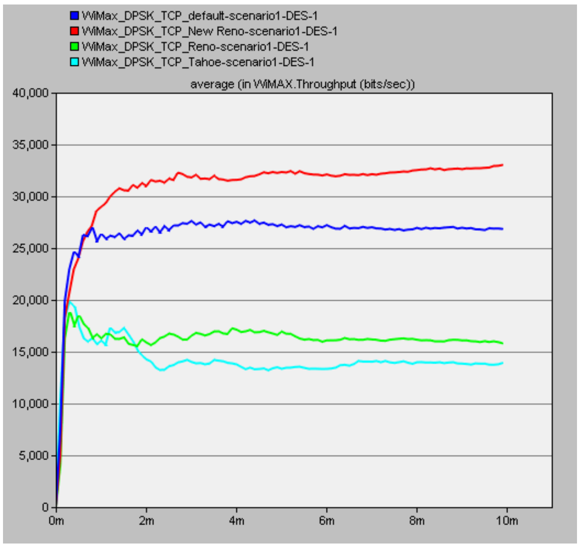

Fig. 7 Average DPSK throughput

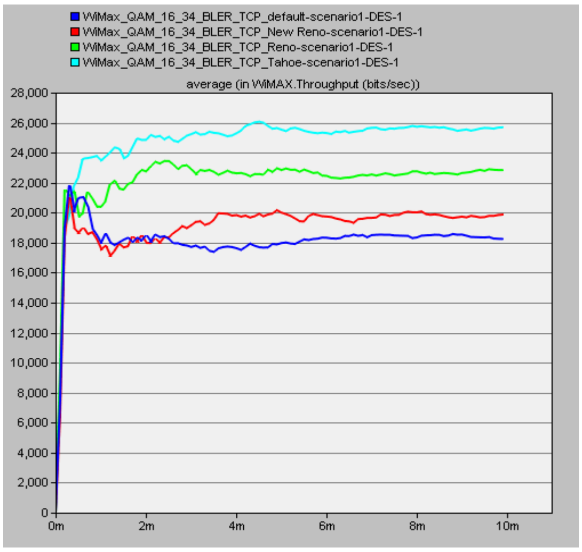

Fig. 8 QAM 16_34 BLER throughput

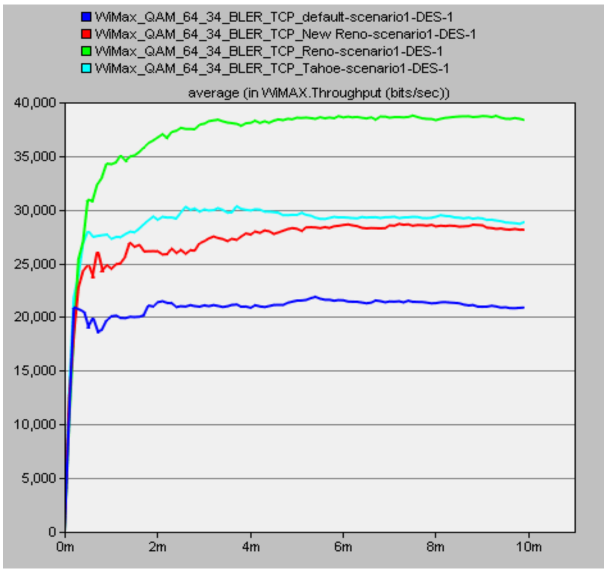

Fig. 9 QAM 64_34 BLER throughput

VI. CONCLUSION

In this paper, performance of the WiMAX networks corresponding each incorporation of the TCP version and Modulation Technique has have been evaluated in terms of delay, throughput. Form all the results it has been concluded that under the given configuration parameters, TCP Reno outperforms all other TCP versions in the case of BPSK and QAM 64_34 BLER modulation techniques. If the performance of the network is evaluated on the basis of the throughput of the network, DPSK and QAM 16_34 BLER, TCP New Reno and TCP Tahoe perform better. In future, the performance of network is extended by using other versions of TCP protocol and other parameters, to make the results more justified.

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