Impact of High Speed Modulation Technique on Wireless Network Parameters

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*Abstract***— Mobility in wireless network is essential for users to move seamlessly. The type of modulation adopted plays a vital role in the performance of wireless network. In this paper, a wireless network has been implemented in OPNET to analyze the effect of modulation techniques on the network parameters such as BER and throughput at low transmission powers of 10 mW for different communication distances. It is observed that BER increases and throughput decreases as the order of modulation technique increases.**

Keywords— Jamming, Modulation, OPNET, Wireless network

I. INTRODUCTION

A great deal of attention has been gathered by researchers, including those in the field of mobile computing and communications in recent years [1]. Wireless networks are based on Open System Interconnect (OSI) architecture. In OSI the physical layer has the primary function to transfer information bits across a communication channel from one system to another. Bit is the basic unit of exchange at this layer [2]. The major functions and services performed by the physical layer are, providing a standardized interface to physical transmission media, modulation, pulse shaping, signal processing of physical signals, forward error correction and channel coding.

In [3], implementation of wireless network has been discussed. It describes about how to create transmitter, receiver and jammer node in wireless network using OPNET modeler. Results shown for specific trajectory of jammer are analyzed with the help of time controller. In [4], performance evaluation of WLAN has been presented using OPNET modeler. The performance has been analyzed by evaluating network parameters like delay and throughput using different load values for access point and stations. Jamming effect on various modulation techniques has been discussed in [5]. The authors conclude that BPSK and QPSK provide better performance than higher order modulation schemes.

In this paper, the effect of high speed modulation techniques: QAM-64 and 8-PSK, on wireless parameters such as Bit Error Rate (BER) and throughput has been presented. It has been observed that by using high speed modulation technique the throughput decreases and BER increases.

A wireless network of size 100 sq. Km. has been simulated in OPNET by creating a transmitter, receiver and jammer node along with jammer trajectory. The speed of jammer trajectory has been set to 10 m/sec. This achieves variation in signal to noise ratio between transmitter and receiver in a said wireless network. The modulation and power attribute has been promoted initially so as to select multiple values during simulation.

Different simulation scenarios are created by varying the jamming power, modulation technique and communication distance. As jammer power increases the BER increases and SNR decreases. The effect of modulation is that for higher order modulation such as QAM-64 the BER increases and throughput decreases whereas for lower order modulation such as BPSK the BER decreases and throughput increases. When communication distance is increased SNR decreases hence BER increases and throughput decreases.

The paper is organized as follows; Section II explains the implementation of transmitter, receiver and jamming node of wireless network in OPNET. Section III discusses different scenarios for simulation of wireless network. Simulation results for various scenarios are presented in Section IV. A comparative study has been done in Section V and Section VI concludes the paper.

II. WIRELESS NETWORK IN OPNET

A wireless network has been implemented in OPNET of size 100 sq. Km. using an enterprise network.

A. Implementation of a transmitter and jammer node

The transmitter node model of wireless network consists of a packet generator, a radio transmitter and an isotropic antenna module [5]. The packet size of the packet generator has been set to 1024 bits with an inter arrival time of 1 packet/sec. The modulation option of radio transmitter has been set to promote mode in order to facilitate change in modulation technique for different simulation scenarios. The data rate of radio transmitter has been set to 1024 bits per sec and its packet capacity has been set to 1000.

The jammer node model also consists of a packet generator, a radio transmitter and an isotropic antenna module similar to the transmitter node except the choice of channel power and modulation. The modulation of jammer node has been set to jammod modulation whereas the data rate and packet capacity is same as that of transmitter node. Jammer is responsible for adding noise to the packet data in order to vary the signal to noise ratio at the input of the receiver. The implementation of transmitter and jammer node is shown in Fig. 1.

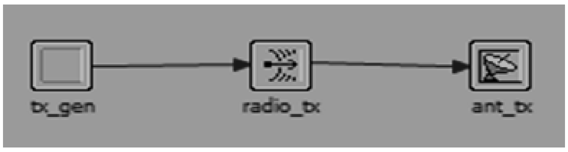

Fig. 1. Transmitter and jammer node model

B. Implementation of a receiver node

The receiver node model consists of a packet sink, a radio receiver, point processor and an isotropic antenna module. The data rate of radio receiver has been set to 1024 bits per sec. The modulation option of radio receiver has been set to promote mode. Sink processor is used to receive the packet and the point processor is used to point packets towards the receiver. The implementation of receiver node model is shown in Fig. 2.

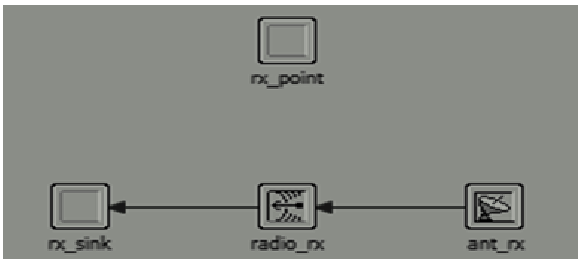

Fig. 2. Receiver node model

After creation of wireless nodes (transmitter, receiver and jammer) a process model is defined for every wireless node. Process model controls the underlying functionality of the node model like modulation and transmission parameters. At last a network model has been created. A network model is an empty scenario where previously created nodes such as transmitter, jammer and receiver are deployed. Network parameters like network size and network type are set. For all the simulation scenarios presented in this work the antenna pattern is isotropic in nature. The size of the network has been set to 100 sq. km. and the network type is an enterprise network with an empty scenario. Transmitter and receiver node performance has been analysed for different communication distances by changing the modulation techniques, transmission power and jamming power.

III. NETWORK SCENARIOS

Three main network scenarios have been implemented based on different trajectories of jammer as shown in Figs. 3 to 5. Trajectory contains data specifying time and location that the jammer node will pass through as the simulation progresses.

A. Scenario 1: Network with simple trajectory

The network with wireless topology where the jammer node has simple trajectory is as shown in Fig. 3.

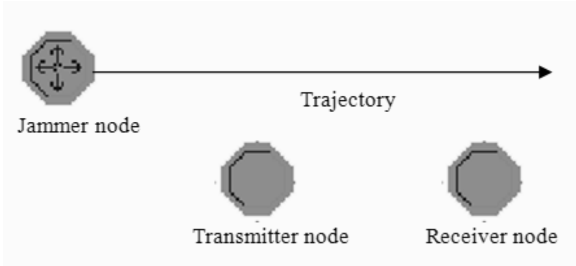

Fig. 3. Wireless network with simple jammer trajectory

Under this scenario simulation parameters are set as per Table 1. The network parameters BER and throughput are observed for two different modulation techniques BPSK and QAM-64. Simulation has been performed for 20W jamming power and 2W transmission power. The distance between the transmitter and receiver node is 1000m. Simulation has been performed for 420 seconds. Simulation results are shown in the Fig. 6 and Fig. 7.

Table 1: Simulation parameter for scenario 1

NAME	VALUE
Antenna Type	Isotropic
Network Size	100 Sq. Km.
Type	Enterprise Network
Jamming Power	20 W
Transmission power	2 W
Distance	1000m
Modulation	BPSK and QAM-64
Simulation Time	420 sec.

B. Scenario 2: Network with trajectory passing through the center of transmitter and receiver

The network with wireless topology, where jammer trajectory passes through the center of transmitter and receiver path is as shown in Fig. 4. Simulation has been performed for 800 seconds and for a 2W transmission power. The jamming power is kept variable. Results are collected for each scenario. The distance between the transmitter and receiver node is 1000m. In this scenario a comparative study on different jamming power has been done. Simulation results are shown in the Fig. 8, Fig. 9 and Fig. 10.

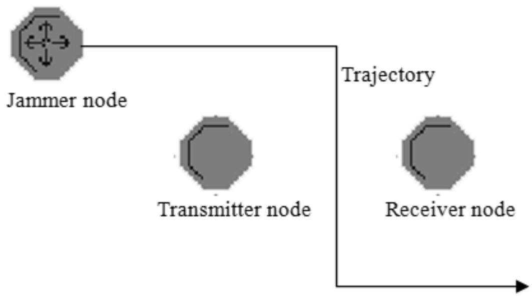

Fig. 4. Wireless network with jammer trajectory between Transmitter and Receiver

Table 2: Simulation parameter for scenario 2

NAME	VALUE
Antenna Type	Isotropic
Network Size	100 Sq. Km.
Type	Enterprise Network
Jamming Power	Variable (0-30W)
Transmission power	2 W
Distance	1000m
Modulation	BPSK and QAM-64
Simulation Time	800 sec.

C. Scenario 3: Network with trajectory ending at the receiver

The network with wireless topology where the jammer node has trajectory ending at the receiver is as shown in Fig. 5. In this scenario the jammer power has been set to 20W and transmission power to 2W. Simulation has been performed for 800 seconds and results are collected for each scenario for different modulation. The distance between the transmitter and receiver node has been kept variable.

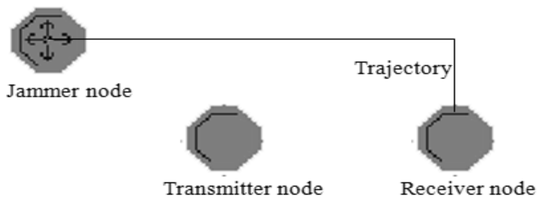

Fig. 5. Wireless network with jammer trajectory at the receiver

Table 3: Simulation parameter for scenario 3

NAME	VALUE
Antenna Type	Isotropic
Network Size	100 Sq. Km.
Type	Enterprise Network
Jamming Power	Variable (0.01-30W)
Transmission power	0.05 W
Distance	Variable (100, 500 and 1000m)
Modulation	Variable (BPSK, QPSK, QAM-16 and QAM-64)
Simulation Time	360 sec.

IV. SIMULATION RESULTS

This Section assimilates simulation results for different scenarios discussed in Section 3.

A. Simulation results for scenario 1

Results are presented for BPSK and QAM-64 modulation techniques. Fig. 6 shows the BER w.r.t time for scenario 1. The BER increases as the distance between the jammer and the receiver node decreases. The BER reaches a maximum value of 0.27 for BPSK and 0.96 for QAM-64 when the distance between jammer and receiver has been set to 500m for the simulation.

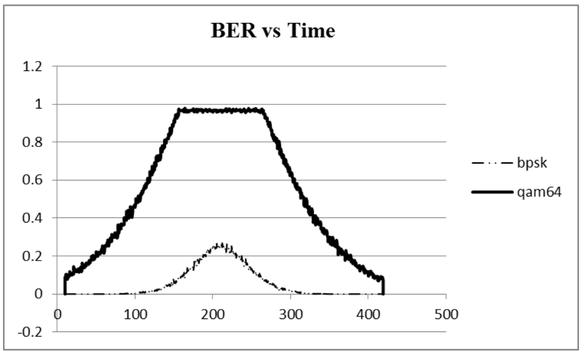

Fig. 6. BER received for scenario 1 with different modulation

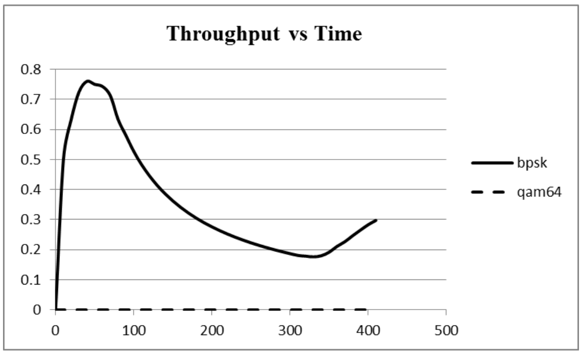

Fig. 7. Throughput received for scenario 1 with different modulation

Fig. 7 shows the throughput for scenario 1. The throughput decreases as the jammer distance increases w.r.t the receiving node. The throughput reaches a maximum value of 0.76 for BPSK modulation whereas for QAM-64 the signal is jammed and there is no throughput generated.

B. Simulation results for scenario 2

This scenario consists of two sub scenarios: Case 1and Case 2. In Case 1 the modulation technique has been set to BPSK whereas for Case 2 the modulation technique is QAM-64. Results are shown for different jammer powers such as 0W, 1W, 2W, 3W, 5W, 10W, 15W, 20W & 30W respectively. Simulation has been performed for 800 seconds.

Case 1

In this case results are shown for BER and throughput with different jammer powers using BPSK modulation.

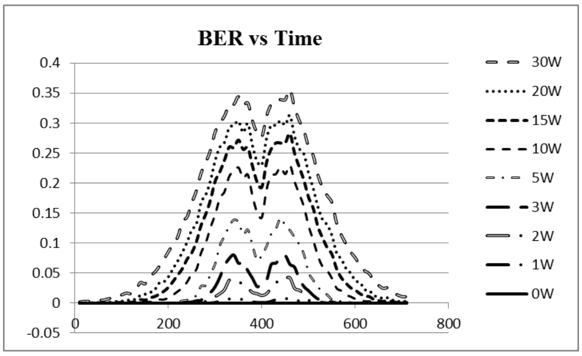

Fig. 8. BER for scenario 2 with BPSK modulation

Fig. 8 shows the BER at the receiver for BPSK modulation. It can be seen that BER increases and it reaches a maximum of 0.35 when the jammer power has been set to 30W. There are two peaks that are generated they indicate the nearest position of the jammer noise.

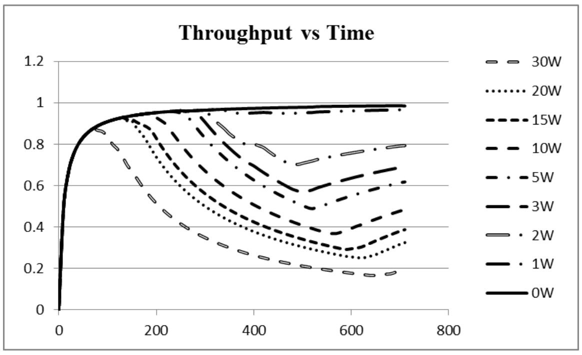

Fig. 9. Throughput for scenario 2 with BPSK modulation

Throughput (packets/sec) versus simulation time (seconds) is shown in Fig. 9 for BPSK modulation. The throughput decreases with the increase in jammer power. The throughput reaches a maximum value of 0.99 for 1W and a minimum value of 0.18 for 30W.

Case 2

In this case results are shown for different jammer power using QAM-64 modulation.

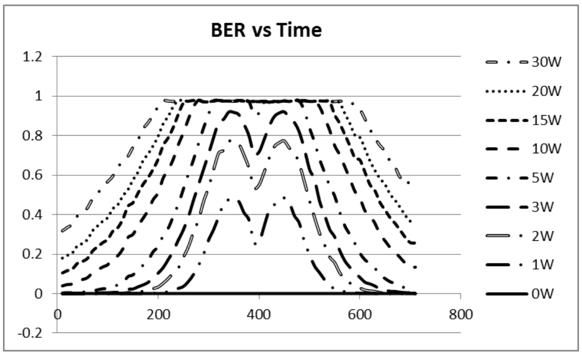

Fig. 10. BER for scenario 2 with QAM-64 modulation

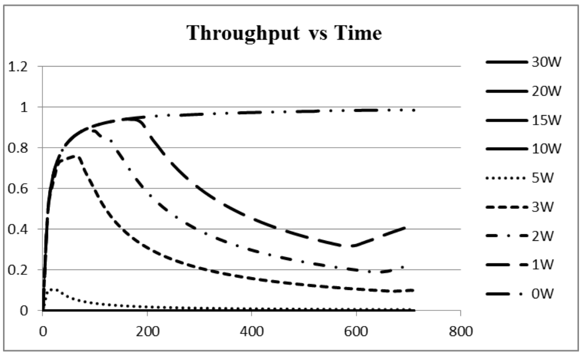

Fig. 11. Throughput for scenario 2 with QAM-64 modulation

It can be seen in Fig. 10 that the BER increases as the jamming power increases. The BER reaches a maximum value of 0.99 for 30W jamming power and a minimum value of 0.22 for 1W jamming power. Fig. 11 shows throughput for QAM-64 modulation for higher jamming power there is no throughput generated. The throughput reaches a maximum value of 0.97 for 1W jamming power and a minimum value of 0.1 for 5W jamming power.

C. Simulation results for scenario 3

Simulation has been performed for 360 seconds with low transmission power of few milliwatts. The different parameters evaluated in this scenario are BER, throughput and SNR.

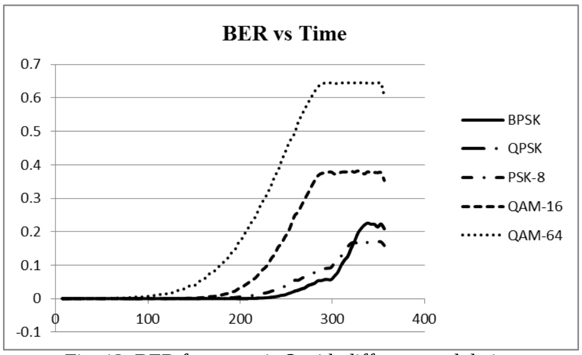

Fig. 12. BER for scenario 3 with different modulation

Fig. 12 shows BER for different modulation techniques. Simulation has been performed for 0.5 Km communication distance. The transmission power has been set to 0.05W and jammer power has been set to 0.5W. It has been observed that BPSK and QPSK show same results and for higher order modulation we get high BER. The BER reaches a maximum value of 0.65 for QAM-64 modulation.

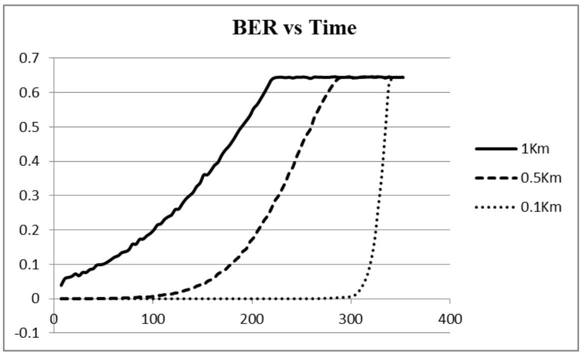

Fig. 13. BER for different distances with QAM-64 modulation

Fig. 13 shows BER for different communication distances with QAM-64 modulation. Simulation has been performed for 0.1Km, 0.5Km and 1Km. The transmission power has been set to 0.05W and jammer power to 0.5W. As the communication distance increases the BER decreases.

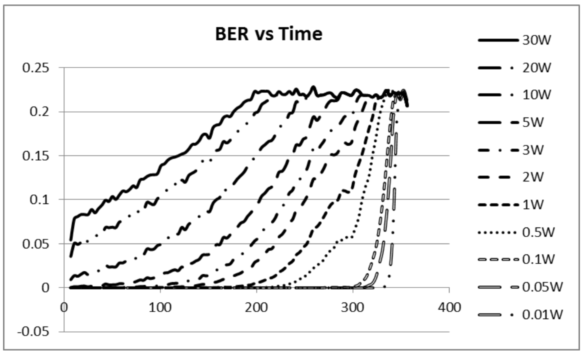

Fig. 14. BER for scenario 3 with different jamming power using BPSK

Fig. 14, 15 and 16 shows BER for different jamming powers with BPSK, 8-PSK and QAM-64 modulation respectively. Simulation has been performed for 0.5 Km communication distance and transmission power to 0.05 W.

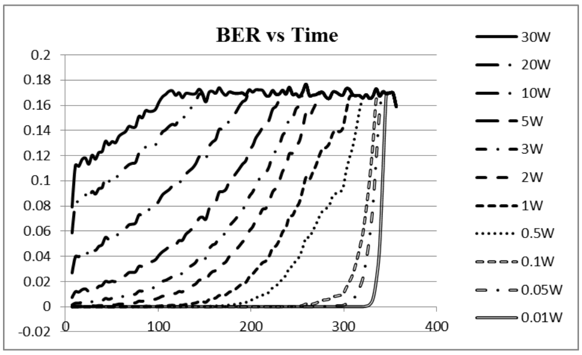

Fig. 15. BER for scenario 3 with different jamming powers using 8-PSK

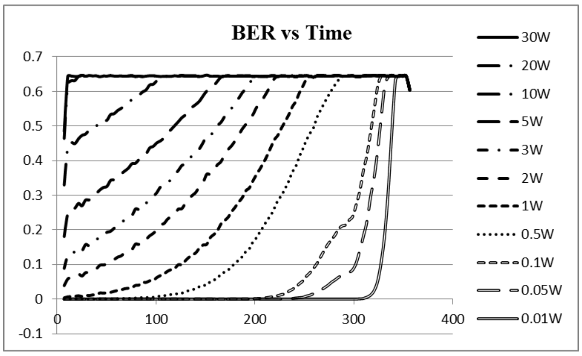

Fig. 16. BER for scenario 3 with different jamming powers using QAM-64

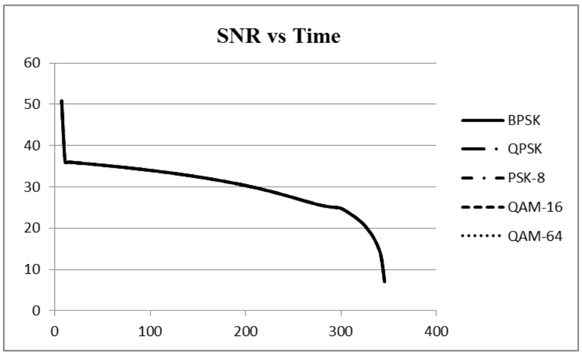

Fig. 17. SNR for scenario 3 with different modulation techniques

Fig. 17 shows SNR for different modulation techniques. Simulation has been performed for 0.5 Km communication distance. The transmission power has been set to 0.05W and jammer power to 0.5W. It has been observed that signal to noise ratio is independent of the modulation techniques used.

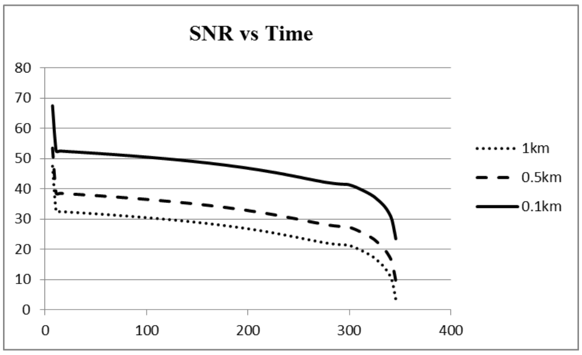

Fig. 18. SNR for scenario 3 with different distances using QAM-64

Fig. 18 shows SNR for different communication distances. It has been observed that SNR decreases with the increase in communication distance. Same results are obtained for BPSK and 8-PSK modulation techniques. The transmission power has been set to 0.05W and jammer power to 0.5W.

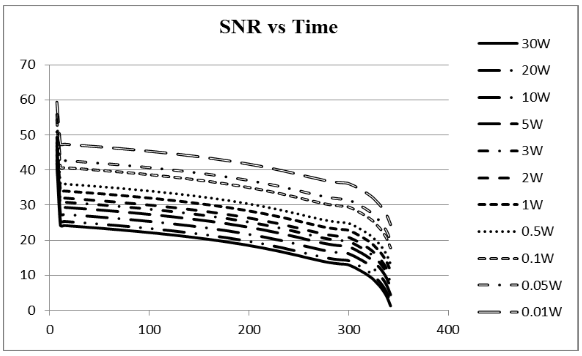

Fig. 19. SNR for scenario 3 with different jamming power using QAM-64

Fig. 19 shows SNR for different jamming powers, it has been observed that as jamming power increases SNR decreases. The different jamming powers are ranging from 0.01W to 30W has been taken into effect as shown in Fig.19. The modulation technique used has been set to QAM-64 modulation and the distance between the transmitter and receiver has been set to 0.5Km.

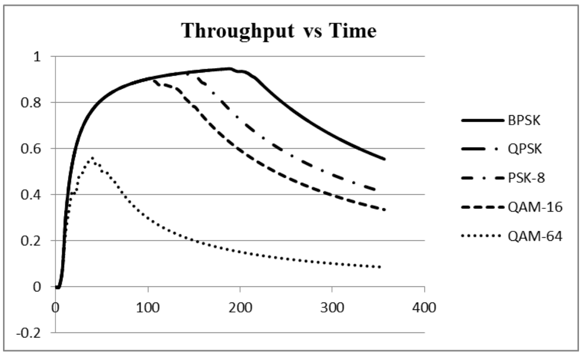

Fig. 20. Throughput for scenario 3 for different modulation techniques

Fig. 20 shows throughput for different modulation. It has been observed that throughput decreases with time. The higher the modulation technique used the less is the throughput. BPSK and QPSK are showing the same result whereas for QAM-16 and QAM-64 the throughput keeps decreasing. The transmission power has been set to 0.05W, jamming power to 0.5W and communication distance to 0.5 Km.

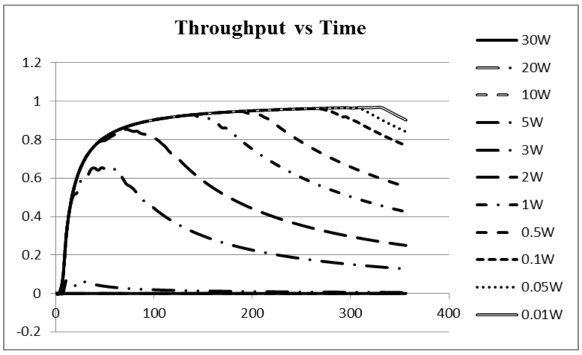

Fig. 21. Throughput for scenario 3 with different jamming using BPSK

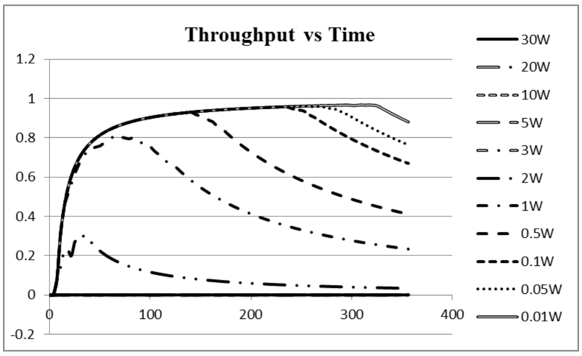

Fig. 22. Throughput for scenario 3 with different jamming using 8-PSK

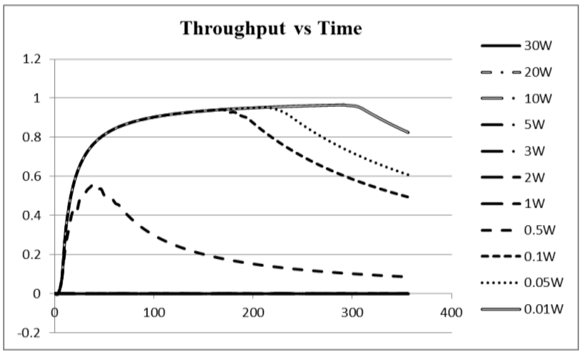

Fig. 23. Throughput for different jamming with QAM-64 modulation

Fig. 21, 22 and 23 shows throughput for different jamming powers with BPSK, 8-PSK and QAM-64 modulation respectively. The transmission power has been set to 0.5W and communication distance to 0.5 Km. It has been observed that as jamming power increases throughput decreases. Fig. 24 shows a graph of throughput for different distances it has been observed that as distance increases throughput decreases.

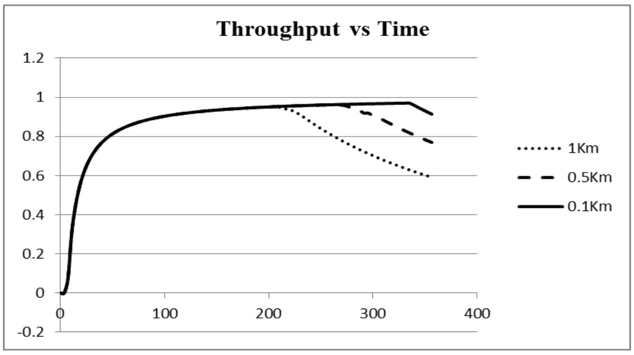

Fig. 24. Throughput for scenario 3 for different distances using QAM-64

V. OBSERVATION AND COMPARISON

It has been observed that in scenario 1 when the network has simple trajectory the BER increases as the jammer comes near to the receiver and throughput decreases. In scenario 2 when the jammer passes through the center of the transmitter and receiver, the result for BER shows two peaks indicating high BER when jammer is near to the receiver. The throughput decreases as the jammer is near to the receiver. In scenario 3 when the jammer is at the receiver it has been observed that BER increases and throughput decreases for higher modulation.

In [5] the authors have shown results for high jamming powers where as here the simulations are performed for low jamming powers. Communication distances has been changes and comparative study has been done for low jamming and transmission powers. In this research the study of parameters like BER and throughput has been done using three different scenarios each having different trajectory and simulation time. It has been observed that as BER increases the throughput decreases.

VI. CONCLUSION

The evaluation of wireless network has been performed here using different modulation techniques for different communication distances, different transmission and jamming powers. From the simulation results it has been observed that BER and throughput depends on the trajectory, transmission power and jamming power while SNR depends on the distance between transmitter and receiver and jamming power.

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