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Effects of Jamming Attacks on Wireless Communication Systems

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Abstract— This paper presents brief overview about simulation using OPNET®Modeler®. Study of jamming effect on various modulation schemes has been presented. How user data rate and the jamming effect are related is also discussed. Transmitter, receiver and Jammer nodes are created in simulation environment. Effect of jammer radiated power is also analyzed.

Index Terms—Modulation Schemes,OPNET® Modeler®, Jamming, Wireless Communication, Data Rate, Spreading, Simulation.

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1 INTRODUCTION

The development of Mobile Communication Systems caused a revolution in terms of mobility in past two decades. People could be reachable and connected to the world with a simple cellular phone, anytime and anywhere. Various modulation schemes are developed to increase the performance of telecommunication systems. All modulation schemes have different characteristics and noise immunity levels. Wireless networks now enjoy widespread commercial deployment because of their ease of use and setup. With development of higher data rate networks, more and more mobile users accessing the Internet wirelessly through various high-end mobile devices already available in the market at affordable prices. However, since accessing wireless media is much easier than tapping a wired network, security becomes a serious concern when implementing any wireless network. Here we discuss Jamming vulnerability of various modulation schemes used in today's communication systems.

2 DIGITAL MODULATION SCHEMES

Various digital Modulation schemes for which we have simulated the jamming effects are Binary Phase Shift Keying (BPSK), Differential phase shift keying (DPSK), 8 Phase Shift Keying (8PSK), Gaussian Minimum Shift Keying (GMSK), Quadrature Phase Shift Keying (QPSK), 16 and 64 Quadrature amplitude modulation (QAM). All modulation schemes have their own advantages and disadvantages. Different scenarios are created for all modulation schemes. Jamming effects are considered for various jammer powers.

We have also simulated jamming effect for three differentdata rates, 10 kbps, 12.2 kbps and 144 kbps. We have considered QPSK modulation with UMTS carrier and bandwidth specifications.

3 NODE MODELS AND SIMULATION SCENARIOS

We have created three node models in OPNET to simulate our scenarios. The nodes are Transmitter, Receiver and Jammer nodes. Transmitter node has three internalmodules, Packet generator, Radio transmitter and Antenna module.Jammer node has same modules but with different parameters. Receiver node has four modules namely point processor, receiver antenna, radio receiver and Packet sink.

All simulation scenarios consists this three nodes. Jammer node has been assigned one trajectory. Jammer moves along with this trajectory during the simulation. This enables the study of relation between distance and required jammer power.

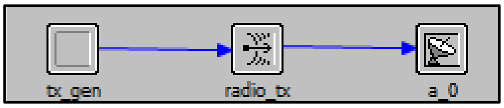

Figure 1 : Jammer and Transmitter Node model

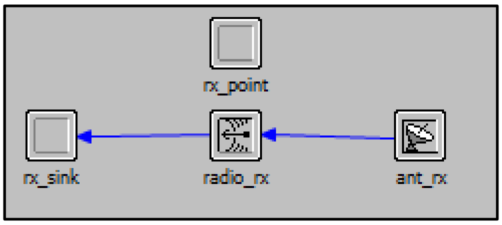

Figure 2 : Receiver Node Model

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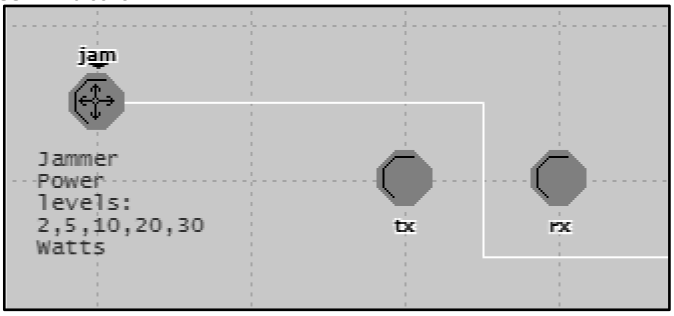

Figure 3 Simulation Scenario

Jammer node contains three modules, Source, radio transmitter channel and antenna. Source parameters for the jammer are packet inter–arrival time, packet size, jammer start time, stop time and transmitter power. Radio parameters are data rate, packet formats, frequency and bandwidth. Frequency is chosen according to carrier frequency of target system.

To see the effect of spreading factor we have simulated different user data rates. As in [2], Spreading Factor = Channel Bandwidth/Datarate. As data rate increases, the processing gain decreases. So for higher data rates, system is more prone to noise and interference. Here sender and receiver are configured for UMTS downlink specifications [3] [4].

- Carrier Frequency: 2110 MHz
- Channel Bandwidth: 3840 KHz
- Data Rates: 10 kbps, 12.2 kbps and 144 kbps.
- Modulation: QPSK

Jammer node is also configured according to UMTS downlink frequency. Simulation is performed for different jammer power levels. Bit error rate, Throughput and SNR are the parameters of interest.

4 Simulation Results

Simulation is performed for 400seconds in each scenario. Simulation is performed for 2W transmission power for transmitter. Results are collected for various jammer powers, 0W, 2W, 5W, 10W, 20W and 30W in DES-1, DES-2, DES-3, DES-4, DES-5 and DES-6 respectively. At first we see the obtained results for BPSK modulation scheme. Figure 4 shows the received power at receiver from transmitter of the jammer node. Figure 5 shows the corresponding Signal to noise ratio. Figure 6 shows the corresponding Bit Error Rate at the receiver.

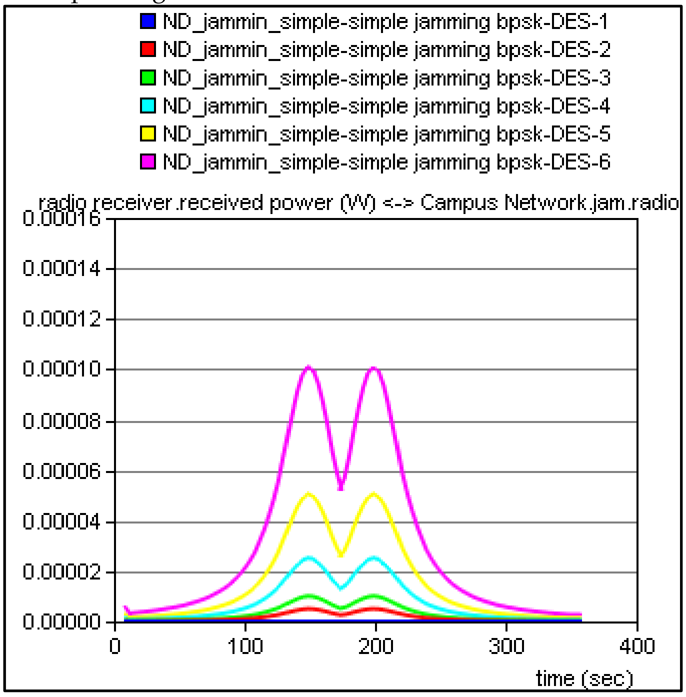

Figure 4 : Power received from Jammer at Receiver

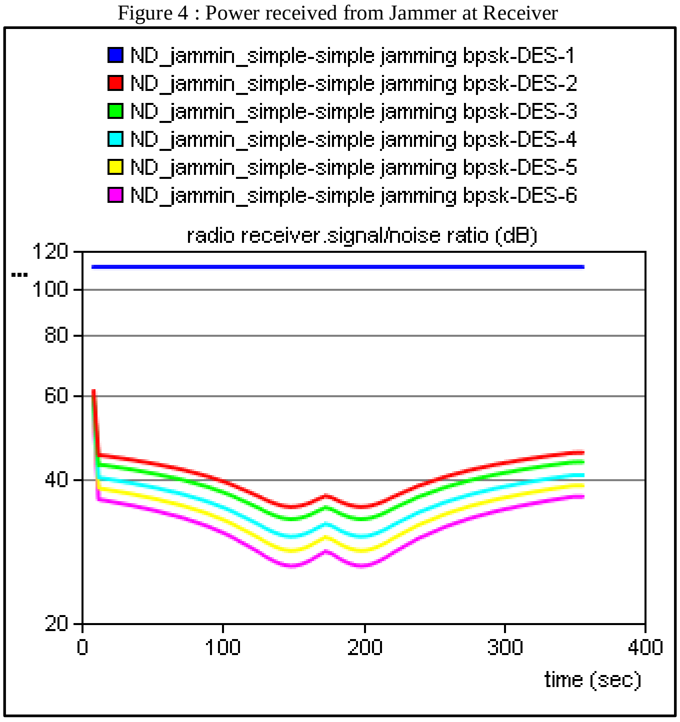

Figure 5 : SNR at Receiver

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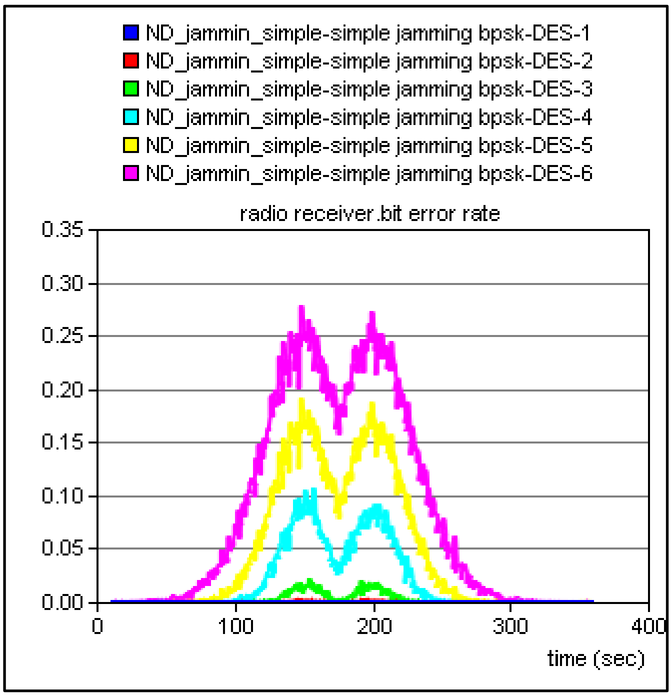

Figure 6 : BER at Receiver

It can be seen that BER increases as SNR decreases. SNR decreases due to increase in the received jammer power at the receiver antenna. BER reaches maximum to 0.28 when the jammer power is set to 30 W. Two peaks indicate s the nearest position of jammer when the noise at receiver is maximum. Figure 7 shows the corresponding effect on the throughput at the receiver. With 0W jammer power there is no degradation in the performance.

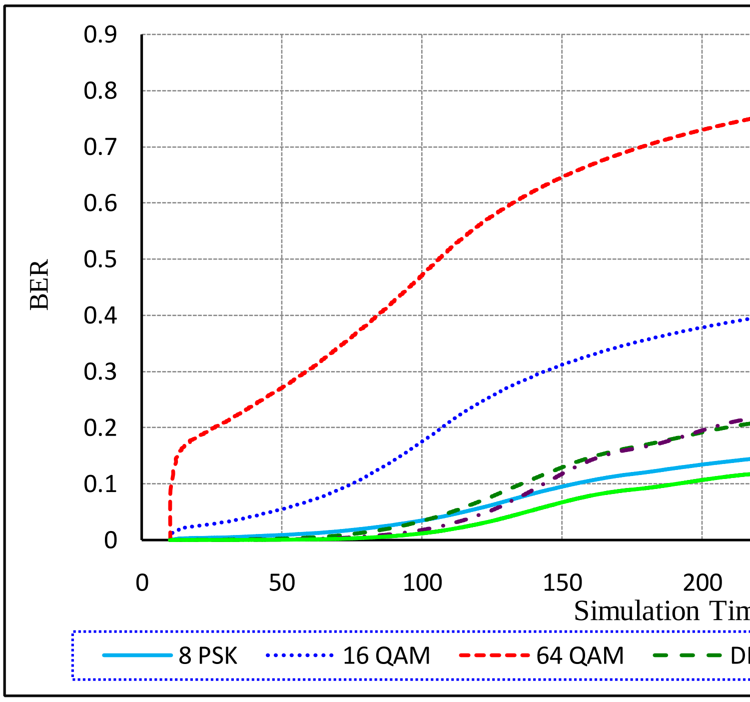

Figure 8 : BER for various

Now wecompare the BER for all modulation schemes. We have used 30W jammer power for simulation. Results are as shown in figure 8. It is observed that DPSK and GMSK have nearly same jamming immunity. 64 QAM suffers the most in noisy communication environment. BPSK, QPSK and 8 PSK provides similar performance.

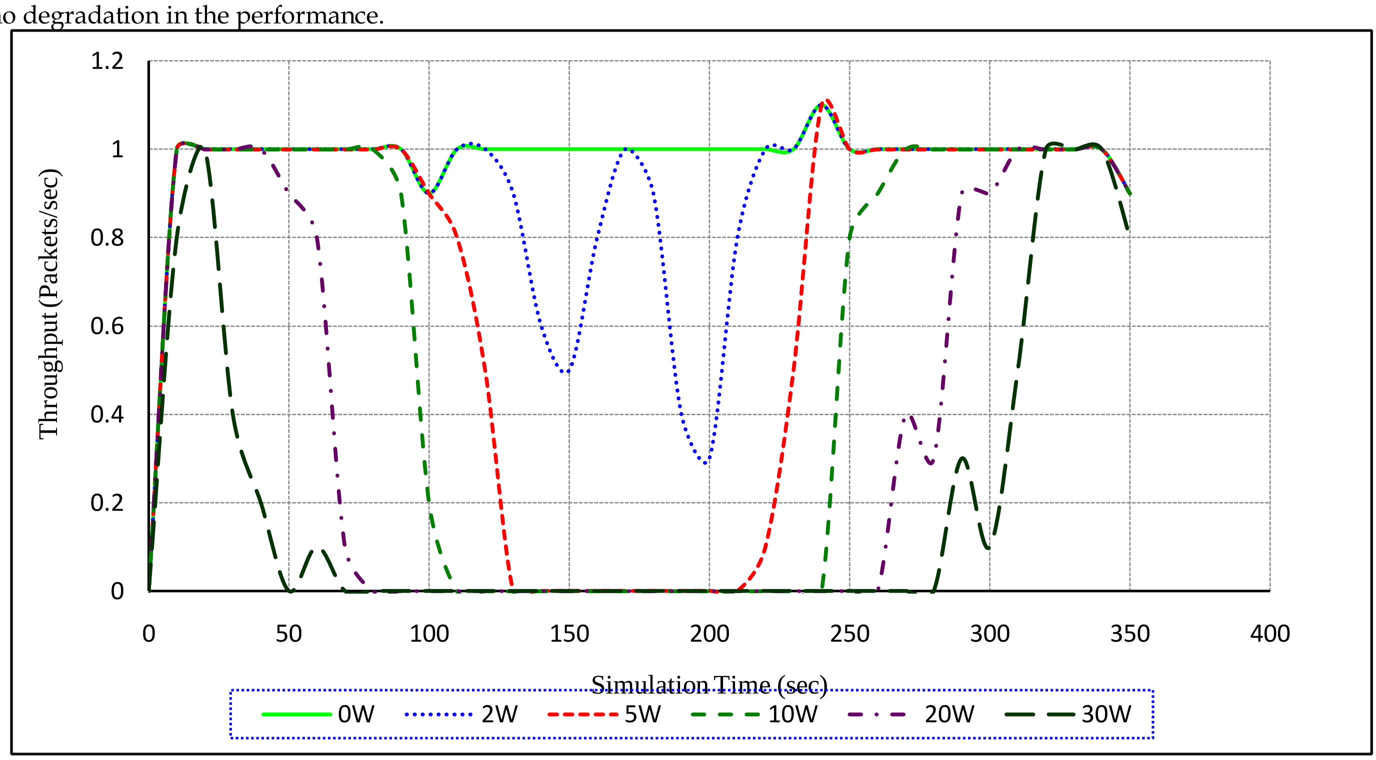

Figure 7 : Received Throughputs for BPSK Modulation

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Increase in BER will reduce the throughput of the system. Figure 9 shows how Throughput reduces according to BER in Figure 8. As seen, 64 QAM has minimum throughput because of the highest BER at the receiver. BPSK and QPSK have almost the same throughput. Throughput for 8 PSK is slightly greater than that for 16 QAM.

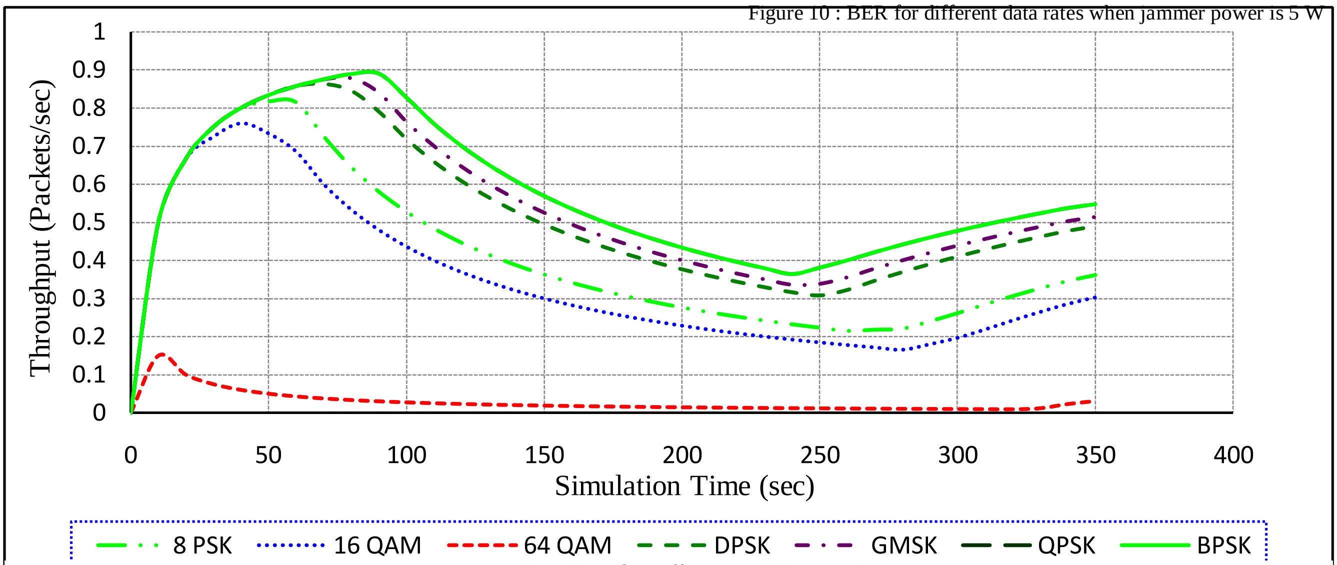

Figure 9 : Throughput for Different Modulation Schemes

Now to analyze the effect of user data rate we have simulated 10 kbps, 12.2 kbps and 144 kbps user data rates for different jammer powers. Figure 10 shows the BER when 5W jammer power is used.

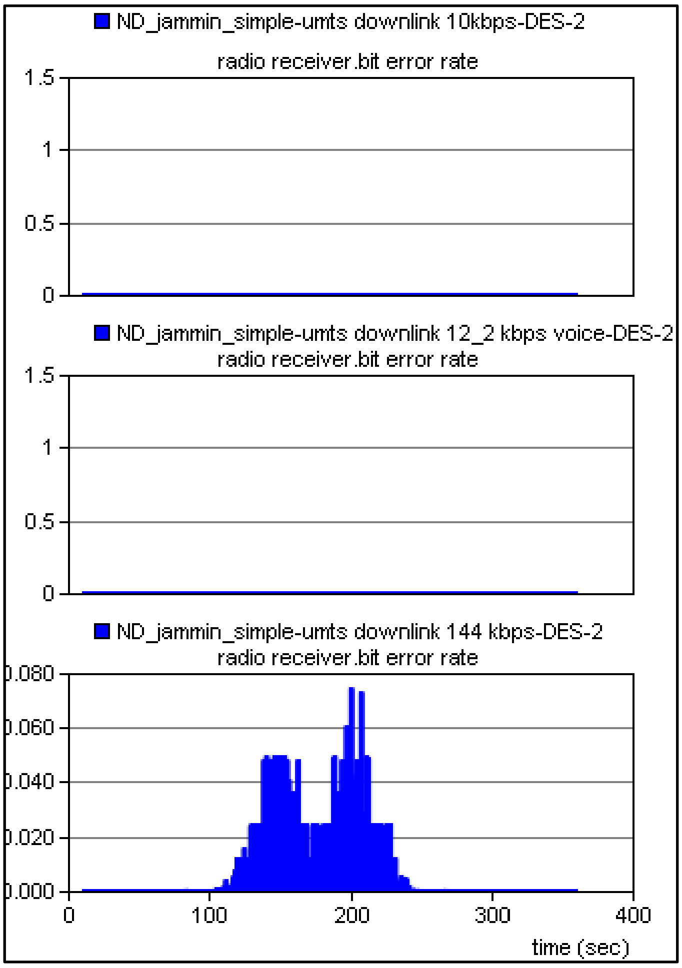

Figure 10 : BER for different data rates when jammer power is 5 W

Figure 11 shows the BER when 10W jammer power used. From figure 10 and figure 11 it can be seen that for constant channel bandwidth, lower data rate communication suffers less from jamming.

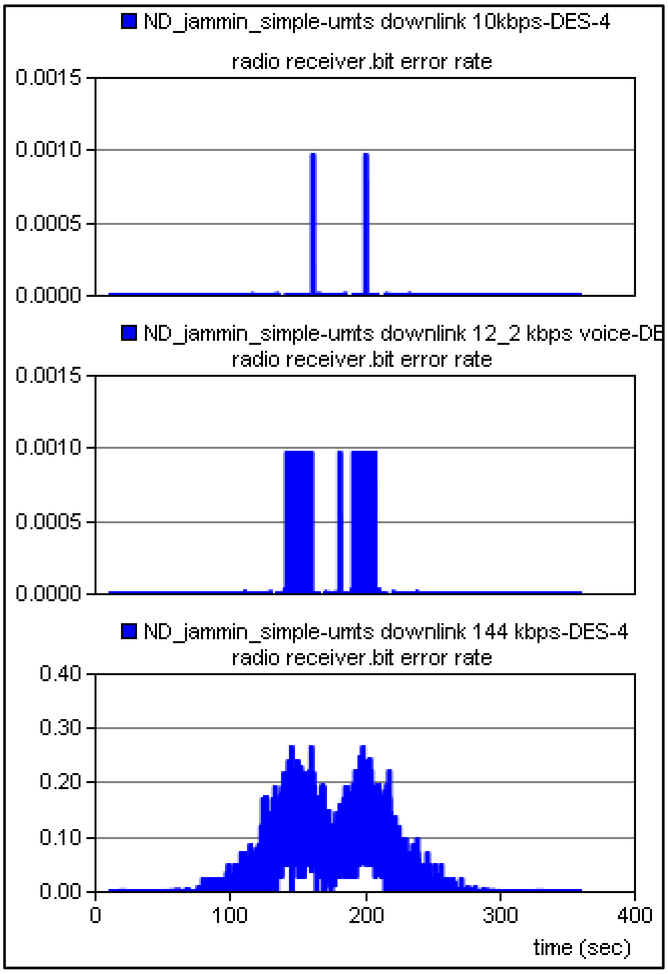

Figure 11: BER for different data rates when jammer power is 10 W

Figure 12 shows the throughput received at receiver when jammer radiation power is 5 W. It can be seen that 10 kbps and 12.2 kbps users does not feel any effect of jamming at this power. But 144 kbps user data rate suffers even in this small amount of jammer noise. This happens because at higher data rates, spreading gain decreases, provided that channel bandwidth is constant.

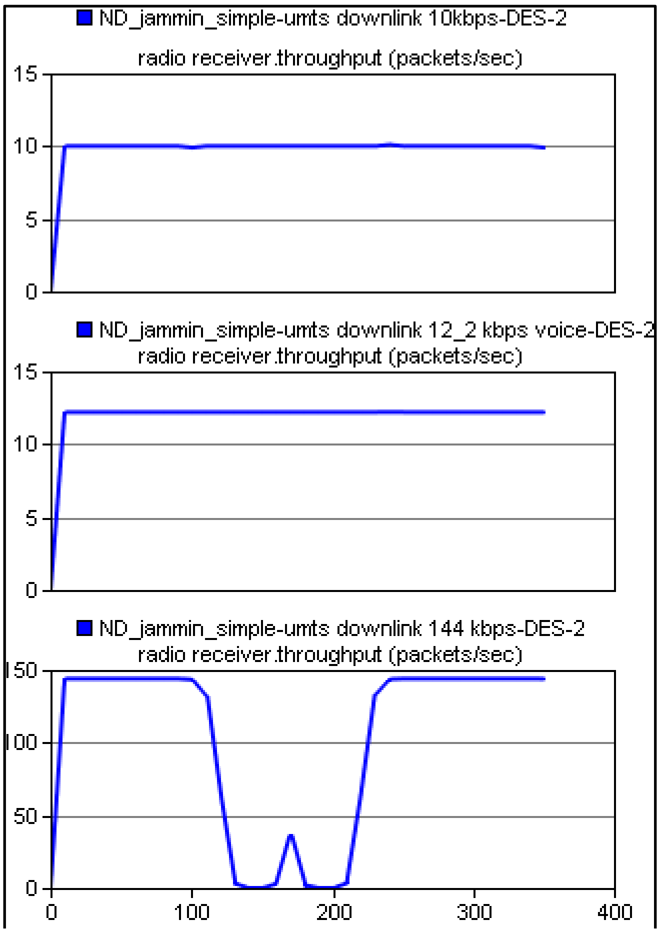

Figure 12: Throughput when jammer power is 5 W.

This effect can be well understood by analysis of figure 13. This figure shows the radio receiver throughput when jammer radiation power is 20 W. At this noise power, 10 kbps and 12.2 kbps users also notice the effect of jamming. For 144 kbps user, throughput is reduced to nearly zero when jammer is near to receiver. Low data rate users have better performance compared to high data rate users. This shows that every spread spectrum based wirelesscommunication system is more prone to noise when we use maximum allowable data rate when full bandwidth is used. This happens due to reduction in processing gain or spreading gain. At 10 kbps and 12.2 kbps user data rates, effect of jammer comes only when jammer is closest to the receiver. This happens at two places as jammer moves along the trajectory. While for 144 kbps userdata rate, effect of jamming is more and communication is destructed for long period.

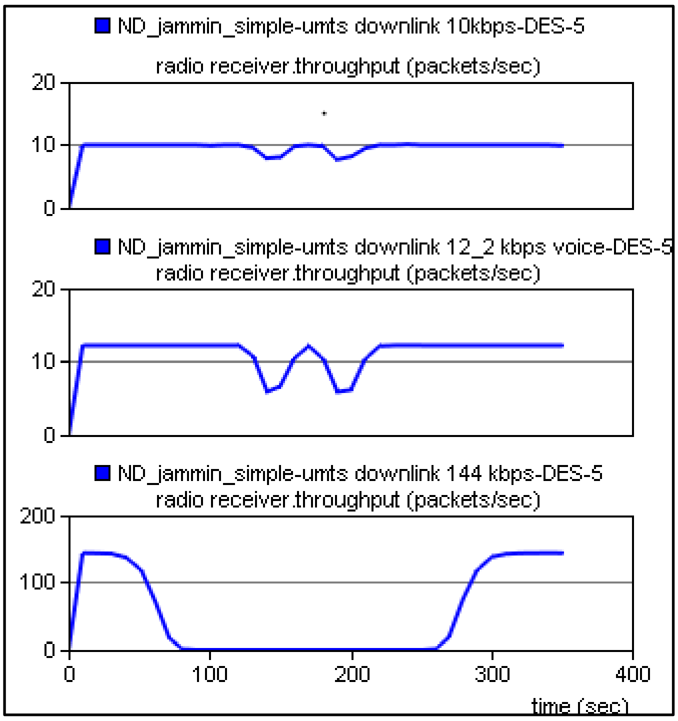

Figure 13 : Throughput when Jammer Power is 20 W.

5 CONCLUSIONS AND SUMMARY

In this paper we have simulated the effect of jamming on various modulation schemes. Performance of BPSK and QPSK is found better than other modulation schemes. We have also simulated three different scenarios for three different user data rates. Simulation results shows that low data rate users are less prone to noise than high data rate users. This paper also shows the effect of processing gain in wireless communication. Here we have considered only one transmitter receiver pair. Further study can be done using simulation of large scale network.

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