International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:9, No:1, 2015

Optimization of Bit Error Rate and Power of Ad-hoc Networks Using Genetic Algorithm

Anjana Choudhary

Abstract**—**The ad hoc networks are the future of wireless technology as everyone wants fast and accurate error free information so keeping this in mind Bit Error Rate (BER) and power is optimized in this research paper by using the Genetic Algorithm (GA). The digital modulation techniques used for this paper are Binary Phase Shift Keying (BPSK), M-ary Phase Shift Keying (M-ary PSK), and Quadrature Amplitude Modulation (QAM). This work is implemented on Wireless Ad Hoc Networks (WLAN). Then it is analyze which modulation technique is performing well to optimize the BER and power of WLAN.

Keywords**—**Bit Error Rate, Genetic Algorithm, Power, Phase Shift Keying, Quadrature Amplitude Modulation, Signal to Noise Ratio, Wireless Ad Hoc Networks.

I. INTRODUCTION

WIRELESS ad hoc networks (WLAN) are multi-hop networks in which mobile nodes operate in distributed manner without help of any central infrastructure or these are temporary network connection developed for a specific purpose such as transferring data from one active node to another. IEEE 802.11 provides are Distributed Coordinate Function (DCF) to manage concurrent transmission. A Novel closed form expression for the Average Bit Error Probability (ABEP) of binary modulation schemes in a network with aggregate newly derived formula expressed in terms of fox-H-function and is valid for any arbitrary real value of the characteristics exponent, alpha, which depends on the path loss coefficient in the propagation environment, all the analytical results developed are corroborated by Monte Carlo simulation results, indicating the validity of the proposed mathematical analysis. The ABEP increases as SINR increases so the effect of SINR ABEP depends on the Poisson process parameters. It is severe for high values of the interference density [1]. Broadcasting algorithm improves the packet transmission rate of the network. Based on the energy performance of the network and minimizes the BER for different transmission modes which improves the energy efficiency of the network. Opportunistic Large Array (OLA) based on broadcast transmission minimizes BER in different transmission mode like half duplex, full duplex, after considering Maximal Ratio Combining (MRC) on cooperative broadcast. This gives when SNR increases the BER is decreases for all the modes up to 10^{-3} value [2].

Multi-hop wireless ALOHA ad hoc networks which evaluating the BER using an alteration of the Friis propagation model that allows its application to any node density with random network topology and obey the law of conservation of energy. To find out the end to end BER performance of WLAN in which nodes are uniformly randomly distributed in the network area. The BER diminishes with the increase in node density until a point at which total interference is greater than the utile received power. The route BER overestimates the received power on those nodes which have neighbors located at distance smaller then 1m [3]. An analytical scheme to evaluate the route BER performance of a WLAN which exploits minimum distance routing, also showing the route BER depends on link BERs and the number of hops, it is evident from the node density threshold BER which is optimal node density that degrades route BER performance. Increasing the node density makes transmitter and receiver node closer this increases the average link SNR which in turn decreases the average route BER. However, increasing the node density beyond a certain point brings interfering nodes closer to the receiver nodes. This increases the interference power. After the node density threshold average interference power becomes dominant and higher than the average received power which leads increase in the average route BER [4]. High data rate like 8-PSK can send 3 bits per symbol. When a large power is available, it is easy to reduce the BW of a modulation scheme; similarly high power is not needed to achieve a low BER if a wide BW can be tapped. Modulation schemes which are able to deliver more bits per symbol are more immune to errors caused by noise and interference in the channel. Moreover, errors can be easily generate as the number of users are increased and due to users mobility. Thus, it has driven many researches into the application of higher order modulations. [5].

A novel decode combine forward scheme for multi-hop transmission in WLAN where information generated by independent sources has to be sent to a common destination based on multiple relay cooperation. For the low Signal to Noise Ratio (SNR) values the achieved diversity at the destination means that the slope of BER curve slowly increases with the number of relays. Thus, for a small number of relays the increment of the diversity is not significant. The reason is path loss attenuation in the signals. On the other hand, as the number of relays increases, the achieved diversity starts to increase since the path loss attenuation becomes less significant due to the increment of the signals. For higher SNRs the BER differences reduce drastically as the number of relays increases. Therefore for high SNRs, adding more relays

Anjana Choudhary is pursuing M.Tech (Communication and Signal Processing) in the Department of Electronics and Communication Engineering, Jaipur National University, Jaipur, Rajasthan, India-302025, (e-mail: ac71433@gmail.com).

in order to reach a distant point practically does not degrade the performance of the system, which makes the system suitable for multi-hop WLAN. Higher order modulations allow the binary channel code to have a lower rate for the same total spectral efficiency. The drawback of using a higher modulation is diminished by computing the joint likelihood probability [6].

Characterizing the performance of WLAN has been a topic that has garnered significant interest of the learners over the last decade. Understanding how the performance metrics scale with size of WLAN has also kindled many research efforts in this field [7]. R. E. and Mohammadi et al. the scalability of a random WLAN in terms of capacity determines the outage probability and ergodic capacities for various networks and channel parameters. Bit Error Rate (BER) is another metrics of importance in communication networks. The wireless channels results in error prone links and lost or corrupted packets which in turn can trigger retransmissions. As a result of retransmissions the delay and overhead can increase therefore it is important to study metrics such as BER that capture multilayer interactions [8]. A semi analytical model for calculation of route BER performance of a sensor network with random topology is proposed which shows that increasing node density leads to a decrease in route BER [9]. Several drawbacks of 802.11 have been identified in past several years. Most of the power control techniques for WLAN have been proposed to minimize the energy consumption. BER directly or indirectly affect the communication system performance through various factors these may be throughput, power, delay, energy consumption, transport capacity, Quality Of Service (QoS), BW. So it is the prime need to minimize the BER and power of WLAN system.

The remainder of this paper is organized as follows, section II focus on the analytical equations of BER of Binary Phase Shift Keying (BPSK), M-ary Phase Shift Keying (M-ary PSK), and Quadrature Amplitude Modulation (QAM).. Section III ascribe about GA and simulation model. Section IV presenting the results. Finally last section concludes the work.

II. EQUATIONS OF BER

BER is a key parameter that is used in assessing systems that transmit digital data from one location to another. Systems for which BER is applicable include fiber optic data systems, radio data links, Ethernet or any system that transmits data over a network of some form where interference, phase jitter, and noise may cause degradation of the digital signal. Even though there are some differences in the way of these systems working and the way in which BER is get affected, the basics of BER itself are still the same.

When data is transmitted over a communication link, there is a possibility of errors being introduced into the system. If errors are present in the data, then the integrity of the system may surely compromise. So it is necessary to assess the performance of the system, and BER provides an appropriate way in which this can be achieved.

Bit Error Rate (P_b) = Number of bit in error /Total number of transferred bits

The bit error probability of BPSK modulation is given by

$$P_{be} = Q(\sqrt{\gamma}) \qquad (1)$$

Here $\gamma = \mathrm{Eb/No}$; signal to noise ratio; Eb = Transmitted signal energy per bit; N_o = Noise power spectral density (PSD).

The bit error probability of M-ary PSK modulation is given by

$$P_{be} = \frac{2}{k} Q\left(\sqrt{2k\gamma}\right) \sin\frac{\pi}{4} \qquad (2)$$

Here k= $\mathrm{Log}_2 M$; M is modulation index; k is number of bits transmitted; $\gamma = \mathrm{Eb/No}$, γ = signal to noise ratio.

The bit error probability of M-ary QAM is given by relation

$$P_{be} = \frac{4}{k}\left(1 - \frac{1}{\sqrt{M}}\right) Q\left(\sqrt{\frac{3\mathrm{k}}{\mathrm{M}-1}}\right) \qquad (3)$$

Here $M=2^k$ number of message bit transmit; k is even value.

The performance of each modulation is measured by calculating its probability of error with assumption that systems are operating with AWGN.

Factors Affecting Bit Error Rate- By controlling the variables it is possible to optimize a system to provide the performance levels that are required. This is usually undertaken in the design stages of a signal transmission system so that the performance parameters can be adjusted at the initial design concept stages. The interference levels exist in a system is set by external factors and cannot be changed by the system design. However it is possible to set the BW of the system. By reducing the BW the level of interference can be reduced. However reducing the BW limits the data throughput that can be achieved, with the increase of power level of the system so that the power per bit is increased. These should be balance against factors including the interference levels to other users and the impact of increasing the power output on the size of the power amplifier and overall power consumption. One can compare the digital modulation technique on the basis of the SNR required to achieve specified POE however such a comparison would not be very meaningful, unless these are made on the basis of some constant, like fixed data rate of transmission, on the basis of a fixed BW for multiphase signals, channel BW required is simply the BW of the equivalent low pass signal pulse g(t) which depends on its detailed characteristics. Assume pulse g(t) of duration T and its BW is approximately equal to the reciprocal of T. thus BW= 1/T and ,since $T=k/R=(\log_2 M)/R$ it gives.

$$BW = R/\log_2 M \qquad (4)$$

Therefore, as M is increased, the channel BW required when the bit rate R is fixed decreased. The BW efficiency is measured by the bit- rate- to- BW ratio which is $R/BW=\log_2 M$ [10].

The BW efficient method for transmitting Pulse amplitude modulation (PAM) is single side band (SSB) then the channel BW required to transmit the signal is approximately equal to 1/2T and T=k/R = $\log_2 M/R$ it follows R/BW= 2 $\log_2 M$ which is a factor of 2 better than PSK. In the case of QAM, there are two orthogonal carriers with each carrier having a PAM signal. Thus, twice the rate relative to PAM however, QAM signals must be transmitted via double side band (DSB). Consequently, QAM and PAM have the same band width efficiency when the BW is referenced to the band pass signal. Orthogonal signal have totally different BW requirement. If M $=2^k$ orthogonal signals are constructed by means of orthogonal carriers with minimum frequency separation of 1/2T. For Orthogonal signals the BW required for the transmission of k= $\log_2 M$ information bits is given by

$$\mathrm{BW}=\frac{M}{2T}=\frac{M}{2(k/R)}=\frac{M}{2\log_2 M}R \quad (5)$$

Here the BW increases as M increase. Similar relationships obtain for simplex and bi-orthogonal signals. In the case of bi-orthogonal signals, the required BW is one half of that for orthogonal signals.

A compact and meaningful comparison of these modulation methods is one based on the normalized data rate R/BW (bits/sec./Hz of BW) versus SNR per bit (Eb/N0) required to a given error probability. Orthogonal signals for the case in which the error probability is $P_b = 10^{-5}$. In the case of PAM, QAM, PSK increasing M results in a higher bit rate to BW ratio (R/BW) however, the cost of achieving the higher data rate is an increase in the SNR per bit. Consequently these modulation are appropriate for communication channels that are band limited where R/BW is >1 and where there is sufficiently high SNR to support increases in M.

M-Ary orthogonal signals yield R/BW≤1. As M increases, R/BW decreases due to an increase in required channel BW the SNR per bit required to achieve a given error probability ($P_b = 10^{-5}$) decreases as M increases consequently M-ary orthogonal signals are appropriate for power limited channels that have sufficiently large BW to accommodate a large number of signals.

III. GA SIMULATION MODEL

The GA is a stochastic global search method that mimics the metaphor of natural biological evolution. GA's operate on a population of potential solutions applying the principle of survival of the fittest to produce (hopefully) better and better approximations to a solution. At each generation a new set of approximate values are created by the process of selecting the individuals according to their level of fitness in the problem and breeding them together with the help of operators borrowed from natural genetics. This procedure leads to the evolution of populations of individuals that are best suits to their environment than the individuals that they were created from, just as in natural adaptation. This algorithm taking the decimal values of chromosome not the binary values of chromosome as other GA learner do. Using this method repeatedly the population will hopefully evolve best solutions. Specifically, the elements of a GA are:

i. Selection (according to some measure of fitness)
ii. Crossover (a method of reproduction) and mutation (adding a bit of random noise to the offspring, changing their genes). The following steps illustrate the basic process in GAs [11].

1. Start Generate random population of *n* chromosomes (suitable solutions for the problem)
2. Fitness Evaluate the fitness *f*(*x*) of each chromosome *x* in the population.
3. New population Create a new population by repeating the following steps until the new population is complete.
   a) Selection Select two parent chromosomes from a population according to their fitness (the better fitness, the higher the probability to be selected)
   b) Crossover With a crossover probability (usually higher probability) crossover the parents to form a new offspring (child- If no crossover was performed; offspring is an exact copy of parents.
   c) Mutation means change, with a mutation probability mutate new offspring at each locus (position in chromosome).
   d) Place the new offspring in a new population.
4. Replace Use new generated population for further run of algorithm.
5. Test if the end condition is satisfied stop and returns the best solution in current population.
6. Loop Go to step 2.
7. END [12].

On this objective function *f(x)*; Genetic algorithm will be applied to optimize the bit error rate and power [13]. The simulation work is performed in MATLAB environment. Consider a ad hoc network having N number of nodes are randomly distributed over a uniform area. The following parameters are used in the simulation the received signal power range 1-50 Pico watts, N_o 1.38×10^{-23}, data rate ($R=BW*\log_2 M$) depends on the type of modulation, The set of chromosomes consider SNR range 19-26 dB, BW 25-26 MHz, modulation index 2, 8. Modulation type BPSK, 8 PSK, 8-QAM are use. Population size 20, number of generations is 500. The following results are found for the BER.

IV. RESULT

A. BPSK

As Eb/ N_o indicates that if N_o value is high SNR is low means desired signal information is lost in the form of noise. The graph of received signal power v/s theoretical and simulated SNR values of BPSK signal indicates that the low values of received signal power about 0-15 db there is presence of less noise after simulation result. After 20dB of power both theoretical and simulated curves matches indicates that the received power increase SNR increase means negligible noise in the system as shown in Fig. 1. Fig. 1 is showing the BER and Signal to noise ration relation for BPSK modulation.

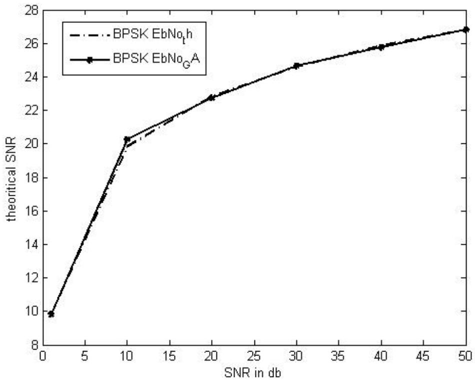

Fig. 1 Received signal power v/s theoretical and simulated SNR values of BPSK

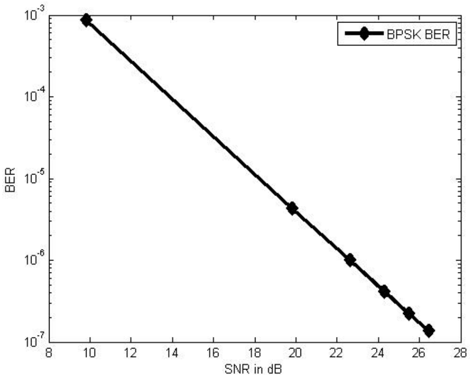

Fig. 2 BER and SNR performance of BPSK

Fig. 3 shows a comparison of theoretical and GA simulated BER versus SNR performance of BPSK modulation. GA is performing well than the theoretical value as ad hoc networks BER should be less than 10^{-3}. And here it is starting at SNR 8 dB 10^{-5}. As increase in SNR value after 20 dB GA is giving same values of BER as the theoretical values.

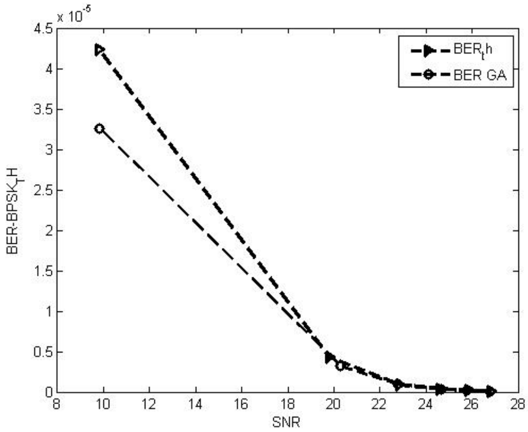

Fig 3 Comparison of theoretical versus simulated BER plot of BPSK

Best value and overall fitness value of optimized BER of BPSK modulation for model is shown in Figs. 4 and 5, the BER is optimizes at the 50 generations.

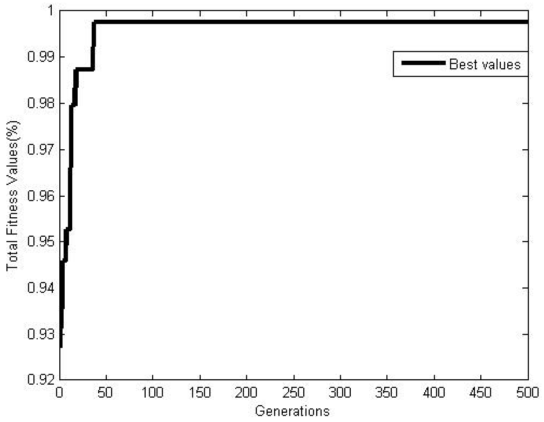

Fig. 4 Best value of BER for WLAN from BPSK Modulation

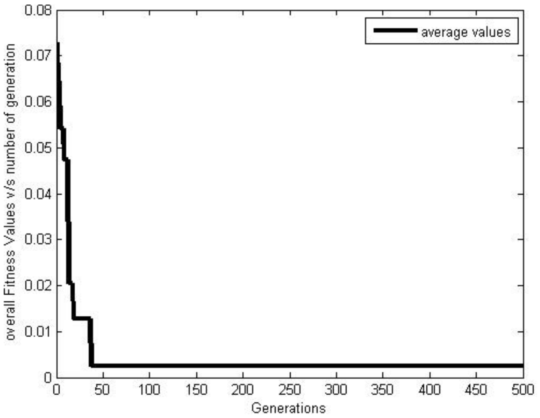

Fig. 5 Overall fitness value of BER for BPSK Modulation

Received signal power is exactly same as the GA simulation shown in Fig. 6 there is less optimized value of power as compare to BPSK at the low SNR. Fig. 7 shows BER versus SNR plot of 8-PSK; here at less than 6 dB SNR BER obtained is 10^{-4} which is good for WLAN. But this is somewhat better than BPSK technique. Almost similar values are obtained from GA simulation of 8-PSK. The optimized values of BER performing better than the theoretical values of BER this is shown in Fig. 8.

B. 8-PSK Modulation

Figs. 9 and 10 show the best and overall fitness value of BER for 8-PSK these are better than BPSK because these are optimizes at less than 40 generations. On comparing BPSK, 8-PSK, 8-QAM modulation methods BER plot then 8-PSK is performing well as permissible values of BER required for WALN is less than 10^{-3} which is full filled by the 8-PSK modulation technique. This obtained at less than 6 dB of SNR which is clearly observed from Fig. 11. Comparison of received signal power and theoretical power versus simulated SNR of 8-QAM is obtained in Fig. 12 it is observed that power consumption is more at less than 14 dB SNR and above 15dB it is exactly optimized as theoretical curve.

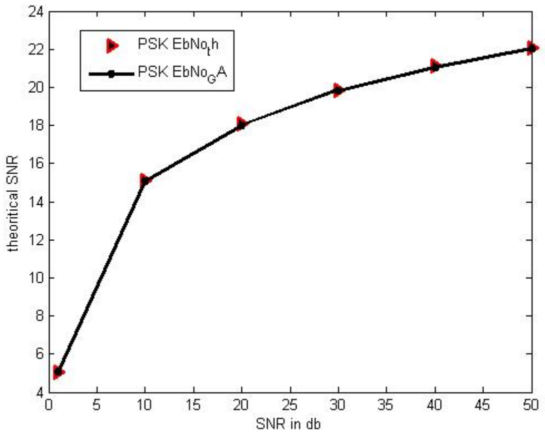

Fig. 6 Received signal power v/s theoretical and simulated SNR of 8 PSK

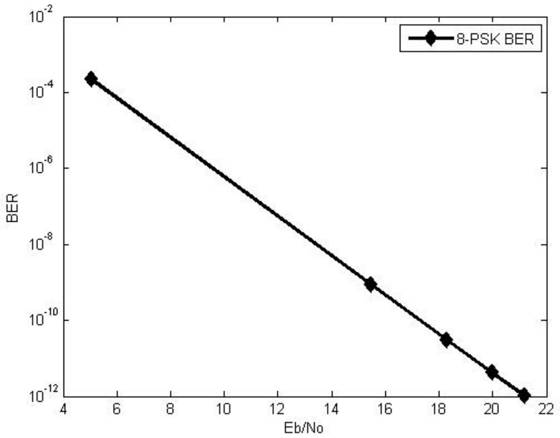

Fig. 7 BER and SNR performance of 8-PSK

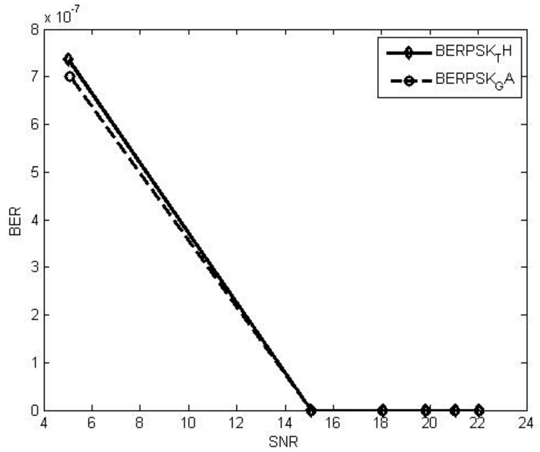

Fig. 8 Comparison of theoretical versus simulated BER plot of 8 PSK

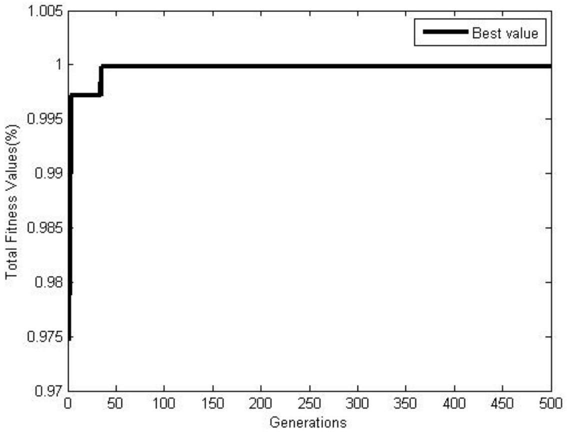

Fig. 9 Best value of BER for WLAN from 8-PSK Modulation

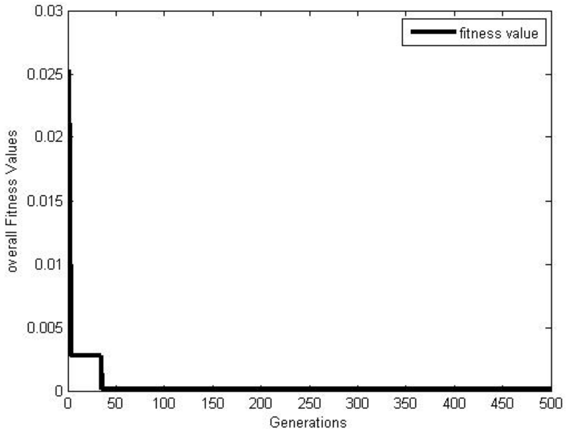

Fig. 10 Overall fitness value of BER of 8-PSK Modulation

C. 8-QAM

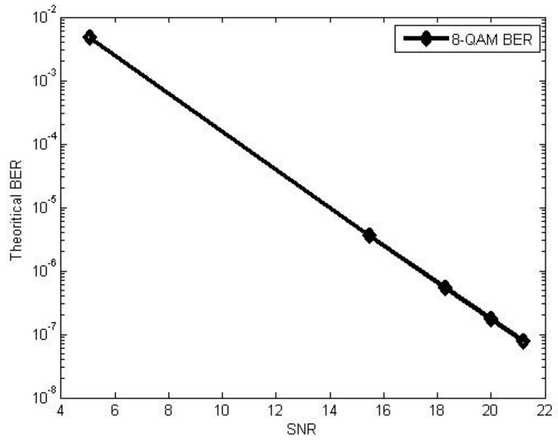

Fig. 11 BER and SNR of performance of 8-QAM

A better optimized value of BER is observed from the graph of theoretical versus simulated BER plot of 8-QAM but there is less benefit as prime requirement is minimum BER at minimum SNR value. But the value of SNR obtained is below 20 dB which is not much beneficial. This is shown in Fig. 13. Figs. 14 and 15 shows the best and the overall fitness value of

8-QAM BER it is observed that fitness value obtained below 20 generation. So the conclusion is 8-PSK is performing well as this is full filling the proper requirement of WLAN.

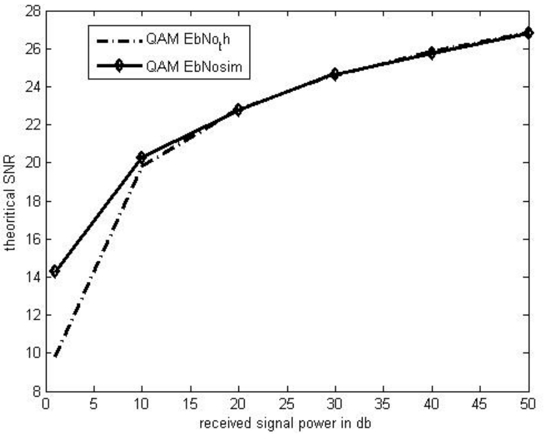

Fig. 12 Received signal power v/s theoretical and simulated SNR of 8 QAM

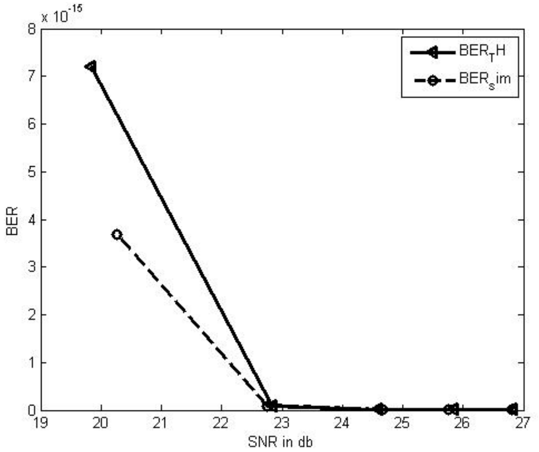

Fig. 13 Comparison of theoretical versus simulated BER plot of 8 QAM

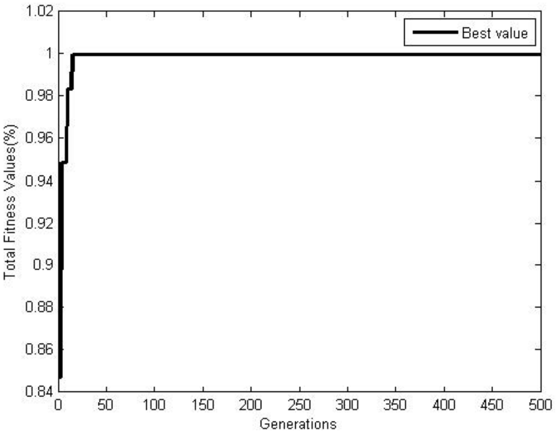

Fig. 14 Best value of BER for WLAN from 8-QAM

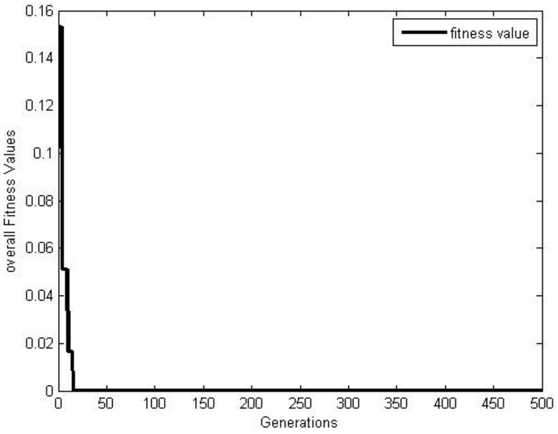

Fig. 15 Overall fitness value of BER for WLAN from 8-QAM

V. CONCLUSION

It is well known fact that increasing the SNR BER decreases to analyze the effect of increasing the modulation index increases the BW but at the same time it influences the network performance in terms of noise in the signals. By keeping constant data rate and transmitted power in order to obtain network connectivity at low BER, the packet transmission rate has to be decreased. This is because lower packet transmission rates reduce the interference among the nodes hence a better probability of error value can be obtained. On the other hand increasing the node transmitted power alone gives a better BER provided that the desire BER with interference is higher than the BER value. It is observed that the minimum transmitted power increases as the data rate increases, or higher data rate reduces the vulnerable interval and hence a smaller interference may occur, this gives an increase in the BW which raises the thermal noise, so the minimum transmitted power for the network connectivity has to be increased as well.

REFERENCES

[1] V.A. Aalo, K. P. Pappas, G. Efthymoglou, M. Alwakeel and S. Alwakeel, "Evaluation of Average Bit Error Rate for Wireless Network with Alpha-Stable Interference", Electronics Letter Vol. 50, Pp 47-49, 2nd Jan 2014.

[2] Swati Chowdhuri, Santanu Maiti, Dr. Sheli Sinha Chaudhuri and Dr. P.K.Baneerjee, "Implementing Packet Broadcasting Algorithm Of MIMO Based Mobile Ad-Hoc Networks To Exploit Diversity" International Journal of Network Security & Its Applications (IJNSA), Vol.6, No.2, pp 33-42, March 2014.

[3] Ghobad, P.C. deMoraes, "BER Analysis with an Appropriate Friis Formula for Multi-Hop ALOHA Dense Ad Hoc Network", R.M. Vehicular Technology Conference (VTC Fall), IEEE, Pp:1–5, 2012.

[4] Sanatkar, M.R.Natarajan, B. Mohammadi, "Route BER estimation in wireless ad hoc networks exploiting minimum distance routing", A Consumer Communications and Networking Conference (CCNC), IEEE pp 926 – 930, 2012.

[5] Geetu, Hardeep Singh, Malika Singh "Optimization Method for Analysis of Bit Error Rate with BPSK Modulation Technique" International Journal of Scientific & Engineering Research, Volume 3, Issue 6, June-2012 1 ISSN 2229-5518.

[6] Mikel Hernaez, Pedro M. Crespo, "A Novel scheme for message forwarding in multi-hop ad hoc wireless networks", IEEE 73rd Vehicular Technology Conference (VTC Spring), Vol- pp-1 – 5, 2011

[7] M. R. Sanatkar, A Mohammadi, "scalability analysis of Wireless sensor network using analytical techniques", in proc of the 8th comm. Networks and services research conference 2010.
[8] Rezagah, R.E; Mohammadi; A.; "capacity estimation of wireless ad hoc networks in fading channels", communications IET, vol 3, no. 2, pp 293-302, February 2009.
[9] S. Panichpapiboon, G. Ferrari and O.K Tonguz, "sensor networks with random versus uniform topology MAC and Interference considerations, IEEE 59th vehicular technology conference VTC, 2004.
[10] Digital Communications, Fourth Edition, by John G. Proakis, Chapter 5, Page No.280-282
[11] "Genetic Algorithms in Control Systems Engineering" (GR/J17920).Version 1.2, User's Guide.
[12] Alaa Sheta, Mohammad Salamah, Hamza Turabieh and Haneen Heyasat "Selection of Appropriate Traffic of a Computer Network with Fixed Topology Using GAs", IAENG International Journal of Computer Science, 34:1, IJCS_34_1_6
[13] T. newman, B. barker, A. wyglinski ,J. evans, G.minden, P.hd thesis "Cognetive Engine Implementation For Wireless Multicarrier Transceivers" ,Wiley wireless communication & mobile computing edition, 2005.

Anjana Choudhary She completed her B.Tech Degree in Electronics and Communication Engineering from Rajasthan Technical University, Kota in year 2010. She is pursing M. Tech in Communication and Signal Processing from Jaipur National University, Jaipur, India. Her areas of interest include ad hoc Wireless Networking, Communication, Digital Signal Processing, Digital Electronics, and Circuit Analysis.