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Assessment of WIMAX System Performance using Concatenated Coding Technique

Shubhro Chakrabartty
Dept. of Electronics and Communication Engineering
Aurora's Engineering College
Bhongir, Telangana

Naeem Innus Sutar
Dept. of Electronics and Communication Engineering
Aurora's Engineering College
Bhongir, Telangana

R. P. S. Gangwar
Dept. of Electronics and Communication Engineering
College of Technology,
G. B. Pant University of Agriculture and Technology, Pantnagar

Chandrasekhar Kandagatla
Dept. of Electronics and Communication Engineering
Aurora's Engineering College
Bhongir, Telangana

Ayyappan
Dept.of Electronics and Communication Engineering
Aurora's Engineering College
Bhongir, Telangana

Amit Gangopadhyay
Dept. of Electronics and Communication Engineering
Aurora's Technological and Research Institute
Parvathapur, Hyderabad, Telangana

ABSTRACT—Worldwide Interoperability Microwave Access (WIMAX) is a telecommunications protocol that provides fixed and mobile Internet access. The present WIMAX (Wireless Interoperability microwave access) technology provides rate of up to 40 Mbit/s with the IEEE 802.16m and expects to supply up to 1 Gbit/s for mounted networks. Concatenated coding technique is very powerful for error correction and detection to reduce the noise. In this work the performance parameter in term of Bit Error Rate (BER) with Signal to Noise Ratio (SNR) is done by considering concatenated coding over different channels. WIMAX system model is simulated in MATLAB 2013 by varying modulation schemes with 3/4 rate of convolutional codes for Rayleigh and Nakagami channel.

Keywords—WIMAX; SNR; BER; QPSK.

I. INTRODUCTION

The explosive growth of wireless systems contributed a huge impact in the proliferation of laptop computer and palmtop computers indicate a bright future for wireless networks, each as complete systems and as a part of the larger networking infrastructure [1].However, many technical challenges remain in designing robust wireless networks that deliver the performance necessary to support emerging applications. WIMAX is anadvanced wireless communication protocol that provides fixed and mobile Internet access. WIMAX network design is based on principles of spectrum, topology, IP connectivity, mobility management. WIMAX defined two MAC system profiles, the basic ATM and the basic IP along with two primary PHY system profiles, the 25 MHz-wide channel for use in (US deployments) the 10.66 GHz range and the 28 MHz-wide channel for use in (European deployments) the 10.66MHz. The current WIMAX revision provides data rate of up to 40 Mbit/s with the IEEE 802.16mand expects to offer up to 1 Gbit/s for fixed networks. The forum describes WIMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL" [2].

The information theory, coding theory, forward error control code (FEC) or channel coding plays an important role for controlling errors in data transmission over unreliable or noisy communication channels [3-4]. In-fact

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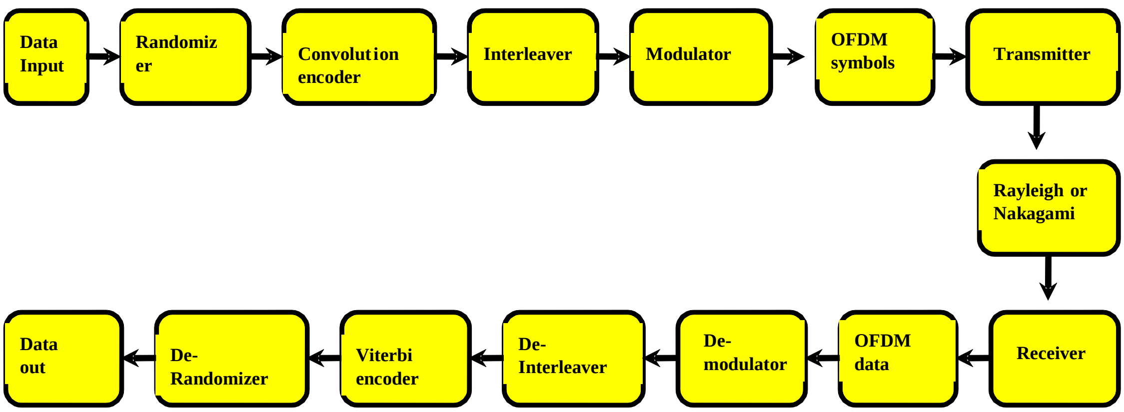
the sender encodes their message in redundant way by using an error control code (ECC). The renowned mathematician of America Sir Richard Hamming developed the first error correcting code in 1950, known as Hamming code. The redundancy allows the receiver to detect a limited number of errors that may occur anywhere in the message and often to correct these errors without retransmission [5]. Many FEC coders can also generate a bit-error rate (BER) signal which can be used as feedback to fine-tune the analog receiving electronics. The maximum fractions of errors or of missing bits that can be corrected are determined by the design of the FEC code, so different forward error correcting codes are suitable for different conditions. Here in this work we have done the comparative study for the performance parameter in term of Bit Error Rate (BER) with Signal to Noise Ratio (SNR) by considering concatenated coding over Rayleigh and Nakagami channels.

II. MODELLING

The system model of WIMAX consists of three main components namely transmitter, receiver and channel. Transmitter consists of channel coding and modulation sub-components and receiver includes channel decoding and demodulation scheme. The channel coding used are convolution and reed Solomon code. Rayleigh channel and Nakagami channels are considered in this system. The downlink transmission using the wireless Man is being considered. WIMAX system depends on OFDMA (Orthogonal frequency-division multiple access) physical layer as specified in the IEEE.802.16e standard. A block diagram of the physical layer of WIMAX is depicted in Block diagram 1. The binary data bits after randomization are fed into the encoder. After interleaving, the sequence of binary bits is fed into the modulator for mapping which means converting them to a sequence of complex values and modulates them by BPSK (Binary phase-shift keying), QPSK (Quadrature phase-shift keying) and 16 QAM (Quadrature amplitude modulation). Pilot symbol are allocated onto pilot sub-carriers which allow the receiver to estimate and track the Channel State Information (CSI). By this procedure the OFDM (Orthogonal frequency-division multiplexing) symbols are constructed in the frequency domain, and then Inverse Fast Fourier Transform (IFFT) is used for converting the OFDM symbols into the time domain.



Block diagram 1: Diagrammatic representation of Physical Layer of WIMAX

III. RESULTS AND DISCUSSION

The WIMAX model is simulated by considering the different modulation schemes with 3/4 rate of convolutional codes for Rayleigh and Nakagami channels with the help of MATLAB simulation tool. The

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performance parameter such as BER versus SNR plots for BPSK, QPSK and 16-QAM according to the IEEE 802.16e standard is determined and compared for various OFDM symbols (100 and 1000). The simulation is carried out at a carrier frequency of 5 MHz channel bandwidth for the physical layer of WIMAX at both the transmitter and the receiver. The simulation parameters used for simulation is given in Table 1.

Table 1: Simulations Parameters

STANDARD	**802.16e**
CHANNEL MODEL	**Rayleigh/ Nakagami**
MODULATIONSCHEME	**BPSK,QPSK,16QAM**
CONVOLUTION CODE RATE	**3/4**
OFDM SYMBOL	**100,1000**
CYCLIC PREFIX	**1/4, 1/8**
BANDWIDTH	**5 MHz**
FFT SIZE	**256**

3.1 BER of WIMAX system for various modulation schemes in the presence of Rayleigh channel with 100 OFDM symbols

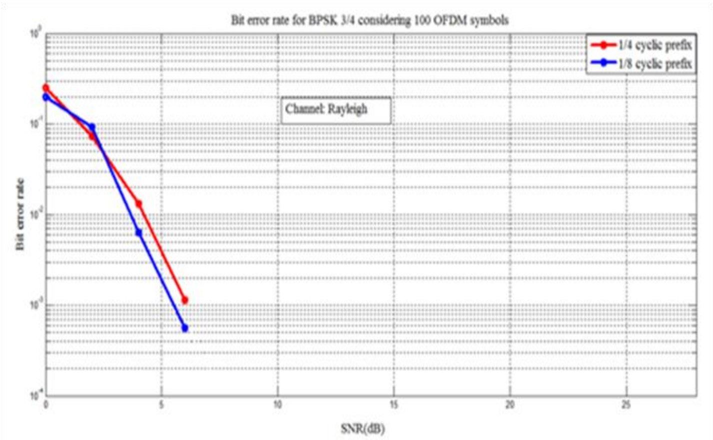

Figure 3.1 BER with respect to SNR for BPSK with 100 OFDM symbols

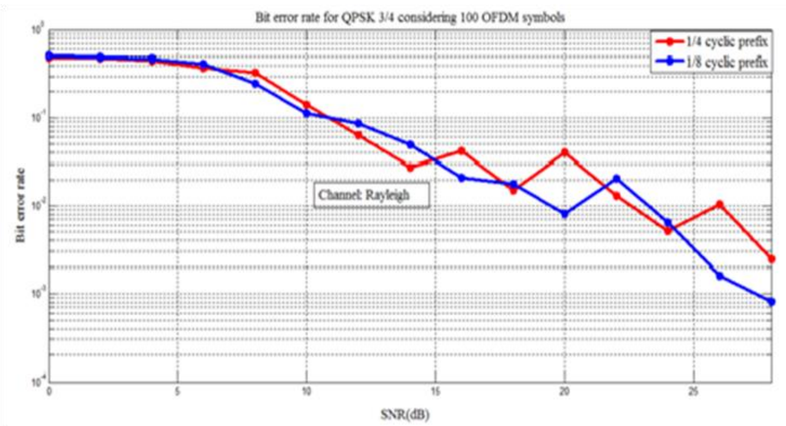

Figure 3.2 BER with respect to SNR for QPSK with 100 OFDM symbols

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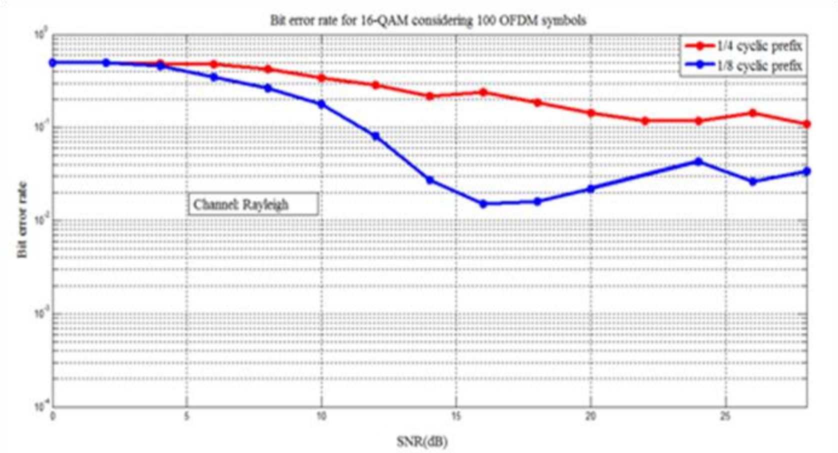

Figure 3.3 BER with respect to SNR for 16QAM with 100 OFDM symbols

It is inferred from Figure 3.1, Figure 3.2 and Figure 3.3 that BPSK and QPSK shows better performance than 16-QAM with 100 OFDM symbols for various values of cyclic prefix. Also it is observed that BPSK,QPSK achieves a reduced bit error rate of below 10^{-3} at a SNR of 7dB and about 30 dB, while bit error rate of below10^{-1} approaching10^{-2}at about30 dB is achieved by using 16QAM respectively.

3.2 BER of WIMAX system for various modulation schemes in presence of Rayleigh channel with 1000 OFDM symbols

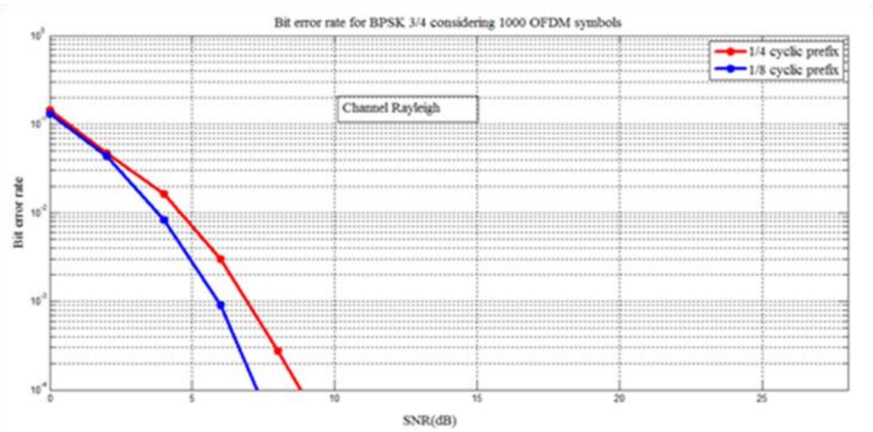

Figure 3.4 BER with respect to SNR for BPSK with 1000 OFDM symbols

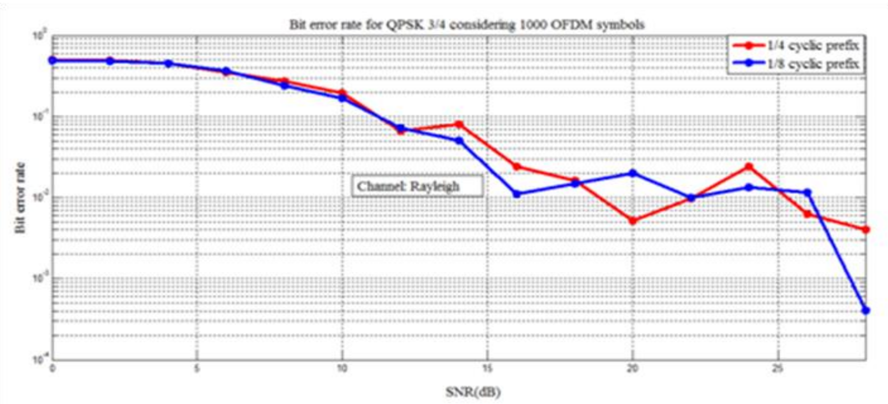

Figure 3.5 BER with respect to SNR for QPSK with 1000 OFDM symbols

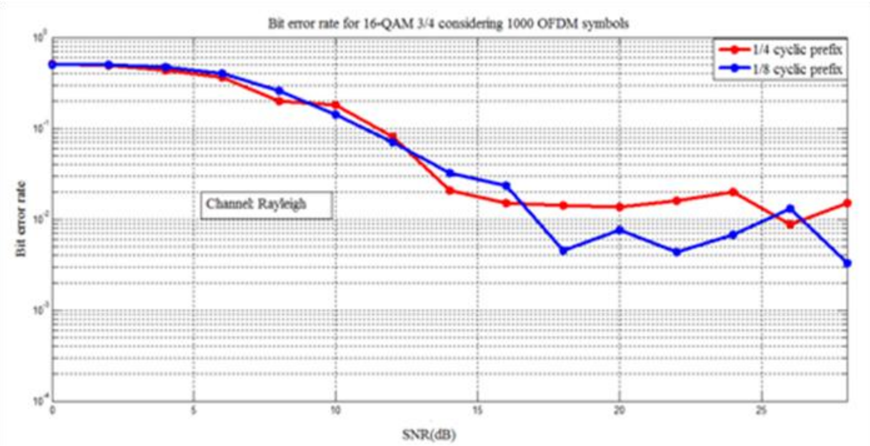

Figure 3.6 BER with respect to SNR for 16QAM with 1000 OFDM symbols

It is inferred from Figure 3.4, Figure 3.5 and Figure 3.6 that BPSK and QPSK shows better performance than 16-QAM with 1000 OFDM symbols for various values of cyclic prefix. Also it is observed that BPSK, QPSK achieves a reduced bit error rate of below 10^{-3} at a SNR of 8 dB and about 30 dB, while bit error rate of below10^{-2} approaching 10^{-3}at about 30 dB is achieved by using 16QAM respectively.

3.3 BER of WIMAX system for various modulation schemes in presence of Nakagami channel with 100 OFDM symbols

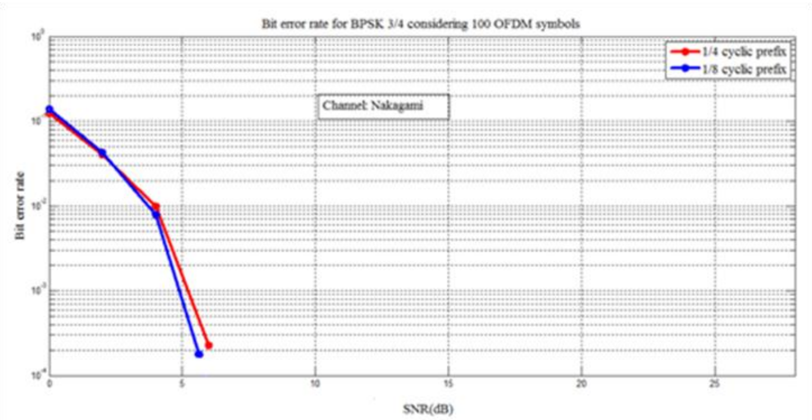

Figure 3.7 BER with respect to SNR for BPSK with 100 OFDM symbols

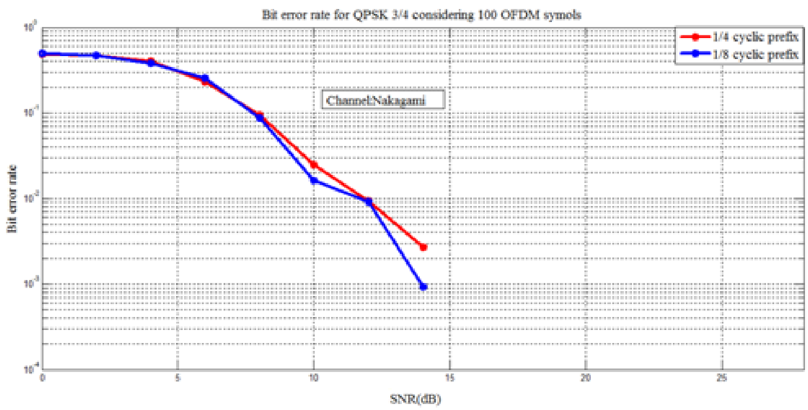

Figure 3.8 BER with respect to SNR for QPSK with 100 OFDM symbols

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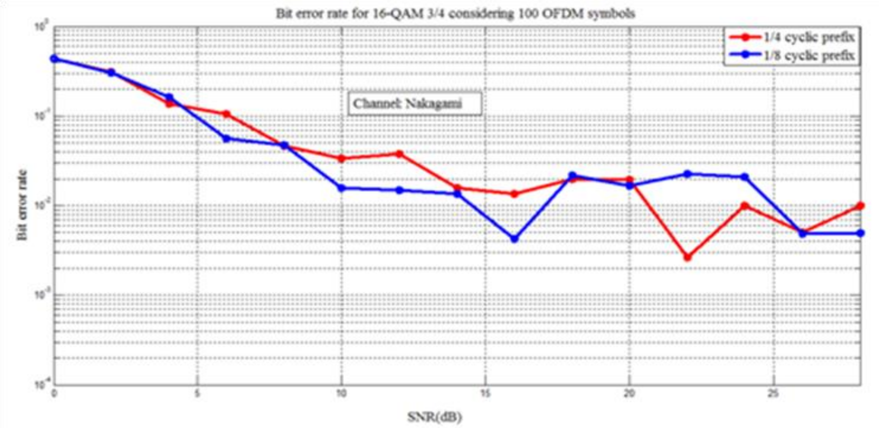

Figure 3.9 BER with respect to SNR for 16-QAM with 100 OFDM symbols

It is inferred from Figure 3.7, Figure 3.8 and Figure 3.9, that BPSK and QPSK shows better performance than 16-QAM with 1000 OFDM symbols for various values of cyclic prefix. Also it is observed that BPSK, QPSK achieves a reduced bit error rate of below 10^{-3} at a SNR of 6 dB and 14 dB, while bit error rate of below10^{-2} at about 30dB is achieved by using 16QAM respectively.

3.4 BER of WIMAX system for various modulation schemes in presence of Nakagami channel with 1000 OFDM symbols

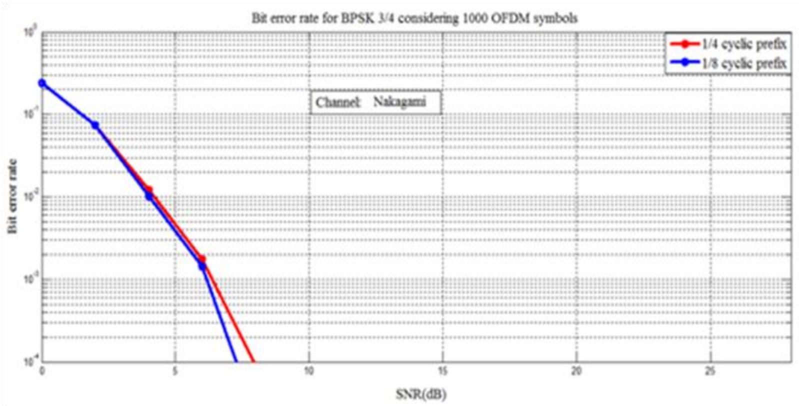

Figure 3.10 BER with respect to SNR for BPSK with 1000 OFDM symbols

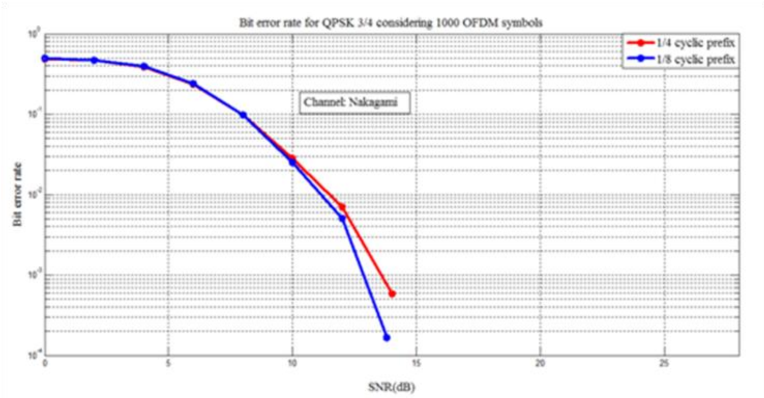

Figure 3.11 BER with respect to SNR for QPSK with 1000 OFDM symbols

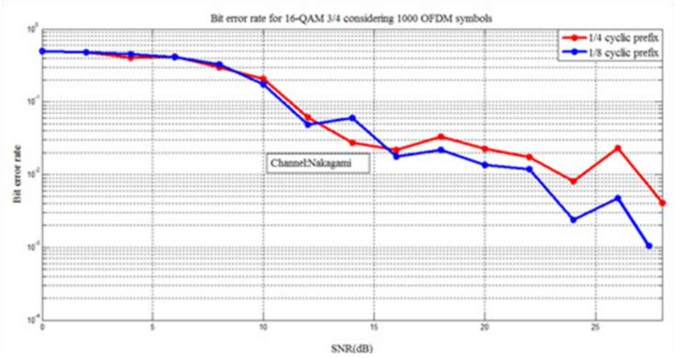

Figure 3.12 BER with respect to SNR for 16QAM with 1000 OFDM symbols

It is inferred from Figure 3.10, Figure 3.11 and Figure 3.12, that BPSK and QPSK shows better performance than 16-QAM with 1000 OFDM symbols for various values of cyclic prefix. Also it is observed that BPSK, QPSK achieves a reduced bit error rate of below 10^{-3} at a SNR of 7 dB and 14 dB, while bit error rate of 10^{-3} at about 28 dB is achieved by using 16QAM respectively.

IV. CONCLUSIONS

WIMAX system model is simulated in MATLAB by varying modulation schemes with 3/4 rate of convolutional codes for Rayleigh and Nakagami channel. According to the IEEE 802.16e standard, the performance parameter such as BER versus SNR plots for BPSK, QPSK and 16-QAM are determined and compared for OFDM symbols (100 and 1000). WIMAX delivers high throughput at long ranges with a high level of spectral efficiency. BPSK and QPSK is more tolerant of interference than 16-QAM. For this reason, where signals are expected to be resistant to noise and other impairments over long transmission distances, BPSK and QPSK are the normal choice for low data rate system. Higher-order QAM systems, such as 16-QAM and 64-QAM, are required for high data rates systems. Implementation of BPSK, QPSK modulation with 3/4 rated channel coding technique provides satisfactory result among the modulation schemes with limited SNR. In the context of system performance, it can be concluded through the simulation results that Nakagami channel gives better results for various modulation schemes (BPSK, QPSK, and 16-QAM) in comparison with Rayleigh channel. So in noisy environment Nakagami channel should be used in long distance and wide band communications.

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