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Performance Analysis of Adaptive Modulation and Coding Over AWGN Channel in an OFDM System

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***Abstract*: Orthogonal frequency division multiplexing (OFDM) as a special multi-carrier transmission technology has good resistance to narrow-band interference and frequency selective fading ability. Compared with traditional modulation techniques, adaptive modulation can enhance bandwidth efficiency and system capacity. Therefore, applying adaptive modulation in OFDM systems can take full advantage of spectrum resources, and it is suitable for the high-speed and reliable mobile communication systems in the future. The purpose of this paper is to investigate the effect of adaptive modulation and coding in OFDM system to improve bit error rate performance over AWGN fading channel. In this paper OFDM system performance in terms of bit error rate (BER) is investigated using fixed and adaptive modulation technique using convolutional coding and BCH coding over AWGN channel. From the comparative result analysis of adaptive modulation using convolutional coding and BCH coding over AWGN channel, it can be concluded that Bit Error Rate (BER) is improved by using Adaptive modulation with Convolution coding in comparison with adaptive modulation with BCH coding over AWGN channel.**

***Keywords*: OFDM, ISI, BER, SNR, QPSK, QAM, AWGN.**

1. Introduction

With the advancement in the communications technology, the demand for higher data rate services such as multimedia, voice, and data over both wired and wireless links is also increased. In many transmission systems employing double sideband modulation schemes, spread spectrum technologies has less spectral efficiency. These systems cannot easily adapt to severe channel conditions without complex time-domain equalization. These systems are not robust against narrow-band co-channel interference, inter symbol interference (ISI) and fading caused by multipath propagation. Also, they are very much sensitive to time synchronization errors.

Therefore, advanced digital transmission standard is required to transfer the large amount of data with robustness against narrow-band co-channel interference, inter symbol interference (ISI) and fading caused by multipath propagation with high data rate, allowable Bit Error Rate (BER), and maximum spectral efficiency. Orthogonal Frequency Division Multiplexing (OFDM) is the best solution for it. Orthogonal Frequency Division Multiplexing (OFDM) is a type of digital transmission used in digital modulation for encoding digital (binary) data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, used in applications such as digital television and audio broadcasting, DSL internet access, wireless networks, power line networks, and 4G/5G mobile communications.

In OFDM, the incoming bit stream representing the data to be sent is divided into multiple streams. Multiple closely spaced orthogonal subcarrier signals with overlapping spectra are transmitted, with each carrier modulated with bits from the incoming stream so multiple bits are being transmitted in parallel. The main advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without the need for complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI) and use echoes and time-spreading (in analog television visible as ghosting and blurring, respectively) to achieve a diversity gain, i.e., a signal-to-noise ratio improvement. This mechanism also facilitates the design of single frequency networks (SFNs) where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be re-combined constructively, sparing interference of a traditional single-carrier system.

In an OFDM transmission system, each subcarrier is attenuated individually under the frequency-selective and fast fading channel. The channel performance may be highly fluctuating across the subcarriers and varies from symbol to symbol. If the same fixed transmission scheme is used for all

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OFDM subcarriers, the error probability is dominated by the OFDM subcarriers with highest attenuation resulting in a poor performance. Therefore, in case of frequency selective fading the error probability decreases very slowly with increasing average signal-to-noise ratio (SNR). This problem can be mitigated if different modulation schemes are employed for the individual OFDM subcarriers. The resilience to severe channel conditions can be further enhanced if information about the channel is sent over a return-channel. Based on this feedback information, adaptive modulation, channel coding and power allocation may be applied across all subcarriers, or individually to each subcarrier. In the latter case, if a particular range of frequencies suffers from interference or attenuation, the carriers within that range can be disabled or made to run slower by applying more robust modulation or error coding to those subcarriers.

Therefore, in adaptive transmission (adaptive modulation and coding) in OFDM system can maintain a constant performance by varying transmitted power level, modulation scheme, coding rate or any combination of these schemes. This allows us to vary the data rate without sacrificing BER performance. Thus, Adaptive modulation and coding can be an effective way to achieve with high data rate, allowable Bit Error Rate (BER), and maximum spectral efficiency to transmit multimedia information over mobile wireless channels.

2. Related Work in Adaptive Modulation and Coding

Megha Gupta et al., [1], 2002 has investigated an OFDM System Using MMSE & MLSE Equalizer Over Rayleigh Fading Channel through the BPSK, QPSK,4 QAM & 16 QAM Modulation Technique in terms of comparative performance analysis of un equalized systems with MMSE and MLSE algorithm enabled equalized system and found that the bit error performance is improved. N. K. Noordin et al. [2], 2004 presented a review on various link adaptation techniques used in OFDM transmission and interpreted that coded OFDM performs better in terms of SNR requirements as compared to uncoded system in any QAM modulation. Mrs. C. Geetha Priya et al., [3], 2009 proposes a method for reducing the Bit Error Rate (BER), Frame Error Rate (FER) in OFDM system using Spatial Multiplexing and compares the performance using Data Rate and Error Rate. J. Faezah et al., [4], 2009 proposes an adaptive transmission scheme according to channel fading condition in OFDM to improve the performance and found that with adaptive modulation and convolutional coding there is significant improvements in terms of bit error rate (BER) and throughput as compared to fixed transmission schemes. D. Sreenivasa Rao et al., [5], 2010 proposed a MPC algorithm using higher order modulation schemes such as 256-QAM and 128-QAM at low SNR values in order to reduce PAPR and enhance the data rate without degrading the SER performance especially at low SNR values. Susmita Das et al., [6], 2010 proposed that Pulse shaping techniques are very effective and mitigate problems associated with PAPR in OFDM.CCDF of PAPR and BER are analyzed through MATLAB simulation which proves the efficacy of the proposed pulse shaping scheme. Rajeshree Raut et al., [7], 2012 proposed that the highest spectral efficiency with the lowest possible combining complexity, given the fading channel conditions and the required error rate performance increases the spectral efficiency with a slight increase in the average number of combined path for the low signal to noise ratio (SNR) range while maintaining compliance with the bit error rate (BER). Serkout N. Abdullah et al., [8], 2012 proposed that an adaptive coded modulation for coded OFDM system using punctured convolutional code, channel estimation, equalization and SNR estimation maintains fixed BER under changing channel conditions. Suverna Sengar et al., [9], 2012 proposed that an OFDM is an efficient method of data transmission for high-speed communication systems. However, the main drawback is PAPR of the transmitted signals. Significant reduction in PAPR has been achieved using PAPR reduction methods -PTS and SLM. The performances of the two methods are compared. Mohit Pant et al., [10], 2012 proposed that μ-Law companding technique has been proposed to improve the performance of OFDM System by reduction of Peak-to-Average Power Ratio (PAPR). Manjushree Bhardwaj et al., [11], 2012 proposed that an OFDM is one of the techniques for parallel transmission used to achieve high throughput and better transmission quality. The basics of OFDM techniques, role of OFDM in this era, its benefits and losses and also some of its applications are discussed. Piyush Vyas et al., [12], 2012 proposed that companded OFDM System Using Non-Linear Symmetric Approach improves the performance in comparison in various aspects like PAPR, BER, OBR, functions of FFT, IFFT etc. to existing symmetric methods when filtering is necessary for band limited conditions. Pallavi Dhok et al., [13], 2013 proposed that there is performance improvement in bit error rate (BER) and overall system performance by employing nonlinear companding technique for PAPR reduction in digital video broadcasting (DVB-T) system. T. S. Harivikram et al., [14], 2013 proposed that an OFDM has been recently applied widely in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency and its robustness to multipath delay. Mewara et al., [15], 2015 proposed that the information rates and channel limit of a wireless MIMO OFDM framework can be enhanced by executing a dynamic connection adjustment calculation (Link Adaption Algorithm). Spatially Adaptive Modulation and Coding (SAMC) plan is implemented. T. Jaya et al., [16], 2016 proposed that an adaptive OFDM provides maximum data rate, robustness against multipath fading and bandwidth saving up to fifty percentage compared to conventional methods. The performance of the system is improved according to the channel fading conditions, when adaptive modulation is employed. Nandi et al., [17], 2017 proposed that ISI and ICI are reduced to a great extent with use of OFDM. A Cyclic Prefix (CP) is inserted between OFDM symbols to eliminate both the ISI and ICI. The effect of the CP on the BER is evaluated with Cyclic prefix OFDM using adaptive modulation technique. Suchi Barua et al., [18], 2020 proposed that a real-time OFDM based adaptive UA communication system, the SNR calculated at the receiver for clusters (group of subcarriers) to reduce the computational and feedback load is used as a performance metric to switch the modulation mode of each cluster which is fed back to the transmitter for data transmission. Ravi Kumar M G et al., [19], 2021 proposed an idea of MIMO-OFDM receiver design using Adaptive modulation and channel estimation for underwater acoustic communication. In this work, the channel is estimated using Kalman filter, a well-known algorithm for estimation and prediction especially when data has a lot of noise. Rahim Khan et al., [20], 2021 proposed that an adaptive modulation under various parameters, such as signal to interference plus noise ratio (SINR), and communication channels distances minimize bit error rate (BER), improve throughput and utilize the available bandwidth efficiently.

3. Proposed Research Work

This research work investigates the comparative performance analysis of OFDM systems without and with adaptive modulation method over AWGN channel using convolutional coding and BCH coding using MATLAB programming and simulation methodology.

Following steps are adopted for performance evaluation.

1) An OFDM system model using Fixed Modulation methods (QPSK,16-QAM and 64-QAM) and adaptive modulation method with convolutional coding over AWGN channel is developed using MATLAB programming. The simulation results are obtained in terms of SNR v/s BER characteristics.
2) An OFDM system model using Fixed Modulation methods (QPSK,16-QAM and 64-QAM) and adaptive modulation method with BCH coding over AWGN channel is developed using MATLAB programming. The simulation results are obtained in terms of SNR v/s BER characteristics.
3) The comparative performance analysis of simulation results in terms of SNR V/s BER characteristics of an OFDM system model without and with adaptive modulation method with convolutional and BCH coding over AWGN channel is evaluated.

OFDM system model with adaptive modulation and coding:

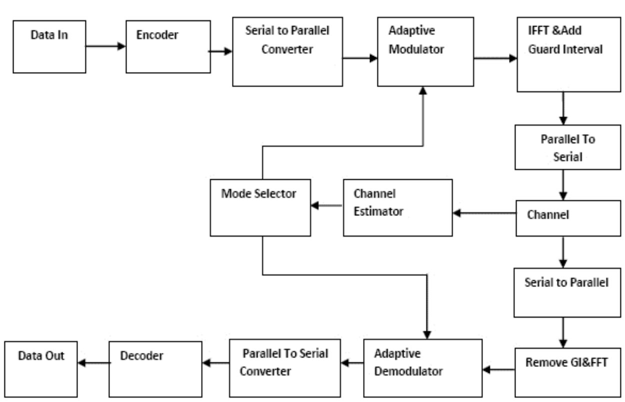

Fig. 1. Adaptive modulation based OFDM system

The schematic illustration of the Adaptive modulation based OFDM technique is shown in fig. The input data is encoded and go after by Serial-to-Parallel(S/P) converter to give low rate sub streams. Each user symbol is then modulated in parallel by suitable modulation techniques, such as Quadrature PSK, and M-PSK etc.

The Inverse FFT block converts frequency domain samples into time domain samples and still it maintains the orthogonality between subcarriers. The effect of ISI on symbol can be reduced by the adding guard period at the starting and ending of every frame. Guard band interval should be higher than the delay spread of the channel. After the guard interval has been included, the signals are changed into serial form. An AWGN model is then added with the transmitted signal. This model tolerates for the Signal to Noise Ratio variations. The receiver executes the reverse process of the transmitter.

The receiver section removes the guard band interval, FFT process and decoding of data. The adaptive OFDM model consists of adaptive switch. The input information is formatted into word depends on the modulation method need for transmission. At the receiver section, the SNR value is calculated by using above formula and this value is directly applied to the mode selector block through the channel estimator. Based on this SNR value the mode selector switch chooses the correct modulation technique, which satisfy the threshold limit.

Additive White Gaussian Noise Model:

The simplest radio environment in which a wireless communications system or a local positioning system or proximity detector based on Time of flight will have to operate is the Additive-White Gaussian Noise (AWGN) environment. Additive white Gaussian noise (AWGN) is the commonly used to transmit signal while signals travel from the channel and simulate background noise of channel. The mathematical expression in received signal r(t) = s(t) + n(t) that passed through the AWGN channel where s(t) is transmitted signal and n(t) is background noise.

Bit Error Rate (BER):

The BER, or quality of the digital link, is calculated from the number of bits received in error divided by the number of bits transmitted. BER= (Bits in Error) / (Total bits received). In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The BER is the number of bit errors divided by the total number of transferred bits during a particular time interval. BER is a unit less performance measure, often expressed as a percentage. IEEE 802.11 standard has ability to sense the bit error rate (BER) of its link and implemented modulation to data rate and exchange to Forward Error Correction (FEC), which is used to set the BER as low error rate for data applications. BER measurement is the number of bit error or destroys within a second during transmitting from source to destination. Noise affects the BER performance. Quantization errors also reduce BER performance, through incorrect or ambiguous reconstruction of the digital waveform. The accuracy of the analog modulation process and the effects of the filtering on signal and noise bandwidth also effect quantization errors. BER can also be defined in terms of the probability of error POE) and represented in Eq. (1).

$$POE = \frac{1}{2} (1\text{-erf}) \sqrt{\frac{E_b}{N_o}} \quad (1)$$

where erf is the error function, Eb is the energy in one bit and N0 is the noise power spectral density (noise power in a 1Hz bandwidth). The error function is different for the each of the various modulation methods. The POE is a proportional to Eb/N0, which is a form of signal-to-noise ratio. The energy per bit, Eb, can be determined by dividing the carrier power by the bit rate. As an energy measure, Eb has the unit of joules. N0 is in power that is joules per second, so, Eb/N0 is a dimensionless term, or is a numerical ratio.

Signal to Noise Ratio (SNR):

SNR is the ratio of the received signal strength over the noise strength in the frequency range of the operation. It is an important parameter of the physical layer of Local Area Wireless Network (LAWN). Noise strength, in general, can include the noise in the environment and other unwanted signals (interference). BER is inversely related to SNR, that is high BER causes low SNR. High BER causes increases packet loss, increase in delay and decreases throughput. The exact relation between the SNR and the BER is not easy to determine in the multi-channel environment. Signal to noise ratio (SNR) is an indicator commonly used to evaluate the quality of a communication link and measured in decibels and represented by Eq. (2).

$$SNR = 10 \log_{10} (\text{Signal Power/Noise Power}) \quad (2)$$

4. System Implementation and Simulation

The performance of OFDM systems is evaluated in terms of Signal to Noise Ratio (SNR) v/s Bit Error Rate (BER) using adaptive modulation method and coding over fading communication channels. An OFDM system not using adaptive modulation, conventional modulation methods like QPSK, QAM can be used with suitable channel coding over fading communication channel. In this research work, an OFDM system model is developed using fixed modulation methods like QPSK, 16-QAM and 64-QAM with convolutional and BCH coding over AWGN in MATLAB programming environment. The performance of this OFDM system model is evaluated in terms of SNR v/s BER characteristics by using MATLAB programming and simulation methodology and the results of simulation are obtained. Now the same OFDM system model is simulated in MATLAB programming environment using adaptive modulation with convolutional and BCH coding over AWGN channel and the results of simulations are obtained for analysis and performance evaluation.

Following methodological steps are adopted for performance estimation.

1. Performance estimation is done for fixed and adaptive modulation using convolutional coding over AWGN channel using following methodology,

a. An OFDM system using Fixed Modulation methods with convolutional coding over AWGN channel is simulated using MATLAB programming.
   i. The simulation results of fixed QPSK modulation are obtained in terms of SNR v/s BER characteristics.
   ii. The simulation results of fixed 16-QAM and 64-QAM modulation are obtained in terms of SNR v/s BER characteristics.

b. An OFDM system using adaptive modulation method with convolutional coding over AWGN channel is simulated using MATLAB programming and the simulation results are obtained in terms of SNR v/s BER characteristics.

c. An OFDM system using fixed modulation method and adaptive modulation method with convolutional coding over AWGN channel is simulated using MATLAB programming and the comparative simulation results are obtained in terms of SNR v/s BER characteristics.

Simulation Results for an OFDM system using fixed modulation methods (QPSK,16-QAM,64-QAM) with convolutional coding over AWGN channel:

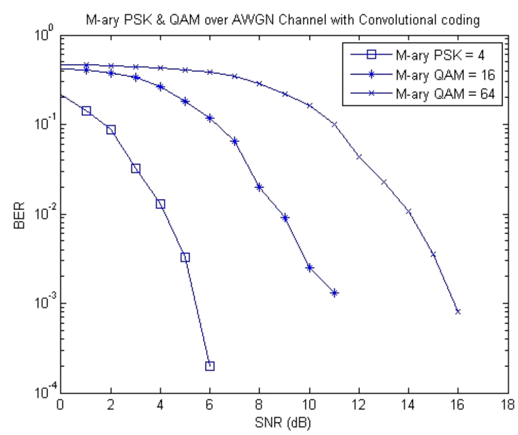

Fig. 2. SNR v/s BER characteristics plot using Fixed Modulation Methods (QPSK,16-QAM and 64-QAM)

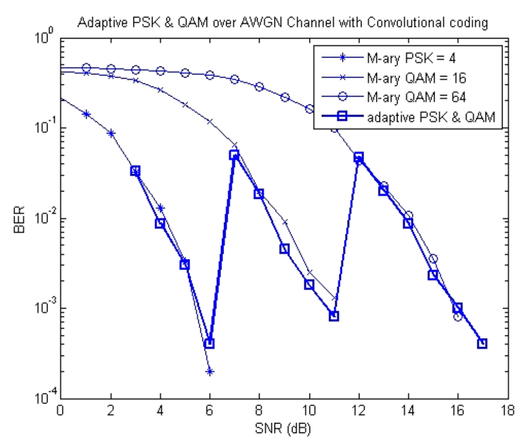

Fig. 3. SNR v/s BER characteristics comparative plot using Fixed Modulation Methods (QPSK,16-QAM and 64-QAM) and adaptive modulation method

2. Performance estimation is done for fixed and adaptive modulation using BCH coding over AWGN channel using following methodology,
  a. An OFDM system using Fixed Modulation methods with convolutional coding over AWGN channel is simulated using MATLAB programming.
    i. The simulation results of fixed QPSK modulation are obtained in terms of SNR v/s BER characteristics.
    ii. The simulation results of fixed 16-QAM and 64-QAM modulation are obtained in terms of SNR v/s BER characteristics.
  b. An OFDM system using adaptive modulation method with convolutional coding over AWGN channel is simulated using MATLAB programming and the simulation results are obtained in terms of SNR v/s BER characteristics.
  c. An OFDM system using fixed modulation method and adaptive modulation method with convolutional coding over AWGN channel is simulated using MATLAB programming and the comparative simulation results are obtained in terms of SNR v/s BER characteristics.

Simulation Results for an OFDM system using fixed modulation methods (QPSK,16-QAM,64-QAM) with BCH coding over AWGN channel

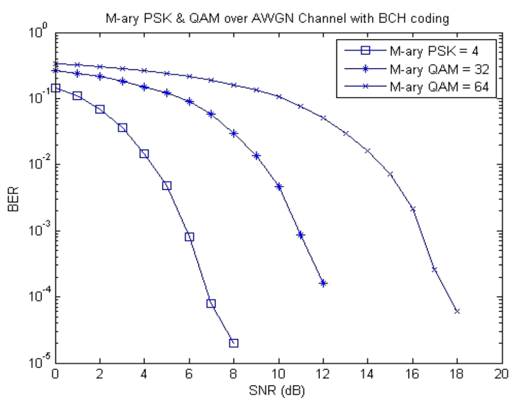

Fig. 4. SNR v/s BER characteristics plot using Fixed Modulation Methods (QPSK,16-QAM and 64-QAM)

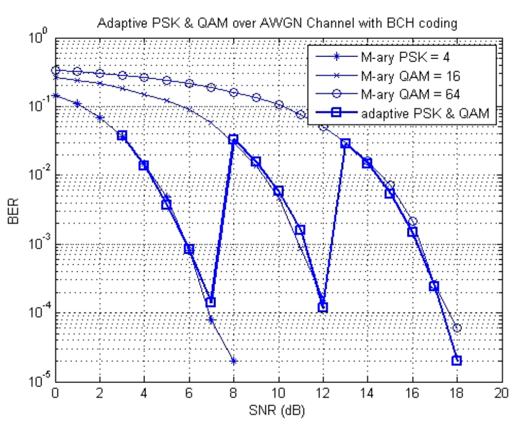

Fig. 5. SNR v/s BER characteristics comparative plot using Fixed modulation methods (QPSK,16-QAM and 64-QAM) and adaptive modulation method

5. Result Analysis and its Interpretation

From the obtained simulation results of OFDM system without and with adaptive modulation with coding (convolutional/BCH) over AWGN communication channel, the result analysis and its interpretation is done as follows,

A. Comparative result analysis of channel SNR and Bit Error Rate (BER) with and without adaptive modulation using convolutional coding and BCH coding over AWGN channel

Table 1
Channel SNR and Bit Error Rate (BER) with and without adaptive modulation

Modulation Method	BER				
	AWGN channel				
	SNR (dB)	Convolutional coding		BCH coding	
		without adaptive modulation	with adaptive modulation	without adaptive modulation	with adaptive modulation
QPSK	3	0.033	0.033	0.038	0.038
	4	0.0128	0.0086	0.0151	0.0151
	5	0.003	0.003	0.00402	0.00402
	6	0.0002	0.0004	0.00064	0.00064
16-QAM	7	0.0642	0.05	-	-
	8	0.0181	0.0181	0.03428	0.03428
	9	0.0091	0.0045	0.01484	0.01484
	10	0.0025	0.0018	0.00526	0.00526
	11	0.0013	0.0008	0.0008	0.0008
64-QAM	12	0.0466	0.0466	-	-
	13	0.0228	0.02	0.02968	0.02968
	14	0.0107	0.0086	0.01514	0.01514
	15	0.0035	0.0023	0.00578	0.00578
	16	0.0008	0.001	0.00188	0.00188

The obtained results can be analyzed as-

a) For the lower SNR values in the range of 4-6dB, with adaptive modulation using QPSK, there is no improvement in BER with convolutional as well as BCH coding over AWGN channel.
b) For the middle SNR values in the range of 8-10dB, with adaptive modulation using 16-QAM, for SNR value of 9dB, there is 50.5% reduction in BER with the use of convolutional coding whereas no improvement with the use of BCH coding over AWGN channel.
c) For the higher SNR values in the rage of 13-15dB, with adaptive modulation using 64-QAM, for SNR value of 14dB, there is 19.62% reduction in BER with the use of convolutional coding whereas no improvement with the use of BCH coding over AWGN channel.
d) Thus, from this analysis it can be interpreted that there is no improvement in BER for SNR values in lower range with adaptive modulation but reduction in the BER is observed for middle and higher ranges of SNR by using adaptive modulation and convolutional coding over AWGN channel.

B. Comparative result analysis of channel SNR range and Average Bit Error Rate (BER) with and without adaptive modulation using convolutional coding and BCH coding over AWGN channel

The obtained results can be analyzed as,

a) For the lower SNR values in the range of 4-6dB, there is 24.52% reduction in average BER value with the use of adaptive modulation and convolutional coding over AWGN channel whereas no improvement in BER with the use of adaptive modulation and BCH coding over AWGN channel.

b) For the middle SNR values in the range of 8-10dB, there is 17.87% reduction in average BER value with the use of adaptive modulation using convolutional coding over AWGN channel whereas no improvement in BER with the use of adaptive modulation and BCH coding over AWGN channel.

c) For the higher SNR values in the range of 13-15dB, there is 16.26% reduction in average BER value with the use of adaptive modulation using convolutional coding over AWGN channel whereas no improvement in BER with the use of adaptive modulation and BCH coding over AWGN channel.

d) Thus, from this analysis it can be interpreted that with Adaptive modulation and convolutional coding, there is reduction in the average BER value for all SNR ranges over AWGN channel.

Table 2
Channel SNR Range and Average Bit Error Rate (BER) with and without adaptive modulation

Modulation Method	SNR Range	AVERAGE BER			
		AWGN channel			
		Convolutional coding		BCH coding	
		without adaptive modulation	with adaptive modulation	without adaptive modulation	with adaptive modulation
QPSK	4dB-6dB	0.0053	0.004	0.0065	0.0065
16-QAM	8dB-10dB	0.0099	0.0081	0.0181	0.0181
64-QAM	13dB-15dB	0.0123	0.0103	0.0168	0.0168

C. Comparative result analysis of percentage improvement in Average Bit Error Rate (BER) with and without adaptive modulation using convolutional coding and BCH coding over AWGN channel

Table 3
Percentage improvement in average BER using adaptive modulation and coding over AWGN channel

PERCENTAGE IMPROVEMENT IN AVERAGE BER USING ADAPTIVE MODULATION AND CODING OVER AWGN CHANNEL			
Modulation Scheme	SNR Range (dB)	Convolutional Coding	BCH Coding
QPSK	4-6	24.52	0
16-QAM	8-10	17.87	0
64-QAM	13-15	16.26	0

From the comparative data analysis it can be interpreted that,

a) With Adaptive modulation and convolutional coding, there is reduction in the average BER value for all SNR ranges (4dB-15dB) over AWGN channel whereas there is no reduction in the average BER value with adaptive modulation and BCH coding.

b) The comparative data analysis of percentage improvement in average BER using adaptive modulation and coding over fixed modulation and coding shows that in terms of channel performance, there is significant improvement (reduction) in average BER value for entire ranges of SNR by using adaptive modulation with convolutional coding as compare to adaptive modulation with BCH coding over AWGN channel.

6. Conclusion

In this research work, an OFDM system model with Fixed Modulation methods like QPSK, 16-QAM/64-QAM using two channel coding techniques like Convolutional and BCH coding over AWGN channel is simulated in MATLAB programming environment and the results of simulations are obtained in terms of channel SNR v/s BER characteristics for different combinations of these modulation methods and coding techniques. The same OFDM system model with adaptive modulation approach is then simulated in MATLAB programming environment for two coding techniques (convolutional and BCH) over AWGN channel and the results of simulations are obtained in terms of channel SNR v/s BER characteristics.

From the result analysis and its interpretation, it can be concluded that-

a) There is no improvement in BER for SNR values in lower range with adaptive modulation but reduction in the BER is observed for middle and higher ranges of SNR by using adaptive modulation and convolutional coding over AWGN channel in comparison with BCH coding.

b) Using adaptive modulation, there is reduction in the average BER values for all SNR ranges over AWGN channel with convolutional coding whereas, there is no reduction in the average BER values using adaptive modulation and BCH coding.

Hence It can be concluded that the Bit Error Rate (BER) is improved by using Adaptive modulation with Convolution coding in comparison with adaptive modulation with BCH coding over AWGN channel.

A. Future Scope

The performance analysis of OFDM system in terms of channel SNR v/s BER characteristics with adaptive modulation using convolutional and BCH channel coding techniques over AWGN channel gives an idea that OFDM system with adaptive modulation approach using convolutional coding can be implemented to reduce Bit Error Rate (BER).

In the methodology adopted in this research work, effect of adaptive modulation on channel performance using convolutional and BCH channel coding has been evaluated in terms of BER. In the same way effect of adaptive modulation and coding can be evaluated over Rician channel and their comparative result analysis can be done in order to find more efficient and robust transmission in an OFDM system.

References

[1] Megha Gupta, Rajesh Nema, Ravi Shankar Mishra, Puran Gour, “Bit Error Rate Performance in OFDM System Using MMSE &MLSE Equalizer Over Rayleigh Fading Channel through BPSK, QPSK, 4-QAM & 16-QAM Modulation Technique,” IJERA, 2002.

[2] N. K. Noordin, B. M. Ali, N. Ismail, and S.S. Jamuar, "Adaptive Techniques in Orthogonal Frequency Division Multiplexing in Mobile Radio Environment," International Journal of Engineering and Technology, 2004.
[3] C. Geetha Priya, M. Sunganthi, M. Madhana Prabha, 'Improving the Data Rate of OFDM System in Rayleigh Fading Channel Using Spatial Multiplexing with Different Modulation Techniques', International Symposium on Computing, Communication and Control (ISCCC 2009)
[4] J. Faezah and K. Sabira, Adaptive Modulation for OFDM Systems, International Journal of Communication Networks and Information Security (IJCNIS), August 2009.
[5] D. Sreenivasa Rao, M. Kanti Kiran & K. Sri Ramakrishna, Algorithm to improve the Performance of OFDM based WLAN Systems, International Journal of Computer Science & Communication, July-December 2010.
[6] Susmita Das, Srabani Mohapatra and Kala Praveen Bagadi, Performance improvement of OFDM System by Peak to Average Power Reduction through Pulse Shaping Technique, ICTACT Journal on Communication Technology, December 2010.
[7] Rajeshree Raut and Priti Subramanium, Optimize Adaptive Coding Techniques to improve BER in OFDM System, International Journal of Electronics Communication and Computer Engineering.
[8] Serkout N. Abdullah Zainab Mageed Abid, Adaptive Coded Modulation for OFDM System, Journal of Engineering, February 2012.
[9] Suverna Sengar and Partha Pratim Bhattacharya, performance improvement in OFDM system by PAPR reduction, Signal & Image Processing: An International Journal (SIPIJ), April 2012.
[10] Mohit Pant and Dhiiraj Nitnawre, Performance Improvement of OFDM System Using PAPR Reduction, International Journal of Advanced Research in Computer Science and Software Engineering.
[11] Manushree Bhardwaj, Arun Gangwar and Devendra Soni, A Review on OFDM: Concept, Scope & its Applications, IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), May-June 2012.
[12] Piyush Vyas and Surendra K. Bohra, Improved Performance of Digital Techniques Companded OFDM System Using Non-Linear Symmetric Approach Under Sufficient Bandwidth, International Journal of Advanced Technology & Engineering Research (IJATER), Sept. 2012.
[13] Pallavi Dhok, S. V. Rathkantiwar, Performance Improvement in BER and PAPR Reduction in OFDM System Using Companding Technique, International Journal of Application or Innovation in Engineering & Management, January 2013.
[14] T. S. Hari vikram, R. Hari Kumar, C. Ganesh Babu, P. Murugamanickam, Adaptive Modulation and Coding Rate for OFDM Systems, International Journal of Emerging Technology and Advanced Engineering, February 2013.
[15] Amit Mewara and Sandhya Sharma, "Adaptive Modulation Technique to Improve OFDM System," Suresh Gyan Vihar University Journal of Engineering & Technology, 2015.
[16] T. Jaya, E. Gopinathan and V. Rajendran, "Comparison of BER Performance of Various Adaptive Modulation Schemes in OFDM Systems," Indian Journal of Science and Technology, October 2016.
[17] S. Nandi, N. N. Pathak, A. Nandi and M. Sarkar, "Performance Analysis of Cyclic Prefix OFDM Using Adaptive Modulation Techniques," International Journal of Electronics, Electrical and Computational System, August 2017.
[18] Suchi Barua, Yue Rong, Sven Nordholm, Peng Chen, Real-Time Subcarrier Cluster-Based Adaptive Modulation for Underwater Acoustic OFDM Communication, Global Oceans 2020: Singapore.
[19] Ravi Kumar M. G., Mrinal Sarvagya, Navya B. R., "Adaptive Modulation based MIMO-OFDM Receiver design for Underwater Acoustic Communication," Turkish Journal of Computer and Mathematics Education, 2021.
[20] Rahim Khan, Qiang Yang, Alam Noor, Sohaib Bin Altaf Khattak, Liang Guo and Ahsan Bin Tufail, "An efficient adaptive modulation technique over realistic wireless communication channels based on distance and SINR," August 2021.
[21] Lianyou Jing, Chaofan Dong, Chengbing He, Wentao Shi and Hongxi Yin, "Adaptive Modulation and Coding for Underwater Acoustic Communications Based on Data-Driven Learning Algorithm," MDPI-Remote Sensing, 2022.
[22] Shiqi Zhang, Guoxin Yu, Shanping Yu, Yanjun Zhang, Yu Zhang. "LSTM-Based Adaptive Modulation and Coding for Satellite-to-Ground Communications," Journal of Beijing Institute of Technology, 2022.
[23] John G. Proakis, "Digital Communications", 3rd Edition, McGraw Hill International Editions, 1995.
[24] William Stallings, "Wireless Communications and Networks", 1st Edition, Pearson Education Asia, 2002.
[25] L. Hanzo, C. H. Wong and M. S. Yee, "Adaptive Wireless Transceivers," John Wiley & Sons, 2002.