An analysis of BER comparison of various digital modulation schemes used for adaptive modulation

Rajesh M N, B K Shrisha, Nishith Rao, H.V.Kumaraswamy

Abstract—**In this paper, a comparative analysis of BER performance of various higher order digital modulation techniques for channel utilization is proposed and the analysis are carried out with SNR as the reference parameter. This performance analysis yields to adaptive modulation technique which can be used to attain high spectral efficiency by modulating the signal at higher order modulation schemes based on channel state information (CSI) from the receiver. Signal over AWGN channel is assumed for the analysis. To achieve lower BER values for a specific SNR, techniques to alter signal characteristics like pulse shaping filters, matching filters and convolution encoding are applied and analysis are carried out. An observation from the above analysis produces lower BER. For 256-QAM at SNR of 20, BER of $4.76X10^{-3}$ and grey coded BER of $3.83X10^{-4}$ is obtained. Highest possible modulation technique is selected with lower BER obtained. Thus, spectral efficiency which is the prime objective of the proposed paper is achieved. The above results are computed and simulated using MATLAB.**

Keywords—Adaptive modulation, channel state information (CSI), bit error rate (BER), signal to noise ratio (SNR), pulse shaping and match filters, convolution coding.

I. INTRODUCTION

With the increase in demand of wireless and multimedia services, spectral efficiency is the prime consideration for future communication systems. One approach to satisfy this requirement is to adapt the modulation technique according to instantaneous propagation conditions, interference scenarios, and traffic or data rate requirements. This technique is called adaptive modulation [1]. As the channel conditions vary fixed modulation schemes do not provide a standard output. Lesser amount of data can be transmitted for a given bandwidth using the lower modulation schemes such as BPSK and QPSK, these modulation schemes are more immune to noise. Higher amount of data can be transmitted for a given bandwidth using higher modulation schemes such as 16-QAM, 64-QAM, 256-QAM etc., but these are less immune to noise.

The radio channels vary rapidly with time due to high mobility of the subscribers. Signals take different paths to reach the destination during transmission. The time varying channels characterized by multipath-fading may incur variable error to the signal which results in variable SNR.

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A fixed modulation scheme is designed for worst case bit error rate (BER), but it fails to adapt itself to the conditions and the time-varying property of the radio channel.[2] Fixed modulation may use lower order modulation scheme for a less noisy channel which is not spectrally efficient for a wireless communication system. Hence, Adaptive modulation is used where the transmission characteristics is varied or adapted according to the channel conditions.[1] The transmission characteristics may be transmission power, data rate, modulation scheme or coding, or it can be a combination of different parameters according to the state of the channel.

A reverse channel is required from the receiver, where the channel state information (CSI) is sent to transmitter. Based on the CSI received at the transmitter the various parameters are adapted accordingly. Three types of SNR estimators are used at the receiver, i.e., Data-aided estimators (DA), Non-Data-aided (NDA) estimators and Envelope-based estimators (EVB). DA estimators are used when the receiver has some information about the transmitting symbols. No information about the transmitting signal is required for calculating SNR in case of NDA estimators. EVB uses received signal magnitude to detect the SNR values. [7]

All the below tables are computed using MATLAB tool only and no hardware implementation is carried out. The inbuilt library functions like: ‘qammod’, ‘reshape’ etc. are used. The function – ‘rcodesign’ is used for pulse shaping filter design which is available only in MATLAB 2015 onwards.

In the past century of wireless communications, applications of adaptive signal processing have a relatively short 20-year history. The very first adaptive signal processing technique applied to wireless communication systems is the adaptive equalizer, such as Viterbi equalizer, which is categorized as an adaptive reception technique. A low outage probability, high Spectral efficiency, and low BER cannot be achieved simultaneously by a traditional system using a single codec.

Hayes suggested in 1968 an “Adaptive Feedback Communications” system to combat the variations introduced by a Multipath Fading Channel with a Rayleigh distributed envelope [Hayes, 1968]. The technique is based on some parameter(s) in the communication system being dependent on the state of the channel. This state is communicated from receiver to transmitter on a separate feedback channel. Then the transmitter can adapt the transmission according to the variations in the CSNR. Varying the size of the modulation constellation used (“adaptive modulation”) according to variations in Carrier SNR [Steele and Webb, 1991] is more attractive. In adaptive modulation, a small constellation is used when the CSNR is low and a large constellation when the CSNR is high, leading to increased Average Spectral Efficiency. [3]

Adaptive modulation can also opportunistically increase the data rate by using higher-order modulations when the

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