Evaluation of Different Coding Methods for Wireless and Satellite Communication

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ABSTRACT

Decoding of turbo codes is analyzed under the assumption of a maximum-likelihood (ML) list decoder the relative asymptotic gains for turbo codes are larger than those for convolutional codes. a rate ½ convolutional encoder and its corresponding Viterbi decoder was used to improve the decibel gain for a target BER. Finally, Reed Solomon (RS) encoder was serially concatenated with the convolutional encoder and BER performance was obtained. Since in mobile wireless access the location of the end user is changing and different users may be moving at different speeds so the RS encoder will further improve the system performance.

Keywords: *Convolutional Coding, Reed Solomon encoder/decoder, Turbo codes,OFDM*

1. Introduction

Since the deployment of the wireless communication, which dates almost as far back as two decades, the cellular communication has grown at a phenomenal rate. Inevitably, cellular mobile phone companies become more famous & rapidly developed. All 1G cellular systems exploited analog frequency modulation schemes together with separate bands for downlink (base station to mobile) and uplink (mobile to base station). Such systems would be known as frequency division duplex (FDD) systems. Also to have higher system capacity in each band frequency division multiplexing (FDM) was used. All 2G cellular networks are known to convert a signal from analog to digital form and apply some form of digital modulation before transmission. This conversion to digital form aids the accommodation of more than one user at a time (multiplexing) per radio channel. The two most popular multiplexing schemes used in 2G systems are time division multiple access (TDMA) and code division multiple access (CDMA). 3G cellular systems have the ability to support high data rate services, advanced multimedia services and global roaming. The goal of 4G is to combine wireless mobile with wireless access communication technologies. 4G mobile networking will be based on an all-IP architecture and connectivity for anyone, anywhere. 4G systems are mostly based on a multi user version of Orthogonal Frequency Division Multiplexing (OFDM). The 802.11a standard is designed to operate in the 5 GHz band (typically 5.15 to 5.35 and 5.725 to 5.825 GHz). The band is not unlicensed, although the devices operating in a majority of countries may not require a license. The devices operating with 802.11a are sometimes called WiFi5 to denote the frequency band of the operation. The band of 5 GHz is characterized by high loss with distance from the transmitter and the inability of signals to pass through obstructions such as walls. In order to overcome these, the 802.11a standard made a major improvement in the physical layer by using the OFDM modulation. In OFDM, the data to be transmitted is divided into a large number of orthogonal subcarriers.

2. OFDM

Orthogonal frequency-division multiplexing, or OFDM, is a process of digital modulation that is used in computer technology today. Essentially, OFDM is configured to split a communication signal in several different channels. Each of these channels is formatted into a narrow bandwidth modulation, with each channel operating at a different frequency. The process of OFDM makes it possible for multiple channels to operate within close frequency levels without impacting the integrity of any of the data transmitted in any one channel. One major advantage of OFDM is that it is bandwidth efficient. One disadvantage of OFDM is its sensitivity to carrier frequency variations. To overcome this problem, OFDM systems transmit pilot carriers along with the subcarriers for synchronization at the receiver. Another disadvantage is that an OFDM signal has a high peak to average power ratio. As a result, the complex OFDM signal requires linear amplification. That means greater inefficiency in the RF power amplifiers and more power consumption.

3. Turbo Code

Turbo codes are a new class of error correction codes that were introduced a long with a practical decoding algorithm. The importance of turbo codes is that they enable reliable communications with power efficiencies close to the theoretical limit predicted by Claude Shannon . Since their introduction, turbo codes have been proposed for low-power applications such as deep-space and satellite communications, as well as for interference limited applications such as third generation cellular and personal communication services. The main principle in the turbo coding scheme is to use two codes in parallel. This means that the information sequence is encoded twice, the second time after a scrambling of the information bits. The component codes are chosen as small convolutional codes in the recursive systematic form. With this encoding one is able to decode the two encoded streams with an iterative process using two soft-in soft-out decoders, one corresponding to each of the encoders. For the simulations shown in this paper we have used a MAP decoder. The decoders exchange information as a priori probabilities for the information bits.

4. Convolutional Codes

Convolutional codes are intensively using to ensure reliable data transfer**.** A convolutional code maps each *k*-bits of a continuous input stream on *n* output bits, where the mapping is performed by convolving the input bits with a binary impuls response. The convolutional encoding can be implemented by a simple shift register and modulo-2 adders. Decoding of convolutional codes is most often performed by soft-decision Viterbi decoding, which is an efficient way to obtain the optimal maximum likelihood estimate of the encoded sequence. The complexity of Viterbi decoding grows exponentially with the constraint length. Decoding of convolutional codes with larger constraint length is possible by using suboptimal decoding techniques like sequential decoding. Since convolutional codes do not have a fixed length, it is more difficult to specify their performance in terms of Hamming distance and a number of correctable errors. One measure that is used is the free distance, which is the minimum Hamming distance between arbitrarily long different code sequences that begin and end with the same state of the encoder, where the state is defined by the contents of the shift register of the encoder.

5. Reed Solomon Codes

Reed-Solomon codes are block-based error correcting codes with a wide range of applications in digital communications and storage. The characteristics of an RS code will be decided based on the number and type of the errors that it is aiming to correct. Reed Solomon codes are non-binary cyclic codes which are used to correct errors that appear in burst. A Reed-Solomon code is specified as RS (*n*,*k*) with *s*-bit symbols. This means that the encoder takes *k* data symbols of *s*-bits each and adds parity symbols to make an *n* symbol codeword. The decoder for a RS (*n*,*k*) code would look at all possible subsets of *k* symbols from the set of *n* symbols that were received. For the code to be correctable in general, at least *k* symbols had to be received correctly, and *k* symbols are needed to interpolate the message polynomial. An ideal decoder would interpolate a message polynomial for each subset, and it would keep track of the resulting polynomial candidates. Unfortunately, due to the fact that there exist a lot of subsets, the algorithm is impractical.

6. Performance evaluation of different scheme

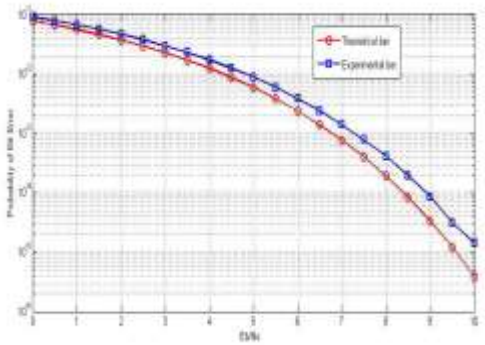

Fig 1 OFDM Performance over AWGN Channel

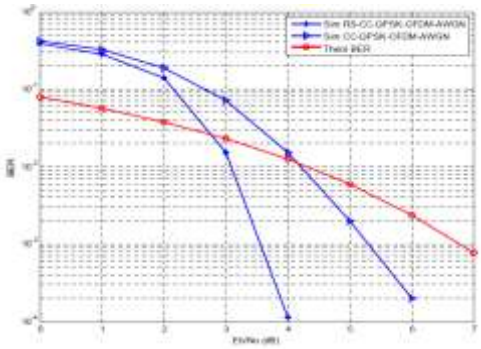

Fig2 RS-CC BER Performance over AWGN channel

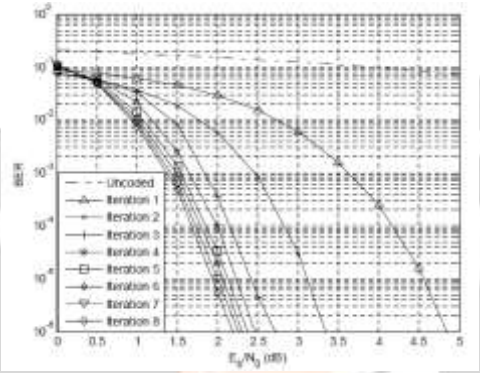

Fig 3 BER performance of different number of iterations

7. Conclusion

From the error performance results, it is evident that turbo codes are quite suitable for the wireless communications applications under consideration with ahead mentioned requirements. the performance of turbo encoder and turbo decoder as a whole system and any changes in these parameters will affect the performance of the turbo codes.

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