To Improve Bit Error Rate (BER) Of Adaptive Orthogonal Frequency Division Multiplexing (AOFDM) Systems Under Different Channels By Using Convolutional Coding

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Abstract-*Orthogonal frequency division multiplexing (OFDM) is the physical layer in 4G wireless local area network. For efficient transmission and reception in fourth-generation wireless system, Adaptive OFDM system (AOFDM) is considered as a potential approach. In AOFDM, adaptive transmission scheme is engaged in accordance with the channel fading condition with OFDM to develop the system performance. In this paper, we have considered only adaptive modulation for OFDM system using quadrature amplitude modulation (QAM) and phase shift keying (PSK) then further we have studied the adaptive modulation of OFDM system using convolutional code, channel estimation, equalization and SNR estimation. While taking the review it shows that a significant improvements in terms of bit error rate (BER) can be achieved using the proposed AOFDM system under different channels by using convolutional coding.*

Keywords - *Adaptive modulation, Bit error rate (BER),Convolutional coding,Orthogonal frequency division multiplexing (OFDM), Transmission blocking.*

1. Introduction

In today‘s scenario there is growing need to transmit information wirelessly, quickly and accurately, So communication engineers have combined various technologies suitable for high data rate transmission with forward error correction techniques and improving bit error rate.

Orthogonal frequency division multiplexing (OFDM) is a very attractive multi carrier modulation technique in which a single high rate data stream is divided into multiple low rate data streams. These data streams are then modulated using subcarriers which are orthogonal to each other. In this way the symbol rate on each subchannel is greatly reduced, and hence the effect of intersymbol interference (ISI) due to channel dispersion in time caused by multipath delay spread is reduced. and is being implemented to achieve high bit data rate transmission. This technique is well suited to overcome adverse effects in hostile transmission environment. This technique provides a reliable reception of signals affected by multipath propagation and selective fading and has been used in broadcast media such as European terrestrial digital video broadcasting (DVB-T) and digital audio broadcasting (DAB) and in the IEEE 802.11a (local area network, LAN) and the IEEE 802.16a (metropolitan area network, MAN) standards. Orthogonal Frequency

Division Multiplexing (OFDM) is a special form of multi-carrier transmission

Guard interval can also be inserted between OFDM symbols to reduce ISI further. The orthogonality between subcarriers can be maintained, even though the signal passes through a time-dispersive channel by cyclically extending the OFDM symbols into guard interval. The main advantages of OFDM are its multipath delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain.

This problem can be moderated if individual OFDM subcarriers are modulated using different modulation schemes. Adaptive OFDM schemes have to be adapted to the SNR of the individual subcarriers. This will considerably improve the BER performance of an OFDM system. However, most of the AOFDM systems do not consider the channel coding across the bits due to higher efficiency of OFDM transmission scheme. But this assumption not always stays in favorable limit specially, in a highly fading environment that can be modeled by Rayleigh distribution. This paper describes an efficient way to improve the BER performance of an AOFDM system by introducing convolutional coding in the system. Efficiency of the resultant system is verified via simulation and analysis.

This paper presents a review on adaptive OFDM system and how spectral efficiency can be achieved by adaptive modulation scheme using convolutional coding under different channel condition. This paper is organized as follows: The adaptive procedure and system model of AOFDM and proposed AOFDM system is illustrated in Section 2. Simulation algorithm and simulation parameters are provided in Section 3. Finally conclusions are made in Section 4.

II. LITERATURE SURVEY

2.1 ADAPTIVE OFDM

The block diagram of adaptive OFDM system is depicted in figure 1.The binary bit stream is fed into the source encoder for encoding them. Then, the encoded serial bit stream is converted to parallel format which in further sent to adaptive modulator. The goal of adaptive modulator is to choose the appropriate modulation mode for transmission in each sub-band, given the local SNR, in order to achieve good trade-off between spectral efficiency and overall BER. Two types of modulation schemes have been used as the option for adaptation mechanism. Rest of the part in transmitter is just same as the traditional OFDM transmitter. The channel estimation and mode selections are done at the receiver side and the information is sent to the transmitter using a feedback channel. In this model the adaptation is done frame by frame. The channel estimator is used to estimate the instantaneous SNR of the received signal. Based on the instantaneous SNR calculated, the best mode will be chosen for the next transmission frame. This task is done by the mode selector block. At the transmitter the adaptive modulator block consists of different modulators block consists of different modulators which are used to provide different modulation modes. The switching between these modulators will depend on the instantaneous SNR.

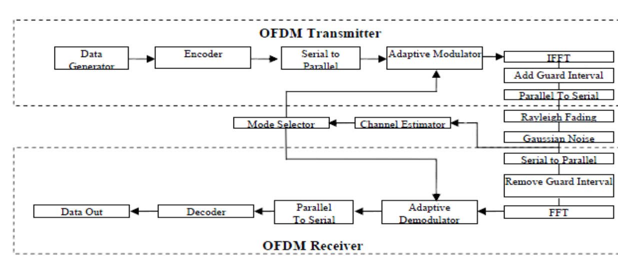

Fig.1 Block diagram of Adaptive OFDM

2.2 SYSTEM MODEL

In this paper, sub-band adaptive transmission schemes are employed to reduce the complexity. In sub-band adaptive OFDM transmission, all subcarriers in an AOFDM symbol are split into blocks of adjacent subcarriers referred to as sub-bands. The same mode is employed for all subcarriers of the same sub-band. The choice of the modes to be used by the transmitter for its next OFDM symbol is determined by the channel quality estimate of the receiver based on the current OFDM symbol. Perfect channel estimation is assumed in this paper. In this simulation the instantaneous SNR of the subcarrier is measured at the receiver. The channels quality varies across the different subcarriers for frequency selective channels. The received signal at any subcarrier can be expressed as:

$$Rn = HnXn + Wn \quad (1)$$

Where, *Hn* is the channel coefficient at any subcarrier, *Xn* is the transmitted symbol and *Wn* is the Gaussian noise sample.

So the instantaneous SNR can be calculated using,

$$SNRn = \frac{H2}{No} \quad (2)$$

Where, *N0* is the noise variance .

The conservative approach in threshold based adaptation is by using the lowest quality subcarrier in each sub-band for controlling the adaptation algorithm . It means that the lowest value of SNR will be used in mode selection. By using this method, the overall BER in one sub-band is normally lower than the BER target. If the overall BER can be closer to the BER target by choosing a more suitable modulation mode or code rate, the throughput of the system will be higher.

Therefore a better adaptation algorithm is used in this paper to provide a better tradeoff between throughput and overall BER by choosing a more suitable scheme for each sub-band. Instead of using the lowest SNR in each sub-band, the average value of the SNR of the subcarriers in the sub-band is going to be used.

2.3 COVOLUTIONAL CODING

Convolutional codes are a bit like the block codes they involve the transmission of parity bits that are computed from message bits. Unlike block codes in systematic form, however, the sender does not send the message bits followed by (or interspersed with) the parity bits; in a convolutional code, the sender sends only the parity bits. The encoder uses a sliding window to calculate r > 1 parity bits by combining various subsets of bits in the window Unlike a block code, the windows overlap and slide by 1, as shown in Figure 3. The size of the window, in bits, is called the code's **constraint length**. The longer the constraint length, the larger the number of parity bits that are influenced by any given message bit. Because the parity bits are the only bits sent over the channel, a larger constraint length generally implies a greater resilience to bit errors. The trade-off, though, is that it will take considerably longer to decode codes of long constraint length, so one can't increase the constraint length arbitrarily and expect fast decoding. If a convolutional code that produces r parity bits per window and slides the window forward by one bit at a time, its rate (when calculated over long messages) is 1/r. The greater the value of r, the higher the resilience of bit errors, but the trade-off is that a proportionally higher amount of communication bandwidth is devoted to coding overhead. In practice, we would like to pick r and the constraint length to be as small as possible

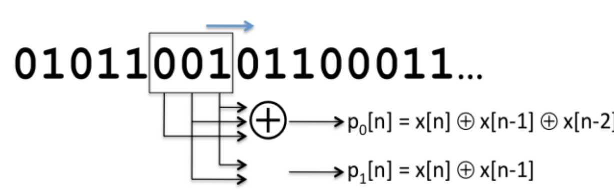

Fig.3 An example of a convolutional code with two parity bits per message bit (r = 2) and constraint length (shown in the rectangular window) K = 3.

Convolutional codes represent one technique within the general class of channel codes. Channel codes (also called *error-correction codes*) permit reliable communication of an information sequence over a channel that adds noise, introduces bit errors, or otherwise distorts the transmitted signal.Elias introduced convolutional codes in 1955. These codes have found many applications, including deep-space communications and voice band modems. Convolutional codes continue to play a role in low-latency applications such as speech transmission and as constituent codes in Turbo codes.

While providing a low enough resulting probability of a bit error. we will use K (upper case) to refer to the constraint length, a somewhat unfortunate choice because we have used k (lower case) in previous lectures to refer to the number of message bits that get encoded to produce coded bits. Although "L" might be a better way to refer to the constraint length, we'll use K because many papers and documents in the field use K (in fact, most use k in lower case, which is especially confusing). Because we will rarely refer to a "block" of size k while talking about convolutional codes, we hope that this notation won't cause confusion. Armed with this notation, we can describe the encoding process succinctly. The encoder looks at K bits at a time and produces r parity bits according to carefully chosen functions that operate over various subsets of the K bits.1 One example is shown in Figure 4 which shows a scheme with K = 3 and r = 2 (the rate of this code, 1/r = 1/2). The encoder spits out r bits, which are sent sequentially, slides the window by 1 to the right, and then repeats the process. That's essentially it. At the transmitter, the only remaining details that we have to worry about now are:

1. What are good parity functions and how can we represent them conveniently?

2. How can we implement the encoder efficiently?

Two Views of the Convolutional Encoder

We now describe two views of the convolutional encoder, which we will find useful in better understanding convolutional codes and in implementing the encoding and decoding procedures. The first view is in terms of a **block diagram**, where one can construct the mechanism using shift registers that are connected together. The second is in terms of a **state machine**, which corresponds to a view of the encoder as a set of states with well defined transitions between them. The state machine view will turn out to be extremely useful in figuring out how to decode a set of parity bits to reconstruct the original message bits.

- **Block Diagram View**

Figure 4 shown in the form of a block diagram. The x[n−i] values (here there are two) are referred to as the state of the encoder. The way to think of this block diagram is as a "black box" that takes message bits in and spits out parity bits. Input message bits, x[n], arrive on the wire from the left. The box calculates the parity bits using the incoming bits and the state of the encoder (the k − 1 previous bits; 2 in this example).

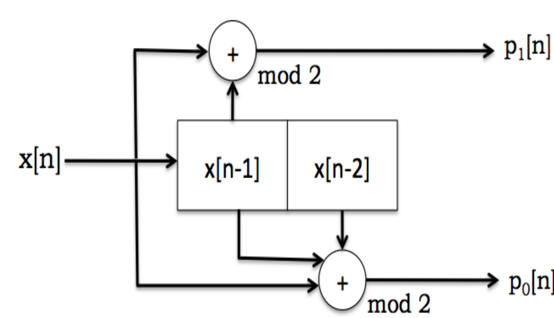

Fig.4 Block diagram view of convolutional coding with shift registers.

After the r parity bits are produced, the state of the encoder shifts by 1, with x[n] taking the place of x[n−1], x[n−1] taking the place of x[n−2], and so on, with x[n−K +1] being discarded. This block diagram is directly amenable to a hardware implementation using shift registers.

- **State Machine View**

Another useful view of convolutional codes is as a state machine, which is shown in Figure 5 for the same example that we have used throughout this lecture.

The state machine for a convolutional code is identical for all codes with a given constraint length, K, and the number of states is always 2K−1. Only the pi labels change depending on the number of generator polynomials and the values of their coefficients. Each state is labeled with x[n − 1]x[n − 2] . . . x[n −K + 1]. Each arc is labeled with x[n]/p0p1 In this example, if the message is 101100, the transmitted bits are 11 11 01 00 01 10.

This state machine view is an elegant way to explain what the transmitter does, and also what the receiver ought to do to decode the message, as we now explain. The transmitter begins in the initial state (labeled “STARTING STATE” in Figure 5) and processes the message one bit at a time. For each message bit, it makes the state transition from the current state to the new one depending on the value of the input bit, and sends the parity bits that are on the corresponding arc.

The receiver, of course, does not have direct knowledge of the transmitter’s state transitions. It only sees the received sequence of parity bits, with possible corruptions. Its task is to determine the best possible sequence of transmitter states that could have produced the parity bit sequence. This task is called decoding.

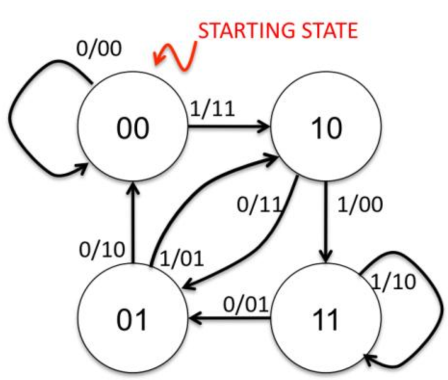

Fig.5 State machine view of convolutional coding.

III. PROPOSED SYSTEM

3.1 PROPOSED AOFDM SYSTEM MODEL

The block diagram of the proposed AOFDM is depicted in figure 6. In the modified model, channel coding is introduced just after the source coder and before the serial to parallel converter. In a typical communication system the channel coding is performed before modulation and after source coding. The same fashion is maintained here. Convolutional coding is the chosen scheme for channel coding. So each parallel data from serial to parallel converter is convolutionally encoded which is further modulated in the process of OFDM mechanism. That means the inputs of the efficient OFDM system are convolutionally encoded which has an elevated possibility to achieve a better BER performance of the overall system.

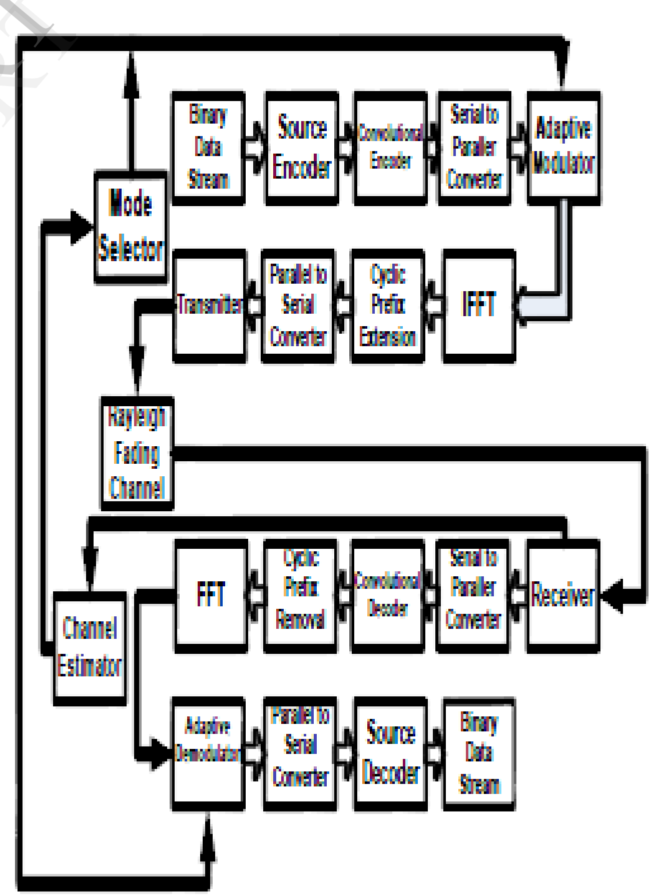

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Fig.6 Block diagram of Proposed AOFDM System

The switching threshold for activating different modes can be determined by extensive simulation of the fixed mode modulation system.. Two types of adaptation modes will be used. The first one is adaptive modulation without transmission blocking and the second one is adaptive modulation with transmission blocking. In adaptive modulation without transmission blocking, data will be constantly transmitted in this scheme even though the channel is in deep fades. If the channel quality is very bad, a robust modulation mode will be used and when the channel quality is good a spectrally efficient modulation will be used. In adaptive modulation with transmission blocking, transmission will be disabled when the channel is in deep fade. This mode is introduced because the signal quality is too bad to guarantee a required transmission [13]. Data will be transmitted if the channel quality improved.

IV SIMULATION ALGORITHM

The performance of the turbo coded OFDM has been measured through MATLAB simulation. The simulation follows the procedure listed below:

1. Generate the information bits randomly.

2. Encode the information bits using a turbo encoder with the specified generator matrix.

3. Use QPSK or different QAM modulation to convert the bi-nary bits, 0 and 1, into complex signals (before these modulation use zero padding)

4. Performed serial to parallel conversion.

5. Use IFFT to generate OFDM signals, zero padding is being done before IFFT.

6. Use parallel to serial convertor to transmit signal serially.

7. Introduce noise to simulate channel errors. We assume that the signals are transmitted over an AWGN (Additive White Gaussian Noise) and Rayleigh channel σ2 . The variance of the noise is obtained as as generate a sequence of normally distributed random numbers, where randn has zero mean and 1 variance. Thus the received signal at the decoder is X“ = noisy (X) Where noisy (X) is the signal corrupted by noise.

$$\sigma^2 = \frac{1}{2 * Eb/N0}$$

8. At the receiver side, perform reverse operations to decode the received sequence.

9. Count the number of erroneous bits by comparing the de-coded bit sequence with the original one.

10. Calculate the BER and plot it.

4.1 SIMULATION PARAMETERS

During the simulations, in order to compare the results, the same random messages were generated. For the radiant function is in MATLAB.

Table.1 Simulation parameters

Parameters	Values
Digital Modulation	QPSK-256, QAM-256,512,1024, 2048.
Turbo code	5/6
SISO Decoder	Log-Map
Code Generator	{000,111}
Interleaver Size	1 x 100
Channels	AWGN, Rician , Rayleigh

V. CONCLUSION

The performances of adaptive transmission scheme for convolutionally coded Adaptive OFDM under different channel condition have been investigated that can be used to improve the spectral efficiency of proposed system. The advantage of employing convolutional coding in adaptive OFDM is revealed by comparing their performance with uncoded transmission system. A better adaptation algorithm can be used to improve BER performance. This algorithm utilizes the average value of the instantaneous SNR of the subcarriers in the sub-band as the switching parameter. The simulation model of AOFDM system can be implemented using Matlab Toolbox package and more better performance for BER analysis for AWGN, Rician & Rayleigh channel model can be further demonstrated.

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