Performance Improvement of IEEE 802.22 With Different FEC techniques

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Abstract-

Wireless communication is very vast and having lot of ideas for increasing capacity and BER performance. This paper describes the modeling and performance improvement of Wireless Regional Area Network (WRAN) (IEEE 802.22) through different Forward Error Correction (FEC) Techniques.In this paper we have used different coding techniques over different modulation scheme. For simulation , we have used MATLAB and obtained different BER curves for different modulation scheme at different FEC Techniques. In final conclusion we have found BER performance of different modulation schemes over different FEC codes. OFDMA technique is used and the channel considered is AWGN.

Keywords- components **:IEEE 802.22,WRANs,OFDMA, cognitive radio , AWGN,BER**

I. INTRODUCTION

Population in rural areas is increasing rapidly and so is demand for internet access. Broadbrand wireless access (BWA) fulfills this requirement due to its acceptable data rates , proper cost and easy use. Wireless systems based on IEEE 802 standards such as IEEE 802.11 (WLAN) So called Wi-Fi and IEEE 802. 16 (WMAN) so called Wi-MAX are examples of BWA systems deployed for local and metropolitan area networks, respectively [1]. The IEEE 802.22 working group [4] has been formed in November 2004 to develop a standard for WRANs ,based on cognitive radio technology.

Cognitive Radio technologies have the capabilities of recognizing the surrounding radio environments with spectrum sensing, and operating in vacant or in intermittently unused spectrum without causing harmful interference to primary users (PUs) or Incumbent users (IUs).Thus, by using CR technology, it will be now possible that the efficiency of the frequency is enhanced and new secondary market is created on the wireless telecommunication field.

The IEEE 802.22 is a fixed point to multipoint technology and the connection between Base Station(BS) and Customer Premise Equipments(CPE) is possible both in line of sight (LOS) and Non Line of Sight (NLOS) propagation. The typical range for WRANs are 30 Km and it can extends upto 100 Km by which we can meet the demands for rural areas.
The minimum data rate of the system is 384 kb/s in the upstream (US) direction , i.e. from CPE to BS, and 1.5 Mb/s in the downstream direction i.e. from BS to CPE. It is expected that a BS supports up to 55 CPEs.

The development of the IEEE 802.22 WRAN standard (802.22 or 802.22 WRAN) is aimed at using cognitive radio techniques to allow sharing of geographically unused spectrum allocated to the television broadcast service, on a noninterfering basis, to bring broadband access to hard-to-reach low-population-density areas typical of rural environments, and is therefore timely and has the potential for wide applicability worldwide. IEEE 802.22 WRANs are designed to operate in the TV broadcast bands while ensuring that no harmful interference is caused to the incumbent operation (i.e., digital TV and analog TV broadcasting) and low-power licensed devices such as wireless microphones[3]
In this paper , we propose several variants of the modulation scheme that aim at reducing the BER performance. The first modulation scheme we have used is BPSK, second is QPSK and third is 16 QAM. Three different FEC used are Convolutional Coding, Reed Soloman Coding & Low Density Parity check.All the three FECs described in section III.

II. PHYSICAL LAYER SPECIFICATION(WRAN)

The IEEE 802.22 standard has specified the physical layer and cognitive radio functions to operate on the TV bands. This standard provides wireless broadband access over a large area (30km-100km) on the VHF/UHF TV broadcast frequency bands of the range between 54 MHz and 862 MHz. The working of physical layer of IEEE 802.22 is based on OFDMA (orthogonal frequency division multiple access) scheme in the Time Division Duplex (TDD) Mode,with plans to define a frequency division duplex mode as a future amendment to the standard and it is close to IEEE 802.16e. OFDMA symbols are created

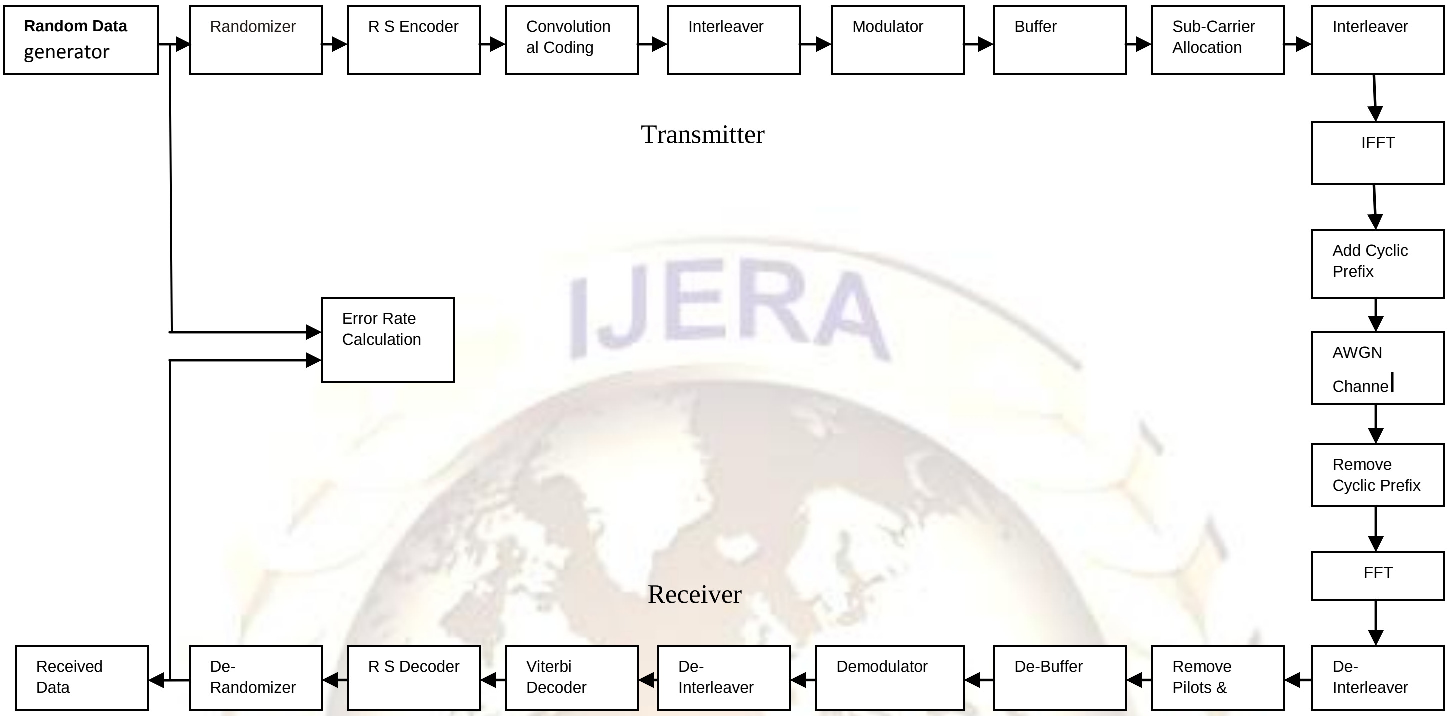

Fig.1 Physical Layer Block Diagram Based on IEEE 802.22 WRAN

using the 2048 FFT on 6,7, and 8 MHz bandwidth which consist of 1440 data subcarriers , 240 pilot subcarriers and 380 guard and DC subcarriers[2].In such a system cyclic prefixes lengths can be 1/4 , 1/8,1/16 and 1/32 of OFDMA symbol duration[3].In this paper we have designed the end to end simulation model of physical layer of WRAN(IEEE 802.22) in MATLAB for US direction.(2)

As seen from Fig. 1[9] , firstly we get random binary data generation then randomization is done, Randomizer operates on a bit by bit basis. The purpose of the scrambled data which is coming from the random data generator ,is to convert long sequences of O's or 1 's in a random sequence to improve the coding performance. The main component of the data randomization is a Pseudo Random Binary Sequence generator which is implemented using Linear Feedback Shift Register[5].

The generator defined for the randomizer is given by Equation[5]

$$1+X^{14}+X^{15} \qquad \text{……….(1)}$$

This randomized data is then coded for forward error correction using convolutional coding or reed soloman coding or low density parity check(LDPC) code etc. In this paper, we have used all these three coding. The working of interleaver is same as a randomizer but it is quite different from the randomizer in the sense that it does not change the state of the bits but it works on the position of bits. Interleaving is done by spreading the coded symbols in time before transmission. The incoming data into the interleaver is randomized in two permutations. First permutation ensures that adjacent bits are mapped onto non-adjacent subcarriers. The second permutation maps the adjacent coded bits onto less or more significant bits of constellation thus avoiding long runs of less reliable bits.

The first permutation is defined **by** the formula:

ink =(Ncbps/ **12)** * mod(k, 12) **+** floor(k/ **12)**

The second permutation is defined **by** the formula:

s = ceil(Ncpc/2)

jk = s * floor(mk / s)+ (ink + Ncbps - floor(2 xmk / Ncbps))mod(s)

where:

Ncpc = Number of coded bits per carrier

Ncbps= Number of coded bits per symbol

k= index of coded bits before first permutation

mk=Index of coded bits after first permutation

jk=Index of coded bits after second permutation

Same permutation is done on the receiver side to rearrange the data bits into the correct sequence[5].

The interleaver sends the data frame to modulator.The buffer puts several burst together that is 5 burst makes 1440 data sub-carriers. Now the pilots are inserted within the data sub carriers. Fig. 2 shows the pilot insertion pattern which is repeated in every 7 OFDM symbols and 7 subcarreirs. the best performance for channel estimation can be obtained through using pilots to meet on every sub-carrier after waiting 7 OFDMA symbols.Utilizing this pattern , all CPEs within a channel can have good channel estimation.This scheme uses the 2048 FFT mode on 6MHz,7 MHz and 8MHz The subcarriers are classified as data subcarriers (1440), pilot subcarriers (240), guard and DC subcarriers (380)[2].After insertion of pilot , guard , DC subcarriers & subcarrier interleaving the IFFT is operated on them to create OFDM symbol . Finally the last part of OFDM symbol , as a cyclic prefix , is added to the beginning. After all these operations, the data are ready to be delivered to the channel [1].

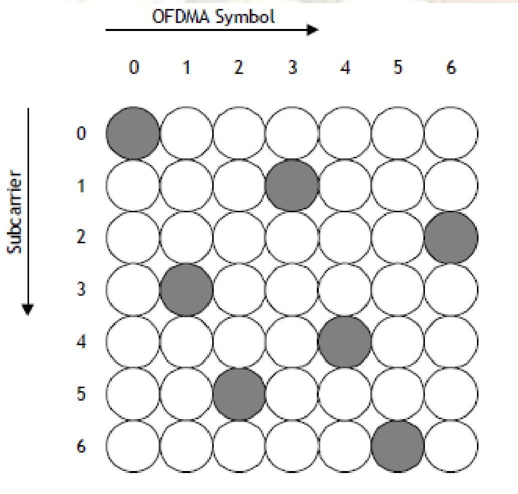

Fig.2 pilot pattern

III. FORWARD ERROR CORRECTION(FEC) TECHNIQUES

Forward Error Correction is done on both the Uplink and the Downlink bursts, and can consist of Convolutional Coding,Reed Soloman Coding and LDPC.

Convolutional Coding

Convolutional codes are used to correct the random errors information symbol to be in the data transmission. A convolutional code is a type of FEC code that is specified by CC(m, n, k), in which each m-bit encoded is transformed into an n-bit symbol, where m/n is the code rate (n > m) and the transformation is a function of the last k information symbols,where k is the constraint length of the code.[5]

Reed Soloman Coding

The purpose of using Reed-Solomon code to the data is to add redundancy to the data sequence. This redundancy addition helps in correcting block errors that occur during transmission of the signal. After randomizer data is passed onto the Reed Solomon Encoder. The encoding process for RS encoder is based on Galois Field Computations to do the calculations of the Redundant bits. Galois Field is widely used to represent data in error control coding and is denoted by $GF(2^m)$.RS encoder requires two polynomials , one is code generator polynomial g(x) which is used for generating The Galois Field Array and second one is field generator polynomial p(x) used to calculate the redundant information bits which are appended at the start of the output data [5]. These polynomials are defined by the standard [6].

Low Density Parity Check(LDPC) coding

Low-Density Parity-Check (LDPC) codes were first introduced by Gallager in [7].LDPCs are linear block codes with a sparse m×n parity check matrix H satisfying the following properties.

1.There are w_r 1s in each row of H, where $w_r << \min\{m,n\}$

2. There are w_c 1s in each column of H, where $w_c << \min\{m,n\}$

The density of a LDPC code is denoted by r and defined by

$r= w_r /n= w_c /m$

or

$m/n= w_c / w_r$

If the matrix H is full rank , then m=n-k

$Rc =1-m/n=1- w_c / w_r$

Otherwise $Rc =1-\text{rank}(H)/n$

The tanner graph of a regular low density parity check code consists of the usual constraint and variable equal to w_r which is much less then the code block length. Similarly the degree of all variable nodes is equal to w_c nodes[8]. The low density constraint of the code however makes the degree of all constraint(parity check) nodes

IV. PERFORMANCE EVALUATION/ RESULTS

To evaluate the simulation results, we used the analytical formula in [8]. BER measurements for BPSK, QPSK and 16 QAM is shown by fig.(3,4,5) with code rates 1/2 respectively. While formula used are as follows:-

$BER_{BPSK} = Q(\sqrt{(Eb/No)})$

$$BER_{QPSK} = Q(\sqrt{(2.Eb/No)})$$

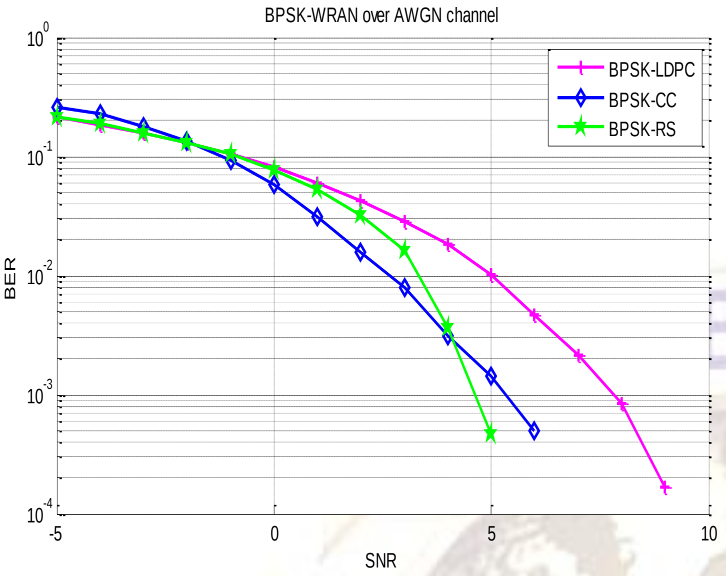

Fig.3

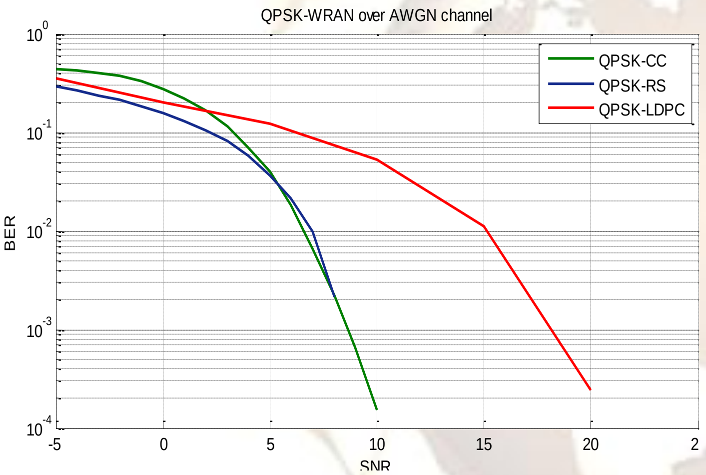

Fig.4

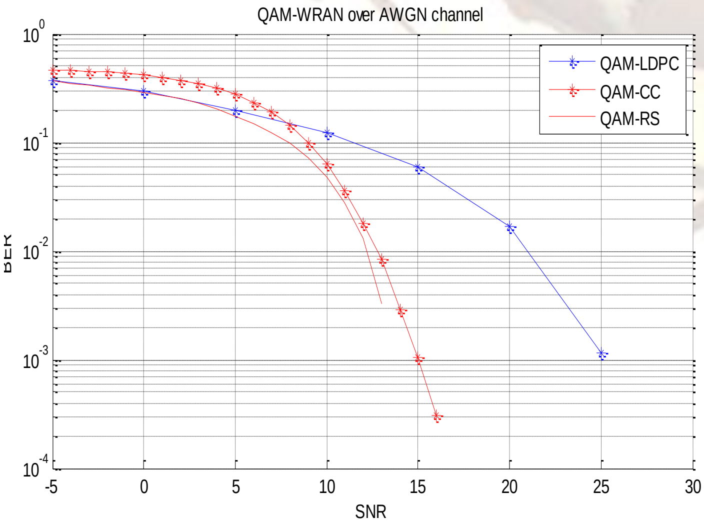

Fig 5

$$BER_{16QAM} = 3/2\times Q(\sqrt{((6\log_2{}^4)Eb/(4^2-1)No)})$$

V. CONLUSION

In this paper , we have presented the baseband simulation model and results for the physical layer of IEEE 802.22 OFDMA based WRAN. We have obtained BER versus SNR curves for different modulation scheme with different FEC techniques.These results will help to design an efficient WRAN system and will increase the efficiency of utilization of the spectrum and provide large economic and social benefits.

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