INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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BER PERFORMANCE ANALYSIS OF WRAN IEEE 802.22 USING FORWARD ERROR CORRECTION

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Accepted Date:
27/02/2013
Publish Date:
01/04/2013

Keywords
WRAN;
IEEE802.22;
PHY layer;
CR;
OFDMA

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Abstract

IEEE 802.22 WRAN (Wireless Regional Area Network) is the first wireless standard which provides the unlicensed operation in VHF/UHF TV broadcast bands from 54 MHz to 862 MHz with full features of CR technologies. The IEEE802.22 working group was formed in November 2004. The first draft of the standard was available in May 2006 but much work still pending however the standard was expected to finalize in first quarter of 2010 but was finally published in July 2011[1]. In this paper to evaluate the BER performance of the system, its Physical layer is introduced & modeled in MATLAB [2]. To evaluate the performance of the system we draw out the BER (Bit error Rate) of the system for QPSK & QAM-16 modulation scheme with Noisy & Fading channel.

INTRODUCTION

The TV broadcast bands in the high-VHF/low-UHF range are ideal for covering large areas in sparsely populated rural environments because of lower industrial noise and ionospheric reflections, reasonable antenna sizes, and good non-line-of-sight (NLOS) propagation characteristics. The development of the IEEE 802.22 WRAN standard is aimed at using cognitive radio techniques to allow sharing of geographically unused/underused spectrum allocated to the television broadcast service, on a non interfering 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. CR effectively reuses the finite frequency resources by intelligent recognition of ideal frequency bands using spectrum sensing [3][4][5]. 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 [6].

The IEEE 802.22 WRAN standard will provide wireless broadband access to a rural area of typically 17–30 km or more in radius (up to a maximum of 100 km) from a base station (BS).[6] It can serve up to 255 fixed units of customer premises equipment (CPE) with outdoor directional antennas located at nominally 10 m above ground level, similar to a typical VHF/UHF TV receiving installation. The minimum peak throughput delivered to CPE at the edge of coverage will be equivalent to 1.5 Mb/s in the downstream (DS) direction (BS to CPE) and 384 kb/s in the upstream (US) direction (CPE to BS).

Basically WRAN system has the similar aspects of WiMAX. The key difference is the service cell coverage and the coexistence with the Primary users which has the priority rights on the TV bands. WRAN is fixed point to multi-point (PMP) system and its connectivity between the base station (BS) and the Consumer premise Equipments (CPEs) is possible in both line-of-sight (LOS) and non line-of-sight (NLOS) situations.

2.PHYSICAL & MAC LAYER

The physical layer & MAC layer performs important task in the operation of WRAN. The PHY layer performs the three primary functions-the main data communication, the spectrum sensing function & the geolocation function. The last two provides the necessary functionality to support the cognitive abilities of the system. The physical layer must be able to adapt to different conditions. Also it should be flexible for jumping from one channel to another without error in Transmission and hence this feature of physical layer is known as dynamic frequency hopping required for adjusting The Band width dynamically, modulation and coding scheme. MAC layer is based on cognitive Radio technology. The MAC layer has two structures frame and super frame. A super frame will be formed by many frames. The Super Frame will have a super frame control header and a preamble. These will be sent by the base station in every channel when a CPE is turned ON, it will sense the spectrum, find out which channels are available and will receive all the information to attach to the BS.

3.IEEE 802.22 PHY layer system model overview

It supports multiple physical specifications. The 802.22 OFDMA PHY is based on OFDMA modulation, which includes OFDM modulation & subcarrier allocation.

A.OFDMA

OFDM belongs to a special transmission scheme of multicarrier modulation in which high bit rate data stream is divided into several parallel lower bit rate streams. Each stream is modulated on separate carrier called, subcarriers .OFDM is the most spectral efficient version of the multicarrier modulation. In OFDM all the subcarrier are orthogonal to each other over one symbol duration. Because of the orthogonality there is no need of non overlapping subcarriers to eliminate the ICI [7] now the subcarriers overlap to each other thus saves the bandwidth. The no. of subcarriers in the OFDMA symbol is always the size of FFT. There are no. Of subcarriers in the OFDMA symbol as follows

- Data carriers- carries the useful data

• Null carriers-no data is transmitted on these carriers & are used to prevent leakage of energy into adjacent channels

• Pilot carrier -are used for channel estimation & synchronization purpose

Since the OFDMA is the multiuser version of OFDM so to enable the multiple access sub channels are used which are formed by grouping the data subcarriers. The all subcarrier that are used to make a sub channel are distributed across all the subcarriers. Number of different sub channels is allocated to the particular user in order to send & receive data. There are two parts in one OFDMA symbol in time domain. The cyclic prefix (CP) time & useful symbol time. CP is used to remove the effect of ISI & ICI in multipath scenario.

CP is the copy of the last part of the OFDM symbol which is appended in the front of the transmitted OFDM symbol. The length of CP or guard time interval must be chosen such that it is longer than the maximum delay spread of the multipath channel [7]. The figure 1 shows the advantage of CP.

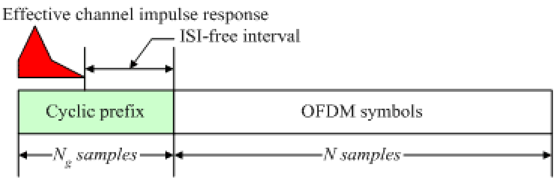

Fig 1. Cyclic Prefix addition

B.Simulation model

Matlab has been used to simulate the physical layer of the system [2].

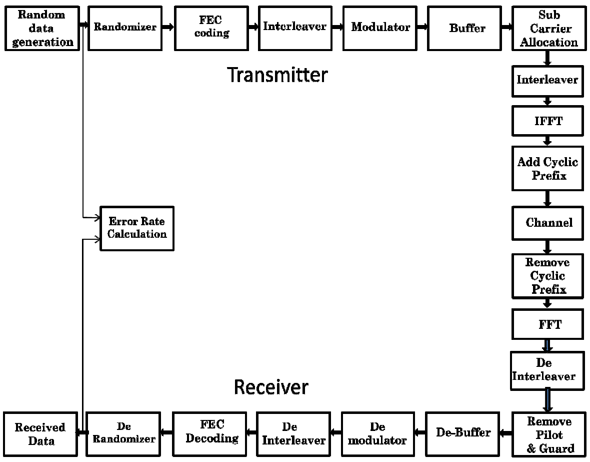

Fig 2. PHY layer set up

1) Random data generation- Random binary data is generated for simulation purpose.

2) Randomizer- Convert the binary sequence to the random sequence to avoid long sequence of ‘0’ & ‘1’ to improve Synchronization.

3) FEC coding- Convolution code with code rate ½ is used as FEC.

4) Interleave- It rearranges the ordering of the sequence of the symbols in predefined manner. Two types of interleaving are used i.e. Time Interleaving & Frequency interleaving.

5) Modulator-QPSK & QAM 16 modulations are used for simulation.

6) Buffer- Buffer is used to stack the data.

7) Subcarrier allocation- Pilots are guard subcarrier are inserted in this stage.

8) IFFT- Inverse fast Fourier Transform converts the frequency domain data set into corresponding time domain. It also generates the sample of the waveform which satisfies the condition of orthogonality.

9) Cyclic prefix- CP copies the last section of a symbol &pastes it to the beginning of symbol. After these operations the data are delivered to the channel[8]

10) Channel- AWGN & RICIAN channel are used for simulation in this paper.

C. Forward Error Correction

Convolutional code

Convolution code with code rate ½ is the only mandatory code for WRAN system. They operate on data stream, not static block.

Convolutional codes have memory that uses previous bits to encode or decode following bit. It is denoted by (n,k,L) where L is the memory depth. In Matlab Trellis description is used to to define encoder connections. Viterbi algorithm is used for decoding.

4.SIMULATION PARAMETERS

Primitive parameter

TV channel bandwidth (MHz)- 6,7 or 8 MHz

Total no. of subcarriers **- 2048**

No. of guard subcarriers - 368

No. of used subcarrier – 1680

No. of data subcarriers- 1440

No. of pilot subcarriers- 240

Guard time to useful symbol time ratio-1/8

5. RESULTS

Fig. 3 shows SNR vs BER performance of WRAN without FEC using QPSK & 16-QAM in AWGN channel. Fig .4 shows SNR vs BER performance of Convolution code using QPSK & 16-QAM in AWGN channel. Fig 4 presents improvement in performance as compared to Fig.3 as it shows for BER value of 10^{-3}, QPSK gives approximate 5 dB gain & 16-QAM gives approximate 2.5 dB gain.

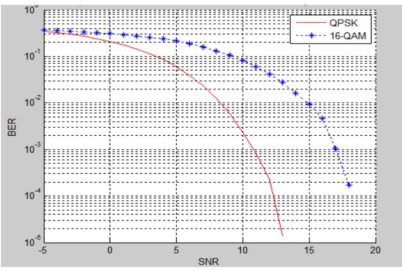

Fig. 3 BER vs SNR performance of WRAN without FEC using QPSK & 16-QAM in AWGN channel.

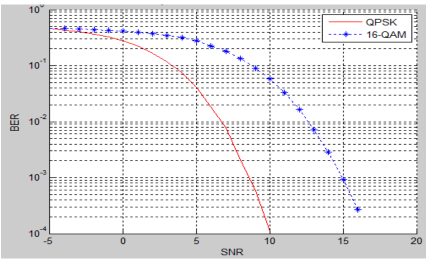

Fig.4 BER vs SNR performance of WRAN with CC using QPSK &16-QAM in AWGN channel.

Fig. 5 shows SNR vs BER performance of WRAN without FEC using QPSK & 16-QAM in RICIAN channel. Fig.6 shows SNR vs BER performance of Convolution code using QPSK & 16-QAM in RICIAN channel. . Fig 6 presents improvement in performance as compared to Fig.5 as it shows for BER value of 10^{-3} ,QPSK gives approximate 3 dB gain & 16-QAM gives approximate 1.3dB gain.

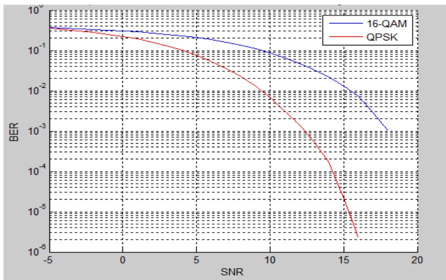

Fig. 5 BERvs SNR performance of WRAN without FEC using QPSK & 16-QAM in RICIAN channel.

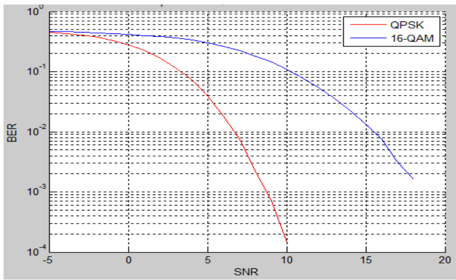

Fig.6 BER vs SNR performance of WRAN with CC using QPSK &16-QAM in RICIAN channel.

6. CONCLUSION

In this paper IEEE802.22 PHY layer is simulated & performance curve are concluded for AWGN & RICIAN channel. It has concluded that CC gives significant performance improvement to without coding. Same simulation can be carried out for other fading channel with different FEC & different code rate for future work.

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