ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

An Efficient Communication System for Wireless Regional Area Network using Digital Modulation Techniques

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ABSTRACT: In this paper, a Digital Communication System of Wireless Regional Area Network is designed using MATLAB. Here we use Convolutional encoding for the data bits generated by binary source. Randomization and Interleaving of the data bits is employed to remove various errors that occur in Digital Communication System. Different modulation techniques are employed to achieve maximum data rate and minimum Bandwidth. AWGN and RICIAN channel models are used which demonstrates the effects of multipath fading in air interface. Signal to Noise Ratio and Bit Error Rate are the parameters which are used to compare the performance of WRAN.

KEYWORDS: AWGN, BPSK, Cognitive Radio, Line of Sight, Non Lone of Sight, OFDMA, QAM, MIMO, QPSK. WRAN.

I.INTRODUCTION

In developing countries like China and India, about 70 percent of the total populations live in rural areas, which are spread far and wide over large geographic areas. For these communities, it is believed that providing communications services are an important step to facilitate development and social equity. However, providing communications to rural area is always challenging due to higher costs and lower demand. Most rural areas have low demand for services if compared to urban areas. To create a viable business, operators must aim for low-cost solutions. There are various standards developed and are used for the wireless communication. Wireless systems based on IEEE 802 standards such as IEEE 802.11 (WLAN) so-called Wi-Fi and IEEE 802.16 (WMAN) so-called WiMAX are examples of Broad Wireless Access (BWA) systems deployed for local and metropolitan area networks, respectively. These technologies have advantages and some drawbacks. Wireless Regional Area Network is an IEEE 802.22 standard which uses white spaces of the TV frequency spectrum. It uses Cognitive Radio to detect unused TV stations.

Cognitive radio is an intelligent software radio which changes its parameters according to available TV channels. The main functions of Cognitive Radio include Spectrum sensing, dynamic spectrum management and Adaptive communications. The development of the IEEE 802.22 WRAN standard is aimed at using cognitive radio (CR) techniques to allow sharing of geographically unused spectrum allocated to the television broadcast service, on a non-interfering basis, to bring broadband and access to hard-to-reach, low population density area, typical of rural environments, and is therefore timely and has the potential for a wide applicability worldwide.

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. The standard typical support range is 30 km. meeting the demands of rural areas, but based on propagation conditions it may cover up to 100 km. The minimum data rate of the system is 1.5 Mb/s in the downstream (DS) direction, i.e. from BS to CPE and 384 kb/s in the upstream (US) direction, i.e. from CPE to BS. It is expected that a BS supports up to 255 CPEs. OFDMA is also a candidate access method for the IEEE 802.22 wireless regional area network.

II. LITERATURE SURVEY

This section includes detailed literature survey which gives information about existing work and other data which helped us to develop our project.

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Sung Hyun Hwang, “Design and Verification of IEEE 802.22 WRAN Physical Layer” (1). This paper describes the design and verfification of IEEE 802.22 WRAN physical layer.
Dr. K. V. Samba Siva Rao, A. Sudhir Babu, “Evaluation of BER for AWGN, Rayleigh and Rician fading channels under various modulation techniques” (2). In this paper the author has evaluated the performance of transmission mode by calculating the probability of BER versus SNR under three Wireless Channel model.
Ying-Chang Liang, “Cognitive Radio on TV Bands: A New Approach to provide Wireless Connectivity for Rural Areas” (3). In this paper this author has presented the challenges of rural communication and reviewed the existing technologies. A brief overview of cognitive radio technology is presented.
“Physical layer performance: Testing the BER”, Technical article, Light wave magazine, September 2004 (4). This article reviews the BER requirements to telecommunication protocols.
Dave Caval Canti, Monisha Ghosh, “Cognitive Radio Networks: Enabling New Wireless Broadband Opportunities” (5). In this paper author has presented the shared spectrum access model and spectrum management model.
Vahid Meghdadi, “BER Calculation” (6). In this paper author has presented the different methodologies to calculate BER for different modulation techniques.
Santa Rahaman, “Comparitive Study between WRAN and WiMAX and Coverage Planning of a Wireless Regional Area Network using Cognitive Radio Technology”, (7). A comparative study between WRAN and WiMAX is given in this paper.

Comparison between IEEE 802.16e and IEEE 802.22 standards.

	IEEE 802.16E	IEEE 802.22
Coverage Area	1-5Km	33-100Km
Air Interface	OFDMA, OFDM, Single carrier	OFDMA
Multiple Antenna techniques	Support Multiplexing, space time coding and Beam forming	Not supported
Coexistence with	Not supported	Spectrum sensing management
Incumbent		Geo Location management, incumbent database query and channel management
OFDMA channel profile (MHz)	28, 20, 17.5, 14, 10, 8.75, 7, 3.5, 1.25	6,7,8 (According to Regulatory Domain)
Self-coexistence	Master frame assignment	Dynamic spectrum assignment

Table 1: Comparison between IEEE802.22 and 802.16e

III.SYSTEM MODEL AND ASSUMPTIONS

The functional Block Diagram of Digital Communication System is as shown below. The upper blocks consists of format, source encode, encrypt, channel encode, multiplex, modulate, frequency spread, multiple access which denote

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ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

signal transformation from source to the transmitter. The lower blocks denote the signal transformation from the receiver to the destination.

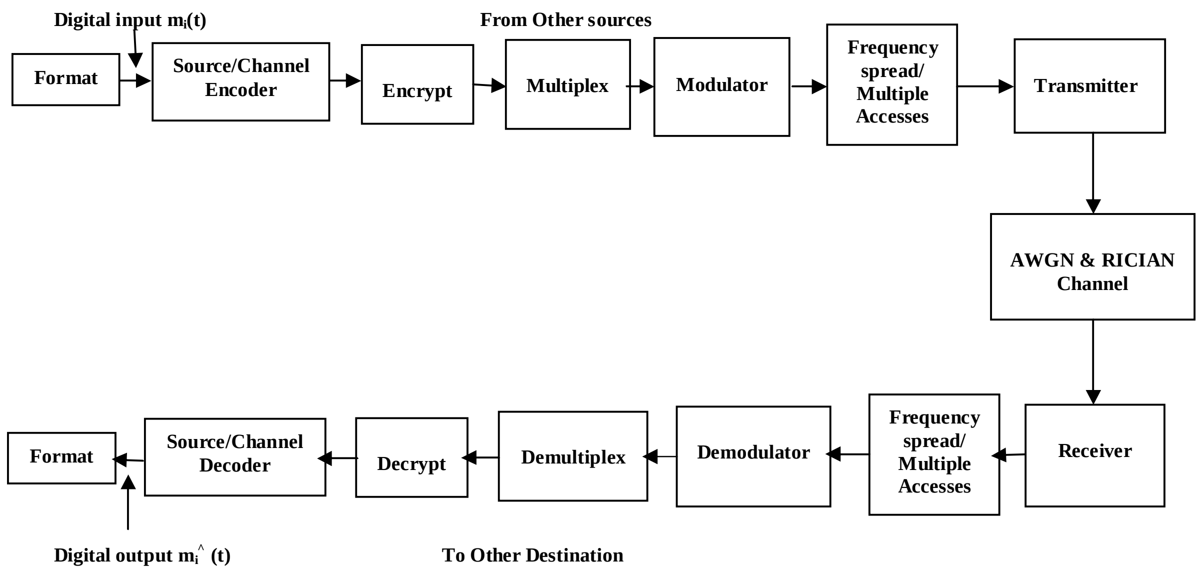

Figure1: Block Diagram of Communication System

Formatting transforms the source information into digital symbols and makes the source compatible with all signal processing steps within the Digital Communication system. Here we have used camera man image as the input to the system which is resized and converted into digital form for the Digital Signal processing, this digital data is given to the source encoder. Source encoding eliminates the redundant information in the source and thus, helps in conserving the system bandwidth. For source encoding we have used randomization to avoid long series of 1's and 0's and interleaving to avoid burst error.

Channel encoding for a given data rate can reduce the probability of bit error but at the cost of system Bandwidth. Frequency spreading can produce a signal which is less susceptible to interference and enhance the privacy of the communicators. Here we use Convolutional coding which is a special case of error-control coding. Unlike a block coder, a convolutional coder is not a memory less device. Encryption prevents unauthorized users from understanding the messages and injecting false messages into the system.

Modulation is the process by which the symbols are converted to waveforms that is compatible with the communication channel. Modulator changes the characteristics of modulating signal. Several Digital Modulation Techniques exists, in this project we use BPSK and QPSK modulation techniques, in phase shift keying the phase of the carrier is changed according to the modulating signal which is digital in nature. In BPSK carrier gets 0 or 180 degree phase shift corresponding to two different voltage level of binary modulating signal. In this method transmitted signal is a sinusoid of fixed amplitude. It has one fixed phase when the data is at one level and when the data is at another level the phase is different by 180.

Thus the transmitted signal is either –

$$VBPSK(t) = \sqrt{2PS}\cos(\omega 0t).$$

$$\text{Or } VBPSK(t) = \sqrt{2PS}\cos(\omega 0t+\pi) \text{ Or } VBPSK(t) = -\sqrt{2PS}\cos(\omega 0t).$$

The received signal has the form VBPSK=b (t) $\sqrt{2Ps}\cos(w0t+\alpha)$ here b (t) is the message signal. In QPSK four different symbols gibe different phase shift to the carrier. These four symbols are 00, 01, 10 and 11.

Modulation techniques are expected to have the following [2] characteristics:

1. Good Bit Error Rate Performance: Modulation schemes should achieve low bit error rate in the presence of fading, Doppler spread, interference and thermal noise.
2. Power Efficiency: Power limitation is one of the critical design challenges in portable and mobile applications. Nonlinear amplifiers are usually used to increase power efficiency. However, nonlinearity may degrade the bit error rate performance of some modulation schemes. Constant envelope modulation techniques are used to prevent the re growth of spectral side lobes during nonlinear amplification.
3. Spectral Efficiency: The modulated signals power spectral density should have a narrow main lobe and fast roll-off of side lobes. Spectral efficiency is measured in units of bit /sec/Hz.

Frequency spreading can produce a signal which is less susceptible to interference and hence can enhance the privacy of the communicators. Multiplexing and multiple access procedures combine different types of signals so that they can share a part of communication resource. OFDMA is a candidate access method used to access WRAN by various CPE's at a time.

CHANNEL MODEL: The main problem [2] faced by Wireless communication is fading of carrier modulated signal in air interface. Fading of the signal occurs due to multipath propagation and is sometimes known as multipath induced fading. Multipath is the propagation phenomenon that results from radio signals reaching the receiving antenna by two or more paths. Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and reflection from terrestrial objects, such as mountains and buildings. The effects of multipath include constructive and destructive interference, and phase shifting of the signal. This distortion of signals caused by multipath is known as fading. In other words it can be said that in the real world, multipath occurs when there is more than one path available for radio signal propagation. The phenomenon of reflection, diffraction and scattering all give rise to additional radio propagation paths beyond the direct optical LOS (Line of Sight) path between the radio transmitter and receiver. Simulating the channels for wireless system is very important for the design and performance evaluation of WRAN, we use AWGN an RICIAN channel models [2].

1. RICIAN fading model: It is used in multipath reception which gives a statistical model for the effect of propagation environment on a radio signal. A strong dominant component is present in this model i.e. non fading signal and is commonly known as LOS.

2. AWGN fading model: The below diagram shows the AWGN channel model where transmitted signal gets distributed by a simple additive white Gaussian noise process.

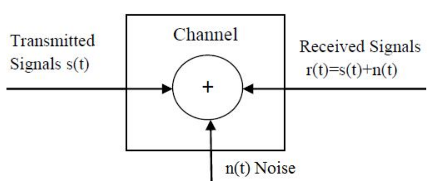

Figure 2: Block Diagram of AWGN Channel model.

It is the simplest radio environment in which wireless communication system or a local positioning system or proximity detector based on time-of-flight will have to operate in the AWGN environment.

III.SYSTEM IMPLIMENTATION

A.BINARY DATA SOURCE: Here we are using camera man image as the input, this image is converted into digital form for further use. A = imread(filename, fmt) is the command used to read image from the destination into the System, this digital image acts as binary data source.

B.RANDOMIZER AND DE-RANDOMIZER: The Randomizer consists of Linear Feedback Shift Register and XOR gate. By randomizer, binary sequences are converted to the random sequences to avoid long series of '0's or '1's.
Figure 3 shows the process of randomization employed using linear feedback shift register and EX-OR gate.

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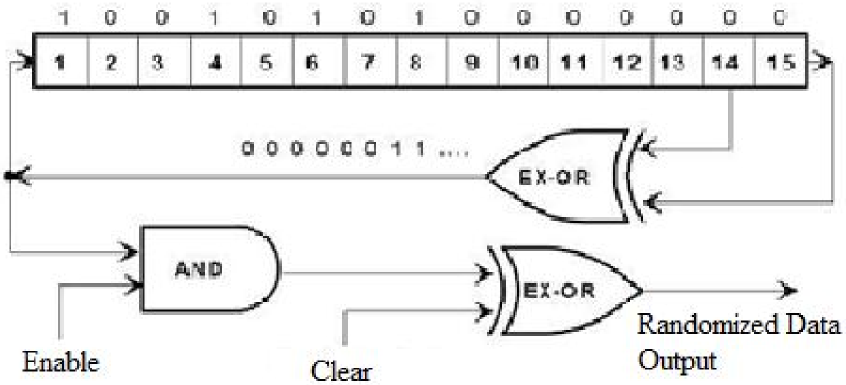

Figure 3: Randomizer/De-randomizer Circuit.

The matlab function randperm performs randomization; randperm(n,k), p contains k unique values. randperm performs k-permutations (sampling without replacement). Figure 4 shows the simulation results of Randomizer and De-Randomizer simulated using Matlab.

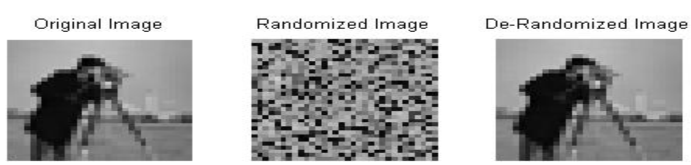

Figure 4: Simulation results of Randomizer/ De-Randomizer.

C.CONVOLUTIONAL ENCODER: The Encoder block encodes a sequence of binary input vectors to produce a sequence of binary output vectors. Convolutional coding is a special case of error-control coding. Unlike a block coder, a convolutional coder is not a memory less device. Even though a convolutional coder accepts a fixed number of message symbols and produces a fixed number of code symbols, its computations depend not only on the current set of input symbols but on some of the previous input symbols. Figure 4.6 represents the convolutional encoder using low-level delay and sum (XOR) blocks. If the encoder takes k input bit streams (that is, it can receive 2k possible input symbols), the block input vector length is L*k for some positive integer L. Similarly, if the encoder produces n output bit streams (that is, it can produce 2n possible output symbols), the block output vector length is L*n. This block accepts a column vector input signal with any positive integer for L. For variable-size inputs, the L can vary during simulation. The operation of the block is governed by the Operation mode parameter. For both its inputs and outputs for the data ports, the block supports double, single, boolean, int8, uint8, int16, uint16, int32, uint32, and ufix1. The port data types are inherited from the signals that drive the block. The input reset port supports double and boolean typed signals. The function convenc (msg, trellis, init_state) encodes the binary vector message using the convolutional encoder; vector message contains one or more symbols. The output vector code contains one or more symbols, each of which consists of log2 (trellis.numOutputSymbols) bits.

D.VITERBI DECODER: Decodes convolutionally encoded data using Viterbi algorithm; if the convolutional code uses an alphabet of 2n possible symbols, this block's input vector length is L*n for some positive integer L. Similarly, if the

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decoded data uses an alphabet of 2k possible output symbols, this block's output vector length is L*k. This block accepts a column vector input signal with any positive integer value for L. For variable-sized inputs, the L can vary during simulation. The operation of the block is governed by the operation mode parameter. There are three main components to the Viterbi decoding algorithm. They are branch metric computation (BMC), add-compare and select (ACS) and trace back decoding (TBD).

E.INTERLEAVER AND DEINTERLEAVER: In telecommunication, a burst error or error burst is a contiguous sequences of symbols, received over a data transmission channel, such that first and last symbols are in error, interleaver is used to control this burst error. Figure 5 shows the operation of Interleaving and Deinterleaving,

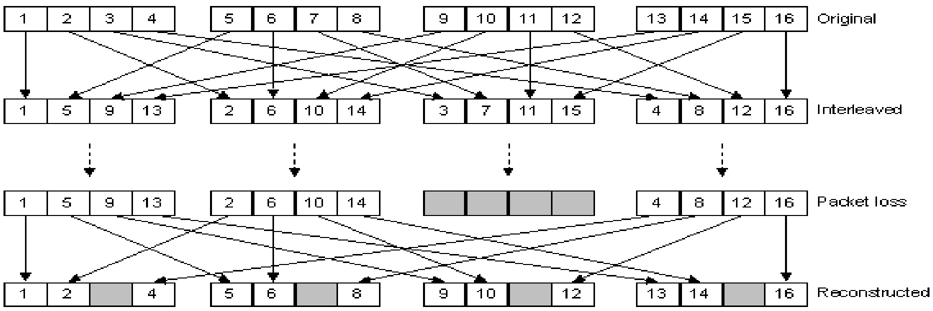

Figure 5: Interleaving and Deinterleaving.

IV. SIMULATION RESULTS

The figure 6 shows the simulation results of the project. Here we have considered digital image as the binary data for the simulation. The decoded image is recovered for the given SNR of 10dB.

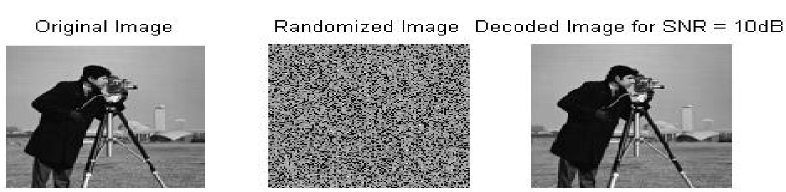

Figure 6: Original Image and Decode Image

Modulation techniques used are BPSK and QPSK; figure 7 shows the BER versus SNR plot of WRAN Using BPSK and QPSK modulation techniques for RICIAN channel. According to BER curves for a given BER the SNR is less in BPSK for RICIAN channel, hence BPSK gives higher performance for WRAN

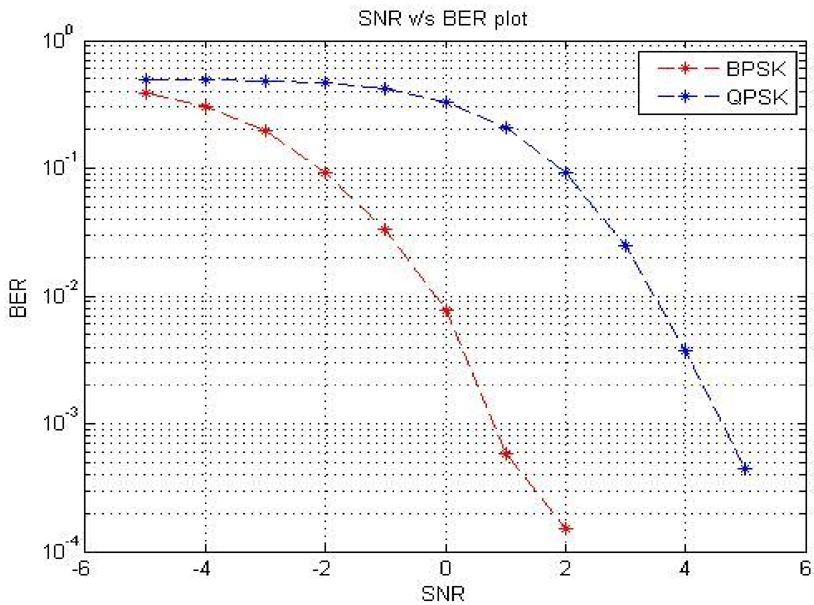

Figure 7: BER Vs SNR Plot for WRAN Over RICIAN Channel

V.CONCLUSION AND FUTURE WORK

In this project, we have shown the design and implementation of Encoder and Decoder which uses Convolutional encoding and Viterbi Decoding algorithm, Randomizer which is used to convert binary sequence into random sequence to avoid long sequence 0's and 1's, Interleaver and Deinterleaver which avoids burst error over the communication link. Modulation technique used is BPSK for RICIAN channel. OFDMA is a candidate access method used to access WRAN.A graph of BER versus SNR is obtained which shows that BPSK is more efficient than QPSK for RICIAN channel. Future work includes comparison of BER versus SNR for QAM and MIMO.

VI. ACKNOWLEDGEMENT

My sincere thanks to my guide **Dr. M. Nagaraja**, Associate Professor, Department of E&C, S.S.I.T Tumkur, **Dr. M.Z Kurian** HOD Dept of ECE SSIT Tumkur for their guidance, constant encouragement and wholehearted support.

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ISSN (Online): 2278 – 8875

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(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2014

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