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Comparative Study between Wireless Regional Area Network (IEEE Standard 802.22) and WiMAX and Coverage Planning of a Wireless Regional Area Network Using Cognitive Radio Technology

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Abstract: ***The first worldwide application of cognitive radio (CR) networks in unlicensed television broadcast bands is IEEE 802.22 wireless regional area network (WRAN). This paper introduces the implementation of IEEE 802.22 Wireless Regional Area Network (WRAN) for broadband Internet access in sub-urban areas. We have investigated how CR through dynamic spectrum access facilitates the efficient use of underutilized spectrum (white spaces). To do this, we have analyzed a coverage planning for WRAN and compared it with a traditional wireless communication standard, IEEE standard 802.16e. We have also observed the comparison for different modulation schemes and shown the results in graphical form.***

Index Terms: CR, TVWS, WiMAX, WRAN.

I. INTRODUCTION

Most of the useful radio spectrum is currently occupied by licensed users such as GSM, WCDMA and TV [1]. However, studies show that RF spectrum is not properly utilized in sub-urban and rural areas [1]. CR is considered as most emerging technology capable of dynamically accessing the underutilized spectrum (white spaces) without causing harmful interference to incumbent users and other secondary users [1]. It is the first initiative to define a standardized air interface based on CR techniques for the opportunistic use of TV bands on a non-interfering basis. WiMAX is based on OFDMA for uplink transmission and on OFDM for downlink. On the other hand, cognitive radio network technology uses OFDMA technique for both uplink and downlink transmission [3].

II. DESCRIPTION OF STANDARDS

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The WiMAX (IEEE Standard 802.16e) technology is widely used now-a-days whereas WRAN (IEEE Standard 808.22) is a developing project of IEEE which was finally published in July 2011.

2.1 WiMAX (IEEE Standard 802.16e) overview

WiMAX is a standards-based wireless technology that provides high-throughput broadband connections over long distances and mobile environment. The IEEE 802.16e is based on Orthogonal Frequency Division Multiple Access (OFDMA) whose main aim is to give better performance in non-line-of-sight (NLOS) environments [5]. IEEE 802.16e introduced scalable channel bandwidth up to 20 MHz, Multiple Input Multiple Output (MIMO) and MAC enabled 802.16e technology to support peak downlink (DL) data rates up to 63 Mbps in a 20 MHz channel through Scalable OFDMA (S-OFDMA) system [4][5].

2.2 WRAN (IEEE Standard 802.22) Overview

The idea behind 802.22 is that there are considerable unused frequencies between VHF and UHF broadcast channels between 54 and 862 MHz [3].
This is possible by using cognitive radio capabilities. These include dynamic spectrum access, incumbent database access, accurate geolocation techniques, spectrum sensing, spectrum etiquette, and coexistence for optimal use of the available spectrum. Essentially this means that it will be possible to send wireless broadband access without interfering with TV signals [6].
It is designed for last-mile service in low populated areas especially rural area. The CR base station covers an area between 33 km (typical) to 100 km and the network is designated to provide the minimum throughput of 1.5 Mbps for the downstream and 384 kbps for the upstream [3].
In additional to conventional PHY and MAC layer functionalities, new features have been included in IEEE 802.22standard. These features are highlighted in the following:

2.2.1 Spectrum Manager (SM)

The SM uses the input from the spectrum sensing and geo-location and the primary user database to determine the TV channel for WRAN base station and the EIRP threshold for a particular WRAN terminals.

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2.2.2 Spectrum Sensing (SS)

The function of spectrum sensing is to analyze the spectrum in the interested channels to determine which channels are occupied by incumbents. In 802.22 standards both the base station (BS) and user terminal must have sensing capabilities but the final decision on channel selection is done by the BS [1].

III. COVERAGE PLANNING OF IEEE STANDARD 802.16e AND 802.22

Coverage planning basically focuses on the cell structure, network design, frequency usage policies. An effective coverage planning requires some pre-calculated parameters such as transmitter and receiver antenna height, distance between transmitter and receiver, signal to noise ratio, modulation schemes etc. WiMAX is based on OFDMA for uplink transmission and on OFDM for downlink [5].

TDM is used for creating bidirectional data links. On the other hand, WRAN technology uses OFDMA technique for both uplink and downlink transmission [3]. The aim of our paper is to review the coverage planning of existing WIMAX technology and try to improve the coverage range by using the IEEE Standard 802.22. We considered a sub-urban area for link budget calculations. Path losses are calculated by Cost-231 Hata Model. Before calculating path loss of Cost-231 Hata Model, some parameters are also calculated such as correction factor for effective mobile antenna height, carrier frequency, base station height, mobile station height, correction factor [2][3].

Our target is to observe the change of cell range with respect to transmitter height, modulation schemes and compare the results to find out the better coverage planning. 700MHz frequency band is used as a TVWS, transmitter and receiver heights are assumed as 30m and 5m. The parameters are considered for QPSK 1/2, QPSK 3/4, 16-QAM 1/2 and 64-QAM 3/4. The results are depicted in figure-1 and figure-2.

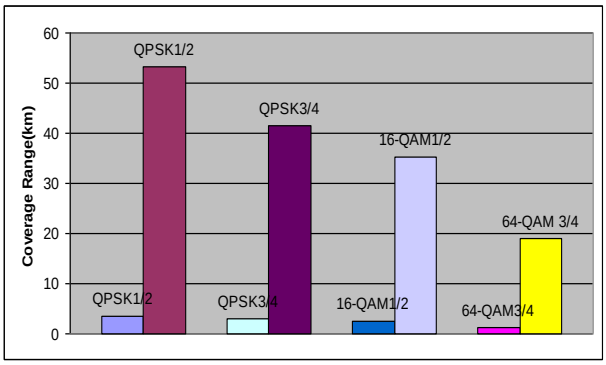

Figure 1: Downlink Coverage Range comparison between WiMAX and WRAN

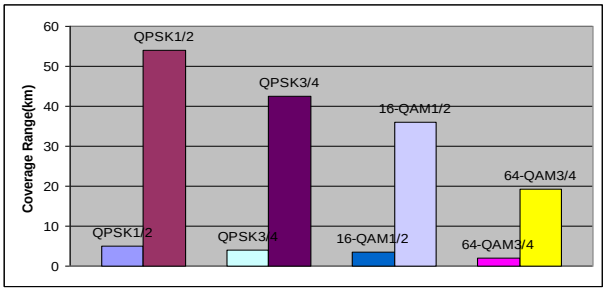

Figure 2: Uplink Coverage Range comparison between WiMAX and WRAN.

IV. COMPARISONSBETWEEN IEEE STANDARD 802.16e AND IEEE STANDARD 802.22

From the above figure, we have observed that coverage range for IEEE Standard 802.22 is much better comparing to IEEE Standard 802.16e which is fruitful for the increasing subscribers in the wireless communication world. The comparison between these two standards is given in Table-1.

Table-1: Comparison between IEEE 802.16e and IEEE 802.22 standards.

	IEEE 802.16E	IEEE 802.22
Coverage range	1-5 Km	33-100 Km
Air Interference	OFDMA, OFDM, single carrier	OFDMA
Multiple Antenna techniques	Support Multiplexing, space time coding and Beam forming	Not supported
Coexistence with incumbent	Not supported	Spectrum sensing management, Geolocation 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

V.CONCLUSION

IEEE 802.22 is a standard for Wireless Regional Area Network (WRAN) using white spaces in the TV frequency spectrum. The 802.22 standard is the first standard to adopt cognitive radio spectrum sensing as a means of gaining greater use of the radio spectrum. By using cognitive radio networking techniques, it is able to sense the environment and adjust the network to accommodate any changes.

This paper investigates on how Cognitive Radio Technology can be developed for better coverage range in sub-urban areas to support broadband access. We observe the comparison between 802.22 and 802.16e (WiMAX) in our work. Since 802.22 is mostly targeted at suburban and remote areas, its coverage range is considerably larger than 802.16e and it is up to 100 km which is far better than WIMAX. So, in our planning a huge number of subscribers can be connected to broadband access in suburban areas which is not possible by WIMAX. Also, 802.16e does not include incumbent protection techniques necessary to operate in licensed bands.

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