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Performance Analysis of Cognitive Radio for WiMAX Signals Using Cyclostationary Spectrum Sensing

Mandeep Singh, Charanjeet Singh,Amandeep Singh Bhandari

***ABSTRACT*- Due to the growing demand of wireless spectrum the Cognitive Radio (CR) is used for the spectrum utilization purpose. Basically the Licensed users use the licensed bands but with the help of CR technology, the licensed bands can also be provided to secondary users. The main aim of cognitive radio is to sense the spectrum continuously. In this paper, we provide the proposal that how the capacity of the system can be increased by reuse the unused licensed band by simulating a Cognitive radio system. The secondary users can occupy free space (spectrum holes) and also licensed bands by continuously monitoring the spectrum.**

Index Terms-**Cognitive Radio, OFDM, Rayleigh fading, Rician fading, Spectrum Sensing, WiMAX.**

I. INTRODUCTION

In present days, wireless communication is most popular communication technique. There are lots of constraints on the available radio spectrum. Radio spectrum is very limited for wireless communication. The Federal Communication Commission (FCC) research report states that, seventy percent of the allocated spectrum is underutilized. So there is a need of technique to deal with this problem. Cognitive radio is the hopeful key for the problem of 'spectrum shortage' caused by rapid development of wireless services. By using the definition adopted by Federal Communications Commission (FCC) "Cognitive radio: A radio or system that senses its operational electromagnetic environment and can dynamically and automatically changes its radio operating parameters to modify system operation, such as maximize throughput, reduce interference, facilitate interoperability, access secondary markets". This capability is a matter that involves technology, standards and spectrum policy and even requires changes in the business model.

CR is an intelligent radio which is considered as software defined radio (SDR). The main dissimilarity between the SDR and CR is that in SDR the radio system is described by software to process the all functions to SDR hardware platform. The sensing node of cognitive radio is SDR dependent, because the CR parameters are dynamically changes.
In Cognitive Radio, there can be two kinds of users which can use spectrum efficiently:

- Primary users (PUs) – licensed users
- Secondary users (SUs) – unlicensed users

Primary users have legacy rights for the particular frequency spectrum band and secondary users are unlicensed users and have lower priority. They access licensed frequency bands without interfering the PUs at some specific times in some specific locations.

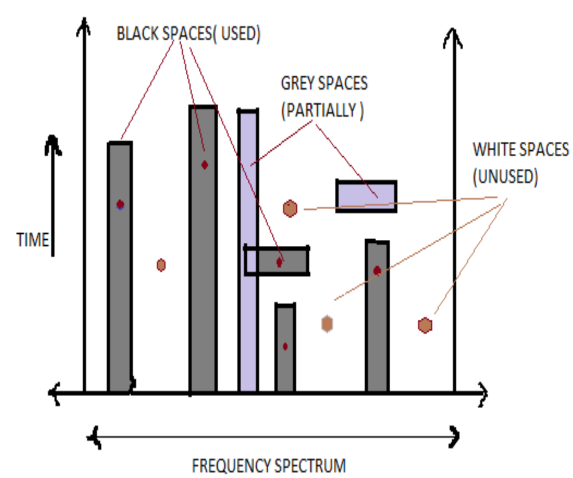

Fig. 1 Frequency spectrum of primary user

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II. FADING IN COMMUNICATION

In the wireless communication system the signal experiences the multipath propagation which produces the rapid signal fluctuation in time called fading. The mobile radio channel produces the fading noise, distortion and interference, when the signal can be transmitted. There are two types of fading:

- Small scale fading
- Large scale fading.

If when the transmitted can transmit the signal and the large number of multiple reflection paths accrues with no line of sight signal path is called Rayleigh fading. In Rayleigh flat fading channel model assumes that the channel induces amplitude which varies in time according to the Rayleigh distortion.

When there is dominant non fading signal component present, so this small scale fading is called Rician fading.

1. *Ricean fading*

The Ricean fading accrues when the signal follows the multiple paths when it reaches at the receiver. When there is direct transmission of the signal then echoes are reaching at the receiver. The echoes can cause interference to the future transmitted symbols.

If there is a signal transmitter and the receiver is at some distance apart from that, large tall building is also near to the receiver. When the signal is transmitted then some part of the signal is received directly without any interference and the other is first strike with building and then reaches at receiver. The signal mismatching accrues this is due to the fading.

2. *Rayleigh fading*

In the small scale fading the radio propagation resulting from the presence of reflector and scattering, they produce the multiple versions of the transmitted signal to arrive at the receiver and produce the distortion in the amplitude, phase and angle of arrival.

The Rayleigh fading is caused by multipath reception. The mobile receiving antenna receives the number of reflected and scattered waves. These fading results because of obstacles block the direct path from the transmitter to receiver.

The deconstructive interference can cause the short term amplitude loss or completely received signal loss. In the Rayleigh fading models when the signal passed through such a transmission medium, signal will vary randomly and the signal can fade according to a Rayleigh distribution.

III. WI-MAX

Worldwide Interoperability for Microwave Access

Wi-MAX (Worldwide Interoperability for Microwave Access) is a communication technology for wirelessly delivering high-speed Internet service to large geographical areas. The 2005 Wi-MAX revision provided bit rates up to 40 Mbit/s with the 2011 update of up to 1 Gbits/s for fixed stations. It is a part of a “fourth generation,” or 4G, of wireless-communication technology.

Wi-Max far surpasses the 30-metre (100-foot) wireless range of a conventional Wi-Fi local area network (LAN), offering a metropolitan area network with a signal radius of about 50 km (30 miles).

The name Wi-MAX was created by the Wi-MAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes Wi-MAX as a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL. Wi-Max offers data-transfer rates of up to 75 Mbit/s, which is superior to conventional cable-modem and DSL connections.However, the bandwidth must be split among multiple users and thus yields lower speeds in practice. In Wi-Fi, the media access controller ("MAC") uses CSMACA (Carrier Sense Multiple Access Collision Avoidance) scheme. In this media access scheme, a station first senses the medium, if it finds the medium busy; it backs off, waits for a random period of time and tries accessing the medium again.

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Hence the Wi-Fi devices are allocated a maximum power limit by FCC which limits their range or coverage. Wi-MAX was designed keeping in mind a WMAN. It is allocated a licensed frequency band and hence interference from other devices is relatively less. Correspondingly the range for Wi-MAX is more. The Wi-MAX Forum website provides a list of certified devices. However, this is not a complete list of devices available as certified modules are embedded into laptops, MIDs (Mobile Internet devices), and other private labeled devices.

Fig. 2:- A WiMAX USB modem for mobile internet

Mobile Wi-MAX was a replacement candidate for cellular phone technologies such as GSM and CDMA, or can be used as an overlay to increase capacity. Fixed Wi-MAX is also considered as a wireless backhaul technology for 2G, 3G, and 4G networks in both developed and developing nations.

In North America, backhaul for urban operations is typically provided via one or more copper wire line connections, whereas remote cellular operations are sometimes backhauled via satellite. In other regions, urban and rural backhaul is usually provided by microwave links. (The exception to this is where the network is operated by an incumbent with ready access to the copper network).

Wi-MAX has more substantial backhaul bandwidth requirements than legacy cellular applications. Consequently the use of wireless microwave backhaul is on the rise in North America and existing microwave backhaul links in all regions are being upgraded. Capacities of between 34 Mbit/s and 1 Gbit/s are routinely being deployed with latencies in the order of 1 ms. In many cases, operators are aggregating sites using wireless technology and then presenting traffic on to fiber networks where convenient.

There is no uniform global licensed spectrum for WiMAX, however the Wi-MAX Forum has published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz, in an effort to drive standardization and decrease cost.

IV. APPLICATIONS OF WI-MAX

The most basic use of Wi-MAX is to provide Wireless broadband services at all times and at all places. It provides fixed and wireless connectivity to all devices in a cell range of 3 to 10 kilometers.

During natural disasters like tsunami in Aceh, Indonesia (Dec 2004) and Katrina in US, all communication infrastructure was destroyed making the survivors unable to communicate with people outside the disaster area and vice versa. Wi-MAX provided broadband access that helped regenerate communication to and from the affected area.

V. ADVANTAGES OF WIMAX

1. No need of the licensed Band for the communication. Because Wi-Fi devices operate in the unlicensed ISM band (Industrial Scientific and Medical Band) centered at 2.4GHz. This frequency band is also used by other devices.
2. Wi-Fi, the media access controller ("MAC") uses CSMACA (Carrier Sense Multiple Access Collision Avoidance) scheme. In this media access scheme, a station first senses the medium, if it finds the medium busy; it backs off, waits for a random period of time and tries accessing the medium again.
3. A packet is allowed to 10 retransmission attempts before it is dropped. Thus all subscriber stations that wish to pass data through a wireless “access point” (AP) are competing for the AP's attention on a random interrupt basis. This can cause distant

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nodes from the AP to be repeatedly interrupted by closer nodes, greatly reducing their throughput.

VI. DISADVANTAGE OF WIMAX

1. Wi-MAX cannot deliver 70 Mbit/s over 50 kilometers (31 mi). Like all wireless technologies, Wi-MAX can operate at higher bitrates or over longer distances but not both.
2. Operating at the maximum range of 50 km (31 mi) increases bit error rate and thus results in a much lower bitrate. Conversely, reducing the range (to less than 1 km) allows a device to operate at higher bitrates.
3. Like all wireless systems, available bandwidth is shared between users in a given radio sector, so performance could deteriorate in the case of many active users in a single sector.
4. In practice, most users will have a range of 4-8 Mbit/s services and additional radio cards will be added to the base station to increase the number of users that may be served as required.
5. This scheduling algorithm is stable under overload and over-subscription (unlike 802.11). It can also be more bandwidth efficient. The scheduling algorithm also allows the base station to control Quality of Service parameters by balancing the time-slot assignments among the application needs of the subscriber stations.

VII. LITERATURE SURVEY

Joseph Mitolaet. al. (1999), presumed the software radios are growing as stands for multiband multimode weirdo communications schemes. Telecast lip-service is the traditional of RF bands, connected interfaces, protocols, and spatial and worldly designs focus amalgam the conformably of the show block. Theoretical telecast spreads the software telecast approximately telecast -domain shape based symbolic concerning such etiquettes. Outlook Scatter enhances the pliancy of distinct professional care look over a transmission Understanding Proclamation Creole.

SudhirSrinivasaet. al. (2007),defined that cognitive radios are promising solutions to the problem of overcrowded spectrum. In this paper they explored the throughput potential of cognitive communication. Different interpretations of cognitive radio that underlay, overlay, and interweave the transmissions of the cognitive user with those of licensed users are described. Considering opportunistic communication as a baseline, we investigate the throughput improvements offered by the overlay methods. Channel selection techniques for opportunistic access such as frequency hopping, frequency tracking, and frequency coding are presented.

Ozgur B. Akan et. al. (2009), defined that dynamic spectrum access stands as a promising and spectrum-efficient communication approach for resource-constrained multihop wireless sensor networks due to their event-driven communication nature, which generally yields bursty traffic depending on the event characteristics.

Abbas Taherpour and MasoumehNasiri-Kenari(2010),analytically computed the missed detection and false alarm probabilities for the proposed GLR detectors. The simulation results provide the available traded-off in using multiple antenna techniques for spectrum sensing and illustrates the robustness of the proposed GLR detectors compared to the traditional energy detector when there is some uncertainty in the given noise variance.

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Ying-Chang Liang et. al. (2011), described that cognitive radio (CR) is the enabling technology for supporting dynamic spectrum access: the policy that addresses the spectrum scarcity problem that is encountered in many countries. In this paper, they provided a systematic overview on CR networking and communications by looking at the key functions of the physical (PHY), medium access control (MAC), and network layers involved in a CR design and how these layers were crossly related.

Eeru R. Lavudiya, Dr. K. D. Kulat and Jagdish D. Kene (2013), have described how to enhance the detection probability by using the different spectrum detection techniques in the cognitive radio system.

Won Mee Jang et. al. (2014),have proposed a blind spectrum sensing method using signal cyclostationary. Often, signal characteristics of the primary user (PU), such as carrier frequency, data rate, modulation and coding may not be known to cognitive users. This uncertainty introduced difficulties in searching for spectrum holes in cognitive radios.

VIII. PROPOSED WORK

Initially we define the autocorrelation function as cognitive sensing node. This idea originates from the instance of having a pulse modulation of single magnitude like $+/-1$ that after square hide any phantom line but the dc one. Then the transformation $y(t) = x(t).x(t-\tau)$ promises spectral lines for $m.f_0$where m is an numeral. Defining $\alpha = mf_0$we declare

$$M_y^\alpha = \langle y(t)e^{-j2\pi\alpha t}\rangle = \langle x(t).x(t-\tau)e^{-j2\pi\alpha t}\rangle \neq 0$$

The Spectral Correlation purpose definition comes from the basic idea of discovery the middling power in the frequency domain as $R\_x\ (0) = |\ x(t)|\text{^}2$. If the correlation in the frequency domain among the shifted forms $v(t)$ and $u(t)$ has to be found then the appearance becomes

$$R_x^0(\tau) = \langle u(t)v*(t)\rangle = \langle |x(t)|^2 e^{-j2\pi\alpha t}\rangle$$

The Power Spectral Density PSD could be imagined as passing the signal $x(t)$ by a narrowband pass filter and scheming the average power, where the filter is simulated all over the band. In the limit where the bandwidths (B) of the filter methods zero:

$$S_x(f) = \lim_{B\to 0}\frac{1}{B}\langle |h_B(t)\otimes x(t)|^2\rangle^n$$

$$S(f) = \int_{-\propto}^{\propto} R_x(\tau)\, e^{-j2\pi f t} d\tau$$

Fourier Transform of autocorrelation

$$S_x^\alpha(f) = \int_{-\propto}^{\propto} R_x^\alpha(\tau)\, e^{-j2\pi f t} d\tau$$

Fourier Transform of cyclic autocorrelation.

The Strip Spectral Correlation Analyzer (SSCA) and FFT accumulation (FAM) are both under the time-smoothing organization. The SCD function of $x[n]$is definite as $S_x(f) = \sum_{k=\propto}^{-\propto} R_x^\alpha(k)\, e^{-j2\pi f k}$by means of the discrete Fourier transform, where

$$R_x^\alpha(k) = \lim_{n\to\infty}\frac{1}{2N+1}\sum_{n=-N}^{N}[x(n+k)e^{-j2\pi\alpha(n+k)}]\,[x(n)e^{-j2\pi\alpha n}]$$

This way:

$$S_x^\alpha(n,f)_{\Delta t} = \frac{1}{T}\langle x_T\left(n, f+\frac{\alpha}{2}\right)x_T^*\left(n, f-\frac{\alpha}{2}\right)\rangle$$

Where $x_T\left(n, f \pm \frac{\alpha}{2}\right)$ are the multifaceted demodulators that the meanings are band pass signals shifted to DC.

FAM is one of the approaches under time-smoothing organization which has good efficiency, calculation wise. There are parameters complicated that are used

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to trade-off determination, reliability and of course computation decrease.

FAM contains of capturing in a time length Δ_ta piece of the received signal $x[n]$ which is the outcome of $x(t)$ sampled atf_s. Approximation of $S_x^{\alpha}(n,f)_{\Delta t}$is achieved over this time length

IX. RESULTS AND DISCUSSION

The simulation results have been performed for the WiMAX system. Modulation used in our simulations is QAM with different constellation size or bits-per-symbol. For WiMAXsystem Simulations are taken with 4 symbol sizes of QAM, *viz.*, 2, 4, 16 and 64.

In first case the SNR vs. BER is calculated by using the Rayleigh channel. The Simulation results are shown in fig3: -

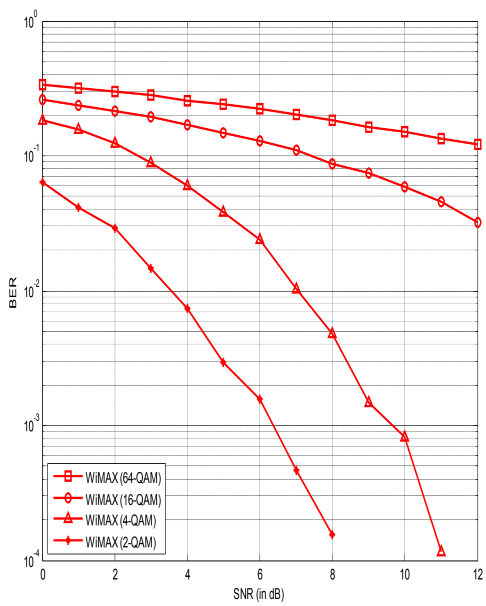

Fig. 3: SNR vs. BER for WiMAX signal using Rayleigh channel

As we seen from above figure that with increase in the size of the constellation of the QAM modulation, BER increases as expected. Also with increase in the SNR, the BER reduces exponentially for every configuration. This proves that the simulated results are in direct correlation with the theoretical results.

In next case SNR vs. BER for WiMAXsignal is simulated by using Rician channel. The value of the K factor is considered as 5 for this simulation result and the resulting graph is shown in fig4: -

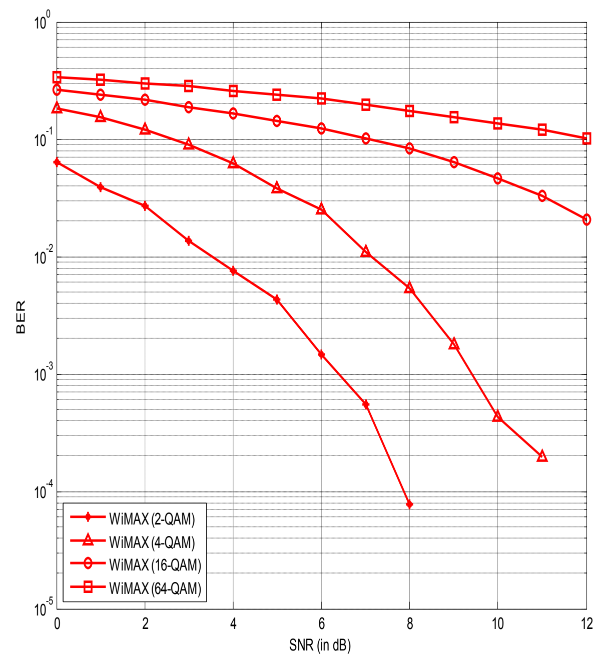

Fig.4: SNR vs. BER for WiMAX signal using Rician channel with K factor = 5

As seen from above figure, with increase in the size of the constellation of the QAM modulation, BER increases as expected. Also with increase in the SNR, the BER reduces exponentially for every configuration. This proves that the simulated results are in direct correlation with the theoretical results.

After that the value of k factor is changed from 5 to 10 and then taking the SNR vs. BER simulation

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results for WiMAXsignal by using the Rician channel with K factor = 10.

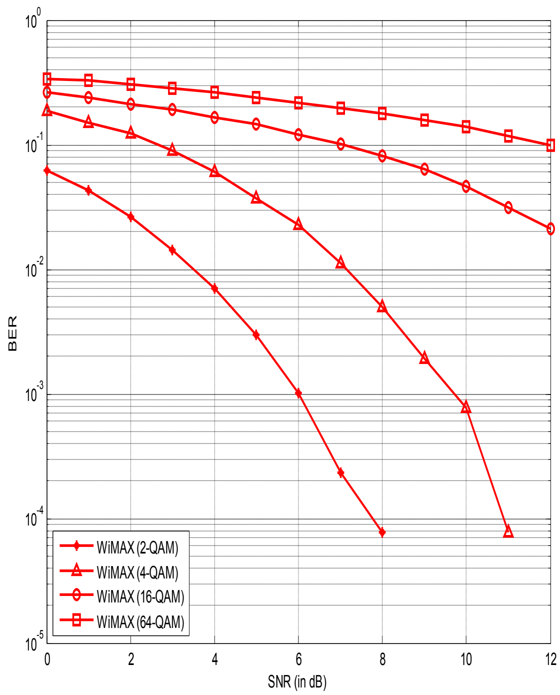

Fig.5: SNR vs. BER for WiMAX signal using Rician channel with K factor = 10

As seen from fig4, with increase in the size of the constellation of the QAM modulation, BER increases as expected. Also with increase in the SNR, the BER reduces exponentially for every configuration. This proves that the simulated results are in direct correlation with the theoretical results obtained in theory under ideal conditions.

X. CONCLUSION

A Cyclostationary Spectrum Sensing technique is used to detect OFDM signals in a noisy (AWGN) environment. For very high speed applications, a spectrum sensing technique should require less computation time and should have less complexity. The proposed system has fulfilled all the requirements to get high efficiency for high frequency applications, such as WiMAX. The proposed system was compared with existing spectrum sensing techniques in terms of bit error rate performance.By changing the fading channel from Rayleigh to Rician and by selecting some of the parameters better results have been obtained.

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