WiMax based Interference Reduction in Cognitive Radio Networks

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***Abstract*— The Worldwide Interoperability Microwave Access (WiMax) is extensively used in communication systems. Mobility is well thought-out at this juncture in WiMAX to attain high data rate over medium. Handover is measured as essential issue in mobile WiMAX. During exchange of data handoff may be occurred. This paper focused on how to lessen handoff in WiMAX and MS (Mobile Station). We furthermore present a sub-optimal approach for solving distance calculation of mobile node over the space which reduces both on-line plus off-line complexity to the huge extent and to diminish signaling transaction for the period of handover practice we use Global Position System (GPS) in the direction of performing handoff more rapidly.**

Keywords— Cognitive Radio Networks ,WiMAX , GPS (Global Positioning System),SEM (Spectral Emission Mask),EVM ((Error Vector Magnitude) ,MCP (Mask Compliant Pre-coder)

1.INTRODUCTION

The notion stuck between Hard Handoff and Soft Handoff are explained. In soft handoff MS is correlated to two BS (Base Station) of a variety of types, soft handover like FBSS (Fast Base Station Switching) and hard handoff the relationship is well-known for serving BS which is interrupted while new base station gets into connection by Handoff Prioritization. In common frequency ranges 2-11 GHz (Giga Hertz) for NLOS (Non-Line of Sight) and 10-66 GHz for LOS (Line Of Sight).In NLOS transmission, the range extension is 8 km with speed up to 70 Mbps (Mega Bits Per Second) and in LOS transmission, the range is about 50 Km (Kilo Meter). WiMAX based on IEEE 802.16 set of standards its range can be extended in wireless access up to 8,000 square km of coverage. A WiMax provides multiple physical layer (PHY) and Media Access Control (MAC) options and WiMAX tower to tower connection are made using of microwave link called backhaul. In NLOS, a tiny antenna on your workstation is connected to tower, a dish points straight at the WiMAX tower from a apex But in our algorithm distance is determined by MS using GPS (Global Positioning System). It is introduced to locate the spot of the MS and BS (Base Station) which are running by spectrum management in CRN [2] (Cognitive Radio Networks) thus MS will manually choose BS by changing parameters involuntarily and routing. The MS finds its location by means of GPS to locate distance to the SBS (Source Base Station) and close by BSs (Base Stations) . The space between two towers can be 30 to 50 km. According to the IEEE 802.16e (Institute of Electrical and Electronics Engineers) standard BS requests report within 10 seconds by sending REP-REQ (Report-Request) to all MSs and receives responses by REP-RSP (Report-Response) or ACK (Acknowledgement). The whole time for completion of handoff is based on the mobility of mobile user. Moreover handover process should be in a fast manner. The MN (Mobile Node) with GPS generates an AP (Access Point) map while it travels within a network. When MN enters into another network, it will download its GPS map from server. The MN gets the latitudes and longitudes by BSSID (Basic Service Set ID), AP's, SSID (Service Set ID) and IPV6 (Internet Protocol Version 6) are configured. By these AP and GPS map, we can place MN's spot in a network and whether a MN moves or not. At last GPS is used to calculate the distance [4]. As an intellectual system with features such as awareness, and learning, CR(Cognitive Radio) represents future of wireless systems with guarantee of offering solutions to various communication problems. However with this new technology, raising interesting research topics. These challenges can be grouped into three categories. The first category includes the challenges that are unique to classical OFDM systems[7], sensitivity to frequency offset and phase noise. The second class includes problems faced by all CRs such as spectrum sensing, cross layer adaptation, and interference avoidance. Our main focus to reduce challenges that arise when OFDM technique is employed by CR systems. In subsequent step, we discuss major challenges to a practical system execution as well as some of the proposed approaches for solving challenges like M-OFDM (Multiband Orthogonal Frequency Division Multiplexing) systems, Location awareness, Signaling transmission parameters, Synchronization, Mutual interference. Multiband

OFDM has already been applied in communication systems due to signaling transaction with high rate of speed and with zero distortion [19].The Multiband OFDM has many characteristics including distance, Line of Sight (LOS), Arrival rate, Ray decay factor, cluster decay factor has been calculated through more channel models using 5G [10]. In location identification of MS and BS is much vital because timing itself gives how effectively we use spectrum and for signal business it is proven by calculating many parameters and the results are shown below.

Server throughput in bits per second (bps)	3160	950	690	583	561
Average Jitter in seconds(s)	0.012	0.012	0.011	0.01	0.02
Average end to end delay in seconds(s)	0.029	0.03	0.03	0.04	0.04

TABLE 1 : COMPARISON CHART

From Table 1 It is experiential that signal contract in cognitive radio networks were calculated through various output parameters counting Server throughput, Average jitter, Average end to end delay. The online computational complexity is major concern for MCP (Mask Compliant Pre-coder) and it is a system of calculating complex interferences during transmission of data when all nodes are connected but offline complexity includes same system but not during transmission.

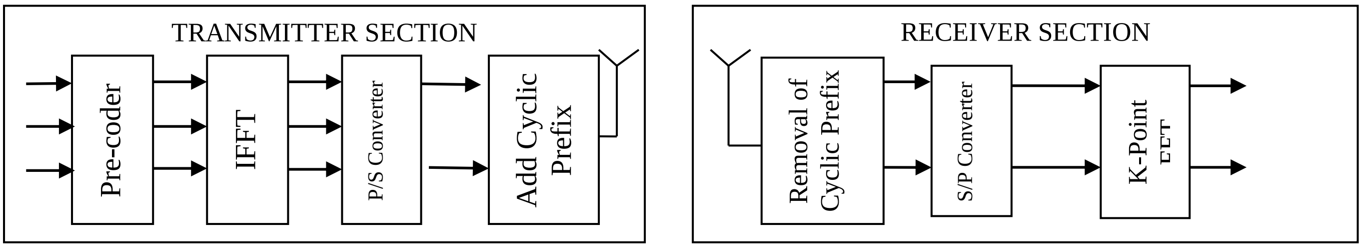

Figure 1: OFDM Transceiver Pair – Side Lobe Suppression

Think about OFDM structure through K = {k0, k1..., k_{K-1}} as shown in Fig. 1. The QAM (Quadrature Amplitude Modulation) symbols d = [dk0, dk1 , ..., dk_{K-1}]T, where T is the transpose operation, are feed keen on the side lobe suppression pre-coder to cause a latest set of signs $\bar{d}$ = [$\bar{d}$k0 , $\bar{d}$k1 , ..., $\bar{d}k_{K-1}$]T , chosen in such a way to offer enhanced spectral emissions. The generated vector $\bar{d}$ is next worn to modulate K subcarriers using Inverse Fast Fourier Transformation (IFFT). The consequential similar data stream is transmitted to a solitary stream with parallel-to-serial converter, and a cyclic prefix (CP) of span higher than greatest intemperance delay of the channel is added to combat the effect of inter-symbol interference[8]-[16]. The appearance of OFDM symbol can be written as

$$s(t) = \sum_{k=0}^{K-1} d_k e^{j2\Pi\frac{k}{Ts}tR_c(t)}$$

Where Rc(t) is a window function and

Ts is the effective symbol time

$$P\{f\} = \frac{1}{T} E\{|S(f)|^2\}$$

As an substitute of forcing the power spectrum to zero, our aspiration is to stay spectrum at a set of predefined frequencies in the out-of-band area below a given Radio Frequency (RF) mask. We sample spectrum of transmitted signal at M frequency locations $f_m \in \{f0, f1, , , , , f_{M-1}\}$ in the out-of-band region. After collecting the M samples [S(f0); S(f1); :::; S(fM1)]T in the vector S, the out-of-band spectrum resulting from pre-coded symbols can be set by

$$S = A\bar{d}$$

Where A = [a(f0); a(f1); :::; a(f_{K-1}))]$^{-T}$ is an M × K matrix with entries ak(fm) representing the side lobe interference from the kth subcarrier at the discrete frequency fm in the out-of-band region because main aim is to manage spectrum emissions, we therefore require power of each sample in S, i.e., jS(fm)j2, to drop underneath mask. This is equal to

$$|[Ad]t|^2 \leq [b]t$$

Where b is an M *1 vector containing the RF mask samples, [A_d]i and [b]i represent the i^{th} entry of vectors Ad and b, respectively. There are many solutions $\bar{d}$ that satisfy above problem, but we are only interested in the vector $\bar{d}$ that is closest to original data vector d in terms of Euclidean distance. That is, we want pre-coded symbols to fall in the same decision region as the original data symbols.

$$\min_{d} \ ||d - \bar{d}||_2^2 \quad \text{subject to } \bar{A}\, d \leq \bar{b}$$

2. Problem Formulations

The goal function along with the constraints can be direct as a quadratic programming trouble with linear disparity constraint. Its response lead to a pre-coder that exactly map information symbols d to a fresh set of symbols having spectral emission enclosed under the RF wrap b, in addition to more marvelously, it ensure that fresh symbols $\bar{d}$ are close to d in the Euclidean distance . Above figure explained system mock-up which gives OFDM output through various sections also IFFT (Inverse Fast Fourier Transformation) has been calculated in transmitter section and the corresponding input is transmitted to receiver segment where FFT(Fast Fourier Transformation) premeditated [23] finally output is produced in the receiver section. The same model have already been explained . The off-line computability of pre-coding matrix reduces the online complexity to a great extent and provide the scope for compensation at the receiver. Also it enables PSDs(Power Spectral Density) for multi user scenario, it can be further improved by convergence manners of mask and allowing multiple user requiring different mask constraints. The off-line computability of pre-coding matrix decreases the online complexity and provides compensation at the receiver. The input we have given 'n' number of sections to the pre-coder [21]which pre-codes it into samples with regular interval and it is applied to the IFFT(Inverse Fast Fourier Transform) that computes discrete quantities of signal/S (Parallel to Serial Converter) converts all parallel signal into serial representation with no loss because of adding cyclic prefix at the end also in the receiver part of the communication system we got signal received as 'n' number of signals.

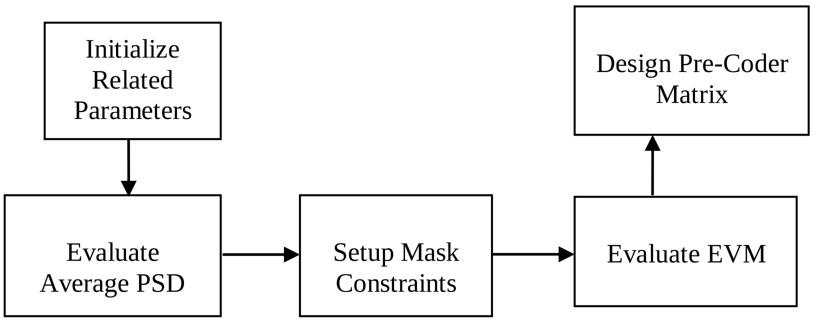

Figure 2: Block diagram of Spectral Out Band Limiting Technique

Using this method, OFDM reduces the dispersion effect of multipath channels encountered with high data rates and reduces the need for complex equalizers . In this paper, we assume a CR system operating as a secondary user in a licensed band. The CR system identifies available or unused parts of the spectrum and exploits them. The goal is to achieve maximum throughput while keeping interference to primary/licensed users to a minimum. An example of such a CR system could be the IEEE 802.22 standard-based system where the spectrum allocated for Television (TV) channels are reused. In this case, the TV channels are the primary users and the standard-based systems are the secondary users. Note that coding type, coding rate, inter-leaver pattern, and other medium access control and higher layer functionalities etc. should also be changed accordingly.

2.1UNITS MCP (MASK COMPLIANT PRE-CODER) NEEDS TO SOLVE A NON-LINEAR OPTIMIZATION PROBLEM ON SYMBOL BY SYMBOL BASIS

MCP yields minimum distortion achieved in [5] but is computationally very expensive we also propose spectral out band limiting technique that provides spectrum efficiency comparable to MCP and on-line complexity restricted to only few multiplications per sub- carrier.

3.MODULES

3.1COMPLEXITY-EVM TRADE-OFF :

From the previous sub-section, it is clear that the number of iterations M is a major factor determining the online and off-line complexity. Any attempt to reduce M will result in reduced online as well as off-line complexity. It can be done by generating a virtual mask below the actual mask and mapping the transmitted waveform to a new mask in each iteration. We try to map the spectrum at,

$$\frac{M(hr)}{\propto} = Tr\left[G^{H}_{(r+1)}A(hr)G_{(r+1)}\right]$$

Where α denotes mask offset. As we increase more portion of the transmitted waveform is forced below M (f) in each iteration. Hence requiring relatively less iterations to generate mask compliant waveform. This gives reduced spectrum efficiency and increased EVM.

3.2 SPECTRAL EMISSION MASK (SEM)

It is applicable only for removing interference due to adjacent cell also it defines power by maximum permitted emission limits Basically, SEM puts a constraint on the transmitted power spectrum by defining a maximum permitted emission limits [22].

3.3 MASK DISCRETE METHOD

It is preferred to pick frequencies touching envelope of transmitted spectrum. For a ZP-OFDM (Zero Padded – Orthogonal Frequency Division Multiplexing) system, envelope frequencies can be selected using fi = 2ni+1 (2Ts) where ni is an integer. It can be verified that separation between two nearest frequencies are equal to one sub-carrier spacing (1/Ts). It is probable to reduce D to a great extent by identifying mask breakpoints where mask changes quickly (four mask breakpoints {±0.5, ±1.5}. These breakpoints are more important from suppression point of view hence the sampling interval should be a small around these critical breakpoints whereas only few samples are required away from these breakpoints.

3.4 OFF-LINE COMPLEXITY

The highest order term in Algorithm 1 is $Tr[G_{(r)}A(hr)G_{(r)}]$ which will determine the order of complexity[23]. Since A(fr) is a unit rank positive semi definite matrix, it can be as the matrix product of two vectors as $a^{H}(hr)a(hr)$.So computing $G_{(r)}a^{H}(hr)a(hr)$ requires 2K² multiplications. This term has to be evaluated D- times in each iteration. If we assume that the algorithm takes M -iterations to reach the solution, then the overall off-line complexity is of the order of O (2DMK²).

3.5 ON-LINE COMPLEXITY

Once G is determined then the on-line complexity of both proposed optimal and suboptimal approaches reduces to K multiplications per subcarrier to obtain pre-coded symbols.

The pre-coding matrix can be obtained as,

$$G = I_K - A^{H}_{M}\lambda(I_M + A_M A^{H}_{M}\lambda)^{-1}$$

Using this implementation the pre-coded symbols can be written as,

$$\bar{d} = d - QAd$$

Where, Q is a K×M matrix defined as,

$$Q = A^{H}_{M}\lambda(I_M + A_M A^{H}_{M}\lambda)^{-1}$$

EVM And Complexity Outputs With Different Methods		
Techniques	EVM%	Complexity
LSNP	8.95%	Low
MCP	7%	High
Proposed Method	7%	Low

TABLE 2 : EVM AND COMPLEXITY OUTPUTS WITH DIFFERENT METHODS

For simulating scenario we use QualNet4.5.We choose environment that contains 8 BS (Base Station) and every BS has one subnet. In this scenario, handover is performed in BS1, BS2, BS3 and BS4. All BS are connected to one switching centre (SC) .

4.SIMULATION RESULTS

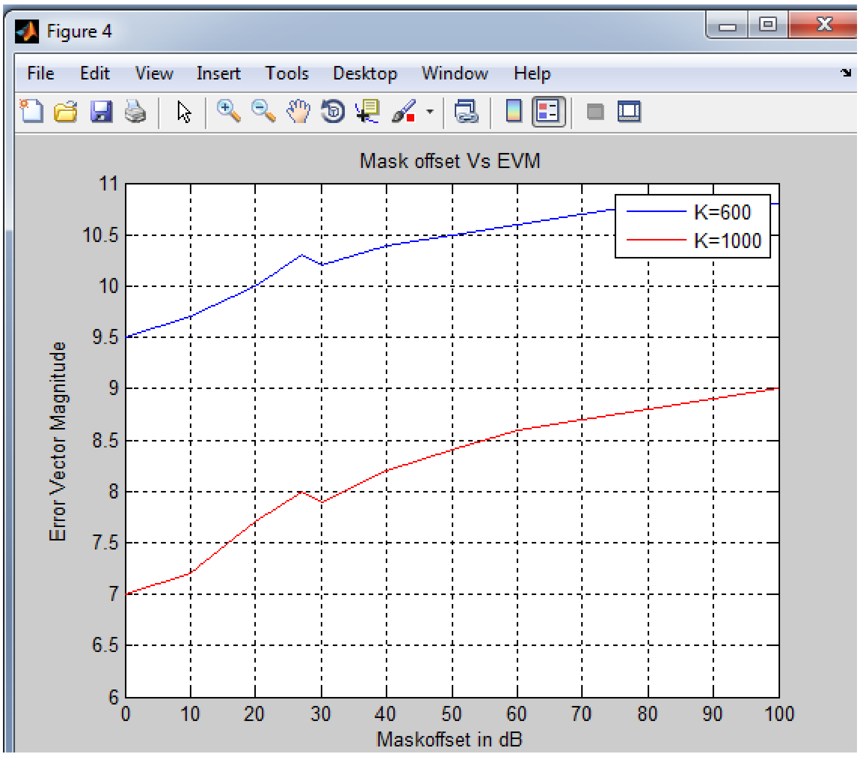

Figure 3: Variation of Mask offset (doted lines) and EVM (solid lines)

The above mentioned figure gives variation in mask offset and Error vector magnitude and we have got different values for k=600 and k=1000, k-constant

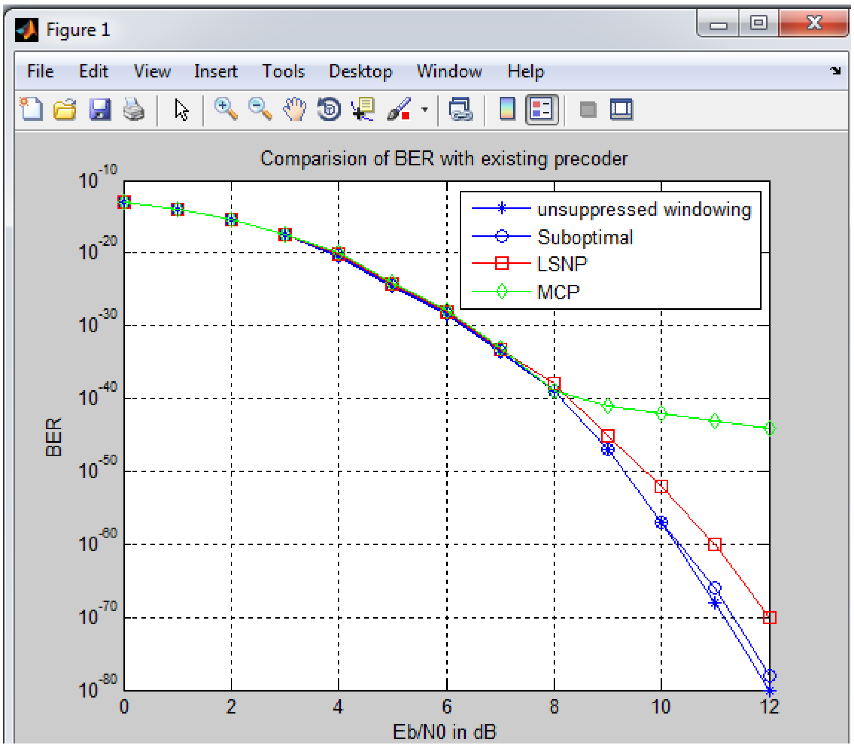

Figure 4: BER curves of the proposed pre-coder with existing pre-coders

It has been observed that proposed suboptimal approach gives better BER curves of the proposed pre-coder with existing pre-coders

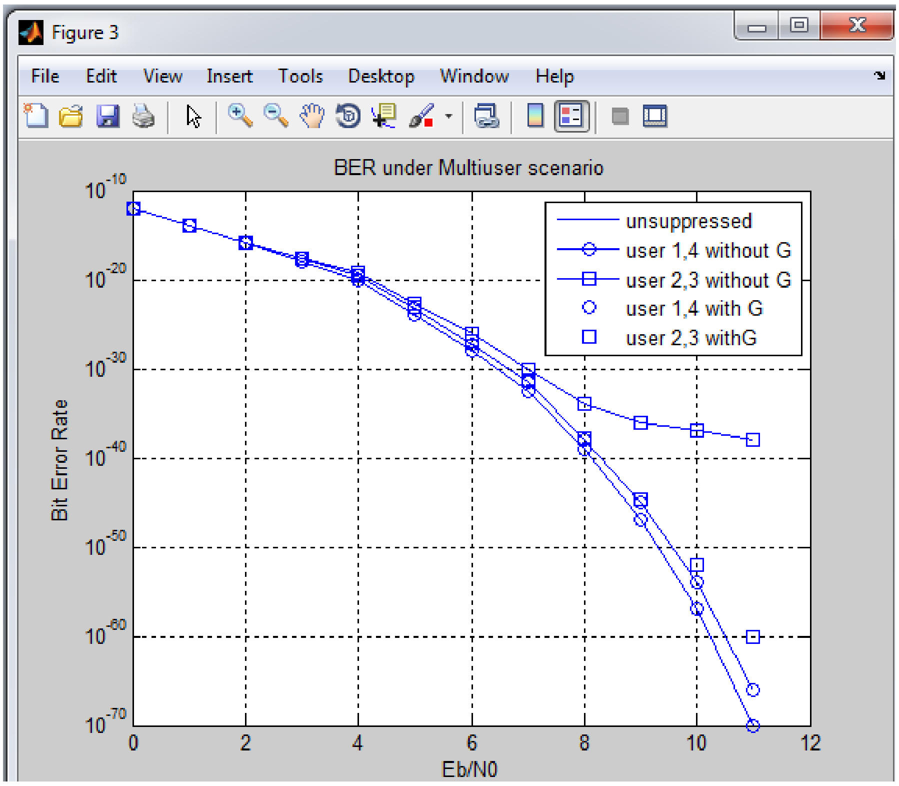

Figure 5 : BER performance under multiuser scenario

The figure 5 describes BER performance under multi user scenario by variation in bit error rate (BER) and signal to noise ratio (SNR)

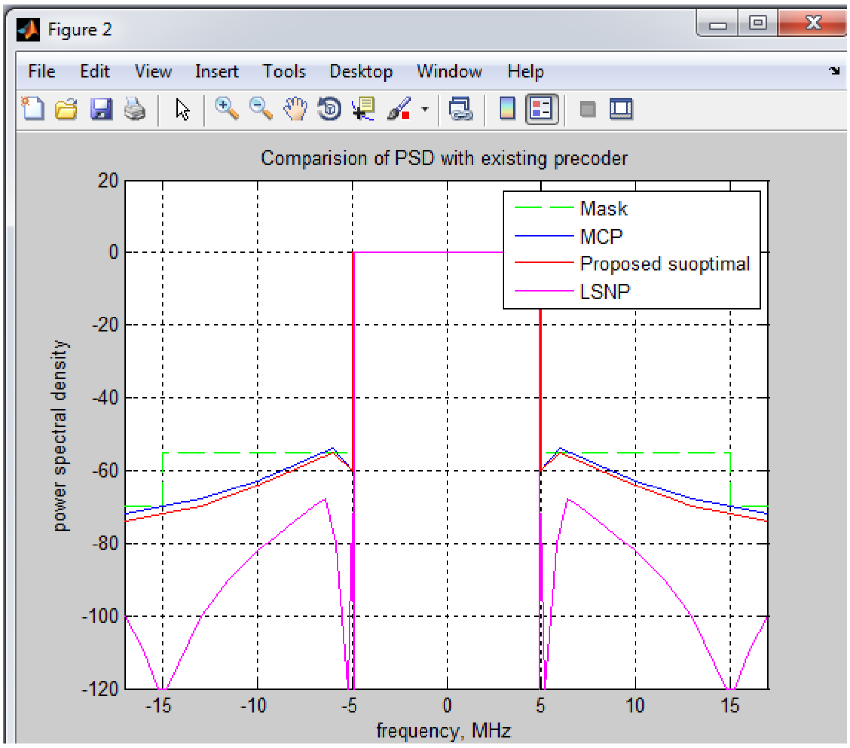

Figure 6 : Transmitted spectrum of notching pre-coder (light spatial noise portrait (LSNP), MCP)

The figure 6 describes Transmitted spectrum of notching pre-coder (light spatial noise portrait (LSNP), MCP) , noise cancellation has been calculated and it is comparatively measured from various method and observed that transmitted spectrum of notching pre-coder gives greater result.

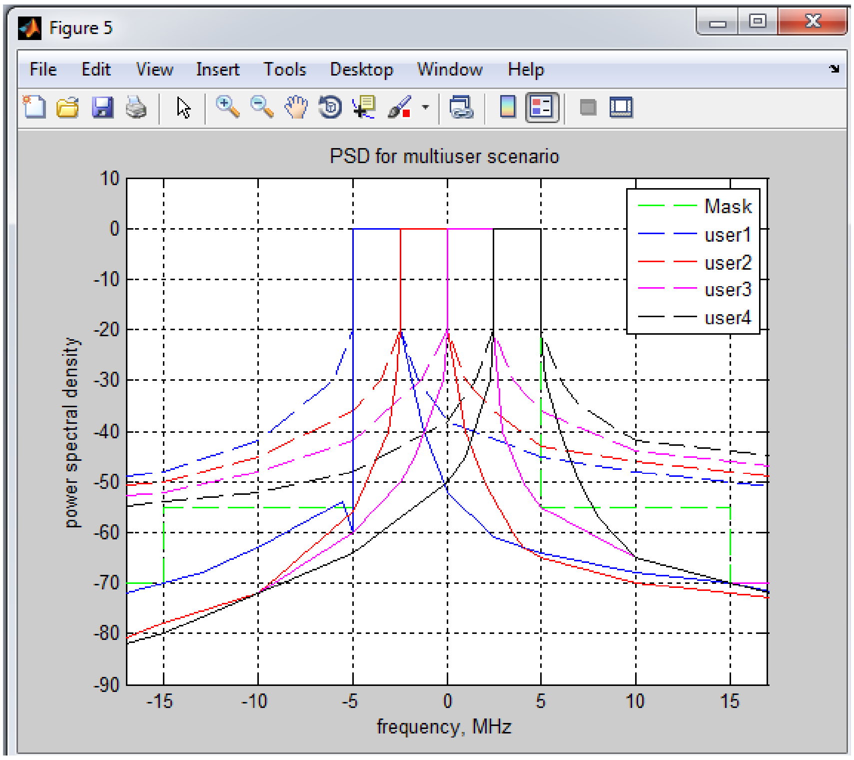

Figure 7 : PSDs under multiuser scenario

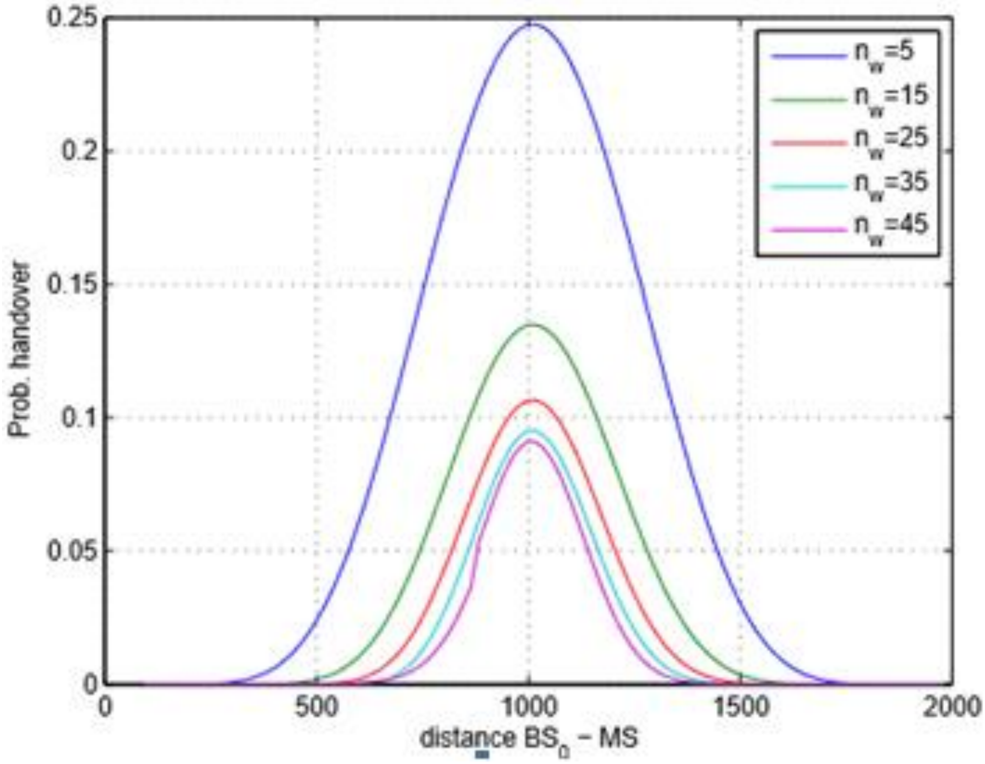

Figure 8 : Handover Vs distance

The above figure shows that amount of probability of handover occurring at different distance for various n values and it is noted that MS-BS selection easily done.

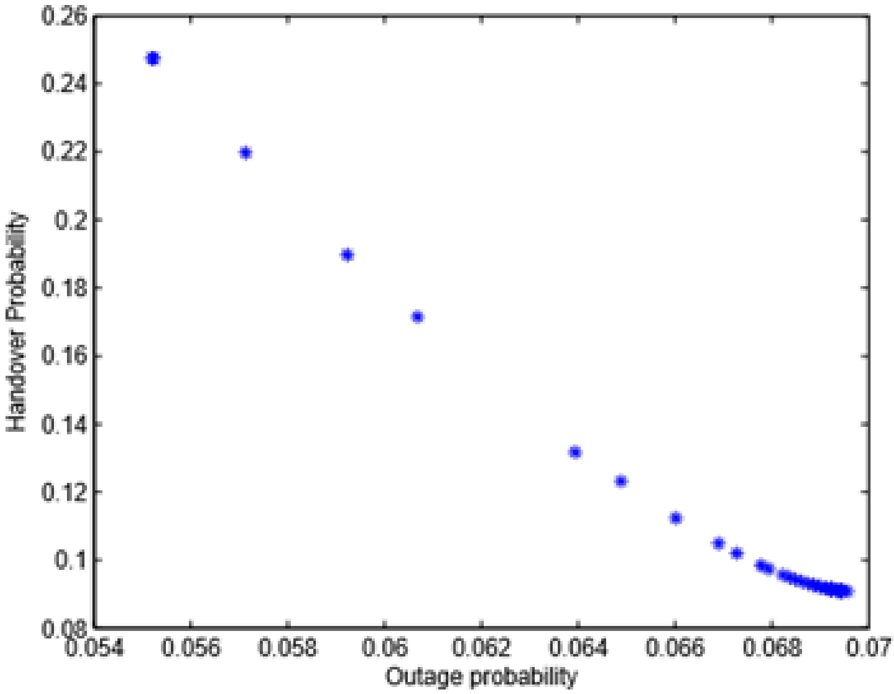

Figure 9 : Handover probability Vs Outage Probability

Figure 9 tells that Handover is performed just in first access level. One MS (Mobile Station) moves and connects to four BSs that are in path and the corresponding outage probability also indicated

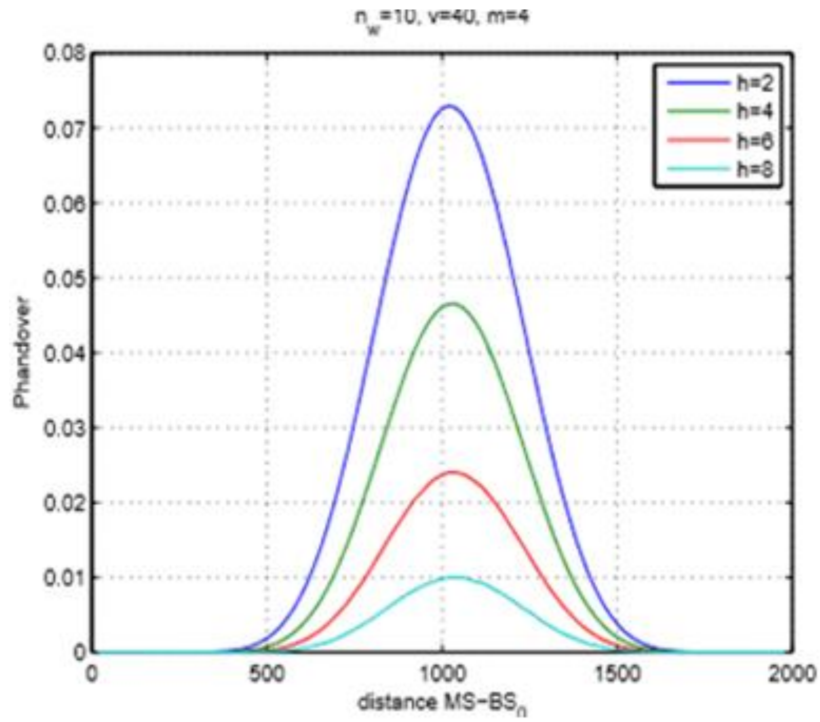

Figure 10 : P handover Vs distance MS-BSn

From figure 10 handover distance calculated for various h values and reduced accordingly by FBSS.

5. CONCLUSION

Here a low complexity mask compliant pre-coder for OFDM based cognitive radio was designed. It can engender spectrum efficient waveforms with much less computational complexity. Simulation results illustrate that plot out performs existing schemes in terms of complexity and BER (Bit Error Rate) recital. It provides grand flexibility to adapt shape of the spectrum according to desired requirements. It is also a suitable choice for multiuser scenario.

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References

1. Varade, P. S., & Ravinder, Y. (2018). Quality constrained multi-attribute energy-efficient resource allocation for heterogeneous cognitive radio networks. IET Communications, 12(18), 2290–2296. doi:10.1049/iet-com.2018.5254
2. Distributed Precedence Queuing for Efficient Spectrum Management in Cognitive Radio Networks M. Bala Krishna University School of Information and Communication Technology Guru Gobind Singh Indraprastha University New Delhi, INDIA ICC2017: WT04-5thIEEE International Workshop on Smart Communication Protocols and Algorithms (SCPA 2017)
3. 2017, 34th NATIONAL RADIO SCIENCE CONFERENCE (NRSC 2017), March 13-16, 2017, Port Said, Egypt Arab Academy for Science, Technology & Maritime Transport “Automated Testbed for Spectrum Allocation in Hostile Environment Based on USRP Cognitive Radio System” Asmaa M. Saafan , Hesham M. El-Badawy Network Planning Department, National Telecommunication Institute (NTI), Cairo, Egypt,
4. Annapurna, K., & Ramanjaneyulu, B. S. (2016). GPS-enabled collaborative sensing in cognitive radio networks for efficient spectrum assignment. 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT).

5. Ali, A., Kwak, K. S., Tran, N. H., Han, Z., Niyato, D., Zeshan, F., … Suh, D. Y. (2018). RaptorQ-Based Efficient Multimedia Transmission Over Cooperative Cellular Cognitive Radio Networks. IEEE Transactions on Vehicular Technology, 67(8), 7275–7289.
6. El Tanab, M., & Hamouda, W. (2017). Resource Allocation for Underlay Cognitive Radio Networks: A Survey. IEEE Communications Surveys & Tutorials, 19(2), 1249–1276.
7. A. Tom, A. Sahin, and H. Arslan, "Mask compliant precoder for OFDM spectrum shaping," IEEE Commun. Lett., vol. 17, no. 3, pp. 447–450, Mar. 2013.
8. K.S.Shaji,G.Joselin Retna Kumar "DESIGN AND ANALYSIS OF MULTIBAND OFDM SYSTEMS OVER ULTRA WIDE BAND CHANNELS"ISSN: 0976-5166 IJCSE VOL 4 NO.1FEB – MAR 2013
9. Proceedings of 2018 15th international bhurban conference on applied science and technology (IBCAST) Islamabad Pakistan 9th-13th January 2018
10. Lv, L., Chen, J., Ni, Q., Ding, Z., & Jiang, H. (2018). Cognitive Non-Orthogonal Multiple Access with Cooperative Relaying: A New Wireless Frontier for 5G Spectrum Sharing. IEEE Communications Magazine, 56(4), 188–195.
11. Zhao, Y., Hong, Z., Luo, Y., Wang, G., & Pu, L. (2017). Prediction-Based Spectrum Management in Cognitive Radio Networks. IEEE Systems Journal, 1–12.
12. Chatterjee, S., Maity, S. P., & Acharya, T. (2016). Energy Efficiency in Cooperative Cognitive Radio Network in the Presence of Malicious Users. IEEE Systems Journal, 1–10.
13. Chen, Q., Wang, L., Gao, Y., Chai, R., & Huang, X. (2017). Energy efficient constrained shortest path first-based joint resource allocation and route selection for multi-hop CRNs. China Communications, 14(12), 72–86.
14. Multicarrier Spread Spectrum Modulation Schemes and Efficient FFT Algorithms for Cognitive Radio Systems Mohandass Sundararajan Umamaheswari GovindaswamyReceived: 17 May 2014 / Revised: 2 July 2014 / Accepted: 4 July 2014 / Published: 17 July 2014
15. T.Archana, M. Suresh Chinna Thampy, " Enabling Radio Resource Allocation Using Low Complexity Algorithm", IJAER, ISSN 0973-4562 Vol. 10 No.2 (2015) pp. 1797-1801
16. X. Zhou, G. Y. Li, and G. Sun, "Multiuser spectral precoding for OFDM based cognitive radio systems," IEEE J. Sel. Areas Commun., vol. 31, no. 3, pp. 345–352, Mar. 2013.
17. J. A. Zhang, X. Huang, A. Cantoni, and Y. J. Guo, "Sidelobe suppression with orthogonal projection for multicarrier systems," IEEE Trans. Commun., vol. 60, no. 2, pp. 589–599, Feb. 2012.
18. J. van de Beek, "Orthogonal multiplexing in a subspace of frequency well-localized signals," IEEE Commun. Lett., vol. 14, no. 10, pp. 882–884, Oct. 2010
19. H. A. Mahmoud and H. Arslan, "Sidelobe suppression in OFDMbased spectrum sharing systems using adaptive symbol transition," IEEE Commun. Lett., vol. 12, no. 2, pp. 113–135, Feb. 2008.
20. E. H. M. Alian, H. E. Saffar, and P. Mitran, "Cross-band interference reduction trade-offs in SISO and MISO OFDM-based cognitive radios," IEEE Trans. Wireless Commun., vol. 11, no. 7, pp. 2436–2445, Jul. 2012
21. Computationally-Efficient Mask-Compliant Spectral Pre-coder for OFDM Cognitive Radio Ravinder Kumar, Student Member, IEEE, and Anshul Tyagi, Member, IEEE
22. Grakhova, E. P., Rommel, S., Vegas Olmos, J. J., Tafur Monroy, I., Jurado-Navas, A., & Sultanov, A. K. (2016). First experimental impulse-radio ultra-wideband transmission under the Russian spectral emission mask. Electronics Letters, 52(10), 877–879.
23. Radix-43 based two-dimensional FFT architecture with efficient data reordering scheme IET Computers & Digital Techniques (Volume: 13 , Issue: 2 , 3 2019) Kala S. ; Jimson Mathew ; Babita R. Jose ; Nalesh S.

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