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MIMO Cognitive Radio Spectrum Sharing Using Spatial Coding and User Scheduling for Fading Channels

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Abstract

Spectrum scarcity is one of the issue in wireless communication. Dynamic spectrum sharing is the solution for this problem in which the underutilized spectrums are utilized efficiently. Multiple Input Multiple Output (MIMO) based cognitive radio using spatial coding is used to dynamically share the spectrum which allows simultaneous usage of spectrum by more than one user. The drawback of spatial coding is the achievable capacity get reduced with the increased number of cognitive users which limits the number of users to share the spectrum. In order to maximize the number of secondary users sharing the spectrum of the primary user, this paper presents a cluster based multiple primary and secondary user's MIMO spatial coding which provides higher capacity. The entire network is divided into number of cluster based on the location such that each cluster will be interference free from other. Each cluster is designed with one primary user and many secondary users and a User Scheduling algorithm called Cluster Based Max Signal Power User Scheduling (CBMSPUS) is proposed to select two best secondary users in each cluster. Since the performance of spatial coder depends on the channel matrix, this paper analyze the spatial pre-coder under Rayleigh, Rican and Nakagami fading channels with multiple users and evaluate the capacity of users under CBMSPUS scheduling algorithm. The results show that the Nakagami fading channel achieves high capacity than others. Primary user calculated capacity is 10.8bits/HZ /channel at low SNR region and 14.2 bits/HZ/channel at high SNR region. The secondary user archives maximum capacity of 9.8bits/HZ /channel at low SNR and 13 bits/HZ/channel at high SNR. The Proposed Scheduling method offers maximum of 15dB gain comparing FIFO scheduling algorithm.

Keywords*: cognitive radio, fading channel, MIMO, Spatial coding, user scheduling*

1. Introduction

Cognitive Radio(CR)technology offers spectrum sharing using three modes namely interleave mode, overlay mode and under lay mode .Among the three modes , interleave is not efficient because it allows to transmit only during the primary user not using spectrum .Therefore continuous communication on the secondary user side is not possible. Multiple Input Multiple output (MIMO) technology enables the possibility of the overlay and underlay communication, in which both the primary user and secondary user can use the same spectrum simultaneously. Power split, interference alignment and linear pre-coding are the methods used to achieve the underlay and overlay communication. Instead of exploiting the spectrum opportunities, MIMO [1] techniques target to harvest the spatial channel gain through intelligent antenna and signal processing techniques for simultaneous usage of spectrum by more than one user without interference. There are few works addressed in the literatures in this direction of spatial domain spectrum sharing. For MIMO Z channel with assumption of primary signal will

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not interfere with secondary, capacity maximizing transmission scheme for the secondary user that satisfy the primary user interference constrain has been presented in [2-3]. Interference minimization pre-coder for interference limited MIMO Z channel is presented [4] to maximize the sum capacity of CR by minimize the interference to primary .The channel with minimal value of singular value is selected and transmitted such that it will introduce minimum interference.

When cooperation is between primary and secondary to share the spectrum, it is possible to do interference alignment with the cooperation such a scheme is called as opportunistic interference alignment. This opportunistic interference alignment is successfully used to overcome the interference from secondary to primary radio [5-7].

Most of the reported techniques in literature give priority only for the primary users and designed to minimization of the interference to primary user or nullify the interference to primary user. The secondary user interference from primary is not considered and in presence of primary interference, it can transmit only minimum data rate by satisfying the primary user interference constrain. This paper deals the spatial coding scheme which can eliminate the interference both at primary and cognitive receiver .The achieved capacity of the scheme is analyzed in the fading environment like Rayleigh, rician and nakagami for both primary and secondary user. To allow more secondary users to share the spectrum with good data rate, a clustering mechanism and a user scheduling algorithm is proposed .The rest of the paper is organization as follow: Section 2 discuss the system model. Cluster based architecture has been proposed in Section 3 with Cluster Based Max Signal Power User Scheduling (CBMSPUS) algorithm. The Section 4 presents the performance of the proposed system and Section 5 concludes the paper with the summary of the work.

2. System Model

Since the CBMSPUS algorithm clustering the network and allows to share the spectrum between only one primary user and two secondary users at a time, the system model is formulated with one primary user and two secondary users .The proposed system model consider the primary and secondary radios with MIMO configuration of 2x2. The interference components to primary from secondary and from primary to secondary are considered. This model is known as X –channel model. The system model is represented in Figure.1

Received signal at primary is given as below

$$y_p = H11x_p + \sum_{j=1}^{2} Hj1x_{sj} + N_p \qquad (1)$$

Where y_p is received vector of the dimension 1xM, where M is the number of receiver antennas (here M=2), x_p is the transmitted vector from primary user with dimension of 1xN, where N is the number of transmitter antennas (here N=2). Vector x_{sj} is j^{th} secondary user transmitter data of dimension 1xN, Hj1 is the interference channel from j^{th} secondary user to primary receiver 1, Np is the additive white Gaussian noise and H11 is the channel matrix of dimension 2x2 between the primary transmitter and primary receiver.

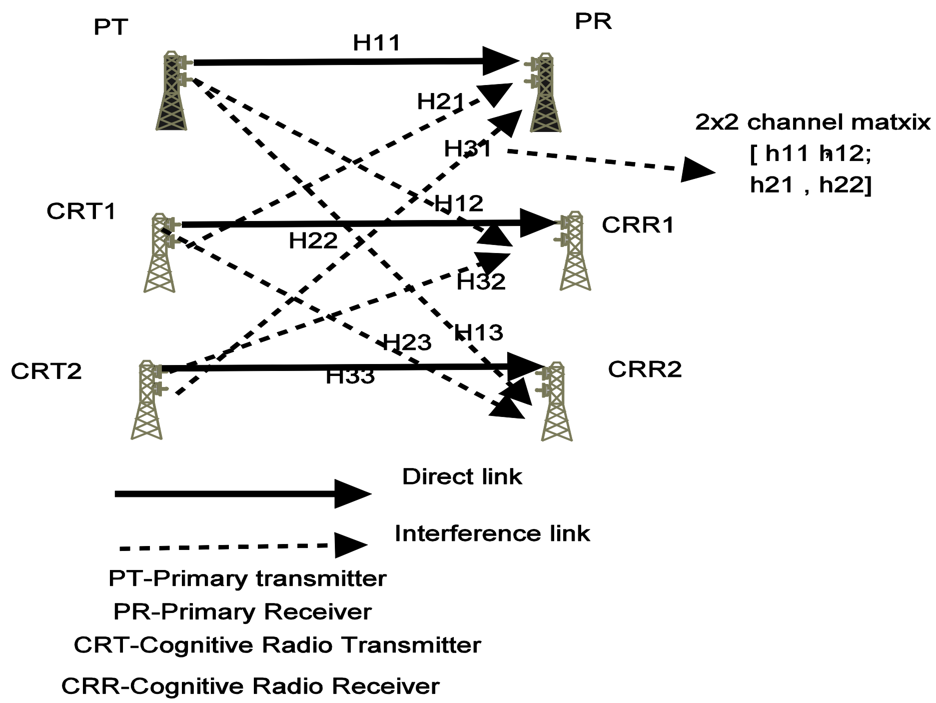

Figure 1. System Model with Two CR and One PR in 2x2 MIMO Configuration

Received signals of the two secondary's are

$$ys1 = H22x_{s1} + H12x_p + H32x_{s2} + N_{s1} \quad (2)$$

$$ys2 = H33x_{s2} + H13x_p + H23x_{s1} + N_{s2} \quad (3)$$

Where the ys1 and ys2 are received signal vectors of dimension 1xM of secondary user 1 and user 2 respectively. The channel matrix H22 and H33 of dimension 2x2 are from secondary transmitter 1 to secondary receiver 1 and from secondary transmitter 2 to secondary receiver 2. H12 is the interference channel from primary user to secondary user 1, H32 is the interference channel from to secondary user 2 to secondary user 1; H13 and H23 are the interference channels from primary user to the secondary user 1 and secondary user 2 respectively.N_{s1} and N_{s2} are additive Gaussian noise added with secondary user 1 and user 2 .x_{s1} , x_{s2} are the secondary user1 and secondary user 2 transmitted signals.

Each transmitter employs a pre-coder vector v_i on the transmitter side and decoder vector u_i on the receiver side to cancel the interference from other user. In order to cancel the interference of other user the pre-coding vector v_i and decoding vector u_i should satisfy the following conditions [8]

$$u_i^H H_{ji} v_i = 0, \forall i \neq j \quad (4)$$

$$rank\left(u_i^H H_{ij v_i}\right) = 1 \quad (5)$$

With the pre-coding and decoding vector at transmission and reception, the received signal equation of the primary user is [8]

$$yp = u_1^H H11\, v_1 x_p + \sum_{j=1}^{2} u_{sj}^H Hj1\, v_{sj} x_{sj} + u_1^H N_p \quad (6)$$

Here the pre-coding and decoding vectors for primary user is denoted by u_1 and v_1.Pre-coding vectors for secondary user1 and secondary user2 are denoted by u_2,u_3.the decoding vector for the secondary user1 and user2 are v_2 ,v_3 .

With the spatial coding, the received signal equation of the secondary users can be represented as [8]

$$ys1 = u_2^H H22 v_2 x_{s1} + u_1^H H12 v_1 x_p + u_3^H H32 v_3 x_{s2} + u_2^H N_{s1} \quad (7)$$

$$ys2 = u_3^H H33 v_3 x_{s2} + u_1^H H13 v_1 x_p + u_2^H H23 v_2 x_{s1} + u_3^H N_{s2} \quad (8)$$

In the above equation the first term is the desired signal, second and third terms are the interference component from other user that can be cancelled out if the pre-coding and decoding vectors are selected such that they can satisfy the equation (4) and (5).Calculation of encoding and decoding vector can be done by solving the equation (4).

Expanding equation (4) for three users of one primary user and two secondary users the equation 9 to 11 are formulated; the first user is the primary user (i=1;j=1) and other two users are the cognitive users.

$$\boldsymbol{u_1^H H_{21} v_1 = 0; u_1^H H_{31} v_1 = 0 \ \forall i = 1; j = 2,3} \quad (9)$$

$$\boldsymbol{u_2^H H_{12} v_2 = 0; u_2^H H_{32} v_2 = 0 \ \forall i = 2; j = 1,3} \quad (10)$$

$$\boldsymbol{u_3^H H_{13} v_3 = 0; u_3^H H_{23} v_3 = 0 \ \forall i = 3; j = 1,2} \quad (11)$$

From equation 9-11 solving for $\boldsymbol{v_i}$[8]

$$\boldsymbol{H_{12} v_2 - H_{13} v_3 = 0_2}; \quad (12)$$

$$\boldsymbol{H_{21} v_1 - H_{23} v_3 = 0_2}; \quad (13)$$

$$\boldsymbol{H_{31} v_1 - H_{32} v_2 = 0_2}; \quad (14)$$

$$\boldsymbol{v_2 = H_{12}^{-1} H_{13} v_3} \quad (15)$$

$$\boldsymbol{v_3 = H_{23}^{-1} H_{21} v_1} \quad (16)$$

$$\boldsymbol{v_1 = H_{31}^{-1} H_{32} v_2} \quad (17)$$

From equation 15-17 $\boldsymbol{v_1}$ can be defined as

$$\boldsymbol{v_1 = H_{31}^{-1} H_{32} H_{12}^{-1} H_{13} H_{23}^{-1} H_{21} v_1} \quad (18)$$

From above equation $\boldsymbol{v_1}$ is solved as below

$$\boldsymbol{v_1 = eigenvector(H_{31}^{-1} H_{32} H_{12}^{-1} H_{13} H_{23}^{-1} H_{21})} \quad [8] \quad (19)$$

From $\boldsymbol{v_1}$ using equation (16) and (15) v_3 and v_2 are solved; once $\boldsymbol{v_1; v_2; v_3}$ are found we can use equation (4) to solve $\boldsymbol{u_1; u_2; u_3}$

$$u_1^H H_{12} v_2 = u_1^H H_{13} v_3 = 0 \quad (20a)$$

$$u_2^H H_{21} v_1 = u_2^H H_{23} v_3 = 0 \quad (20b)$$

$$u_3^H H_{31} v_1 = u_3^H H_{32} v_2 = 0 \quad (20c)$$

The above equations are solved by using SVD method and the $\boldsymbol{u_1; u_2; u_3}$ vectors are obtained.

Simulation of the proposed system has been carried out using the simulation flow diagram of Figure 2. Monte Carlo simulation is used to analyze the capacity for the Rayleigh, Rician and Nakagami fading channel. Table 1 gives the simulation parameter values used. Figure 2 is the generic simulation flow that is used for simulating and analyzing the capacity of primary user and two secondary user .Random bit source is used as binary data source that is modulated by BPSK modulation, coding and decoding vector generator blocks calculate the pre-coding and decoding vector by using the above discussed equations. Encoding process encodes the modulated vector sequence x by using the encoder vector v, the encoded sequence is propagated through the fading channel.

Fading channel is generated by MIMO fading channel realization block. Received sequence is decoded using the decoding vector u, in the decoding process all the interference is eliminated because the encoding and decoding vector satisfying the equation (4).Interference free signal is then used to calculate the capacity of users.

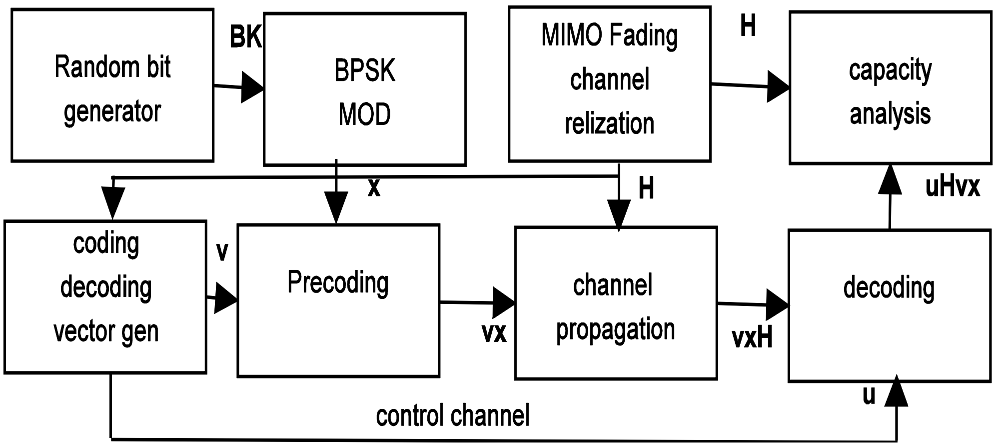

Figure 2. Base Band Signal Processing Model for Simulation

Table 1. Parameters Used in Simulation

Parameter	Parameter value
MIMO configuration of primary user	2X2
MIMO configuration of cognitive user	2X2
Rician fading –LOS component	0.8
Nakagamin - gamma distribution shape parameter A and scale parameter B	A=4; B=4
SNR range	0dB - 30dB
Number of transmit bits	100000
Number of random realization of fading channels	1500
Modulation employed	BPSK

The capacity of the primary user is

$$C_p = log_2 det\left(I_M + {P_{pt} H_{11} v_1 v_1^H H_{11}^H u_1 u_1^H} \Big/ {M u_1^H N_p} \right) \quad (21)$$

The capacity of the secondary user 1 is

$$C_{s1} = log_2 det\left(I_M + {P_{s1t} H_{22} v_2 v_2^H H_{22}^H u_2 u_2^H} \Big/ {M u_2 N_{s1}} \right) \quad (22)$$

Similarly the capacity of the secondary user 2 is

$$C_{s2} = log_2 det\left(I_M + \frac{P_{s2t} H_{33} v_3 v_3^H H_{33}^H u_3 u_3^H}{M u_3 N_{s2}}\right) \quad (23)$$

The SNR, BER and the channel capacity of the primary user is depends on the term $u_1^H H11\ v_1$, similarly the secondary user 1 and user 2 are depends on $u_{s1}^H H22 v_{s1}$ and $u_{s2}^H H33 v_{s2}$ term respectively

3. Cluster Based Max Signal Power User Scheduling (CBMSPUS) for Multiple Cognitive Users

User scheduling is used to select one or a set of users among multiple users at a given time to use the wireless channel .Various approaches of user selection were reported in the literature. Under cognitive radio environment, the user selection involves the selection of the cognitive radio for sharing the spectrum with the primary user such that the selected users will not degrade the performance of the primary user. Cognitive user can be opportunistically selected to obtain the multi-user diversity gain [10]. In general, the selection of SUs is done by two approaches, the SUs who generate minimum interference on primary receiver (PR) are selected [11] and the SUs who achieve the highest throughput for the secondary network are selected, while keeping the interference to PR under certain constraints [12–14]. In [13] as a first step each CR power allocation is done such that the interference generated to PR is within a certain interference temperature constraint. Then, in second step, the CR link with the highest signal-to-interference-plus-noise-ratio (SINR) is selected.

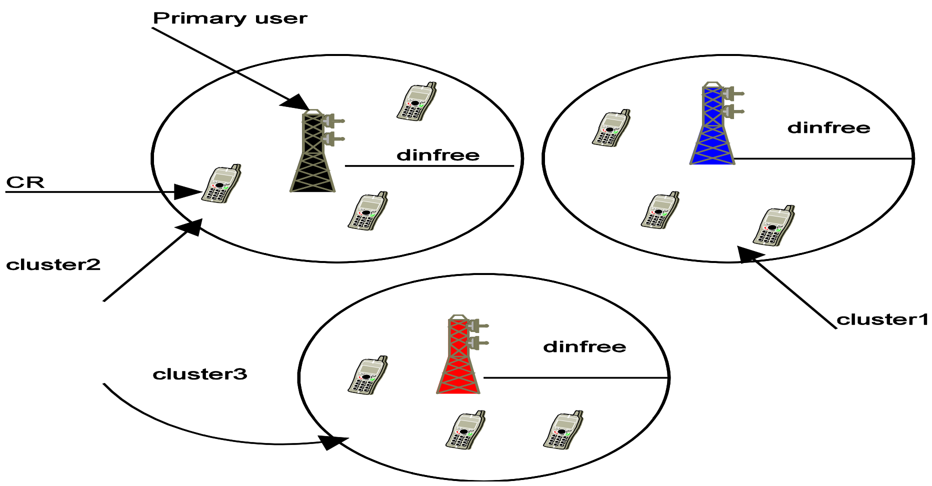

Figure 3. Cluster Architecture with 3 Clusters with One PU in Each

In this work the entire set of the primary and cognitive user nodes are clustered such that each cluster is interference free from each other and it is based on the location and the maximum transmit power of the node. Each cluster only one primary user and multiple cognitive users are considered.Figure.3 shows the cluster architecture and this model assumes that every node will know it's location and other nodes location in the network. Clustering is done based on the location of CR node from the PR nodes. Any CR node within interference free distant to another PR will be a part of the cluster. The Cluster Based Max Signal Power User Scheduling (CBMSPUS) algorithm is applied to cluster the entire network and to select the two cognitive user such that the selected users will maximize the signal power component of the primary user. This adaptive user selection is done for every μ interval, which can be fixed by minimum transmission time requirement of the CR user to achieve the required quality of service and coherence time of the channel. In the spatial coding the signal amplitude determining term for the i^th user can be written as

$$\beta_i = u_i H_{ii} v_i \quad (24)$$

The i^th group in a cluster, which is selected for allow simultaneous transmission under scheduling can be written as

$$G_i = \{P, CR_{1i}, CR_{2i}\} \; \forall \; i = 1,2,3 \ldots N_{CR} \quad (25)$$

Optimal current set G_{jopt} with primary P_j and cognitive users is one which maximize the signal power of the primary user at a given time

$$G_{jopt} = \{P_j, CR_{1opt}, CR_{2opt}\} \quad (26)$$

The optimal group set to transmit at the given time can be obtained by solving

$$G_{jopt} = arg \max_{G_j} \beta_j \quad (27)$$

Where β_j is P_j primary user signal power component in j^th cluster, where G_{jopt} is optimal group with one primary user and two secondary users after scheduling. Detailed scheduling algorithm CBMSPUS is given below.

Cluster Based Max Signal Power User Scheduling

(CBMSPUS) algorithm

Step 1.Colect all CR node location L_i

Step 2. If $L_j \sim L_i \leq d_{infree}$, with each primary P_j add i^th CR node in Cluster C_j

Step 3.User selection: in each cluster C_j ; solve the spatial coding vectorsu_{jj}, v_{jj}

Step 4.Set G_{jopt} by solving the following problem with the valuesu_{jj}, v_{jj}

G_{jopt} =arg $\max_{G_j}$ β_j

Step 5.Appy spatial coding on G_{jopt} set and do Transmission of data

Step 6.Wait for $t_w = \min_t (t_{coh}, d_{max})$ time and continue the communication with current set G_{jopt}

Step 7. If $t \geq\equiv t_w$ go to step 3.

The interference free distant between the primary and CR user is set as d_{infree}, the location of j^th primary user and i^th secondary users are L_j and L_i ,the coherence time of the primary user channel is t_{coh} , maximum delay that will not affect the QOS requirement of secondary user is d_{max} ; and the allowed time interval to transmit using current schedule or the time interval between consecutive scheduling is t_w.

4. Result and Discussion

Simulation has been carried out for the discussed cluster based CR system .Values of N and M is set to 2. For different values of SNR from 0 dB to 30 dB, capacity of the primary and secondary user under different fading channels are studied. Figure 4 shows the capacity of primary and two secondary users for Rayleigh fading channel realization. From the Figure 4 it is clearly understood that the primary user achieves higher capacity than the two secondary user because the scheduling algorithm maximize the PR signal power.

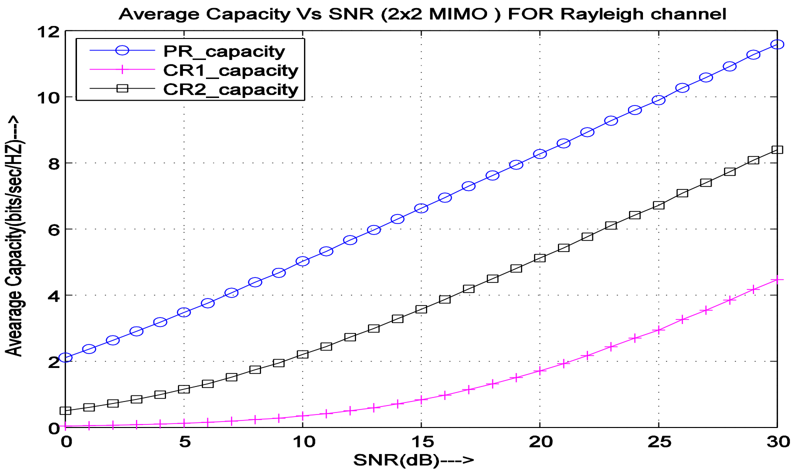

Figure 4. Capacity of Spatial Coded 2x2 MIMO under Rayleigh Fading.

For the primary user the capacity is around 5bits/HZ /channel at low SNR region and it is around 11.6 bits/HZ/channel at high SNR region. The secondary user archives maximum capacity of around 2.2bits/HZ /channel at low SNR region and it is around 8.4 bits/HZ/channel at high SNR region.

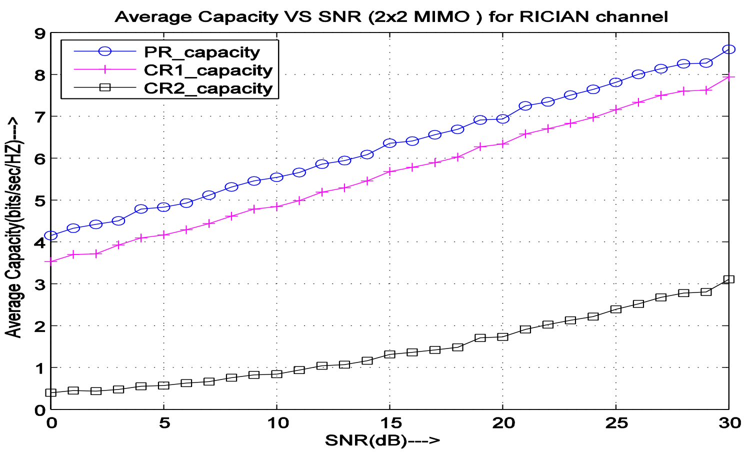

Figure 5. Capacity of Spatial Coded 2x2 MIMO System under Rician Fading

Rician channel is realized with line of sight component value as 0.8 and from Figure 5, the achieved capacity of rician channel can be observed. For the primary user the capacity is around 5.7bits/HZ /channel at low SNR region and it is around 8.7 bits/HZ/channel at high SNR region. The secondary user achieves maximum capacity of around 4.8bits/HZ /channel at low SNR region and it is around 8 bits/HZ/channel at high SNR region.

For Nakagami channel realization the m samples of Nakagami can be generated by well-established method of random generation, such as the percentile transformation method or the rejection method. By generating gamma distributed samples (*e.g.*, the gamrnd (·) matlab function) and it's square root the desired Nakagami-m samples are realized [9]. For gamma distribution the A and B parameters are set to 4. Figure 6, shows the achieved capacity of the primary and secondary users under the Nakagami channel.

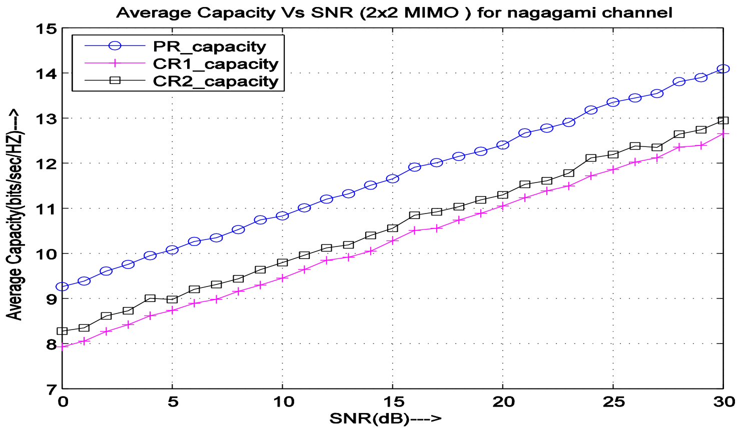

Figure 6.Capacity of Spatial Coded 2x2 MIMO System under Nakagami Fading

Simulation results show that the capacity for Nakagami fading channel is higher than that of others fading channels. For the primary user the capacity is around 10.8bits/HZ /channel at low SNR region and it is around 14.2 bits/HZ/channel at high SNR region. The secondary user archives maximum capacity of around 9.8bits/HZ /channel at low SNR region and it is around 13 bits/HZ/channel at high SNR region. Rayleigh fading achieves next high level of capacity and Rician achieves the least capacity among the three.

Performance of the proposed scheduling algorithm is compared with the Fist In Fist Out (FIFO) cognitive user scheduling algorithm .Figure 7 shows that the capacity of the primary user with FIFO and the CBMSPUS scheduling algorithm. From the Figure it is evident that the primary user achieves maximum capacity under CBMSPUS scheduling around 4.4 bits/HZ/channel at low SNR region and around 6.8bits/HZ/channel at high SNR region. But for FIFO case it is around 2.5bits/HZ/channel at low SNR region and around 4.7bits/HZ/channel at high SNR region. At low SNR region for the same capacity of 3 bits/HZ/channel, the proposed scheduling algorithm provides 15dB gain comparing FIFO algorithm. At high SNR region for 6.8 bits/HZ/channel, CBMSPUS scheduling provides 13dB gain to that of FIFO algorithm.

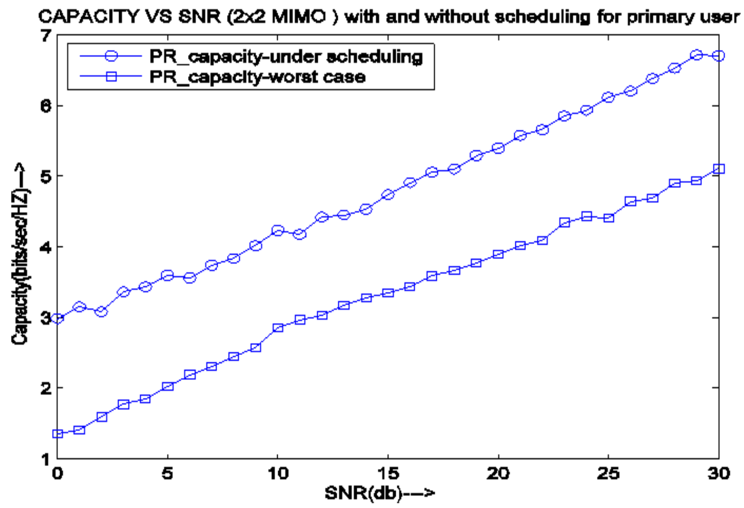

Figure 7. Capacity of PU User with FIFO and CBMSPUS Scheduling for Rayleigh

5. Conclusion

MIMO cognitive radio is the current research topics under which various underlay and overlay cognitive spectrum sharing transmission schemes are proposed. Spatial degree of freedom offered by the MIMO system enables to develop various spatial coding system to mitigate the interference while sharing the spectrum between primary and secondary users. In this research study, the achievable capacity of primary and secondary user under Rayleigh, Rician and Nakagami fading channel are simulated by Monte Carlo method. Using spatial coding, the interference from other user can be fully eliminated but the capacity of the user's decreases with the increase number of users. So spatial coding fixes a upper bound on the number of secondary user. To facilitate multiple cognitive user to share the spectrum with good data rate a cluster design is proposed With two secondary and one primary user and a Cluster Based Max Signal Power User Scheduling (CBMSPUS) algorithm is presented which will select adaptively two cognitive user for a given single primary user in a cluster such that the signal power of the primary user will be maximum.

References

[1] D. Tse and P. Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, **(2005)**.

[2] R. Zhang and Y. C. Liang, "Exploiting Multi-Antennas for Opportunistic Spectrum Sharing In Cognitive Radio Networks", IEEE J. Sel. Topics. Signal Process, vol. 2, no. 1, **(2008)**, pp. 88–102.

[3] M. Kang, B. Jung, D. Sung and W. Choi, "A Pre-Whitening Scheme in a MIMO-Based Spectrum-Sharing Environment", IEEE Communication Letter, vol. 12, no. 11, **(2008)**, pp. 831–833.

[4] M. Jung, K. Hwang and S. Choi, "Interference Minimization Approach to Pre-coding Scheme in MIMO-Based Cognitive Radio Networks", IEEE Communications Letters, vol. 15, no. 8, **(2011)**, pp. 789-91.

[5] S. M. Perlaza, N. Fawaz, S. Lasaulce and M. Debbah, "From Spectrum Pooling to Space Pooling: Opportunistic Interference Alignment in MIMO Cognitive Networks", IEEE Trans. Signal Process, vol. 58, no. 7, **(2010)**, pp. 3728–3741.

[6] V. Cadambe and S, Jafar, "Interference Alignment and Degrees of Freedom of the User Interference Channel", IEEE Trans. Inf. Theory, vol. 54, no. 8, **(2008)**, pp. 3425–3441.

[7] M. Razaviyayn, G. Lyubeznik and Z. Q. Luo, "On the Degrees of Freedom Achievable through Interference Alignment in a MIMO Interference Channel", IEEE Trans. Signal Process, vol. 60, no. 2, **(2012)**, pp. 812–821.

[8] Y. Qiao and Y. Xiao, "A Spatial Coding Approach for MIMO Cognitive Radio Networks' Bandwith Sharing", Proceeding of the International Conference On Electronics and Communication Systems, Island, Greece, **(2013)**, pp. 123-126.

[9] C. Jos´e, S. S. Filho, M. D. Yacouba and G. Fraidenraich, "A Simple Accurate Method for Generating Auto-correlated Nakagami-m Envelope Sequences", IEEE Communications Letters, vol. 11, no. 3, **(2007)**, pp. 231-33.

[10] P. Viswanath, P. T. Laroia, "Opportunistic Beam Forming Using Dumb Antennas", IEEE Trans. Inf. Theory, vol. 48, no. 6, **(2002)**, pp. 1277-1294.

[11] C. Shen and M. P. Fitz M, "Opportunistic Spatial Orthogonalization and Its Application in Fading Cognitive Radio Networks", IEEE J. on Selected Topics in Signal Processing, vol. 5, no. 1, **(2011)**, pp. 182-189.

[12] L. Zhang, Y. C. Liang, Y. Xin, "Joint Beam forming and Power Allocation for Multiple Access Channels in Cognitive Radio Networks", IEEE J. Selected Areas in Communications, vol. 26, no. 1, **(2008)**, pp. 38-51.

[13] T. Ban, W. Choi, B. C. Jung and D. K. Sung, "Multi-User Diversity in A Spectrum Sharing System", IEEE Trans. Wireless Communication, vol. 8, no. 1, **(2009)**, pp. 102-106.

[14] R. Zhang and Y. C. Liang, "Investigation on Multiuser Diversity in Spectrum Sharing Based Cognitive Radio Networks", IEEE Comm. Letter, vol. 14, no. 2, **(2010)**, pp. 133-135.

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