INTERFERENCE CANCELLATION IN MULTIPLE INPUT MULTIPLE OUTPUT COGNITIVE RADIO NETWORKS

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Abstract

Spectrum is becoming a valuable resource and its usage is highly increasing demand nowadays. In order to efficiently utilize the spectrum,, cognitive radio (CR) technology was introduced. Spectrum efficiency can be further improved by MIMO (Multiple Input Multiple) CRN(Cognitive Radio Network) systems. Primary and secondary users are present in CR systems. Single and multiple antennas are equipped with the primary and secondary users respectively. Here interference is the major concern when the primary and secondary users are transmitting simultaneously. To overcome the interference among the users, successive interference cancellation (SIC) method was suggested and evaluated, which is done with MATLAB software and the performance of the system is analyzed.

Keywords: Multiple Input Multiple Output (MIMO), Cognitive Radio(CR), Multiple Antennas , Interference cancellation.

I. Introduction

Cognitive radio (CR) is a technology that promises to significantly improve the availability and utilization of radio spectrum. Cognitive nodes intelligently adapt their transmissions and co-exist with other users. CR divides the users into two classes, namely, primary users (PUs), which have unrestricted access to the spectrum, and secondary users (SUs), which can access the same spectrum but must ensure that their transmissions do not interfere excessively with the PUs.

In cognitive radio systems, primary users have legal rights to utilize the spectrum resource than the secondary users. Therefore, one fundamental issue by introducing spectrum sharing is to ensure the quality-of service(QoS) of the primary users while maximizing the achievable throughput of the secondary users. Recently, there has been a great deal of research related to this interesting problem. When the primary users are legacy systems that do not actively participate in transmit power control, the QoS of the primary users is maintained by introducing interference-power constraint measured at the primary receiver [1].

In CR networks, time and frequency domains plays a major role on radio resource allocation during the single antenna equipped with both the primary and secondary transceivers. Wireless transmissions via multiple transmit antennas and multiple receive antennas, or multiple-input multiple-output (MIMO) transmissions, have received considerable attention during the past decade[2], [3]. To achieve the most advantageous functions in wireless transmissions multiple antenna technologies was suggested. The functions are such as capacity increases without bandwidth expansion, substantial improvement of transmission reliability via space-time coding and effective co-channel interference suppression for multiuser transmissions [4]. However, the role of multi-antennas in a CR network is completely advisable . Generally, multi-antennas can be used to allocate transmit dimensions in space and hence provide the secondary transmitter in a CR network more degrees of freedom in space in addition to time and frequency so as to balance between maximizing its own transmit rate and minimizing the interference powers at the primary receivers. This motivates the research of this paper to be done, with an aim to address the issue of MIMO channel interference in a CR network.

II. System model and problem statement

An important issue in the interference cancellation approach is how it will interact with more advanced technologies. The future wireless communication systems will have the significance of MIMO technologies. Here, multiple antennas are equipped at both the transmitter and receiver ends inorder to achieve the simultaneous data streams along with separate paths between pairs of antennas. Although, the superposition principle applies to MIMO as well as interference cancellation techniques are orthogonal to MIMO systems.

The major part of the wireless future will be at the same time of heterogeneous devices. Nowadays, Bluetooth, 802.11, 802.15.4 (e.g. Zigbee), RFID, and other devices such as cordless phones and microwaves all operate in the same part of the spectrum, but in practice there are adverse interactions in their interoperation . In an OFDM based CR, interference should be minimized in the LU band for co-existence purposes. To achieve this, active interference cancellation (AIC) has been proposed in [5], for a UWB based multiband OFDM system [6]. We believe that the future of wireless will be marked by further heterogeneity in the ISM bands, and the systematic cancellation of interference will become critical for good performance in the presence of heterogeneous interfering devices [7], [8].

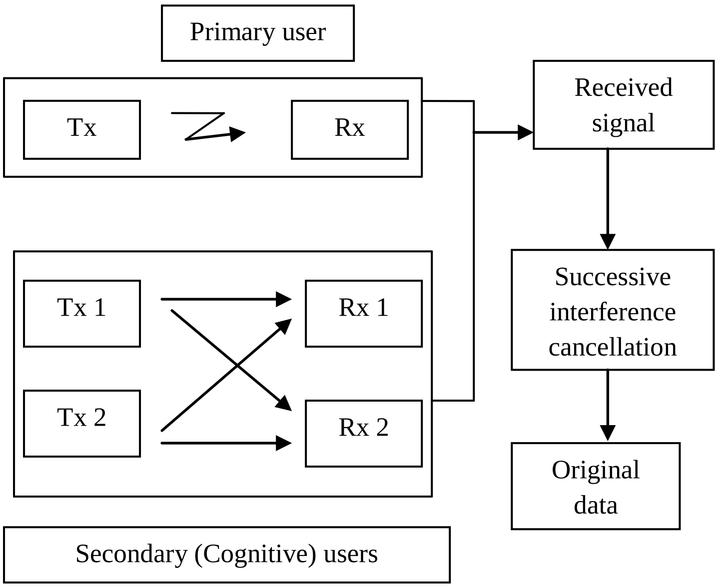

Figure 1 Block Diagram

The above figure [9] shows that single antennas are equipped with primary users and multiple antennas are equipped with secondary users. When there is the simultaneous transmission takes place interference occurs between the users. To overcome that type of interference successive interference cancellation algorithm is used.

III. Successive Interference Cancellation (SIC) method

Successive interference cancellation (SIC) is a promising technique to improve the efficiency of the wireless networks with relatively small additional complexity [10].When the receiver receives two or more signals concurrently in the receiver side there is some collision in today's systems . This can be reduced by successive interference cancellation technique. SIC is possible because the receiver may be able to decode the stronger signal, subtract it from the combined signal, and extract the weaker one from the residue. We focus on two simple assumptions:

(1) Two transmitters sending to a common receiver, and

(2) Two transmitters sending to distinct receivers. We find that the characteristics of SIC in these simple topologies reflect on the behavior of larger, real world networks such as enterprise or residential wireless LANs.

Our key observations may be summarized as follows:

(1) In the case of distinct receivers (*T*1!*R*1 and *T*2!*R*2),the gains from SIC are marginal.

(2) In the case of common receivers (*T*1!*R*1Ã*T*2), SIC may offer modest MAC layer throughput gains if transmitters are carefully coordinated with techniques such as transmitter pairing and power reduction. However, somewhat counter-intuitively, the throughput gain is maximized when the system is forced to operate below the physical (PHY)
layer capacity.

(3) We find that these behaviors hold even under various real-world network architectures (e.g., enterprise WLANs, where multiple APs are connected via a wired backbone) [11].

SIC is known to be able to achieve much better performance than the naive approach of treating interference as noise in interference-limited networks [12].

Interference in MIMO cognitive radio networks

Interference involved in MIMO CR networks can be classified into two types:

- Intra-network interference, and
- Inter-network interference.

Intra-network interference is also known as self-interference model, which refers to the interference caused within a single network, which means either a primary or secondary (CR) network. Some examples of intra-network interference include inter-symbol interference in frequency selective channels and multi-access interference (MAI) in multi-user networks. Intra-network interference exists to some extent in every wireless communication system and there is a wealth of techniques established to mitigate them effectively.

Inter-network interference is also known as mutual interference model, which means interference occurs between the primary and CR networks. The problem of inter-network interference management is two-fold. First, CR transmitters need to carefully control their emissions to guarantee that the QoS of the primary network is not harmfully degraded by the CR primary interference. Second, CR receivers should be able to effectively combat the primary-CR interference and provide useful QoS to the CR application [13].

IV. Simulation and results

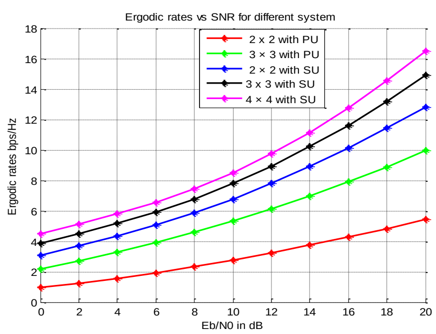

Figure 2 CRN with different MIMO Configurations.

The above figure shows that the capacity of the system can be increased based on the number of antennas used . Here, MIMO concept is implemented in secondary user (CR) side to improve the capacity of the system. Capacity of the system is inversely proportional to total power.

Simulation Environment

Parameters	Specifications
N_t	2
N_r	2
FFT Length	64
No. of Sub Carriers	256
Cyclic Prefix	16
Channel	AWGN, Rayleigh, Pedestrian B
Modulation	PSK

Table 1 Simulation Parameters

The above specifications are used in the simulation environment.

Table 2 Ergodic Rates for Different MIMO Configurations

Received Signal strength (E_b/N_0) in dB	Ergodic Rates				
	2x2 with PU	3x3 with PU	2x2 with SU	3x3 with SU	4x4 with SU
4	1.8	3.6	5.2	5.6	6
8	2.2	4.2	6	7.2	7.6
12	3.8	6	8	8.5	10
16	4	8	10	11.9	12.5

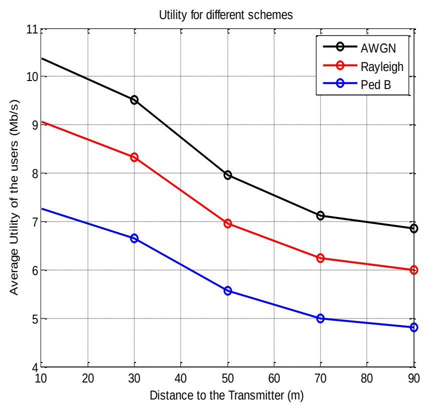

Figure 3 Utilization of different models

Here, different channel models are analyzed for MIMO CRN techniques. Pedestrian channel B generates the noise between AWGN and Rayleigh . It is a well known channel to represent the multipath conditions in micro cells and it has low transmission powers when comparing with the other two models.

Table 3 Comparison between Channel Models Based on distance

Distance (m)	Utility for different schemes		
	AWGN	Rayleigh	Pedestrian B
20	10.2	9	7.2
40	8.8	7.8	6.2
60	7.8	6.8	5.4
80	7.2	6.2	5

Interference Cancellation Scheme

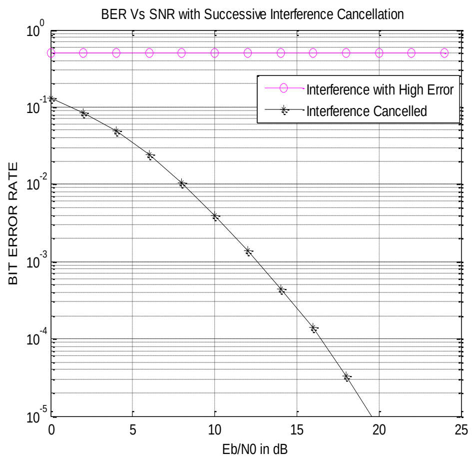

Figure 4 Interference Cancellation Scheme

In a general communication systems, channel induces a phase shift and attenuation. MIMO CRN technique is widely used for broadband wireless communication system. However, a main problem is its vulnerability to frequency offset errors due to which the orthogonality is destroyed that result in Inter carrier Interference (ICI). ICI causes power leakage among subcarriers thus degrading the system performance.

Bit error rate degrades with respect to increasing signal strength. Here, we can observe that the least amount of interference occurs , because the error performance of the system is reduced after applying interference cancellation scheme.

Table 4 Signal strength for with and without interference

Received Signal strength (E_b/N_0) in dB	Bit Error Rate	
	Interference with high Error	Interference Cancelled
5	10^{-1}	10^{0}
10	10^{-2}	10^{0}
15	10^{-3}	10^{0}
20	10^{-4}	10^{0}

V. Conclusion

This paper describes the performance of cognitive radio systems when it performs multiple transmissions. During multiple transmissions and reception interference may occur which can be reduced by means of successive interference cancellation algorithm. And throughput of the system can also be increased. The average utilization of the users can be analyzed for different channel models.Simulation results shows that both the primary and the secondary network achieve higher utility in MIMO-CRN than in the conventional schemes. Rayleigh fading of signal which leads to inter symbol interference (ISI).Maximum likelihood sequence estimation are used to improve the performance. The future work will be done in MIMO CRN is to optimize the power level of the system.

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