International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3 Issue No: Special 2, pp: 36-39 22 March 2014

Capacity Maximization of Cognitive Radio Based On Power Allocation in OFDM-MIMO System

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ABSTRACT: In the recent times, usage of mobile devices has been increased many fold. So, this is very serious problem in wireless communications. This leads to inaccessibility to the mobile services. If this is the situation in today's scenario then in future it would be more hard to provide valid access to all the users simultaneously. Cognitive Radio is a future technology to provide worldwide roaming TO IMPROVE CONNECTIVITY AND also to have worldwide roaming and interoperability the "cognitive radio" concept was coined. In this proposed paper ,a scheme including power allocation scheme and a prioritization scheme is used to achieve higher capacity with the same power .This is done by utilizing a simulated cognitive radio scenario.
Keywords: cognitive radio, MIMO-OFDM, Capacity maximization, prioritization, power allocation

I. INTRODUCTION

Radio in which some or all of the physical layer functions are software defined"Software-Defined Radio (SDR) refers to the technology wherein software modulesrunning on a generic hardware platform consisting of DSPs and general purpose microprocessors are used to implement radio functions such as generation of transmitted signal (modulation) at transmitter and tuning/detection of receivedradio signal (demodulation) at receiver .Cognitive Radio provides the groundbreaking concept under which a simple transreciever can be used to make a simple receiver A wide range of radio applications like Bluetooth, WLAN, GPS, Radar,WCDMA, GPRS, etc. can be implemented using SDR technology.

II. PROBLEMS IN WIRELESS TECHNOLOGIES

2.1 Non Technical Problems

The following are the problems which are responsible for the rise of cognitive radio:

a) Due constant changes in service providers' networks like changing from 3G to 4G and so on , the subscribers are forced to change their devies. This leads to heavy increase in E-waste.

b) While changing the new changes , heavy initial costs are pretty much higher, for which the commercial players are not ready.

2.2 Technical problems

a) The commercial service providers are constantly changing the protocols like from 2G to 2.5G/3G to 4G in lesser time without any proper gap.This leads to constant upgrades.

b) Governments are not providing same kind of protocols from country to country(for e.g. European wireless networks are predominantly GSM/TDMA based while in USA the wireless networks are predominantly IS95/CDMA based).

c) Due to lesser time , the technologies are often are not totally utilized. This leads to several underutilized frequency bands to be abandoned.

With features like reconfigurable, Ubiquitous Connectivity and interoperability, Cognitive Radio can be the possible solution for the above mentioned problems.

In cognitive radio system, there are many kinds of transmission schemes for accommodating both Primary User (PU) and Secondary User(SU)

Underlay systems will enable SUs to transmit in a frequency lower than PUs. This is not preferable as it will increase the overall noise floor.

Whereas overlay systems will enable the SUs to transmit in the same frequency as of the PU. This is recommended when both PUs and SUs want to access the frequency band simultaneously for a limited time. Under heavy interference levels, overlay method is the best suited method.

Since active PUs pay for the frequency band, secondary ones, SUs’ transmission must not disturb PUs’ transmission. This has led to two main purposes in overlay structure. The first one is minimizing of the causedinterference in PUs’ transmission and secondly, to exploit the spectrum holes maximally [5].

The method of exploiting holes can be termed as interweave paradigm. This is a opportunistic sharing method. SUs always target the loops which occur in the

The amalgamation of multiple-inputmultiple-output (MIMO) and Orthogonal Frequency Division Multiplexing(OFDM) which is called MIMO-OFDM has attracted great attention recently. In a hybrid scheme, MIMO is used to increase the capacity and diversity gain, whereas OFDM is used to transform frequency selective channel of MIMO to flat fading sub channels.

The most prior researches on radio resource allocation forCR networks have been centred on OFDM-based structures ,and single antenna employed at secondary transceivers However, to date, no research has been done on power allocation for MIMO–OFDM-based CR systems[1].

For instance, the MIMO–OFDM system proposed in [2] fulfils the maximum capacity of a system with total power

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constrain and a MIMO–OFDM system based on minimum required power in order to service users with a specific fixed rate is designed in [3]. However, it is shown that present power allocation algorithms in MIMO–OFDM systems do not have enough capacity due to primary and secondary user interference.

The paper will discuss about the various power allocation schemes in Cognitive Radio(CR). And chooses the best one too. The later part will discuss about the prioritization schemes which can be used to maximize the capacity.

III. SYSTEM DESCRIPTION

Let us consider a one-cell wireless system, in which the PU and SU transceivers coexist in the same geographical location. The scenario is investigated for downlink path and for a CR user. PUs' base station transmits signals to N PUs, each of which occupies a determined frequency band in the available spectrum[4]. A CR network has an individual base station that identifies the spectrum holes after collecting information about spectrum; then inactivates PUs' sub-carriers and transmits its users' information by the remained sub-carriers (Fig. 1).

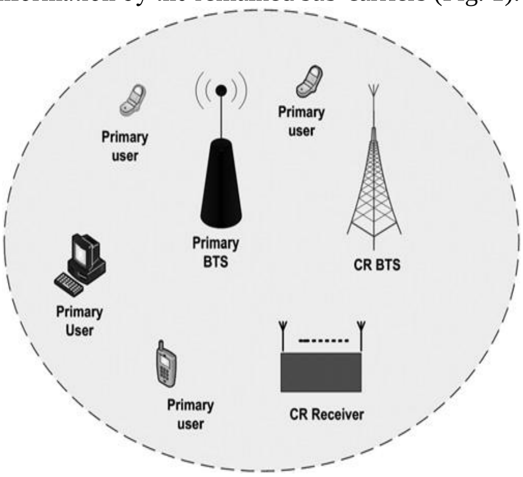

Fig. 1 System design of CR with coexistence of primary and secondary networks .

Let the PU and SU transrecievers coexist under the same network. It is assumed that perfect Channel State Information (CSI) is known at the SU's reciever. Its is better to have a small transmitter along with the receiver at the SU side for transmitting pilot signal. This arrangement is done so that prioritization of users can be accommodated .Moreover, SUs are assumed to be mobile and PUs are assumed to be stationary .Let there are N_R transmitters and N_T receivers.

The channel gain between the SU transmitter and the l^{th} PU receiver for the i^{th} sub-carrier is denoted by a 1 × M matrix, where $g_{i,n,m}$ denote the channel gain for the channel between the SU's m^{th} transmit antenna and the l^{th} PU receiver antenna. Since, perfect CSI is applicable here, we can divide the channel into parallel by Singular value decomposition.

$$H_i = U_i \Lambda_i V_i \qquad (1)$$

where H_i is the SU and channel gain for m^{th} transmit and the n^{th} recieve by $h_{i,n,m}$. $\mathbf{U_i} \in \mathbf{C^{NrXNr}}$ and $\mathbf{V_i} \in \mathbf{C^{NtXNt}}$ are unitary matrices and $\boldsymbol{\lambda_i} \in \mathbf{C^{NtXNt}}$ is a rectangular matrix whose diagonal elements are non-negative real numbersis a rectangular matrix whose diagonal elements are non-negative real numbers by multiplexing independent data onto these independentchannels, the capacity of i^{th} subcarrier can be obtained by

$$c_i = \sum_{i=1}^{n_{min}} log_2\left(1 + \frac{p_{ij}\lambda_{ij}^2}{N_0}\right) \qquad (2)$$

Where
C_i= Capacity of the system
P_{ij}=power of jthantenna at ith sub carrier
N_o=Additive White Gaussian Noise

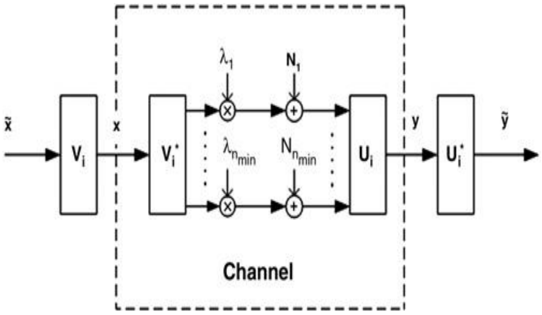

Fig. 2. Converting the MIMO channel into parallel channels by SVD

Table. 1: Various Power Allocation Schemes in Cognitive Radio

Name of the Algorithm	Remarks
Water Filling Algorithm	The capacity of a channel is given by the formula $C = \sum_{l=1}^{n_{min}} log_2\left(1 + \frac{p_{ij}\lambda_{ij}^2}{N_0}\right)$ This is a traditional Algorithm which can be modified to have a variable capacity of channel based on user requirement and channel specification. This has usually a low capacity than the others
Optimal Algorithm	If we need to maximize the capacity $\max C = \sum_{l=1}^{n_{min}} log_2\left(1 + \frac{p_{ij}\lambda_{ij}^2}{N_0}\right)$ The above problem can be solved by $p_{ij}^{*} = max\left\{0, \mu - \frac{N_0}{\lambda_{ij}^2}\right\}$ more capacity than the water filling algorithm and higher hardware complexity.

Sub optimal Algorithm	Water filling Algorithm can be solved by a simpler solution $p_{ij}^* = \max\left\{0, \mu\forall - \frac{N_0}{\lambda_{ij}^2}\right\}$ And applying uniform water filling algorithm to provide equal power to all the antennas.

The above table concludes that the sub optimal power allocation scheme is the best available option to have better usage and capacity.

Increase in the number of antennas increases the capacity and for the same number of transmitter and receiver antennas, no significant change can be observed.

IV PRIORITIZATION IN COGNITIVE RADIO NETWORKS

This can be done by using traditional handoff schemes to have better reuse of the channels by both PU and SU .There are certain basic guidelines which can govern the scenario for Secondary Users(SUs):

a) Don't transmit until you can decode your data.

b) Have a standpoint of protecting the legacy users& maximize the spectrum usage.

c) Apart from modulation scheme and codebook of transmission, the SU should have a small transmitter too, for pilot signal transmission.

d) This is to have a proper synchronization between SU and PU which can reduce the barrier caused due to the quantization of the signals.

Auctioning the amount of data before each month can also help to improve QoS and also improve the overall capacity of the System.

There are two traditional techniques for improving capacity with the help of prioritizing the users in Cognitive Radio scenario

a) Varian and Mackie-Mason(VMM)

Features:

(i) Longer queue lengths means lower payments

(ii) Payment is done only for dropped packets but not for the delay imposed on the packets.

Drawback:

i) It estimates the externality as no information about other buyers is available with other buyers.

b) Babaioff et al (BKS)

Definition 1 (BKS): Given an allocation rule A and a parameter μ ϵ(0,1),the BKS procedure in our setting is to change the transformed bids in a different way.

Definition 2:A mechanism is truthful in expectation if a risk-neutral buyer maximizes expected utility by bidding truthfully, whatever the bids of others and whatever realizes demand, where the expectation is taken worth respect to random coin flips mechanism

This algorithm has 2 scenarios:

(a) Buy Side

(b) SellSide

V. SIMULATION RESULTS

Fig. 3 :Performance analysis of water filling algorithm SNR vs capacity

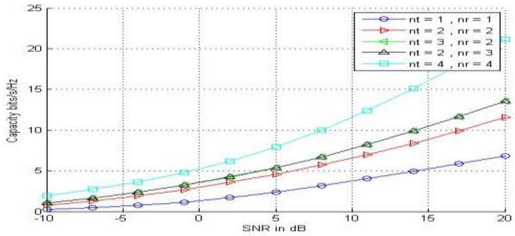

Fig. 3 :Performance analysis of water filling algorithm SNR vs capacity

Fig. 4 : Comparison of various power loading algorithms

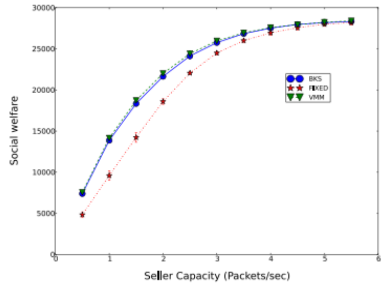

Fig. 5. BKS algorithm provides truthfulness without loss of efficiency

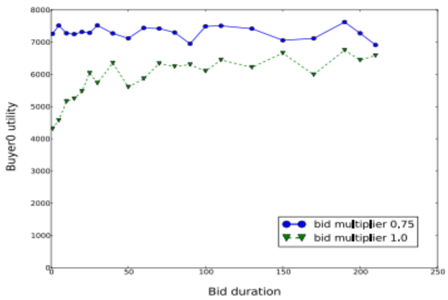

Fig .5 .Effect of manipulation on BKS after frequent revision in bids

CONCLUSIONS

In this proposed paper, we have provided a pathway which can be followed as guidelines to have a proper usage of the frequency bandwidth and thus increase the capacity of the Cognitive Radio scenario. However, as these techniques are older techniques which are in current usage these can prove to be easily applied to future wireless networks .By combining the Optimal power allocation scheme and by applying BKS

Algorithm to it we can achieve improved capacity in cognitive radio scenario with multiple service providers and Users. SUs are assumed to be mobile and PUs are assumed to be stationary with perfect CSI available at SU side

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