IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Optimized Beamforming for Cognitive Network

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Abstract

Cognitive Radio technology will have significant impacts on upper layer performance in wireless networks. In this paper, a jointly-optimized beam forming is applied for cognitive networks that maximize the achievable transmission rates, where primary and cognitive users share the same spectrum and are equipped with multiple antennas. With the help of beam forming signals, co-ordination is not required between the primary and cognitive users and the interference cancellation is done at the cognitive user. Specifically, the beam forming vectors of the cognitive link are designed to maximize the signal to noise ratio (SNR). This paper also deals the required algorithms that are need for the beam forming in the cognitive networks.

Keywords: Beam forming, Primary User, Cognitive User.

Introduction

With the development of wireless network, spectrum resource limitation becomes a problem in this area .In fact, the spectrum resources are auctioned to companies that provide wireless services, but a great number of them are idle sometimes. That's to say, spectrum resources are not to make full use. To resolve this problem, cognitive radio (CR) has been proposed. In cognitive radio networks, the available set of channels may be changing because of the fluctuating nature of the available spectrums. In such situation, some problems, such as, the reliable multi-hop communication became more complicated, the delay, noise and interference occur in the transmission between primary and cognitive users.

In this paper, a jointly-optimized beam forming algorithms is proposed for cognitive networks to maximize the achievable rates, where primary and cognitive users share the same spectrum and are equipped with multiple antennas .Let’s consider the transmission of a single information stream in both primary and secondary links. No coordination is required between the primary and cognitive users and the interference cancellation is done at the cognitive user. Specifically, the beam forming vectors of the cognitive link are designed to maximize the achievable rate under the condition that the interference both at the primary and cognitive receivers is completely nullified.

Cognitive Networks

COGNITIVE NETWORKS is an enabling technology to allow cognitive users (CUs, i.e., unlicensed users or secondary users) to operate on the vacant parts of the spectrum allocated to primary users (PUs, i.e., licensed users).CR is widely considered as a promising technology to deal with the spectrum shortage problem caused by the current inflexible spectrum allocation policy. It is capable of sensing its radio environment and adaptively choosing transmission parameters according to sensing outcomes, which improves cognitive radio system performance and avoids interfering with Primary Users.

Wireless networks have increasingly developed in the last decade. EEE 802.11 can provide multiple non-overlapping channels at the same time, multiple channels and multiple Radio protocols also have been proposed to make full use of channel resources.

A cognitive network consists of a number of traditional wireless service subscribers and the so-called cognitive users. The traditional wireless service subscribers have the legacy priority access to the spectrum and are usually called the primary users. On the other hand, cognitive users, which are also known as the secondary users, are allowed to access the spectrum only if communication does not create significant interference to the licensed primary users. For example, the cognitive user can transmit concurrently with the primary users under an enforced spectral mask.

Another strategy, commonly referred to as spectrum sensing, is to have the cognitive users monitor the spectrum and access it when an unused slot is detected. Since the primary user network should not be required to change their infrastructure and topology for spectrum sharing with the secondary users, the secondary users should be able to detect the presence of primary users in the spectrum independently and efficiently.

Principle of Working

Beam forming exploits channel knowledge at the transmitter to maximize the signal-to-noise ratio (SNR) at the receiver by transmitting in the direction of the eigenvector corresponding to the largest Eigen value of the channel.

Consider a cognitive network with a single primary user and a single cognitive (secondary) user as depicted in Fig. 1.Each user consists of a transmitter and a receiver. The primary transmitter and receiver are equipped with NPt and NPr antennas, respectively. Receiver is denoted by W whereas the one between the secondary transmitter and receiver is denoted by H. The interference channel from the primary transmitter to the secondary receiver is denoted by D and the interference channel from the secondary transmitter to the primary receiver is denoted by G. So the individual channel elements in W, H, D, and G, as independent and identically distributed zero mean complex Gaussian random variables with unit variance(Rayleigh fading).

Linear vector precoding for downlink cognitive systems is considered in. In particular, an optimal interference-free precoding scheme removes the interference to the other system. However, multiple antennas are considered only at the transmitter side and as a result, beam forming vectors can be used only at the transmitters. Thus also consider multiple antennas at the transmitter side and show that in a device with K+N antennas can completely nullify N − 1 interferers while achieving a diversity gain of K + 1. Consequently, a network with N such devices is essentially interference-free and therefore the capacity of the network can be increased .In this paper, uncoordinated beam forming techniques in cognitive networks to completely remove the cross interference between the primary and secondary users using multiple antennas at both the transmitters and receivers.

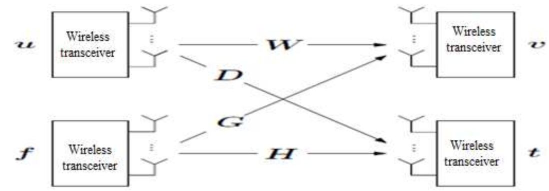

Figure.1 Multiple input and multiple output system

Network and Channel Models

Consider a cognitive network with a single primary user and a single cognitive (secondary) user as depicted in Fig. 1.Each user consists of a transmitter and a receiver. The primary transmitter and receiver are equipped with NP t and NP r antennas, respectively. Likewise, the secondary transmitter and receiver are equipped with NC t and NC r antennas, respectively. Unless stated otherwise, NC t≥ 2, and NC r≥ 2 is assumed.

Furthermore, assume that the antennas are uncorrelated and the channel is frequency non-selective which can be easily achieved by using multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) . Note that, however, our solution is not directly related to the channel model. Once channel information is known, the cognitive transmitter and receiver can compute the transmit/receive beamforming vectors using the proposed algorithms. The MIMO channel between the primary transmitter and receiver is denoted by W whereas the one between the secondary transmitter and receiver is denoted by H. The interference channel from the primary transmitter to the secondary receiver is denoted by D and the interference channel from the secondary transmitter to the primary receiver is denoted by G. We model the individual channel elements in W, H, D, and G, as independent and identically distributed (i.i.d.) zeromean complex Gaussian random variables with unit variance (Rayleigh fading).

Cognitive Networks

In communication networks, cognitive network (CN) is a new type of data network that makes use of cutting edge technology from several research areas (i.e. machine learning, knowledge representation, computer network, network management) to solve some problems current networks are faced with.

Features of cognitive radio technologies

Cognitive radios have the ability to use spectrum which is already used by other spectrum users, i.e. they can share spectrum with other users. To do so, they need to perform three key activities: 1) obtain complete knowledge of the radio operational environment and location, 2) decide on the gathered

information and 3) act based on this decision (dynamically and autonomously).
These three key functions are described below.

The first key activity of cognitive radio technologies is to obtain knowledge of the radio operational environment and location information including the frequency band assignments/allocation. This implies features such as:

- Spectrum sensing: the ability to sense radio signals from other (nearby) radio transmitters
- Location awareness: the ability of a device to determine its location and the location of other transmitters or receivers.

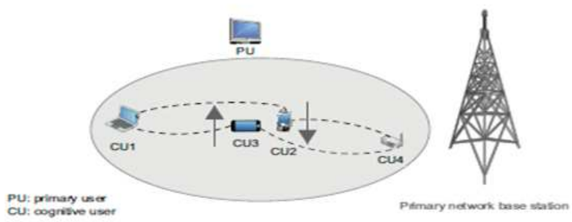

Figure.2 Network model

The CR will also need to have information about the relevant spectrum rules and use restrictions of the bands it senses. These rules and use restrictions can have various levels of complexity depending on the designation of the band and the sharing mechanisms: frequency sharing (overlay, underlay), time sharing and geographical sharing.

The CR will have to map this information with its own capabilities. The exploitation of an opportunity may require dynamic adjustment in order to transmit without causing interference to other radio transmissions. This dynamic adjustment of a cognitive radio system could encompass several actions, such as changing the active radio access technologies or changing the operating frequency.

Proposed System Applications

Cognitive Network

The Cognitive Radio (CR) concept is a new wireless communication paradigm that improves the spectrum usage efficiency by exploiting the existence of spectrum holes. A cognitive radio is a kind of two-way radio that automatically changes its transmission or reception parameters, in such a way that the entire wireless communication network -- of which it is a node -- communicates efficiently, while avoiding interference with licensed or unlicensed users. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behaviour and network state.

Mobile Communication

A mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell. When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission. The spectrum sharing is mainly used to share the spectrum with the specified users for improving the gain and efficiency of the system.

Conclusion

In this paper, the interference cancellation and rate maximization via

Optimized beam forming in a cognitive network which consists of a single primary and secondary user. The secondary cognitive user was allowed to transmit concurrently with the primary licensed user. The beam forming vectors of the cognitive user were designed such that the interference is completely nullified both at the primary and secondary receivers while maximizing the rate of the cognitive link. Since no interference is created at the primary receiver, traditional approaches can be used to design the beam forming vectors or pre-coding matrices of the primary user.

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 ISSN: 2277-9655

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