A cognitive way to access the frequency spectrum

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ABSTRACT

Cognitive radio (CR) is an emergent technology in wireless communication. It aims at improve considerably spectrum use by allowing dynamic spectrum access (DSA). The DSA can be performed in different ways, e.g. interweave and underlay approach. In the interweave approach the CR systems can access frequency bands that are not occupied. In the underlay approach, CR systems can transmit over busy bands with a low power spectrum density.

In this paper, a new architecture for CR system implementation with a hybrid DSA is proposed. To maintain stability and improve the spectrum efficiency, a system combining interweave and underlay approach is proposed. Using spectrum sensing the CR system determines the free and busy bands. Then, the system performs a classification method to obtain the modulation over the busy bands. Knowing the modulation, the system determines the maximum power to transmit. Over the free bands, the system use interweave approach meanwhile, an underlay approach is use to access the busy bands.

When considering an OFDM CR system that cohabits with another OFDM system, simulation results show the performance of the proposed system.

1. INTRODUCTION

Nowadays, wireless communication systems provide us high data rates services. However, the increase in the number of users and data rates demands are producing an overload of the frequency spectrum (Oh and Choi, 2010).

Cognitive Radio (CR) has been proposed as a solution to tackle this spectrum scarcity (Arpanei et al., 2011). A CR system is a wireless communication system that cohabits with a conventional wireless system without disturb it. Unlike conventional system that employs static spectrum access, CR systems allow a dynamic spectrum access (DSA) that improves the spectrum efficiency.

The DSA techniques can be classified as interweave and underlay approach (Ma et al., 2011).

In the interweave approach, CR systems also called secondary users (SU) are adapted to sense spectrum holes and transmit data in an identified idle band. This technique avoids considerably the interference between the conventional user also called primary user (PU) and the SU. However, this method does not guarantee the emission and throughput stability of SUs.

In the underlay approach, SUs are admitted to access frequency bands allocated to PUs only if interference caused by SUs is regulated below a predetermined power level.

In this paper, a new architecture based on several antennas called secondary receiver control antennas (SCRA) that perform a digital signal processing to identify the spectrum utilization is proposed. A hybrid interweave-underlay DSA is presented. Using the interweave approach the spectrum efficiency is maximize while using the underlay approach the throughput stability of SUs is guaranteed.

2. ARCHITECTURE OF THE CR ENVIRONMENT

The general architecture is presented in figure 1. Three different antennas are showed. PUs antennas, that can be associated to conventional wireless communication systems such as LTE or WiMAX, SUs antennas and the SRCA. The spatial diversity of the SRCA allows us to estimate the frequency spectrum utilisation. Each SRCA performs the following procedure:

Firstly, a spectrum sensing is done to determine the idle and busy bands. Then, an automatic modulation classification (AMC) is carrying out to obtain the modulation over the busy bands (Wu and Natarajan, 2007). Finally, the information is transmitted to a database that determines the maximum power level to transmit without interfere with PUs.

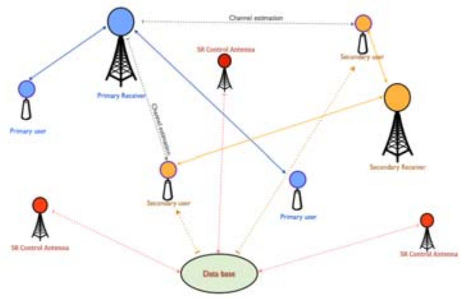

Figure 1: Architecture of the CR Environment

2.1 SPECTRUM SENSING

Let the propagation channel be known by the SRCA, H_0 the hypothesis that the received signal $r(n)$ at the nth sample is only composed of noise and H_1 corresponds to the case where signal is present. Under these hypotheses, one defines:

$$(H_0) \qquad r(n) = w(n) \qquad (1)$$

$$(H_1) \qquad r(n) = e^{j2\pi\theta_c n} x(n-\theta) + w(n) \qquad (2)$$

where $w(n)$ is a zero mean white Gaussian noise with variance σ^2, $x(n)$ is the emitted signal, θ_c is the carrier offset frequency, and θ the timing offset. Then, the likelihood ratio between the conditional probability of both hypotheses is calculated. Finally, the Neyman Pearson criterion allows to determine a threshold and identify if the receive signal belong to $H(0)$ or $H(1)$ (Ramkumar, 2011).

2.2 AUTOMATIC MODULATION CLASSIFICATION

Classification methods can be divided into two families. On the one hand, likelihood-based algorithms can be considered. Theoretically optimal, they require expensive computing if no approximations are considered. Within this family, Bayesian, non-Bayesian and Hybrid algorithms can be distinguished. The other main family of classification algorithms is built on empirical observations. For more details about AMC, the reader is referred to (Ramkumar 2011).

2.3 DATABASE PROCESSING

The database processes the information send by the SRCA and broadcast to SUs. Considering the qualities of service (QoS) known and the modulation scheme detected, the minimum required signal-noise-ratio (SNR) can be found based on the maximum allowable raw bit error rate (BER). The difference between the minimum required SNR and the SNR estimated, indicates the power level to transmit without interfere PUs.

3. SIMULATIONS RESULTS

Simulations have been done considering PU and SU communication links. BPSK modulation and OFDM have been used in PU and SU systems. Several AMC have been implemented. The impact of SU interference on PU is evaluated. In figure 2, BER performances with an increasing interference rate are observed.

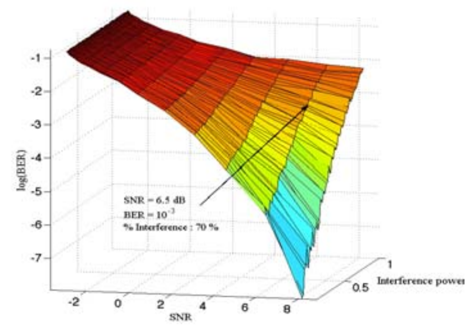

Figure 2: BER performances evolution

For instance, if the PU QoS is fixed to 10^{-3} and the SNR estimated is around 6.5dB, we can estimate that the maximal interference power is around 70 %.

4. CONCLUSION & FURTHER WORK

Thanks to this interweave and underlay hybridization we could maximise the spectrum efficiency and guarantee throughput for SU. Moreover, the increment of the bandwidth increases considerably the channel capacity. In the future we propose to integrate a relay structure to our architecture.

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