Sensing Users' Temporal Behavior in Cognitive Radio Networks Using Wideband Chirp Signal

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Abstract—**Sensing the radio environment is the most important and challenging role played by the cognitive radio handset in mobile next generation networks. In related work, we have introduced a novel approach for sensing the frequency using wideband chirp signal. In this paper, we utilize the inherent characteristics of the chirp signal to sense the temporal (time related) behavior of primary users. Our method shows promising results in terms of accuracy and complexity.**

Index Terms— **Cognitive radio, spectrum sensing, interference characterization..**

I. Introduction

Mobile Next Generation Network (MNGN) is characterized as heterogeneous network where variety of access technologies are meant to coexist. Cognitive radio stands out as a candidate technology to address many emerging issues in MNGN such as capacity, quality of service and spectral efficiency.

Cognitive radio networks promises improving spectral efficiency by opportunistic use of available radio frequencies. The success of this transmission strategy depends greatly upon the agility in sensing frequency, time, or space in dynamic radio environment. Thus a cognitive radio user behaves accordingly not to contribute excessive interference to primary (incumbent) users of the radio channel.

The problem of spectrum sensing is a typical tradeoff problem where the accuracy and system simplicity are inversely related. The most known sensing techniques used are match filtering, energy detection, and cyclostationary features detection [4][5]. Match filtering is the technique with optimal detection, however due to system requirements it is practically difficult to implement [5]. Though at a lower level of implementation difficulty the performance of cyclostationary features detection is near optimal, system complexity is not trivial [5]. Energy detection is the least complex and most inaccurate among the three methods [4].

Wideband chirp signal offers distinctive characteristics that can be exploited in variety of applications in communications engineering. In [6], a novel spectrum sensing technique in infrastructural cognitive radio network based on the use of the chirp signal is used. Simulation results have shown ability to sensing primary users' carriers with Signal to Noise Ratio (SNR) as low as -25 dB. This accuracy has been attributed to the virtue of chirp signal matched filter's output which impressively filters out the noise component of received signal.

Sensing duration (i.e. how long should cognitive radio switch to sensing mode) is a challenging aspect in spectrum sensing as primary users can claim their frequency at any time [2]. Thus Sensing frequency (i.e. how often cognitive radio should perform spectrum sensing) brings about a tradeoff between time of sensing and accuracy [2]. Although we don't focus on this tradeoff, we argue that our method could contribute toward this issue as it improves sensing the temporal behavior of primary user.

In this paper, we look into methods to sense time related aspects of a primary user taking advantages of chirp signal's characteristics. We rely on the chirp signal cross correlation characteristics in time domain to determine the time of the transmission. The goal is to equip cognitive radio user with capabilities to characterize the interference and hence behave accordingly.

This paper is organized as follows; in II, we briefly talk about the chirp signal and its characteristics. In III, we outline the network architecture. In IV, related work on frequency sensing is presented. In V we explain the temporal sensing methodology. In VI, we present the simulation model. In VII, the results are shown and discussed and in IX we conclude.

II. Chirp Signal

Wideband chirp signal is a result of linear frequency modulation of digital signal. The instantaneous frequency of the chirp signal increases or decreases linearly with time, Figure 1a shows a chirp signal. The bandwidth of a chirp signal, F, extends from the starting frequency sweep, f_1, to the final frequency sweep f_2. With proper choice for processing gain i.e. FT product, where T is the bit period, the spectrum of chirp signal has a distinctive near square shape, Figure 1b.

Chirp signal has very interesting correlation characteristics that gave it multi use in different applications [7]. In our methodology we are interested in two characteristics which will be helpful for sensing both frequency and time related behavior of primary user.

As for frequency sensing, spectral resolution in the presence of white noise is sought. The spectral resolution is obtained by cross-correlating the chirp signal with locally generated copy of itself (i.e. matched filtering). The result of this is optimal