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Spectrum sensing based on Forward Active Channel Allocation in wireless 5G communications

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ABSTRACT

Spectrum sensing is an important function to enable cognitive radios to detect the underutilized spectrum licensed to the primary systems and improve the overall spectrum efficiency . Some well-known spectrum sensing techniques are energy detection, matched filter and cyclostationary feature detection that have been proposed for narrowband sensing. In these methods, based on the signal properties, a decision is made to detect presence or absence of a primary user in the considered band.

The proposed model for wideband spectrum sensing is illustrated in Figure 2. The analog received signal at the sensing cognitive radio is sampled by the multicoset sampler at a sample rate lower than the Nyquist rate. The sampling reduction ratio is affected by the channel occupancy and multicoset sampling parameters. The outputs of the multicoset sampler are partially shifted using a multirate system, which contains the interpolation, delaying and down sampling stages. Next, the sample correlation matrix is computed from the finite number of obtained data. Finally, the correlation matrix is investigated to discover the position of the active channels by subspace methods. We evaluate this method by computing the probability of detecting signal occupancy in terms of the number of samples and signal to noise ratio (SNR).

I. Introduction

What has motivated cognitive radio technology, an emerging novel concept in wireless access, is spectral usage experiments done by FCC. These experiments show that at any given time and location, much of the licensed (pre-allocated) spectrum(between 80% and 90%) is idle because licensed users (termed primary users) rarely utilize all the assigned frequency bands at all time. Such unutilized bands are called spectrum holes, resulting in spectral inefficiency. These experiments suggest that the spectrum scarcity is caused by poor spectrum management rather than a true scarcity of usable frequency[1]. The key features of a cognitive radio transceiver are radio environment awareness and spectrum intelligence. Intelligence can be achieved through learning the spectrum environment and adapting transmission parameters[2,3].

The dynamic spectrum access (DSA) allows the operating spectrum of a radio network to be selected dynamically from the available spectrum. DSA is applied in cognitive radio networks, which has a hierarchical access structure with primary and secondary users as shown in Fig. 1 The basic idea of DSA is to open licensed spectrum to secondary users (which are unlicensed users) while limiting the interference received by primary users (which are

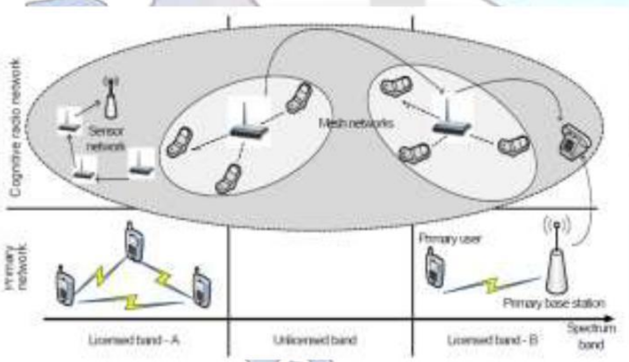

Figure 1: A basic cognitive radio network architecture.

licensed users)[2,3,4]. This allows secondary users to operate in the best available channel opportunistically. Therefore, DSA requires opportunistic spectrum sharing, which is implemented via two strategies

II. Overview of the Paper

In section 3 we discuss the proposed work , in section 4 we discuss proposed work, Forward Active channel allocation algorithm evaluated by use of Receiver Operating Characteristics (ROC) curves over additive white Gaussian noise (AWGN) and fading (Rayleigh & Nakagami-m) channels. Results show that for single user detection, the energy detection technique performs better in AWGN channel than in the fading channel models. The performance of cooperative detection is better than single user detection in fading environments. In section we discuss the results and Conclusions and along with Future work.

III. Proposed Method

A. Previous Spectrum Sensing Techniques

Spectrum sensing techniques include energy detection, matched filter, cyclo stationary feature detection, and eigen value detection.

The drawback of Energy detection is, it performs poorly under high noise uncertainty and background interference [7].

Matched Filter requires the perfect knowledge of the channel response, its performance degrades dramatically when there is lack of channel knowledge due to rapid changes of the channel conditions.

Cyclostationary feature detection is able to distinguish among the primary user signals, secondary user signals, or interference it needs high sampling rate and a large number of samples, and thus increases computational complexity as well[9].

The above said methods are limited in capacity and maximized in complex and response and only depend on spectrum gaps not on active channel identification .We propose a new method which entirely depends on Active channel due to this speed of detection increases

B. Forward Active Channel Method for Spectrum Sensing

The received signal x(t) is assumed to be an analog wideband sparse spectrum signal, band limited to $[0,B_{max}]$. Denote the Fourier transform of x(t) by X(f). Depending on the application, the entire frequency band is segmented into L narrowband channels, each of them with bandwidth B, such that $B_{max} = L \times B$. It is assumed that the signal bands are uncorrelated with each other. The channels are indexed from 0 to L − 1.

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Those spectral bands which contain part of the signal spectrum are termed active channels, and the remaining bands are called vacant channels[11,12]. Denote the number of such active channels by N. The indices of the N active channels are collected into a vector

$$b=[b_1, b_2, \ldots, b_N] \quad (1)$$

which is referred to as the active channel set.

In the considered system, N and b are unknown. However, we know the maximum channel occupancy which is defined as

$$\Omega_{max} = \frac{N_{max}}{L} \quad (2)$$

where $N_{max} \geq N$ is the maximum possible number of occupied channels. Figure 1 depicts the spectrum of a multiband signal at the sensing radio, which contains L = 32 channels, each with a bandwidth of B = 10 MHz. The signal is present in N = 6 channels, and the active channel set is b [8].

The problem is, given B_{max}, B and Ω_{max}, to find the presence or absence of the signal in each spectral band or equivalently find the active channel set, b, at a sub-Nyquist sample rate.

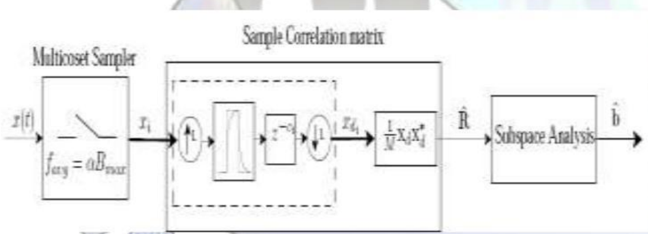
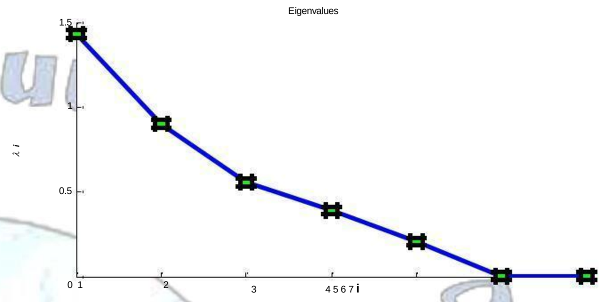
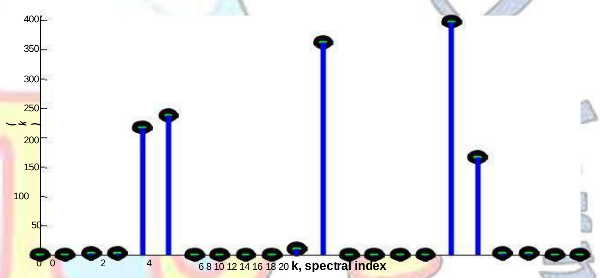


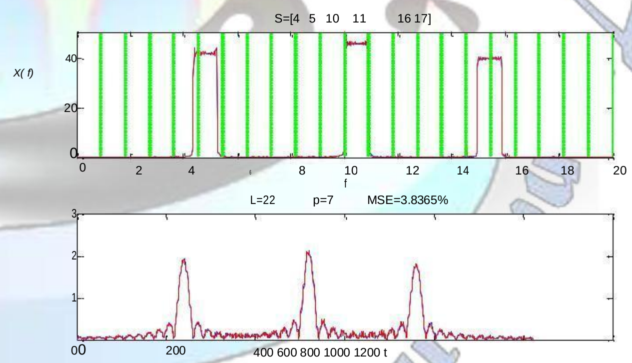
Figure 3. Proposed spectrum sensing model.

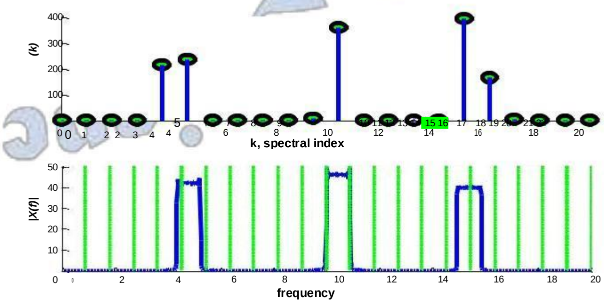
The proposed model for wideband spectrum sensing is illustrated in Figure 3. The analog received signal at the sensing cognitive radio is sampled by the multicoset sampler at a sample rate lower than the Nyquist rate. The sampling reduction ratio is affected by the channel occupancy and multicoset sampling parameters. The outputs of the multicoset sampler are partially shifted using a multirate system, which contains the interpolation, delaying and down sampling stages. Next, the sample correlation matrix is computed from the finite number of obtained data. Finally, the correlation matrix is investigated to discover the position of the active channels by subspace methods [9, 10, 12].

IV. Results and Conclusion









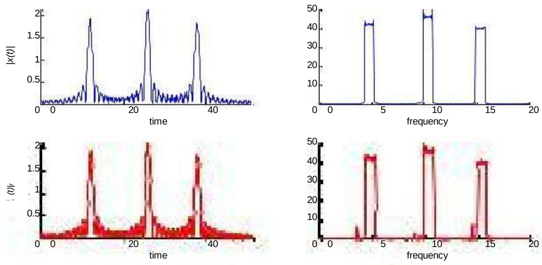


Fig 4: Performance of Forward Active Channel method for Spectrum Sensing

A method of wideband spectrum sensing for cognitive radio is proposed to mitigate the limitations of high sampling rate, high complexity and noise uncertainty. The proposed technique utilizes a multicoset sampling scheme that can use arbitrarily low sampling rates close to the channel occupancy. With low spectrum utilization assumption, this would bring substantial savings in terms of the sampling rate. The coset samples are fractional shifted and used to compute the correlation matrix of the signal. The computation cost of this step is linear in the amount of data. The problem of spectrum sensing is turned into the problem of parameter estimation and then is solved by subspace methods that today are standard tools in signal processing. We evaluate the detection performance of this method for a typical case. The results show that even in low SNR with taking enough number of samples a perfect detection is possible. For a typical wideband system with $\Omega_{max} = 0.25$ and SNR=1dB by taking M = 31 samples, at $\alpha \approx 0.3$ of the Nyquist rate, $P_d = 0.99$ and $P_f = 10^{-3}$ are achieved.

V. Future Work

In future, we would like to explore other types of feature detection and evaluate their performance comparatively with energy detection. In-band sensing of wireless micro-phones should be another subject of our future work.

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