International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 3, Issue 4(April 2014), PP.50-55

OFDM Based Spectrum Sensing In Time Varying Channel

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Abstract:- This paper proposes a spectrum sensing in time varying channel based on Orthogonal Frequency Division Multiplexed (OFDM) signals in cognitive radio networks. Cognitive radio is a new concept of reusing spectrum in an opportunistic manner. Cognitive radio is motivated by recent measurements of spectrum utilization, showing unused resources in frequency, time and space. Introducing cognitive radios in a primary network inevitably creates increased interference to the primary users. Secondary users must sense the spectrum and detect primary users‟ signals at very low SNR, to avoid causing too much interference.

Keywords:- Cognitive Radios. Spectrum Sensing, time varying channels**.**

I. INTRODUCTION

One of the most important components of the cognitive radio concept is the ability to measure, sense, learn, and be aware of the parameters related to the radio channel characteristics, availability of spectrum and power, radio‟s operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions. In a cognitive radio network, there are two types of users, namely primary users (PU) and secondary users (SU). Secondary users have the ability to sense and use available spectrum holes when primary users do not transmit data on the assigned spectrum. However, spectrum sensing errors may happen due to uncertainty of wireless channels and unpredictable interference, and imperfect spectrum sensing can influence system performance. It is hence important to conduct performance analysis for both primary and secondary users taking into consideration the impact of imperfect sensing. Queuing theory has been proved to be a useful method to deal with queueing problems in communication networks. It has also been employed in performance analysis of cognitive radio networks, where some results have been obtained, such as packet waiting time in queue and delay.

The determination of empty spectrum is typically done by spectrum sensing and is a critical challenge in cognitive radios. In particular, (i) spectrum sensing has to reliably determine the presence or absence of ongoing licensed transmissions, and (ii) sensing of multiple radio channels (possibly spanning several hundreds of MHz) has to be done as fast as possible.

In this paper, we assume that the primary user is employing OFDM based communication system for signal transmission and our aim is to sense the spectrum for detection of an OFDM signal in the radio spectrum based on auto-correlation characteristics of the sensed signal

A. CONGNITIVE RADIO (Or) CONGINITIVE NETWORKS

A cognitive radio (CR) is a transceiver device that can adapt its transmission parameters based on the knowledge of its surrounding radio environment. Thus, a CR network is a network that employs spectrum-aware communication protocol.

There are two main types of cognitive radio, full cognitive radio and spectrum-sensing cognitive radio. Full cognitive radio takes into account all parameters that a wireless node or network can be aware of. Spectrum-sensing cognitive radio is used to detect channels in the radio frequency.

B. SPECTRUM SENSING

Spectrum sensing defined as the task of finding spectrum holes by sensing the radio spectrum in the local neighborhood of the cognitive radio receiver in an unsupervised manner. The term "spectrum holes"[stands for those sub-bands of the radio spectrum that are underutilized (in part or in full) at a particular instant of time and specific geographic location.

C. SPECTRUM SENSING IN CR NETWORKS

Spectrum sensing is crucial for CR networks to detect active primary users and avoid causing interference. Let us briefly go through important parameters that characterize spectrum sensing in CR networks.

- **Signal to Noise Ratio (SNR):** When a primary user is active, the higher the SNR of the primary user‟s signal at the receiver of a CR device, the easier it is to detect. We denote this SNR by .
- **Probability of Detection: This** is the probability that a CR network accurately detects the presence of an active primary user. The higher the value of , the better the protection for primary operation.
- **Sensing Time:** This is the time that a CR network needs to postpone all communications to sense a channel. In general, the longer the value of , the more accurate the sensing outcome.
- **Detection Time :** This is the time taken to detect a primary user since it first turns on.

D. Challenges In Spectrum Sensing For Cognitive Radio

- High detection probability to protect the primary users (>=90%)
- Low false alarm probability so that the spectrum can be utilized when it is available (<=10%)
- Very low SNR (hidden primary transmitter, about -20dB in 802.22)
- Unknown signal and fading channel from primary user.
- No synchronization
- Noise and interference vary with time and location.

1. Underutilization Of Signal Statistics

The vast majority of papers written on the topic of spectrum sensing for CR employ some form of energy detection (ED) to distinguish between the two basic situations of signal-present and signal-absent. ED has universal applicability because all signals possess energy. However, it is well known to suffer performance degradation when the noise power is not known accurately or is variable, the propagation channel is harsh, or co-channel (inband) interference is present. Moreover, ED has severely limited capability to distinguish between different modulations types, and so cannot be used to classify the signals inhabiting the bands of interest. The provided justification for this widespread and persistent use of ED is simplicity.

II. CLASSIFICATION OF SPECTRUM SENSING TECHNIQUES

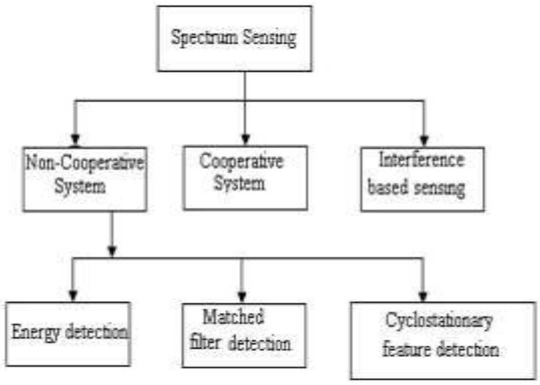

Figure 2. Classification of spectrum sensing techniques

Figure 2 shows the detailed classification of spectrum sensing techniques. They are broadly classified into three main types, transmitter detection or non cooperative sensing, cooperative sensing and interference based sensing. Transmitter detection technique is further classified into energy detection, matched filter detection and cyclostationary feature detection.

III. OFDM DETECTION METHODS

This paper makes the following contributions;

- Analysis of the auto-correlation based detector for OFDM signal detection under varying channel conditions.
- Development of an improved detector to detect OFDM signal blindly in cognitive radio.
- Effect of increasing sample length on probability of detection for OFDM signal.

IV. EXISTING SYSTEM

The sensing duration and channel selection for periodic spectrum sensing have been investigated.

A cooperative decision method for sensing parameters has been proposed, where the transmission duration is adaptively adjusted according to the number of CR users.

A parametric adaptive spectrum sensing architecture is proposed in, which takes into account the statistics of the channel availability.

In an adaptive compressive spectrum sensing algorithm has been proposed, which can adaptively adjust compressed measurements without any sparsity estimation efforts.

All the previous works are based on time –invariant. Sensing schemes are based on the priori knowledge of the primary user activities.

A. Disadvantage:

- Slower than the sensing/transmission activities.
- This assumption is not satisfied sometime

V. PROPOSED METHOD

An adaptive and cooperative spectrum sensing method is proposed where the sensing parameters are optimized adaptively to the number of cooperating users.

Simulation results show that the proposed sensing frame work can achieve maximum sensing efficiency and opportunities in multi-user/multi-spectrum environments, satisfying interference constraints.

The proposed algorithm has been employed to perform the „listen-before-talk" function of a cognitive radio, and performance results have been obtained with respect to the improvement in the sensing utilization, and interference rate.

VI. SYSTEM MODEL

In this paper, we consider a cognitive radio network with two input flows as illustrated in Fig.4, where fl^P and fl^S represent the aggregated flows from primary users and secondary users, respectively. For ease of expression and with the focus on the impact of sensing error and retransmission, the wireless channel is assumed to be error free with a constant service rate *C*. The analysis can be easily extended to consider stochastically.

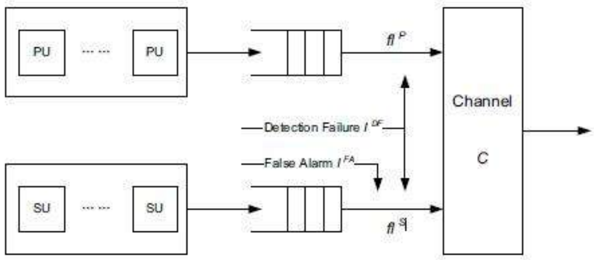

Fig 6. Two input channel model

From the fig two input channel that can be expressed with a stochastic service curve. The primary users" flow has preemptive priority over the secondary users" flow. If one packet arrives into the system and cannot be transmitted immediately, it will be stored in the corresponding buffer in a First-In-First-Out (FIFO) manner, where the buffer is assumed to be large enough and therefore no packet will be dropped.

The system is supposed to be synchronized and the time is divided into slots with length *T* and indexed by **[0, 1, ..., s, ..., t, ...].** At the beginning of each slot, secondary users will try to sense the spectrum to decide whether it is idle or busy. In this paper, it is assumed that the time period used for spectrum sensing is small and its effect is not considered.

It is also assumed that PUs and SUs can negotiate respectively among themselves before transmitting so no collision will happen between PUs or between SUs. But spectrum sensing errors may occur and they can have significant influence on the system performance.

Typically, spectrum sensing errors can be classified into two types , i.e., mis-detection (MD) and false alarm (FA). Misdetection means that the spectrum is occupied by PUs but the spectrum sensing result says it is available for SUs, which will result in transmission collision and influence both PUs" and SUs" current transmission. However, false alarm occurs in the opposite way, when SUs believe that the spectrum is being used by PUs but actually the spectrum is idle, which will waste transmission opportunities for SUs. Let *Pe* denote the average probability that a sensing error (either MD or FA) happens in one time slot. Let φ be the probability that this error is a mis-detection. Then the average probability in one time slot for MD and FA can be respectively expressed as

$Pe^{MD} = pe \cdot \varphi$ **and** $Pe^{FA} = pe \cdot (1 - \varphi)$.

VII. RETRANSMISSION SCHEMES

Retransmission technology is a commonly used method to deal with transmission errors, and different schemes can result in different outcomes. In this paper, the following three retransmission schemes will be discussed, where the first two are extreme cases and the third one is a tradeoff.

i. WITHOUT – RETRANSMISSION (WO-RT):

In this scheme, it is assumed that there is no physical layer retransmission. In other words, when one packet is transmitted through the wireless channel, it will be removed from waiting queue no matter it will be received correctly or not. Therefore, sensing error process will not influence backlog and delay, but will affect transmission error.

ii. Retransmission Until Success (Rt-S):

One packet will be removed from the waiting queue only if it has been received by the receiver successfully. Otherwise, it will be backlogged in buffer as long as needed. Therefore, no transmission error will occur. However, spectrum sensing impairments will lead to larger backlogged queue and longer waiting time

iii. Max-N-Time Retransmission (Max-N-Rt):

This scheme is a tradeoff between WO-RT and RT-S, in which one packet can be retransmitted at most *N* times. After that, the packet will be removed from the queue no matter it has been received correctly or not. It can be expected from Max-N-RT that the transmission error can be reduced to some extend as compared with WO-RT, while the backlog and delay can be better guaranteed as compared with RT-S.

VIII. ENERGY DETECTION

This technique is suboptimal and can be applied to any signal. Conventional energy detector consists of a low pass filter to reject out of band noise and adjacent signals. Implementation with nyquist sampling A/D converter, square-law device and integrator as shown in Figure 9(a) . An energy detector can be implemented similar to a spectrum analyzer by averaging frequency bins of a FFT.

Without loss of generality, we can consider a complex baseband equivalent of the energy detector. The detection is the test of the following two hypo-theses:
H0: Y [n] = W[n] signal absent
H1: Y [n] = X[n] +W[n] signal present
n=1,…,N; where N is observation interval (2)
A decision statistic for energy detector is:

$$T=\sum_N (Y[n])^2 \qquad (3)$$

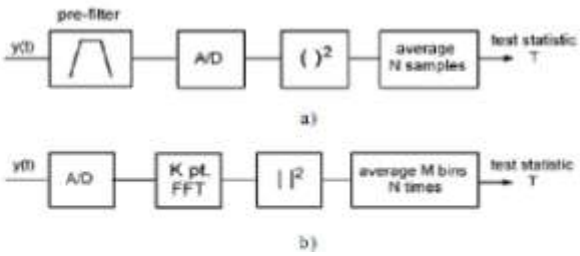

Fig 9.(a) Implementation with analog pre-filter and square-law device (b) implementation using periodogram: FFT magnitude squared and averaging

Note that for a given signal bandwidth B, a prefilter-matched to the bandwidth of the signal needs to be applied. For narrowband signals and sinewaves this implementation is simple as shown in Figure 9 (a). An alternative approach could be proposed by using a periodogram to estimate the spectrum via squared magnitude of the FFT, as depicted in Figure 9(b). This architecture also provides the flexibility to process wider bandwidths and sense multiple signals simultaneously. As a consequence, an arbitrary band-width of the modulated signal could be processed by selecting corresponding frequency bins in the periodogram.

IX. CHANNEL STATE INFORMATION

In wireless communications, channel state information (CSI) refers to known channel properties of a communication link. This information describes how a signal propagates from the transmitter to the receiver and represents the combined effect of, for example, scattering, fading, and power decay with distance. The CSI makes it possible to adapt transmissions to current channel conditions, which is crucial for achieving reliable communication with high data rates in multi antenna systems. CSI needs to be estimated at the receiver and usually quantized and fed back to the transmitter (although reverse-link estimation is possible in TDD systems). Therefore, the transmitter and receiver can have different CSI. The CSI at the transmitter and the CSI at the receiver are sometimes referred to as CSIT and CSIR, respectively.

X. OFDM SPECTRUM SENSING ALGORITHM

In this paper, we perform an analysis of auto-correlation based signal detection for OFDM signal corrupted with noise at various SNRs. This improves the probability of OFDM signal detection better than auto-correlation OFDM signal detection methods. Moreover, we do not employ assumption of synchronization between primary user transmitter and secondary user receiver. Effects of various pilot allocation strategies and length of sample sequence on OFDM signal detection are explored. This is one of the major contributions in this paper.

In our experimental study, we intend to detect WIBRO OFDM signal and assume that primary user is employing the following OFDM transmission characteristics; IEEE 802.16e, frequency bandwidth 2.3 GHz, max mobility 60
km/hr, cell coverage ~ 1 Km, data rate about 25
Mbps and modulation scheme QAM. Further, cyclic prefix is inserted in OFDM symbols to avoid inter symbol interference. In addition to this, pilot signal is also embedded in OFDM signal to achieve channel equalization.

Since, performance of auto-correlation based techniques to detect OFDM signal decreases when the sensed signal is highly corrupted, i.e. 0 dB

12. Matched Filter Detection

Matched-filtering is known as the optimum method for detection of primary users when the transmitted signal is known [16]. The main advantage of matched filtering is the short time to achieve a certain probability of false alarm or probability of misdetection [17]. Block diagram of matched filter is shown in Figure 12.

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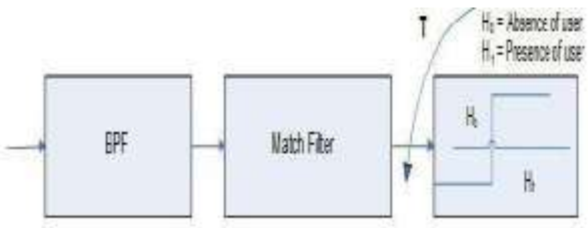

Fig12. Block diagram of matched filter

Initially the input signal passes through a band-pass filter; this will measure the energy around the related band, then output signal of BPF is convolved with the match filter whose impulse response is same as the reference signal. Finally the matched filter out value is compared to a threshold for detecting the existence or absence of primary user.

The operation of matched filter detection is expressed as

$$Y[n] = \sum_{k=-\infty}^{\infty} h[n-k]x[k]$$

Where ‗x‚‚ is the unknown signal (vector) and is convolved with the ‗h‚‚ the impulse response of matched filter that is matched to the reference signal for maximizing the SNR. Detection by using matched filter is useful only in cases where the information from the primary users is known to the cognitive users. This technique has the advantage that it requires less detection time because it requires less time for higher processing gain.

13. Simulation Results.

In decentralized sensing, the primary transmitter signal detects users on the basis of their independent local observations. However, there are some limitations in decentralized detection such as: a higher level of decision making ability is required at each radio and the cognitive radio network might have to be set up in a more ad hoc fashion. Sensing functions and data transmissions can be co–located in a single user device. This architecture is considered as suboptimal spectrum sensing because of conflicts between sensing and data transmission. A wireless device cannot sense the medium and transmit at the same instance, as co-locating sensing functions and data transmissions in a single user device can hugely deteriorate data transport efficiency. To avoid these kinds of problems, two networks are deployed separately, such as a sensing network for cooperative spectrum management and an operational network for data transmission. A sensing network will be deployed, which will sense the spectrum and gather radio spectrum information.(2) The operational network uses this information from maps created by the sensing network and then determines the available spectrum for operation.

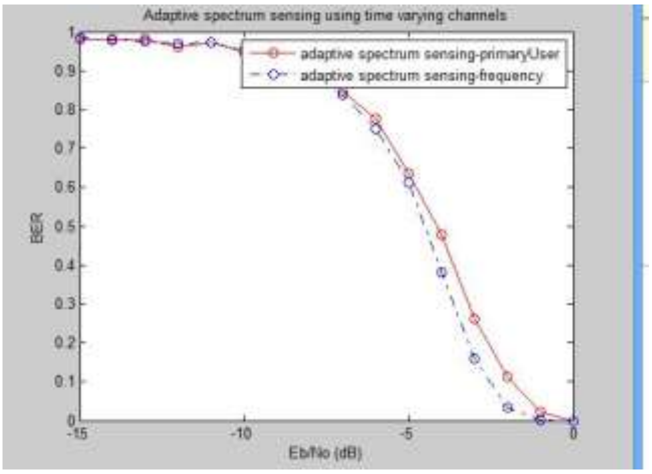

Fig 13.Comparison Graph

XI. CONCLUSION

An adaptive spectrum sensing scheme has been developed and analyzed according to the variation of time-varying channels. It found the most explicit way for spectrum sensing based on previous frame duration. This adaptive sensing scheme adjusts spectrum sensing duration according to the previous sensing results and CSI of the time-varying channel. Unlike other sensing scheme, this adaptive sensing scheme can be applied even the channel model of the primary network is unknown. Numerical results show that it remarkably improves the throughput compared with the non-adaptive spectrum sensing scheme. fast detection and BER reduction have been considered. For that purpose we are going to implement spectrum sensing based on different noisy channel with small SNR variation.

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