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Performance Enhancement of MIMO-OFDM System based on Spectrum Sensing Cognitive Radio Networks using Matched Filter Detection

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ABSTRACT: Error-free transmission and increase in multimedia applications is one of the main aims of wireless communication. MIMO-OFDM is the system to improve the reliability of the WiMAX system.
The fundamental tasks that are used in the cognitive radio (CR) networks are spectrum shaping capability and multi-carrier systems. In these structures activation of fundamental (primary) users will generate a defined number of sub-carriers in the secondary users.
In this paper, the design of the MIMO-OFDM system using Matched Filter Detection Spectrum Sensing Cognitive Radio Network is presented.
A matched filter is a spectrum-sensing method that detects the free portions of the primary user's spectrum and allocates it to secondary users. It derives from cross-correlating an unknown signal with known ones to detect the unknown signal's presence based on the basis of its SNR.
Accordingly,an efficient scheme is developed here, having better SNR VSBER against a different MIMO-OFDM system.

KEYWORDS: Wi-MAX, MIMO-OFDM, Cognitive Radio, Matched Filter.

I. INTRODUCTION

The limited available spectrum i.e., the spectrum under-utilization problem have motivated a number of initiatives in the regulatory as well as research communities to develop a new communication paradigm, which can exploit the spectrum bands opportunistically. In addressing the spectrum under-utilization problem, the FCC has recently approved the unlicensed access of the licensed bands [1]. In this context, the term Dynamic Spectrum Access (DSA) has been used to refer to the techniques that implement better spectrum management policies. The key enabling technology that emerges for DSA techniques is the cognitive radio (CR), which is supported by the Software Defined Radio (SDR) technology. CR is usually built upon an SDR platform and is a context-aware intelligent radio, which is capable of autonomous reconfiguration by learning from and adapting to the surrounding communication environment [2]. Formally, the term cognitive radio (CR) can be defined as follows according

to FCC [3]: "A cognitive radio is a radio that can change its transmission parameters based on interaction with theenvironment in which it operates". From the above definition, the two major characteristics of CR can be defined as the cognitive capability and configurability. The cognitive capability refers to the ability of the radio component to capture (using techniques such as autonomous learning and action decision) or sense information (the temporal and spatial variations in the radio environment and the interference level generated to other users) from its surrounding radio environment. On the other hand, the configurability refers to the ability to enable the transmitter parameters to be dynamically programmed and modified according to the dynamics of radio environment.

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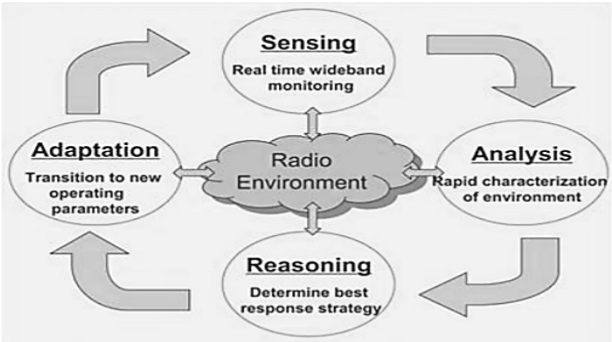

Figure 1: Cognitive Cycle

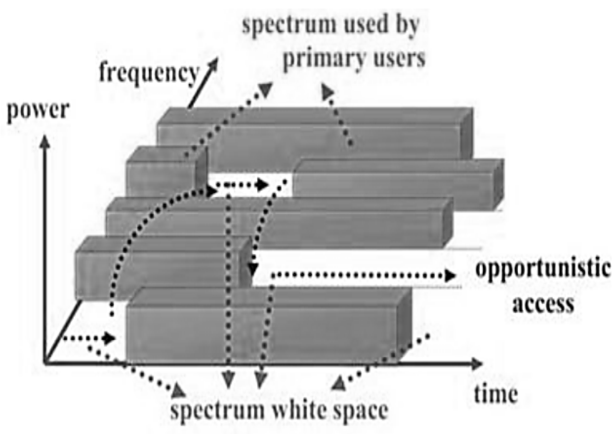

Figure 2: Opportunistic Usage of Spectrum Holes

Therefore, a CR enabled node in the network adapts dynamically to reconfigure several parameters such as the operating frequency (to take advantage of detected spectrum holes on different frequency bands), modulation and channel coding (to adapt to the requirements of application and the instantaneous conditions of channel quality), transmission power (to control the possible generated interference), and communication technology (to adapt to specific communication needs). Depending on the characteristics of the detected spectrum holes, as shown in Figure 1 and Figure 2, the CR enables to switch to different spectrum bands opportunistically [4], while the transmitter and receiver parameters are re-configured accordingly.

II. CR NETWORK ARCHITECTURE

The possible architecture of a CR network as defined is shown in Figure 3. The components of such CR network architecture can be classified into two groups as primary network and secondary network (i.e. cognitive radio network).
Primary network: A primary network is referred to an existing network infrastructure, where the nodes called primary users (PUs) have authorized license for exclusively accessing a certain frequency band. Examples of such networks include the cellular and the TV broadcast networks. Primary user (PU) activities are controlled through the primary base-stations in infrastructure based the primary network. Since the PUs have their priority in spectrum access, the operations of PUs should not be affected by any other unlicensed or secondary users.

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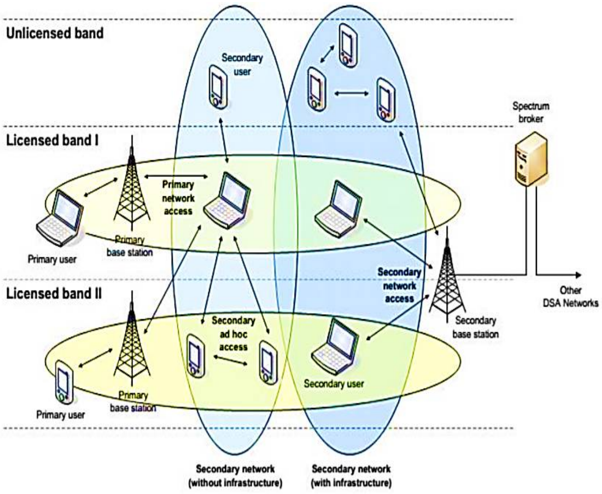

Figure 3: Cognitive Radio Network Architecture

Secondary network: A secondary or unlicensed network is referred to a network, with fixed infrastructure or based on ad hoc communication principle, without license to operate in a desired licensed band. Hence, to share the licensed spectrum band with primary networks, the additional functionalities are used by the nodes called CR users/secondary users (SUs). The infrastructure based secondary networks are equipped with a central entity called CR base station, which implements a single-hop connection to SUs. On the other hand, the secondary ad-hoc networks have no infrastructure backbone and an SU can communicate with other SUs through the ad-hoc connection on both licensed and unlicensed spectrum bands. Furthermore, secondary networks may include spectrum brokers, which can play a role in sharing spectrum resources among different secondary networks.

In the context of network architecture, the spectrum management functionalities are implemented by different entities. For instance, in infrastructure based architecture, the spectrum broker is responsible for coordinating the tasks of spectrum sensing, decision and management (sharing and mobility), while in ad-hoc architecture; CR nodes themselves are responsible for spectrum sensing, decision and management. The former requires a dedicated control channel whereas in infrastructure less architectures use of dedicated control channel is optional.

III. PROPOSED METHODOLOGY

Based on the spectrum sensing schemes, the cognitive radio is proposed to reduce the computational complexity in the MIMO-OFDM system. On the one hand, apply thematching filter algorithm in a different antenna, and employ the linear property of Inverse Fast Fourier transform (IFFT) to increase the number of candidate sequences so as to achieve better SNRand lower MSE performance.

To analyze a signal in the time domain, IFFT (Inverse Fast Fourier Transform) is applied and converted it from parallel to serial. OFDM signal to add a Cyclic Prefix (CP), which helps to avoid interference between OFDM symbols.

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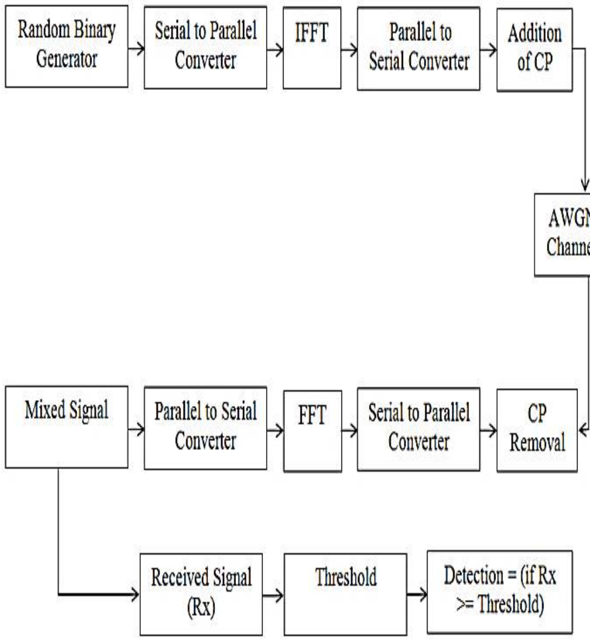

Figure 4: Design of MIMO-OFDM System using Matched Filter Spectrum Sensing Cognitive Radio Network

This signal is then passed through an Additive White Gaussian Noise (AWGN) channel. At the receiver end, the CP is removed and the signal is converted from serial to parallel to get the original, with FFT applied to each symbol for analysis in the frequency domain. After demodulation, the signal is cross-correlated with that of a time-shifted local oscillator.

We implemented the circuit (Figure 4) in MATLAB software, with the main parameters described below. A random binary signal is generated in a serial manner. To analysis a signal in the time domain, apply IFFT (Inverse Fast Fourier Transform) and convert it from parallel to serial OFDM signal to
Add a cyclic prefix (CP), which helps to avoid interference between OFDM symbols. Then feed this signal through an Additive White Gaussian Noise (AWGN) channel. At the receiver end, the CP is removed and the signal converted from serial to parallel to get the original, with FFT applied to each symbol for analysis in the frequency domain. After demodulation, the signal is cross-correlated with that of a time-shifted local oscillator.
SNR to determine whether the signal is absent or present; if the received signal is greater than the threshold value, there will be a detection, otherwise not:

H_0: y(t) = n(t)   PU is absent

H_1: y(t) = h*s(t) + n(t)   PU is present

IV. SIMULATION RESULT

Simulation experiments are conducted to evaluate the SNR vsBit Error Rate (BER) performance of the proposed matched filter detection spectrum sensing 1×1 system is shown in figure 5. To analysis random binary generated signal, a signal in the frequency domain, an IFFT is applied to the signal and converted from parallel to serial for the addition of the CP, one transmitter antenna and one receiver antenna through an AdditiveWhite Gaussian Noise (AWGN) channel.

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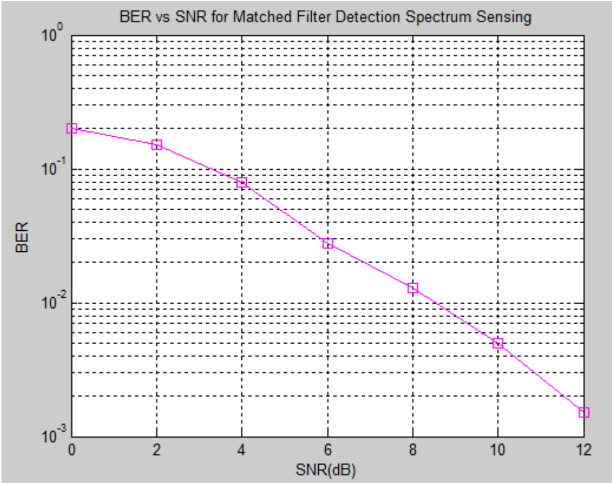

Figure 5: BER vs SNR for Matched Filter Detection Spectrum Sensing 1×1 System

Simulation experiments are conducted to evaluate the SNR VS BER performance of the proposed matched filter detection spectrum sensing 2×2 system is shown in figure 6. To analysis random binary generator signal, the signal in the frequency domain, an IFFT is applied to the signal and converted from parallel to serial for the addition of the CP, two transmitter antenna and two receiver antenna through an AdditiveWhite Gaussian Noise (AWGN) Channel.

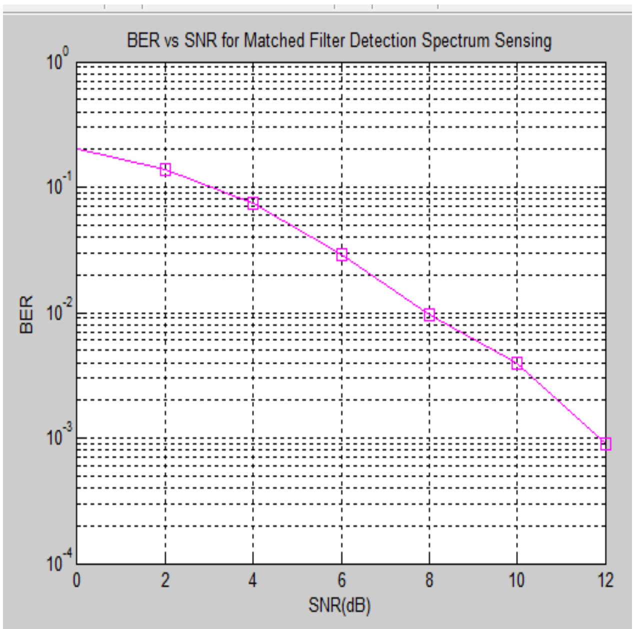

Figure 6: BER vs SNR for Matched Filter Detection Spectrum Sensing 2×2 System

Simulation experiments are conducted to evaluate the SNR VS BER performance of the proposed matched filter detection spectrum sensing 4×4 system is shown in figure 7.

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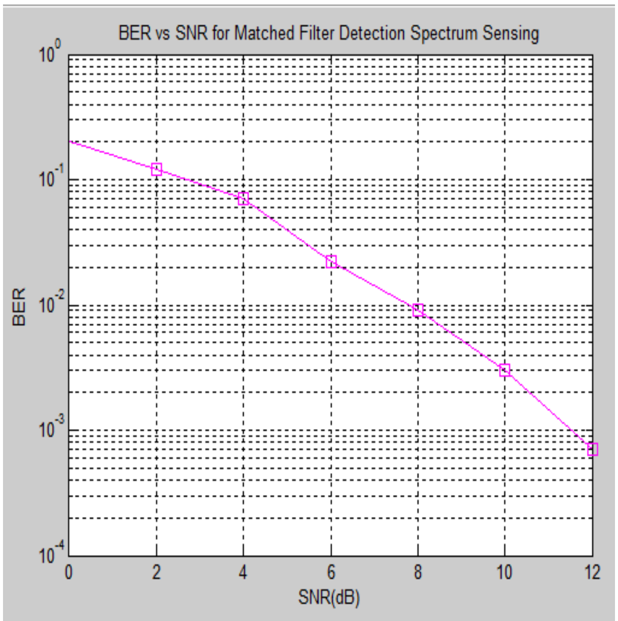

Figure 7: BER vs SNR for Matched Filter Detection Spectrum Sensing 4×4 System

Simulation experiments are conducted to evaluate the SNR VS BER performance of the proposed matched filter detection spectrum sensing different system is shown in figure 8.

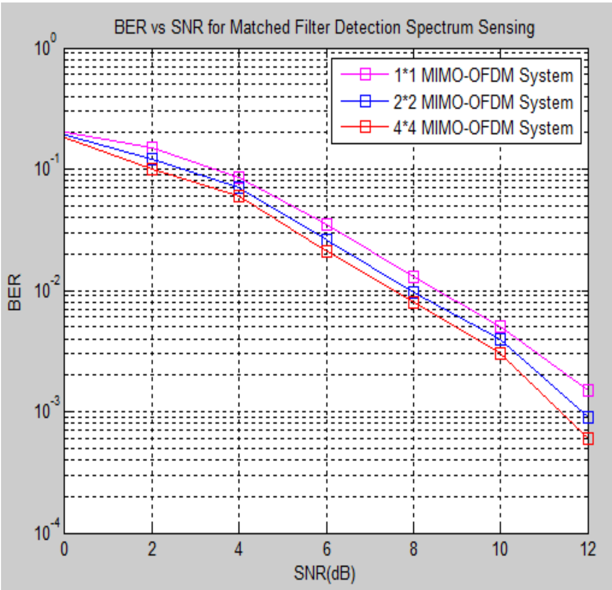

Figure 8: BER vs SNR for Matched Filter Detection Spectrum Sensing Different System

Simulation experiments are conducted to evaluate the SNR VS BER performance of the proposed matched filter detection spectrum sensing and Cyclo-Stationary detection spectrum sensing is shown in figure 9.

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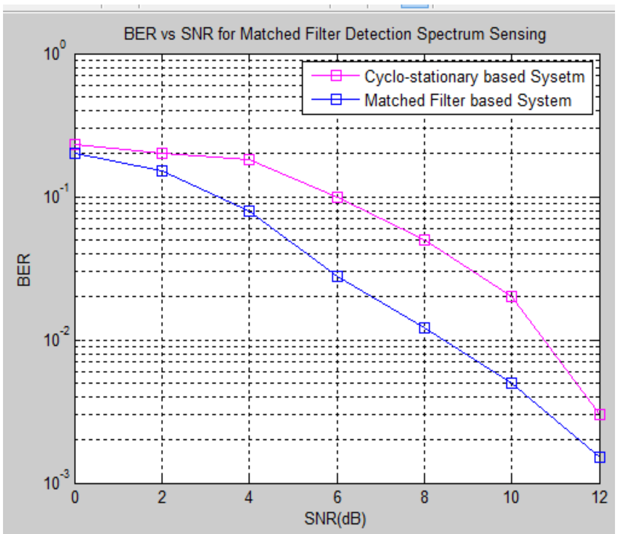

Figure 9: Comparative Result

BER	SNR (dB)						
	0	2	4	6	8	10	12
Previous System	2.3×10^{-1}	2×10^{-1}	1.8×10^{-1}	10^{-1}	5×10^{-2}	2×10^{-2}	3×10^{-3}
Proposed System	2×10^{-1}	1.5×10^{-1}	8×10^{-2}	2.8×10^{-2}	1.2×10^{-2}	5×10^{-3}	1.5×10^{-3}

Table 1: Comparative Result of BER

Table 1,the tabular illustration of the performance of different SNR discussed in this research work in term of Bit Error Rate (BER). From the analysis of the results, it is found that the proposed matched filter detection spectrum sensingCognitive Radio Network gives a superior performance as compared with the previous method.

V. CONCLUSION

Matched filtering is known as an optimal method for detection of primary users when the transmitted signal is known. It is a linear filter designed to maximize the output signal to noise ratio for given input signal. It is obtained by correlating a known signal, with an unknown signal to detect the presence of the known signal in the unknown signal. This is equivalent to convolving the unknown signal with a time-reversed version of the signal. Convolution is at the heart of matched filters.

Convolution does essentially with two functions that it places one function over another function and outputs a single value suggesting a level of similarity, and then it moves the first function an infinitesimally small distance and finds another value. The end result comes in the form of a graph which peaks at the point where the two images are most similar. The matched filter is the optimal linear filter for maximizing the Signal to Noise Ratio (SNR) in the presence of Additive White Gaussian Noise. The performance of implemented method including wireless communication is better as compared to the previous technique algorithm.

The proposed MIMO-OFDM system using Matched Filter Spectrum Sensing Cognitive Radio Network give a lower BER 0.0015 dB as compared with 0.0030 dB for SNR = 12 dB, the previous MIMO-OFDM system using Cyclo-Stationary Spectrum Sensing Cognitive Radio Network. The proposed method having 50% BER improved fromthe previous method.

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