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Analysis and Design of Multicarrier Modulation Protocols in Cognitive Radios

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Abstract - **In this paper new techniques that deal with the issue of spectrum management have to be developed. It is possible to increase the spectral efficiency by either shifting carrier frequencies closer together or altering the roll off factor .The second approach does not seems to be efficient than the first, due to increase in bandwidth, which leads to increase in noise, interference, multipath fading The first concept is able to control the Guard band dynamically. Possibilities to reduce the guard band between successive channels dynamically are to be investigated, thus improving spectral efficiency. This can be done efficiently by Multicarrier modulation Multicarrier modulation which has an ability to increase in the data rates and simultaneously we can decrease in the interference due to multipath fading channels. Multicarrier modulation schemes are of two types namely, Non-contiguous orthogonal frequency division multiplexing and Non-contiguous non orthogonal frequency division multiplexing. The proposed paper aims to investigate the various features of Multicarrier, Multipath system to address the challenges in wireless communications and provide a solution for the optimum utilization of the resources.**

Keywords: **Multicarrier modulation.NC-MCM, Non-contiguous orthogonal frequency division multiplexing, Cognitive Radios.**

I. Introduction

Today wireless systems are characterized by static spectrum allocation strategies in which each system is licensed to operate over a specific frequency band in a given geographic area. However, the spectrum may be used only over short intervals and around a transmitter-receiver pair that are close to each other. As a result, most frequency bands in the majority of geographical areas are underutilized. Cognitive radios (CRs) try to exploit frequency bands which bear not being used by primary users at a particular place and time. To protect the primary systems from the adverse effects of secondary transmissions, “blank spaces” in frequency, time, and space should be reliably detected. Database registry, broad-casting beacon signals, and spectrum sensing are three different approaches that may be used to achieve this goal. And involve collaboration between the primary and secondary networks. In these approaches, the primary network provides the secondary users with the information regarding the current spectrum use either via a centralized database or through broadcasting this information on regional beacons. However, the deployment of these methods involves remarkable modifications to the licensed systems as well as frequent communication between the primary and secondary networks. Furthermore, some of them require positioning information at the secondary terminals, which can be expensive. In the absence of cooperation between the primary and secondary networks, spectrum sensing enables secondary users to monitor a particular licensed band in order to find “spectrum holes” for opportunistic access. The best way to detect spectrum holes is to detect the primary receivers within the communication range of a secondary user. However, this is possible only if the primary receivers collaborate by transmitting a pilot signal. Consequently, most research in this area has focused on primary transmitter detection. This approach is based on the detection of weak signals from nearby primary transmitters through measurements of secondary users. Matched filter detection, energy detection, and cyclostationary feature detection are three commonly used schemes for primary transmitter detection.

When a CR experiences severe shadowing or multipath fading, it can not reliably detect the presence of nearby primary transmitters. To address this problem, collaborative spectrum sensing is proposed in the literature. In these schemes, every CR performs its local spectrum sensing and reports the result to a common receiver. These results are then fused together to make the final decision about the absence or presence of primary users. One of the first works is that of Ghasemi and Sousa who study the performance of collaborative spectrum sensing in fading channels. They consider a scenario where CRs collaborate in spectrum sensing by sharing only their final 1-bit decisions "0" (idle) or "1" (busy). They assume that all the CRs experience independent and identically distributed fading/shadowing, and all the users employ energy-detection with the same decision threshold. A CR receives decisions from other users and fuses them together using the OR-rule or 1-out-of- rule. Therefore, the final decision is "1" if any of the individual decisions is "1." It is shown that the proposed collaborative spectrum sensing scheme significantly increases the reliability of detection in fading and shadowing channels. In a collaborative sensing method is proposed that guarantees a desired sensing diversity order for each primary channel. The design of the sensing policy is transformed into constructing and allocating frequency hopping codes to the collaborating CRs.

In proposed paper, considering increasing demands in wireless communications, spectrum seems to be a limited resource today. Hence, new techniques that deal with the issue of spectrum management have to be developed. It is possible to increase the spectral efficiency by either shifting carrier frequencies closer together or altering the roll off factor. The second approach does not seems to be efficient than the first, due to increase in bandwidth, which leads to increase in noise, interference, multipath fading. The first concept is able to control the Guard band dynamically. Possibilities to reduce the guard band between successive channels dynamically are to be investigated, thus improving spectral efficiency. This can be done efficiently by Multicarrier modulation.

Multicarrier modulation which has an ability to increase in the data rates and simultaneously we can decrease in the interference due to multipath fading channels.Specifically,the divide and conquer data transmission approach employed by multicarrier modulation makes it an eye-catching option for realizing wireless communication systems that don't require a single continuous transmission frequency band. Multicarrier modulation schemes are of two types namely, Non-contiguous orthogonal frequency division multiplexing and Non-contiguous non orthogonal frequency division multiplexing. This will only be achieved by significant advances in multiple aspects of cellular network systems, such as network structure, network management, smart antennas, RF modulation, user allocation, and general resource allocation. A lot of future work to be done for single channel to multi channel considerations. In proposed paper our aims to investigate the various features of Multicarrier, Multipath system to address the challenges in wireless communications and provide a solution for the optimum utilization of the resources.

II. System Framework

In this paper, we examine the design trade-offs associated with a cognitive radio transceiver employing NC-MCM transmission and bit allocation in a single user scenario. Specifically, we will focus on implementations that fully exploit the flexibility offered by NC-MCM using non-uniform bit allocation and compare them with implementations that attempt to reduce the computational complexity and transmission overhead. This paper is organized presents an overview of a multicarrier-based cognitive radio transceiver and NC-MCM. Section III describes the process of bit allocation.

The general setup for a multicarrier-based cognitive radio transceiver. The high speed input symbol stream is demultiplexed into N streams, with stream having bi bits per symbol epoch. The sub carrier values are computed from the channel state information (CSI) provided by the data aided channel estimator at the receiver. We only consider the downlink in this paper, with bit allocation decisions performed solely at the transmitter. Furthermore, information regarding the spectral availability across the transmission bandwidth, obtained through channel sounding and spectrum analysis is also used by transceiver to deactivate subcarriers, i.e that can potentially interfere with incumbent transmissions. Once the bit streams are modulated onto one of several signal constellations consisting of Mi2bi points, the outputs, this signal is transmitted across the channel, where the multipath propagation and additive noise are modeled with channel impulse response and noise. The received signal is separated into the N sub channels using the analysis and down sampled by a factor N equalized using frequency-domain equalizers, demodulated, and then multiplexed together. Moreover, the receiver uses the sub carrier information to generate a channel estimate, as well as to locate and identify non-negligible transmissions within the transmission bandwidth as either spurious interference/noise or an incumbent user. The identification process is performed using one of several spectral analysis techniques and references. Once the locations of incumbent transmissions have been obtained, the transceiver then configures itself for NC-MCM,

A. Non-Contiguous Multicarrier Modulation

Given the locations in frequency of spectrum occupied by incumbent users, the goal of the cognitive radio transceiver employing NC-MCM is to deactivate sub carriers that could potentially interfere with these users and transmit over the remaining active sub carriers. The spectral usage of the incumbent (primary) and unlicensed (secondary) users. Notice how the sub carriers of the unlicensed user are evenly spaced through frequency. Moreover, observe how the sub carriers located in the same vicinity as the incumbent spectrum are deactivated, i.e., nulled, resulting in the non-contiguous characteristic of the multicarrier signal. Although very flexible, the amount of overhead information required indicating whether a sub carrier should be activated or not is large, especially if this information is frequently updated.

One solution is to activate or deactivate blocks of sub carriers. In this case, we choose a sub carrier block size across the entire transmission bandwidth of operation. As a result, the amount of overhead information is reduced. Nevertheless, with the reduction in overhead comes the trade-off that the transceiver loses flexibility, resulting in a decrease in throughput. This is due to the fact that instead of nulling a single sub carrier, one must deactivate the entire block containing that interfering sub carrier. Moreover, the larger the block size the greater the chance of having a sub carrier interfering with an incumbent user, resulting in having all the sub carriers in that block nulled. On the other hand, the amount of overhead is substantially reduced. Once the NC-MCM transceiver has decided on which sub carriers to activate, bit allocation can be performed.

B. Bit Allocation

One of the primary advantages of multicarrier modulation is its ability to transform a frequency-selective fading channel into a collection of approximately flat sub channels. As a result, distortion compensation of the transceiver becomes simpler to perform. Furthermore, the agility of the transceiver to tailor its operating parameters to the channel conditions is enhanced due to the resolution of the sub carriers. The sub carrier signal constellation is one operating parameter that can be tailored to the channel conditions.. The process of changing the sub carrier signal constellations is known as bit allocation.

The process of performing bit allocation in order to increase the overall throughput of the system. Disadvantages of exploiting the flexibility of multicarrier modulation is the amount of overhead information generated. One solution is to perform uniform bit allocation. As oppose to non-uniform bit allocation, where the sub carrier signal constellations can vary. Uniform bit allocation imposes the additional constraint of when trying to solve for the objective function. Another solution that employs some of the flexibility offered by multicarrier modulation is to assign a signal constellation to a block of sub carriers.

C. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to independent signals, those produced by different sources. So it is a question of how to share the spectrum with these users. In OFDM the question of multiplexing is applied to independent signals but these independent signals are a sub-set of the one main signal. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier. OFDM is a special case of Frequency Division Multiplex (FDM).

As an analogy, a FDM channel is like water flow out of a faucet, in contrast the OFDM signal is like a shower. In a faucet all water comes in one big stream and cannot be sub-divided. OFDM shower is made up of a lot of little streams.

The main concept in OFDM is orthogonality of the sub-carriers. Since the carriers are all sine/cosine wave, we know that area under one period of a sine or a cosine wave is zero. This is easily shown figure 1.

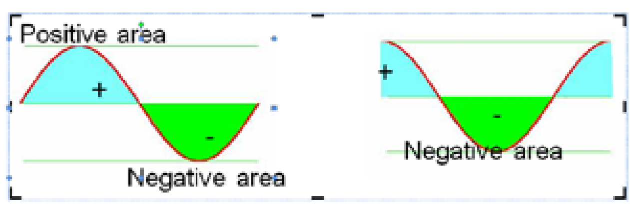

Fig.1 the area under a sine and a cosine wave over one period is always zero.

Let's take a sine wave of frequency m and multiply it by a sinusoid (sine or a cosine) of a frequency n, where both m and n are integers. The integral or the area under this product is given by

$f(t) = \sin m\omega t \times \sin n\omega t$

Orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wide-band digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL broadband internet access, wireless networks, and 4G mobile communications.

OFDM is essentially identical to coded OFDM (COFDM) and discrete multi-tone modulation (DMT), and is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data. The data is divided into several parallel data streams or channels, one for each sub-carrier. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI) and utilize echoes and time-spreading (that shows up as ghosting on analogue TV) to achieve a diversity gain, i.e. a signal-to-noise ratio improvement. This mechanism also facilitates the design of single frequency networks (SFNs), where several adjacent transmitters send the same signal simultaneously at the same frequency, as the signals from multiple distant transmitters may be combined constructively, rather than interfering as would typically occur in a traditional single-carrier system

Advantages of OFDM

- Can easily adapt to severe channel conditions without complex time-domain equalization.
- Robust against narrow-band co-channel interference.
- Robust against intersymbol interference (ISI) and fading caused by multipath propagation.
- High spectral efficiency as compared to conventional modulation schemes, spread spectrum, etc.
- Efficient implementation using Fast Fourier Transform (FFT).
- Low sensitivity to time synchronization errors.
- Tuned sub-channel receiver filters are not required (unlike conventional FDM).

III. Conclusion

In proposed paper Multicarrier modulation which has an ability to increase in the data rates and simultaneously we can decrease in the interference due to multipath fading channels. Multicarrier modulation schemes are of two types namely, Non-contiguous orthogonal frequency division multiplexing and Non-contiguous non orthogonal frequency division multiplexing methods is that errors are propagated, hence estimation of location may not be accurate Collaborative ML: The first concept is able to control the Guard band dynamically. Possibilities to reduce the guard band between successive channels dynamically are to be investigated, thus improving spectral efficiency. And aims to investigate the various features of Multicarrier, Multipath system to address the challenges in wireless communications and provide a solution for the optimum utilization of the resources.

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