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Adaptive Bandwidth Allocation In Cognitive Radio

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Abstract:
Cognitive radio (CR) is a great advancement in the field of radio communications which also paves way for 4G wireless network. It is simply a combination of a transmitter a receiver and a spectrum sensor. The suitable requirements for establishing dynamic bandwidth allocation involves the knowledge about the network, type of modulation, SNR, noise floor, type of channel and also a suitable algorithm. It is essential to identify the performance of the network under various combinations. Here channel allocation must be made such as there is no interference to the primary users due to transmission by the CR's.

Key words*: white slots; channel allocation; SNR (signal to noise ratio), CR (cognitive radio)*

1.Introduction

This project mainly requires three steps of operation. Firstly the nature of the primary signal, the modulation technique used to process the signal and signal to noise ratio, coding rate and the relative performance of the network for various configurations is calculated. Secondly the network exploits the spectrum sensing ability of the CR's to identify the white slots in the network which indicates the bandwidth left free without data being transmitted and ineffective usage of bandwidth. There are many methods to detect them as follows, Matched filter detection, energy detection and feature detection. Of these we use energy detection as it does not require any previous knowledge about the primary signal. It has a disadvantage of producing false alarms which could be eliminated by precoding. Thirdly after identifying the white slots the bandwidth for data transmission of the CR user is allocated only when there is no interference to the primary users signal when the CR transmits in the white slot. Once interference in the primary user signal is identified the protocol is implemented in such a way that the CR is moving away from that location.

2.Network Analyses

2.1.Type Of Modulation And Code Rate

First, a suitable signal is generated and channel model and coding rate is assigned. We estimate the SNR of the same signal transmitted via the same channel at different coding rates and different modulation techniques. When the SNR is thus calculated it is compared against a threshold say 10dB. Then

The channel with the highest SNR for the suitable modulation technique and coding rate is identified and data is to be transmitted

2.2.Spectrum Sensing

2.2.1.Matched Filter Detection
When the information of the primary user signal is known to the CR user, the optimal detector in stationary Gaussian noise is the matched filter. However, the matched filter requires a priori knowledge of the characteristics of the primary user signal.

2.2.2.Feature Detection
In general, modulated signals are characterized by built-in periodicity or *cyclostationarity*. This feature can be detected by analysing a spectral correlation function. The main advantage of feature detection is its robustness to uncertainty in noise power. However, it is computationally complex and requires significantly longer Observation times.

2.2.3.Energy Detection
If the receiver cannot gather sufficient information about the primary user signal, the optimal detector is an energy detector. However, the performance of the energy detector is susceptible to uncertainty in noise power. Also, energy detectors often generate false alarms triggered by unintended signals because they cannot differentiate signal types. This is the technique we use here.

2.3.Finding The Interference To Primary User
When we transmit the data through the white slot then the interference to the primary users has to be calculated.
After that if interference to primary user has been detected then CR is moved away from that location.
Methods under consideration include:

- Simple energy detectors which are independent of known signal properties
- Matched filter detection of known signals such as 802.11x, Bluetooth or cellular
- Cyclo-stationary detectors which employ second- order signal structure for improved detection
- Collaborative (networked) sensing by multiple radios In which multiple spatial observations are combined to form an improved signal estimate

3.**Preparation Before The Spectrum Sensing**
A suitable cognitive radio has to be implemented and a low distortion receiver end has to be formed.

3.1.Channel Models
Each and every channel models such as AWGN(*Additive white guassian noise*)channel,Rician distribution and Rayliegh distribution is taken into consideration and the analysis of the network is done. The bit error rate is kept constant at 10^-3 and the SIR is calculated for the signal.
We shall make use of the well-known complex baseband model. Denoting the transmitted complex baseband signal at time index k by x(k), the received signal after transmission on a flat-fading channel can be written as y(k) =α(k) .x(k)+w(k). Here, α(k) is the fading envelope and w(k) is complex valued additive white gaussian noise (AWGN) with statistically independent real and imaginary components.
In case of Raylieghs channel Calling this random variable R, it will have a probability density function

$$p_R(r) = \frac{2r}{\Omega}e^{-r^2/\Omega},\ r \ge 0$$

where $\Omega = E(R^2)$.

In case of Rician fading,
A Rician fading channel can be described by two parameters: K and Ω. K is the ratio between the power in the direct path and the power in the other, scattered, paths. Ω is the total power from both paths ($\Omega = \nu^2 + 2\sigma^2$), and acts as a scaling factor to the distribution.

The received signal amplitude (*not* the received signal power) R is then Rice distributed with parameters $\nu^2 = \frac{K}{1+K}\Omega$ and $\sigma^2 = \frac{\Omega}{2(1+K)}$.The resulting PDF then is:

$$f(x) = \frac{2(K+1)x}{\Omega}\exp\left(-K - \frac{(K+1)x^2}{\Omega}\right) I_0\left(2\sqrt{\frac{K(K+1)}{\Omega}}x\right),$$

where $I_0(\cdot)$ is the 0th order modified Bessel function of the first kind.

3.2.Modulation Types

- The incoming signal passes through the channel and the type of modulation to be used is unknown.So we consider a system whish could compute for any type of modulation of the incoming signal at that instant. After modulation the key role of selecting the frequency/bandwidth to be transmitted must be taken in to account.
- The above term of selecting frequency could also be termed as spectrum sensing.As we are aware of the concept that the cognitive radio transmission must not make any interference to the transmission of the primary user we need to be aware of the unused bandwidth (ie) white slots and also be aware of all the radios within the same network and their states whether they are transmitting or they are in an ideal state.
- Also the system must learn its previous paths and the channels in use.It must be updated simultaneously as well as be trained to learn and use the previous paths of transmission if they remain free.
- It may be easier if we assign a set of transceivers within a network classifying them as primary users and cognitive radios. We assign the licensed bandwidth to the primary users and we could easily detect the whiteslots remaining unused.
- Then we have to calculate the amount of interference that would persist if we transfer over a particular white slot and it must be calculated for every whiteslot in a sequential manner.The band of frequency which produces less amount of interference to the primary users transmission is selected and the signal is transmitted.
- This will increase the efficient resource usage of the network and also increases the number of users to be assigned within the single network.
- To make this possible the following steps must be followed by both the transmitter and receiver.

3.3.Algorithm

The algorithm could be used only on transmitters and receivers along with a channel state table(*CST*).Each transmitter or receiver within the network must have the CST associated with it. CST_T denotes the channel state table at the transmitter and CST_R denotes the channel state table at the receiver.

- Step 1:The transmitter sends a request to the receiver to allow it to transmit data to intended receiver.It sends the START packet.
- Step 2:The receiver transmits the START_CH packet after analyzing the present channel conditions through the common channel.
- Step 3:The transmitter acknowledges the decision of the receiver and sends an ACK_START_CH so that it may start the data transmission.
- Step 4:Immediately after the ACK_START_CH the data gets transferred from the transmitter to the receiver.
- Step 5:After completing data transfer the transmitter sends END packet to the receiver to terminate their connection.
- Step 6:The receiver acknowledges the end of transfer by sending END_ACK packet.

Thus the algorithm has been explained successfully.Using the above mentioned methods the bandwidth could be allocated on demand without any hindrance.

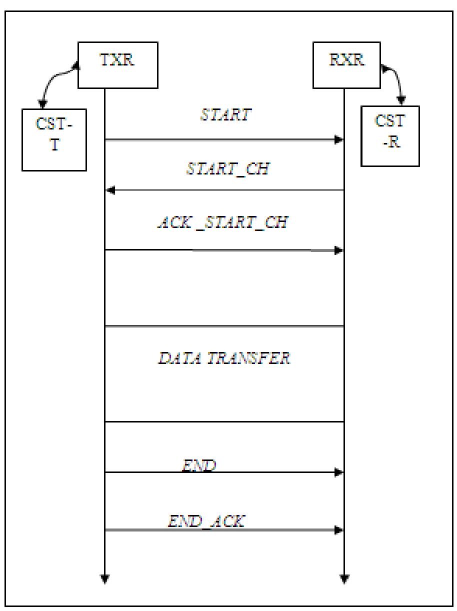

Figure 1: Flowchart Representation Of The Algorithm

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