EFFICIENT CHANNEL SELECTION FOR COGNITIVE RADIO AD-HOC NETWORK

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ABSTRACT:

“Cognitive radio” has emerged as a new model for next-generation wireless networks whose target is to increase utilization of the scarce radio spectrum (both licensed and unlicensed). The cognitive radio transceiver learns from the surrounding environment and adapts itself according to the environment. Intelligent algorithms are used to learn the surrounding environment, and the information obtained is utilized by the transceiver to choose the frequency band (i.e., channel) for transmission as well as transmission parameters to achieve the best performance. This paper presents a scheme for efficiently selecting a channel for transmission in a multichannel cognitive radio ad-hoc network. The hidden PU (primary user) problem is also addressed in this paper.

Keywords: cognitive radio, discrete coordination function, carrier sense multiple access IEEE 802.11

[1] INTRODUCTION

There has been an increased demand from Broadband wireless applications for radio spectrum resources. As a result, there has been a spectrum shortage problem. Cognitive radio (CR) is considered a novel concept to improve the utilization of the electromagnetic spectrum. Cognitive radio is attracting serious attention from industry and academia as a realistic solution to the problem of spectrum scarcity.

Cognitive radio network is a network in which an un-licensed user (secondary user) can use an empty channel in a spectrum band of licensed user (primary users). Cognitive radio allows secondary users to co-exist with primary users without causing interference to
the primary users. Cognitive Radio (CR) nodes have a unique capability which enables them to take advantage of available white spaces in a spectrum.

Most of the CR ad-hoc networks go to channel sensing just before transmission (just-before-transmission sensing), in this process the node first reserves a data channel and checks whether the channel can be used or not for data transmission, by sensing it, the process to reserve a channel and then sense it is repeated until it finds an empty channel for data transmission, due to this the node may suffer long delay to secure a channel for data transmission. To reduce this long data transmission delay of just-before-transmission sensing the CR nodes can be allowed to sense the channels in advance whenever they have any opportunity for channel sensing and maintain a list of empty channels. The CR node can transmit the data without actual channel sensing by selecting the channel from the list of empty channels. Therefore it relatively experiences a shorter transmission delay compared to sensing before transmission.

Two types of channel sensing are defined they are urgent sensing and opportunistic sensing.

• Urgent sensing

When the data transceiver completes its ongoing work, a CR node checks whether there is any channel for urgent sensing, if there are two or more channels then priority is given to the channel with longest elapsed time. This process is repeated until all the channels waiting for urgent sensing is sensed

• Opportunistic sensing

The opportunistic sensing can be performed only when the node does not have data packets to transmit as well as a Channel waiting for urgent sensing this sensing is applied to the idle channels.

[2] PROPOSED MODEL AND BASIC OPERATION

We consider a cognitive radio-based ad-hoc network using multiple channels. There is one control channel and N data channels within the network. It is assumed that cognitive radio network will not be interfered by primary users in accessing the control channel. The transmission power of a cognitive radio node on the control channel is set to be high enough that the packets transmitted through the control channel can be decoded by all nodes within the Cognitive radio network. In other words, the transmission range of a Cognitive radio node on the control channel covers the whole network. The data channels are licensed to Primary user and can be opportunistically used by the Cognitive radio nodes.

In the considered environment the Primary user signal does not have an influence on the whole cognitive radio network, but only on a part of the Cognitive radio network. That is,
there exist the nodes that cannot detect the PU activation, within the Cognitive network. Also a cognitive radio node should transmit data with power as low as possible so that the primary user does not get interfered by the secondary users. In the proposed system each Cognitive radio node is equipped with two transceivers: one is dedicated to the control channel (control transceiver) and the other is used to sense data channels and transmit/receive data on data channels (data transceiver).

The Cognitive radio node uses the control channel to transmit channel management packets or to reserve a data channel for data transmission. [Figure-1] shows the overall operation that a CR node performs with the data transceiver. When the node has completed the current work, it first checks the channel waiting for urgent sensing. If there are such one or more channels, the node selects the channel with the longest waiting time and carries out sensing on the channel. When the node has no channel for which the urgent sensing is required, it can transmit/receive data.

A network is created with certain number of nodes and its transmitting range and sensing range is defined. Nodes (CR nodes) are defined as intelligent nodes capable of sensing and detecting the unused spectrum. It has the capacity to adjust its parameters like frequency and transmission power so that it does not cause interference to the primary traffic.

Three scenarios come into picture:

1. Traffic for which urgent sensing is required.

Whenever there is data which has to transmit immediately the network routes the data to the urgent sensing nodes which can take up immediate transmission of the data after completing the channel establishing process.
2. If no traffic for urgent sensing then it goes for opportunistic sensing.

When there is no data available for immediate transmission then the node detects the unused spectrum and also gathers the information from the neighboring nodes to create a list of candidate channel which can be used for communication.

3. Data transmitted whenever there is data available to be transmitted.

Whenever there is data available for transmission then suitable channel from the list of candidate channel is selected and DCF process is carried out to establish the channel for transmission and then the source node and destination node is defined and then data is transmitted.

In DCF mechanism the CSMA/CA carrier sense multiple access/collision avoidance is used to establish an efficient channel for communication.

**Figure 2: overall operation of cognitive radio system**

[3] DATA TRANSMISSION SCHEME
We use DCF mechanism as a fundamental MAC protocol combining with the characteristics of cognitive radio networks to make it suitable for cognitive environment. A CR node wants to transmit data packets should reserve a data channel. The reservation process of channel for data transmission is described in this section.

- **Control packets for data channel reservation**
  Reservation of a data channel is achieved by exchange of the control packets between the sender and the receiver. The control packet transmission is governed by CSMA/CA.

  Each transmitter before attempting to transmit, it must find the carrier to be idle for a time period of DIFS seconds. After deferring for the DIFS period the station selects a backoff value for an additional deferral time before transmitting. If the channel is free then before the data packet are transmitted CSMA/CA needs to go through RTS-CTS control information interaction. The sender first transmit a request to send (RTS) to the receiver with a list of channels. The receiver will select one of the channels and respond with a clear to send (CTS) then the medium is reserved for communication.

- **Data channel reservation**

  The data channel reservation process is explained with a diagram [Figure-2]. After exchange of control packets the data is transmitted, after the transmission and reception of the data an (ACK) acknowledge frame is sent by the receiver to the transmitter indicating successful reception of packets. The DCF involves four way handshaking.

- **Network allocation vector**

  NAV (Network Allocation Vector), which is presented as time slots units a prognosis for how much longer the medium is expected to be busy for the current frame exchange sequenc.

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**Figure 3: Channel access using RTS/CTS frames.**
[4] SIMULATION AND RESULT

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<tr>
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<th>Parameters</th>
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<tbody>
<tr>
<td>SIFS</td>
<td>10µs</td>
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<tr>
<td>DIFS</td>
<td>50µs</td>
</tr>
<tr>
<td>Time slot</td>
<td>20µs</td>
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Table 1: Simulation parameters

The [Figure-4] shows network model is a 100x100(dimensions in meter) network grid with primary and secondary nodes. There are two types of circles one smaller and one larger, the smaller circle describes the transmitting range whereas the large circle describes the sensing range of a given node.
Node A is defined as secondary node establishing channel with another CR node, D to transmit data. The channel establishment is based on DCF mechanism.

![Figure 5: Channel selection between two cognitive nodes](image)

[Figure-5] describes the network throughput for the cognitive network. As the number of nodes increases the strain on the network increases. A reasonable throughput is achieved even for higher number of nodes.

![Figure 6: Cognitive radio network throughput](image)

[Figure-6] describes the network throughput for the cognitive network. As the number of nodes increases the strain on the network increases. A reasonable throughput is achieved even for higher number of nodes.
Figure 7: Cognitive radio network delay for high load

[Figure-7] indicates the network delay when the traffic is high. The delay is considerably even for higher number of nodes.

[5] CONCLUSION

CR networks are envisaged to solve the problem of spectrum scarcity by making efficient and opportunistic use of frequencies reserved for the use of licensed users of the bands. To realize the goals of truly ubiquitous spectrum-aware communication, the CR devices need to incorporate the spectrum sensing, spectrum decision, spectrum sharing, and spectrum mobility functionalities. An efficient channel establishment mechanism can be obtained using DCF mechanism. This not only eliminates hidden PU problem but also achieves high network throughput and considerably less delay.
REFERENCES


Author[s] brief Introduction

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