SSP-Based Routing under Blind Information for Cognitive Radio Ad Hoc Networks

Priya Thomas, Prof. Subbaroyan V

***Abstract*—The concept of opportunistic dynamic spectrum access or the cognitive radio emerged as a result of tremendous increase in the demand for wireless connectivity. In wireless networks, control information is usually carried through a common channel. But in a cognitive radio ad hoc network, secondary users can use only the channels that are not used by primary users. Therefore, it is not possible to have a common channel for all the nodes in the network. In order to compensate for this, multiple broadcasting of control messages to channel sets in different time slots is being used in such networks. However, this may cause channel congestion and packet collisions. In order to tackle the above problems, this paper introduces a server known as the Secondary Service Provider (SSP). It stores and coordinates control information from different nodes. The system is matched to practical scenarios by the inclusion of blind information. Simulation results prove that throughput has increased considerably well with the use of SSPs.**

***Index Terms*—Blind information, cognitive radio ad hoc networks, control information, secondary service provider.**

I. INTRODUCTION

Every application has a specific bandwidth. Due to this fixed spectrum-allocation policy, a major share of the assigned spectrum is underutilized. Cognitive Radios (CR) are a solution to this problem by enabling unlicensed users to exploit the spectrum that is unused by licensed users. The licensed users are called the primary users (PU) and the unlicensed users are called the secondary users (SU) of that spectrum. In a cognitive radio network, every user is free to use all frequencies depending on their availability. There is no restriction on the set of frequencies that can be used. A CR can intelligently detect whether any portion of the spectrum is in use and can temporarily use it without interfering with the transmission of other users [12].

In a dynamic environment like cognitive radio, it is very important that the control information reach every node in the network. Routing information and channel availability information are collectively called as the control information. Hence, proper reception of it is necessary for the secondary users to adaptively adjust their operating parameters. In traditional wireless networks, control information was broadcasted through a common channel. But in cognitive radio networks, the notion of a common channel is not feasible. This is because users acquire different channel sets in different time slots. They do not share a common channel.

In order to overcome this, random and full broadcasts are used. In random broadcast scheme, control information is broadcasted to a random set of channels from the available channels of an SU. Broadcasting is performed multiple number of times in different time slots in order to increase the probability of reception. However, the scheme cannot ensure that all the nodes in the network have received the control message. In full broadcasting, an SU sends control information to all its available channels sequentially. But this increases the average broadcast delay.

In this paper, we introduce a server – the Secondary Service Provider (SSP) that stores control information from every node in its range. These servers are also capable of communicating with each other and thus integrate the control information of all the nodes in the network. This mitigates all the broadcast problems that were discussed earlier. Moreover, the system is considered under blind information – absence of the following information: i) Network topology information; ii) Channel availability information; iii) Time synchronization information. The paper simulates the normal common channel data transmission, ad hoc involvement and the cognitive concept of data transmission using SSPs. Figure 1 shows the cognitive radio network.

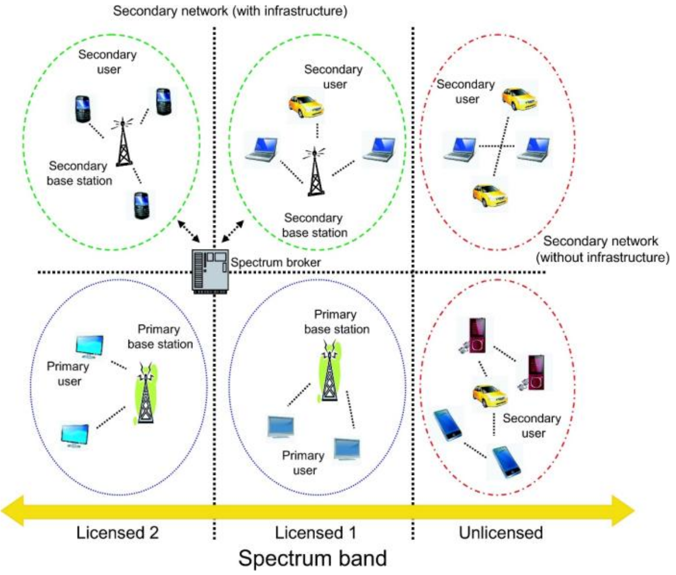

Fig-1: Cognitive Radio Network in Spectrum

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Rest of this paper is organized as follows. Section 2 describes previous works related to the proposed concept. We describe the SSP-based control and coordination for use in cognitive radios in section 3. Section 4 elaborates on the software modules used in the work. In section 5, we provide experimental results and analysis. Finally, in section 6, we discuss advantages, limitations and outline the future scope of the work.

II. RELATED WORK

[11] In this paper, the authors propose a QoS-Based Broadcast Protocol under Blind Information for Multi hop Cognitive Radio Ad Hoc Networks. The protocol designs channel-hopping sequences for both the SU sender and the SU receiver based on random selection of channels. An SU sender randomly broadcasts on a set of channels from its available channels. Broadcasting is repeated on the selected set for multiple time slots to increase the probability of reception.
Pros and cons:
-- This scheme increases the success rate of reception of control messages.
-- It causes delay in delivery as the broadcast has to be repeated periodically on the randomly selected channels.

[12] In this paper, the authors propose a distributed broadcast protocol in multi-hop cognitive radio ad hoc networks with collision avoidance. There are three components for the proposed protocol: 1) construction of broadcasting sequences; 2) distributed broadcast scheduling scheme and 3) broadcast collision avoidance scheme. A time-slotted approach is adopted for SUs where the length of a time slot is sufficient to transmit a broadcast packet.
Pros and cons:
-- It provides a high successful delivery ratio and short broadcast delay.
-- SUs are assumed to be static. Also, each SU is assumed to know the locations of its all two-hop neighbors.

[6] In this paper, the authors address the issue of dynamic assignment of control channel in cognitive radio networks based on time and space varying spectrum environment. They propose a cluster-based architecture that allocates different control channelsat various clusters in the network. The problem is formulated as a bipartite graph problem.
Pros and cons:
-- It facilitates for graceful channel migration when primary radio activity is detected, without the need for frequent re-clustering.
-- Significant computational overhead is involved in the formation of dynamic clusters.

[9] In this paper, the authors present two channel-hopping-based MAC-layer protocols, SYNC-ETCH and ASYN-ETCH, for communication rendezvous in CR networks. SYNC-ETCHassumes that CR nodes can synchronize their channel hopping processes. ASYNC-ETCH does not rely on global clock synchronization.
Pros and cons:
-- The protocols achieve communication rendezvous in CR networks.
-- It is not fully applicable to practical scenarios as it considers time synchronization.

[3] The paper provides a survey on the routing metrics used in CR networks. The authors list the challenges that have to be addressed in designing a good routing metric. They provide taxonomy of different metrics and a survey on how they are used in different routing protocols. The paper also compares different classes of metrics and provides ways to combine individual routing metrics to obtain a global one.

III. SSP-BASED CONTROL

As we have already seen, every node in a network broadcast control information periodically. Many protocols have been designed to increase the probability that every other node in a network receive control messages from every other node. But they cannot be better than having a controller that can collect control messages from all the nodes and perform necessary information exchange with the nodes.In this paper, we introduce a server called as the Secondary Service Provider.

The SSPs reside within Mobile Switching Centres (MSCs) of the network. An SSP stores the control information sent by a node within its range. These SSPs can cover all the nodes in a network by installing sufficient number of them in the network. These servers then communicate with each other to integrate the status information of all nodes present in the network.Depending on the stored information in SSPs, MSC takes decision on the call transfers whenever a service request comes.

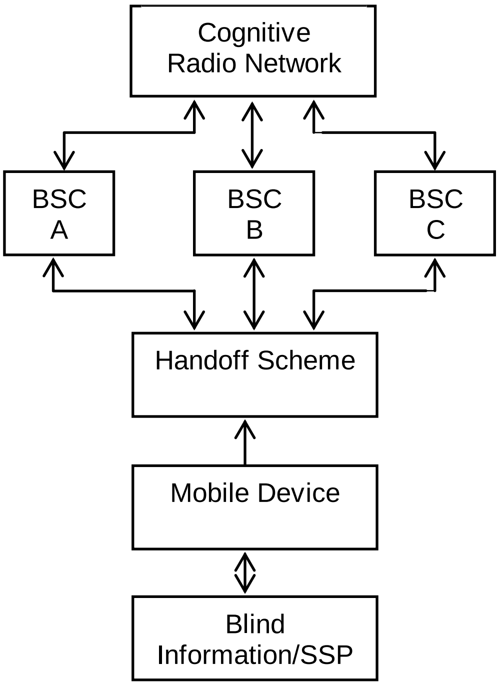

Fig-2: Block Diagram of Proposed System

IV. SOFTWARE MODULES

The system implementation is carried out in four modules. They are:

1. Network selection
2. Spectrum sensing
3. Channel information update
4. Blind information

A. Network Selection

This module deals with the creation of cognitive radio environment. We consider a hybrid architecture of star and ad hoc networks. Such a hybrid architecture has several benefits. It provides self-reconfiguration and adaptability to highly variable mobile characteristics. Re-configurability refers to the radio capability to change the functions dynamically in accordance with the changing radio environment.

A base station acts as a bridge between two remote ad hoc networks or as a gateway to a fixed network. For selecting a network, a node will initially send a request to the SSP. The node will choose the available network based on the reply from the SSP. After selecting the network, the node will hand off its details to the new one.

B. Spectrum Sensing

A CR secondary user can be allocated to only unused portions of the spectrum. Therefore it is necessary to monitor the available spectrum bands and detect spectrum holes. The goal of spectrum sensing is to find out the spectrum status and activity by periodically sensing the available bands.This is done by the SSP in the network. There are two types of spectrum sensing, namely centralized and distributed.

In a centralized architecture, a single entity controls the usage of the spectrum by secondary users. It senses the available frequency bands by integrating the broadcast messages coming from different nodes. In a distributed approach, there is no central controller. As a result, all users should cooperative with each other, sense and share the free channels. Here, we use a centralized approach of spectrum sensing. Spectrum sensing is the most sensitive and important module among the four as it should ensure zero interference to others users.

C. Channel Information Update

The nodes broadcast their status messages periodically to their neighboring nodes. This periodic update is very important for proper channel allocation in a cognitive radio network. The SSP integrates the status updates from all the nodes (spectrum sensing). Whenever a node requests for a channel, the SSP replies it with the network topology information. Based on this, a free channel is selected by the node.

D. Blind Information

Under practical scenarios, the unlicensed users are not aware of the network topology, spectrum availability information, and time synchronization information. This is called the Blind Information. A node will initially send a blind information request to the SSP. The node will choose the available network based on the reply from the SSP. After selecting the network, the node will hand off its details to the new one.

V. RESULTS AND ANALYSIS

A total of 16 nodes are simulated in NS2. Out of these, node-0 is the MSC. Nodes-1, 2, 3 are the Base Station Controllers (BSCs). Nodes-4, 5, 6, 7, 8, 9, 10 are the substations. Nodes-11, 12, 13, 14 are the mobile nodes. Nodes-15 and 16 represent the SSPs. Node-11 is configured as the sender node and node-13 as the receiver node. Each BSC handles a specific band of frequencies. The colors-green, yellow and blue are used to represent the three different frequency sets used by the BSCs. Figure 3 shows the network topology.

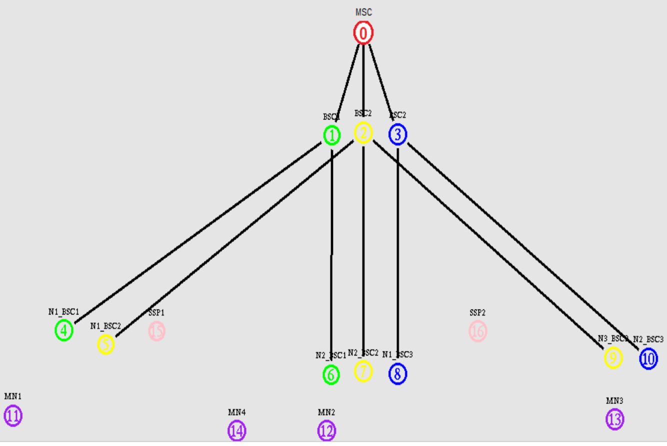

Fig-3: Network Topology

A. Transmission Modes

Screen shots of the different modes of data transmission are shown below.

Initial transmission:
Node-11 is transmitting data to node-13 through BSC-2. This is the initial path of data transmission as shown in figure 4. Control information is broadcasted to the entire network and the neighboring nodes receive it. SSPs are not involved here.

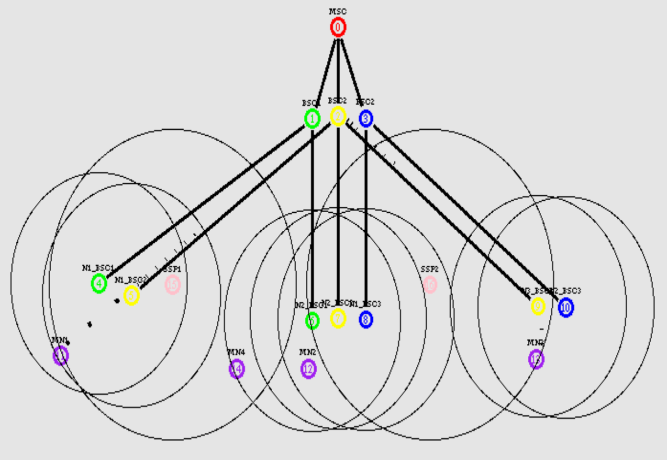

Fig-4: Initial Transmission

Transmission in ad hoc mode:
As node-11 and node-13 move towards each other, at some point they come close enough to use the ad-hoc mode of data transmission. Thus the node-11 sends data to node-13 via node-12. Here nodes-11, 12 and 13 form an ad-hoc network. This is shown in figure 5.

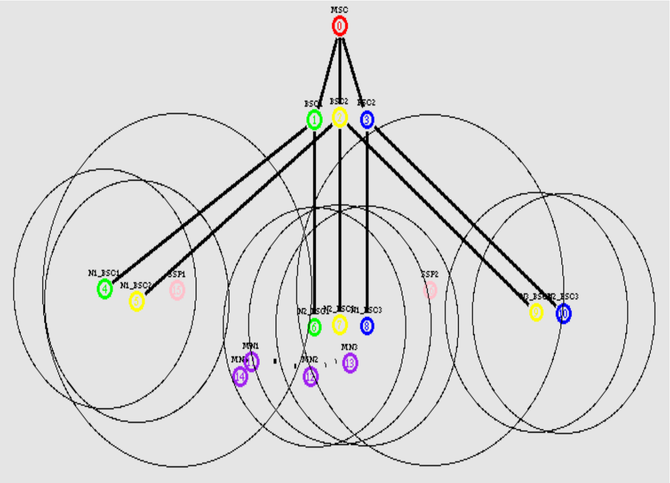

Fig-5: Ad-hoc Mode Transmission

Transmission in cognitive mode:
The sending and receiving paths are under BSC-3 and BSC-1 respectively. This clearly shows that the transmission and reception take place in two different frequencies. This is the cognitive concept of data transmission as shown in figure 6. The nodes obtain network topology information through SSPs. Channels are chosen based on their availability.

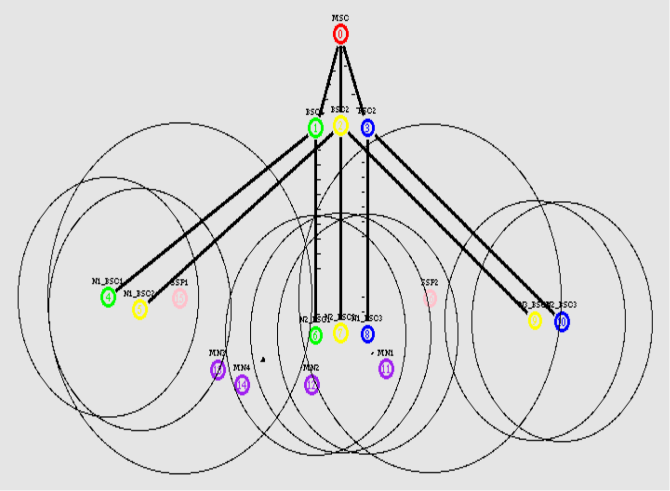

Fig-6: Cognitive Mode Transmission

B. Graphical Analysis

Output graph as shown in figure 7, Throughput against Number of Nodes, is generated after the successful simulation of the system in NS2. It gives an estimation of the performance of both the systems-the existing and the proposed. From the graph, it is clear that for a definite number of nodes, the proposed system gives better throughput than the existing system.

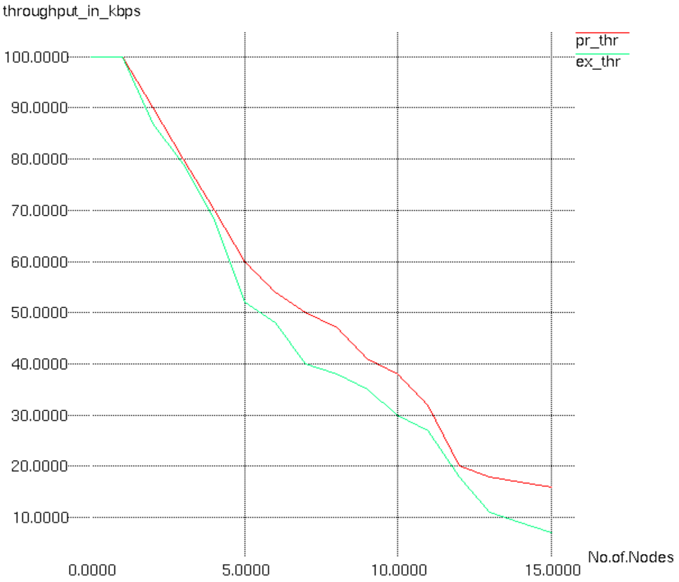

Fig-7: Throughput vs. Number of Nodes

VI. CONCLUSION

In this paper, we have used a server-the secondary service provider to solve the broadcast issues in multihop cognitive radio ad hoc networks. The system is made applicable to practical scenarios with the inclusion of blind information. Software reference models for the existing and proposed systems, communication through a common channel without SSPs as well as through available channels (cognitive concept) with SSPs, are designed and implemented in NS2.

A comparative analysis of throughput in both the schemes is carried out. The proposed system increases the overall throughput of the system. There is greater probability that all nodes in a network successfully receive the control information. It reduces the broadcast delay. Broadcast collisions can also be mitigated.Future work may involve implementing a ranking scheme in SSPs for the efficient selection of channels. This can further improve the throughput and reduce the delay in servicing the requests.

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