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Effective Performance Evaluation of On-Demand Routing Protocol for Cognitive Radio Ad Hoc Network

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Abstract

To solve Spectrum decision and route selection problem which have vital role in cognitive radio ad hoc network (CRAHN), many researchers developed different methodology how efficiently select the proper route between source and destination. In this paper it has been analysed the efficiency and routing load of on-demand routing protocol based on ad hoc on-demand distance vector (AODV) routing protocol for CRAHN. It observed that the overall performance of routing protocol in CRAHN is better at less numbers of secondary users (SUs) presents in the Cognitive radio ad hoc network.

Keywords

Cognitive Radio Network; Ad hoc Network; Routing Protocol;

1. Introduction

Present theory on wireless communication system reveals that the availability of radio frequency has taken a declining shape because of the increased users in the wireless domain. A recent study by Federal Communications Commission (FCC) highlights that many spectrum bands allocated through static assignment polices are used only in bounded geographical areas or over limited periods of time and the average utilization of such bands varies between 15% and 85% [1]. Hence, Cognitive Radio (CR) technology has been emerged as an advance research field which implies efficient utilization of the vacant licensed frequency bands and it works on spectrum bands allocated through dynamic assignment polices. It deals with spectrum availability and detects the presence of Primary users (PU); selecting the best available channel; coordinate access to this channel with other users; vacate the channel when PU is detected; to choose a path and spectrum for data routing in order not to interfere PU's activity. The main objective of CR technology is that CR operation should not interfere transmission of PUs.

Generally in ad-hoc network, the topology changes dynamically. So, cognitive radio ad-hoc network (CRAHN) should adhere to dynamic network topology as well as maintain quality of service. Therefore, proper routing protocol should be used to maintain the quality standard. The main characteristics of CR are awareness of the environment and its corresponding changes; the ability to sense the unused spectrum; the ability to receive and transmit at different frequency bands which enable it to reconfigure its parameters and select the best band.

There are mainly two types of cognitive radio network (CRN) and they are single-hop cognitive radio network (SCRN) and multi-hop cognitive radio network (MCRN). In SCRN, the spectrum information are stored in a centralized entity which allocate best possible spectrum for transmission of CR users and the CR users can directly communicate to centralized entity for transmission [2]. In MCRN, CR users sense and get available spectrum named as spectrum opportunity thereby divide into multiple channels selecting one among them which will not interfere the primary user from these channels via specific policy [3]. However, there are so many challenges in CRAHN because of the dynamic channel availability for each node and dynamic topology. The main issues are efficient data routing through proper channel assignment and routing performance without interfering the PUs activities in CRAHN.

So routing has the important role to transfer the data from source node to destination node efficiently and effectively with less routing overhead. In this case packet delivery ratio (PDR) and normalized routing load (NRL) are two evaluation parameters through which we study the evaluation of routing protocol for CRAHN.

The rest of the paper is started with related work in section 2, followed by routing model and simulation in section 3. Results and discussion have been discussed in chapter 4. Finally conclusion is discussed in section 5.

2. Related Work

The routing protocol proposed by Kaushik R. Chowdhury et al., [2] consists of two stages i.e., spectrum selection stage and next hop selection stage. The major objectives of Chowdhury paper are: Protection for PU receiver, allowing multiple classes of routes and Scalable joint route spectrum selection.

A review paper by Matteo Cesana et al., [4] describes the different challenges and solutions to design effective routing solutions for multi-hop CRAHNs. The authors in [4], describe two categories for routing solutions as approach based on full spectrum knowledge and approach based on local spectrum knowledge. A survey paper by Ian F. Akyildiz et al., [5] explains about spectrum sharing, spectrum mobility, spectrum management and design challenges in cognitive radio networks in details.

An evaluation study by Marco Di Felic et al., [6] analyzes the impact of CRAHNs characteristics over the rout formation process by considering different routing metrics like Route discover frequency, Packet deliver ratio and Route discover algorithms. The routing protocol STOD-RP [7] constructs a spectrum tree in each spectrum band which helps in spectrum selection and route selection in an efficient manner. The main objectives of routing protocol in [7] are to reduce control overhead and to shorten the average end-to-end delay.

In path centric channel assignment protocol [8], the cognitive radio network is modeled by a layered graph which represents the multi-channel wireless network. The objective of the said protocol is reduced packet collision among neighboring nodes which uses same channel for transmission and hence increases the throughput.

A number of routing protocols have been proposed and implemented for better routing performance of CRAHNs. But, in a particular situation they have some advantages as well as disadvantages. In CRAHNs [9] the authors present properties and current challenges of CRAHNs, which mainly describes concepts of spectrum sharing, spectrum decision and spectrum mobility. It also presents a model of cooperative spectrum-aware communication protocols which integrate the spectrum management functionalities.

3. Routing Model and Simulation

CR devices may be used licensed bands spread over several different spectrum and each spectrum band may be composed of multiple channels of varying bandwidths in the cognitive radio ad hoc network. So the frequency range for CR transmission is large and transmission route requests (RREQs) of the routing protocol in each channel of the different bands adds a substantial routing overhead. The spectrum and node selection are required to carry out simultaneously in the cognitive radio ad hoc network.

Each CR user identifies the best spectrum band based on local environmental observations in the network. The destination node in the CRAHN chooses the final route that best meets the goals of the desired routing by a route reply (RREP) of the routing protocol. A route maintenance scheme allows re-construction of a partially or fully broken route caused by node mobility and Primary user (PU) activity during the data transmission in the network system. If path is broken down by switching of node, mobility of node, PU activity and etc., then the route error (RERR) message will be generated. Then after, it starts the route discovery process to re-establish from source node to destination node in the network system.

Using the said process of the routing protocol, it has been evaluated the performances of cognitive radio on-demand routing protocol based on ad hoc on-demand distance vector routing protocol by simulations through Network Simulator-2 (ns-2) [10], based on the Cognitive Radio Cognitive Network (CRCN) simulator [11].

It has been carried out in this simulation that, a multitude of tests with random topology where 10 PUs are randomly placed in 500m x500m. The transmission range of each user is adjusted to 250m. Two-ray ground propagation model is used at the radio layer. Each source node transmits constant bit rate (CBR) traffic and data packet size is 512 bytes. It has been considered as source node and destination nodes work in different spectrum bands. The number of SUs in the network is varying from 10 to 100 with multipath traffic exists in the simulation. It has adopted the classical IEEE 802.11b protocol to demonstrate the performance evaluation of routing protocol. It has been carried out the simulation as per table-1.

Table-1. Simulation Parameters for CR-AODV

S.No	Parameters	Values
1	Area size	500m x500 m.
2	Transmission range	250 m.
3	Simulation time	900 s.
4	Nodes speed	5 m/s
5	Pause times	10 s.
6	Data rate	5 Kbps
7	Mobility model	Random any point.
8	Interference	1
9	Number of channel	1
10	No. of PUs	10

It has been taken The Normalized Routing Load (NRL) and Packet delivery ratio (PDR) as performance metrics to compare the performance of routing protocols. Normalized Routing Load (NRL) is the sum of all transmissions of routing packets per total delivery packets and each transmission over one hop the packets transmitted count as one transmission. Packet delivery ratio (PDR) is performance evaluation parameter which measures effectiveness, reliability and efficiency of a protocol and defined as the percentage of the ratio between the number of received packets at destination and the number of packets sent by sources.

4. Result and Discussion

It has been compare the network routing load of cognitive radio ad hoc on-demand distance vector routing protocol for different size of secondary users in the CRAHN. Source and destination nodes work in different spectrum bands in CRAHN. Therefore intermediate nodes are required for establishing the route between them and participate to transmit the data from source to destination in the network system. As a result in figure-1, it displays that NRL is more when the number of SUs is more which imply less SUs presents in the CRAHN provide better result. Similarly we detected from figure-2 that the PDR is dependent on number of SUs, as PDR decreases with increasing number of SUs except in some cases. It shows how the reliability of the routing protocol varies with number of SUs and the performance is better at less secondary users with some exceptional case.

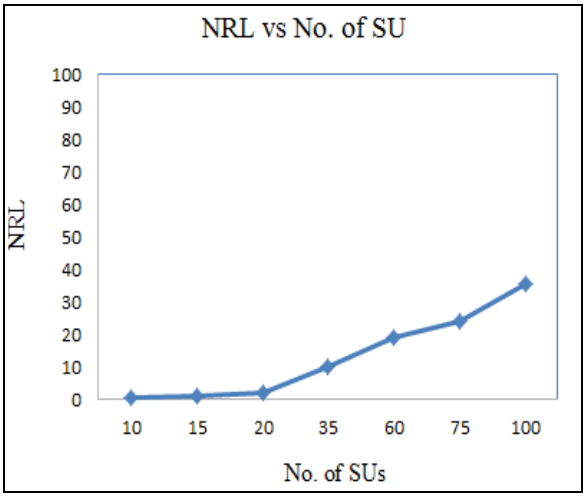

Figure 1: NRL vs No. of Sus

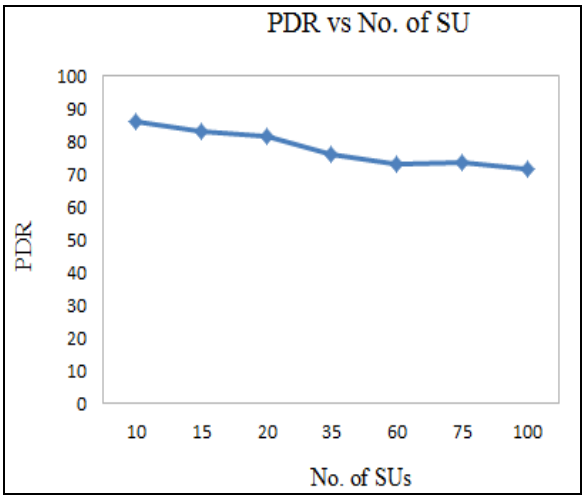

Figure 2: PDR vs No. of Sus

5. Conclusion

Routing protocols in new modern arena of telecommunications, internet systems and etc., play projecting role to develop better communication between end users in network system. In this paper, the simulation study of routing protocols deployed over cognitive radio ad hoc network using mentioned parameters with respect to network load and packet delivery ratio. It has been analysed the performance of the cognitive radio on-demand routing protocol in the cognitive radio ad hoc network. It has been found that less numbers of secondary user presents in the network generate less overhead and more effective comparative to more numbers of secondary users.

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