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MAC Algorithm for Cognitive Radio Networks Based on Traffic Type

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Abstract: ***The radio spectrum is a scarce resource. Cognitive radio enables secondary users to access the portions of the spectrum that are not currently used by the primary users. Coordination is a central issue in cognitive radio networks whenever users share resources. There may be collision, congestion or interference, with loss of performance in a absent coordination. For this previously a protocol is proposed that enable secondary users to learn and teach with the goal of coordinating to achieve a round-robin Time Division Multiple Access (RRTDMA) schedule. But the problem in this solution is no consideration is given for type of traffic and urgency of traffic like voice and video. All the traffic is seen in the same level so the secondary users with higher priority traffic are not satisfied by this protocol. This paper proposes a priority based round-robin Time Division Multiple Access (PRRTDMA) schedule protocol that improves the throughput of the secondary users with higher priority traffic. The protocol is completely distributed, fast, efficient and scalable.***

Keywords: cognitive radio networks, cognitive medium access control, distributed protocols, TDMA, priority, QoS.

1. Introduction

Most of the radio spectrum is wasted as they are reserved for the users who use them only for a fraction of time. Cognitive radio networks are considered as a solution to address this problem by allowing secondary users to operate in portions of the spectrum that are not currently used by the primary users.

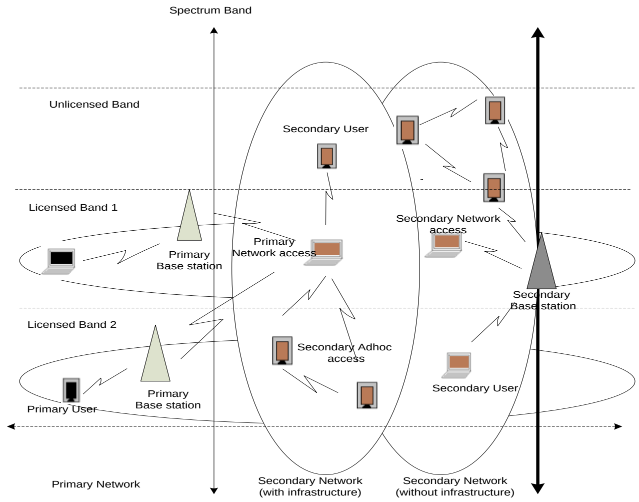


Figure 1: Cognitive Radio Architecture

The Cognitive radio network architecture shown above comprises of two network groups namely Primary network and Secondary network.

Primary Network: An existing network infrastructure is called Primary network. The user in this network has rights to operate certain spectrum of band called licensed band.

The examples of this network are Television Broadcasting network and cellular communication networks.

Secondary Network: It does not have any desired band to operate and thus it operates in the unlicensed band.

Due to the scarcity of radio resources, time varying channel conditions, and very diverse quality of service (QoS) requirements the radio resources must be efficiently used. Most of the work has been done to develop the physical layer technologies that allow secondary users to detect the presence of the primary users and coexist with them with minimal interference to improve the efficiency of the cognitive radio networks. Less work has been done in developing the MAC layer protocols that allow secondary users to coordinate with other users and share a channel in Time Division Multiple Access fashion. If there is no coordination between users there may be collision, congestion, with loss of performance.

A spectrum sharing protocol must exist to coordinate the spectrum access with the SUs as there exist a large number of SUs and all of the SUs have the right to access the available spectrum band by dividing the available spectrum band among the current SUs. Surveys on MAC techniques for CRNs can be found in [5-10]. In this paper, we propose protocols for efficient sharing of a frequency band. The protocols are completely distributed, fast, efficient and scalable. If there is only 1 user attempting to use the channel in that period/slot that user will succeed and receive an acknowledgement. A user will observe only whether the channel was idle or busy if it does not attempt to use the channel.

We can address two distinct problems by dividing MAC protocols for cognitive radio networks into two distinct strands of research([1][2]). The first strand of research focuses on identification of the vacant portions of the spectrum by the SUs and transmit in them while PUs currently not using it with minimal interference; work on this strand includes [3][4]. The second strand of research is to develop protocols to obtain coordination among the SUs to access the spectrum that have been identified. Examples related to this work includes [11] (auction mechanisms) and [12] (allocation of the spectrum opportunities by central centralized spectrum moderator). However in this work allocation of the spectrum opportunities among the SUs relies on the centralized coordinator. These methods require more information exchange and are costly. By contrast, our protocols are fully distributed and do not require a dedicated control channel or information exchange. By this we attain a perfect coordination and utilize all the available spectrum. We propose a priority based round robin TDMA that accommodates different traffic models given different priority levels for each traffic and the availability of each frequency channel.

The remainder of this paper is organized as follows. Section 2 presents the related works. Section 3 brings the proposed spectrum sharing approach. Some simulation results are presented in Section 4, followed by conclusions and references in section 5.

2. Related Work

Different spectrum sharing approaches have been investigated in recent years for cognitive radio networks, addressing issues as spectrum utilization efficiency.

William Zame, Jie Xu, and Mihaela van der Schaar, Fellow*",* Cooperative Multi-Agent Learning and Coordination for Cognitive Radio Networks", [13] The radio spectrum is a scarce resource. Cognitive radio stretches this resource by enabling secondary stations to operate in portions of the spectrum that are reserved for primary stations but not currently used by the primary stations. As it is whenever stations share resources, coordination is a central issue in cognitive radio networks: absent coordination, there may be collision, congestion or interference, with concomitant loss of performance. Cognitive radio networks require coordination of secondary stations with primary stations (so that secondary stations should not interfere with primary stations) and of secondary stations with each other. Coordination in this setting is especially challenging because of the various types of sensing errors. This paper proposes novel protocols that enable secondary stations to learn and teach with the goal of coordinating to achieve a round-robin Time Division Multiple Access (TDMA) schedule. These protocols are completely distributed (requiring neither central control nor the exchange of any control messages), fast (with speeds exceeding those of existing protocols), efficient (in terms of throughput and delay) and scalable. The protocols proposed rely on cooperative learning, exploiting the ability of stations to learn from and condition on their own histories while simultaneously teaching other stations about these histories.

Rolla Hassan, Fadel F. Digham , Mohamed E. Khedr, "Priority-Based Scheduling for Cognitive Radio Systems", [14] Cognitive radio is becoming one of the most important technologies enhancing the utilization of the constrained radio resources, the major bottle neck of the improvement of the next generation radio frameworks. Here a versatile downlink scheduling for real time and non-real time applications with the thought of the primary user activity is proposed. In this paper calculation fulfills different traffic models based on the QoS level of each traffic type and the spectrum availability and planning to outline an efficient scheduling algorithm to guarantee an interference-free environment for the primary users. The target here is to plan an efficient scheduling algorithm to accomplish a good tradeoff between system throughput, delay and fairness while representing the primary users' activities.

3. Proposed System

3.1 System Model

In this paper, we consider CRN providing communication services to SUs where, finite set of users Z interact over a infinite time horizon. Time is divided into slots, indexed by $t=0,1,2,\ldots$. The exact number of users is unknown but bounded by $N^*<\infty$. In each slot each user either transmits or remains silent. A{1,0} is a set of possible actions; 1 indicates user transmits, 0 indicates user remains silent. We consider a cell that is completely distributed with uniformly distributed users throughout. SUs will observe only the signal of the channel rather directly observe the channel state. We assume that the user can only observe whether the transmission is succeeded or not when it is transmitted in a given slot and the user that did not transmit in a given slot can observe only whether the channel was idle or busy. We assume at a specific timeslot, only one user access the available channel and the SU does not share this available channel with other SUs. The priority based round robin TDMA schedule gives priority for real-time traffic over non-real time traffic.

3.2 Traffic model

Classifying the traffic based on their priority. Highest priority is given for the voice traffic as they are delay sensitive. Slightly lower priority is given for the video traffic and lower priority is given for the FTP traffic. Our goal is to provide more slots for voice and video traffic than FTP traffic.

3.3 The Basic protocol

Suppose the true number of users N is known and that users can observe the true channel state. All users randomize equally and set Z of users are partitioned into two disjoint non-empty subsets Z0 and Z1. Users in Z0 remain silent and users in Z1 randomize again. Repeating in this way, we reach a point where all users are N singletons and assign index to each of the users. Finally our protocol must completely provide this information to all users and users must have the ability to both learn and to teach.

3.4 Individual Description of the Basic Protocol

The protocol is divided into four phases: Initialization, Coordination, Synchronization, Transmission. The protocol make each user to begin in the initialization phase and set the collection of counters. Once initialization is done protocol moves user to coordination phase where process repeats until each user believes prefect coordination is achieved. User moves to the synchronization phase once it believes perfect coordination is achieved. In synchronization phase each user carries out the sync test. The user returns to the initialization phase if it fails the sync test and repeats the entire process from the beginning, if the user passes the sync test it moves to the transmission phase. From the system perspective the goals of the various phases are: Initialization phase- To keep track of the positions of the users it sets the counters. Coordination phase- count the number of users and consider the priority of it, complete ordering of the users is constructed and its place in this ordering is informed to each of it. Synchronization- detection of the errors in the coordination. Transmission phase- Arrange the transmissions in TDMA/priority based round-robin fashion, and transmit indefinitely.

3.4.1 Initialization Phase

Each user z starts in a initialization phase and set a collection of counters. C(z) counts slots in the transmission, D(z) counts the total number of slots, H(z) counts the number of subsets into which the set of stations *Z* has been partitioned, W(z) counts the number of singleton sets in the current partition, Y(z) counts duration in the Transmission phase, hc(z) labels the priority of station z, wc(z) indicates whether user z belongs to a singleton set in the current partition, and if so, specifies in which position user z transmits, yc(z) counts the number of errors in transmission, ic(z) counts the unusage of the slot, fc(z) enables user z to teach other users to adjust their priority counters, pr(z) decides the priority of the traffic. Initially: H(z) = 1 and C(z) = D(z) = W(z) = hc(z) = wc(z) = yc(z) = 0. H(z) = W(z) exactly when user z believes the set of users *Z* is completely partitioned into singletons but that W(z) < H(z) before that point. After initialization is complete user moves to Coordination Phase.

3.4.2 Coordination Phase

This phase determines whether the user z believes the system has become perfectly coordinated. If H(z) = W(z) then z believes all users are perfectly coordinated and ready for transmission. If H(z) != W(z) user continues the partition until all the users are singletons. If wc(z) > 0 then z is completely partitioned and waits for the coordination phase to complete. Construct the complete ordering of the secondary users by partitioning the number of users competing the channel according to their priority. Arrange the transmissions in TDMA/priority based round-robin fashion until the prescribed number of slots has elapsed. In the synchronization phase, secondary user carries out the sync test. If it fails the test, it returns to the initialization phase and begins entire procedure from the beginning, if it passes it continues the transmission. If f(z) = 1 then z has had successful transmission in the previous slot, so now z teaches other users to adjust their counters appropriately.

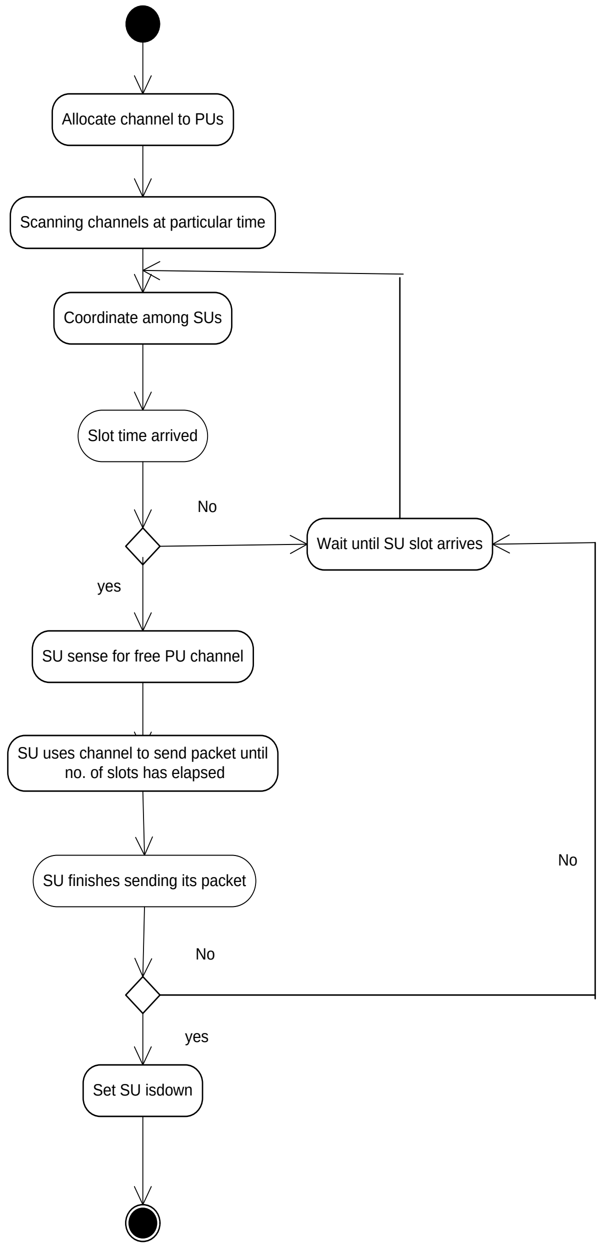


Figure 2: Assigning slots to users according to their priority to use the available channels

Figure 2 shows the stepwise activities. Once the channels are allocated for the PUs, the SUs starts scanning the free PU channel. The Secondary users that are competing for the channel coordinate among them to get the slot time for the transmission. If that particular SU slot time has arrived it senses the free primary user channel and occupies it for the transmission until its slot time elapses. If SU completes its transmission it is made down if not made it to wait for another slot.

4. Simulation Results

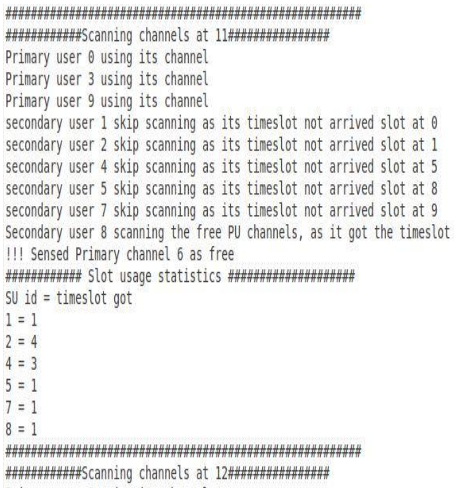
The simulation in this section is to demonstrate the performance of our priority based round-robin TDMA protocol using NS2.

In the simulation, a total number 10 nodes are randomly deployed in a 900 by 900 field, where few nodes are considered as primary and few as secondary nodes. Due to the randomly generated topology, we first specify 4 nodes as primary nodes and rest as secondary nodes. However, the nodes with the highest priority have more slots than nodes with the lower priority. Here we satisfy the highest priority nodes by decreasing the waiting time and increasing the throughput in PRRTDMA. This indicates that priority based round-robin TDMA efficiently utilize the available channel and increases the performance.

Table 1: Simulation parameters

Parameters	Value
Number of Nodes	10
PU nodes	4
Mobility of Nodes	Dynamic
Topology Size	900x900
Propagation	Two Way Ground
Antenna	Omni Antenna
SU nodes	6
Channel	Wireless Channel
MAC Protocol	802.11
Routing Protocol	AODV
Traffic Type	CBR,UDP

The used simulation parameters are listed in Table 1. These parameters are changed either up or down in various scenarios. This is done to test the proposed protocol upon several constrains and then prove its efficiency.



```
########################################################
###########Scanning channels at 11###############
Primary user 0 using its channel
Primary user 3 using its channel
Primary user 9 using its channel
secondary user 1 skip scanning as its timeslot not arrived slot at 0
secondary user 2 skip scanning as its timeslot not arrived slot at 1
secondary user 4 skip scanning as its timeslot not arrived slot at 5
secondary user 5 skip scanning as its timeslot not arrived slot at 8
secondary user 7 skip scanning as its timeslot not arrived slot at 9
Secondary user 8 scanning the free PU channels, as it got the timeslot
!!! Sensed Primary channel 6 as free
########### Slot usage statistics ###################
SU id = timeslot got
1 = 1
2 = 4
4 = 3
5 = 1
7 = 1
8 = 1
########################################################
###########Scanning channels at 12###############
```

Figure 3: Slot occupancy of the secondary users after round trip 1

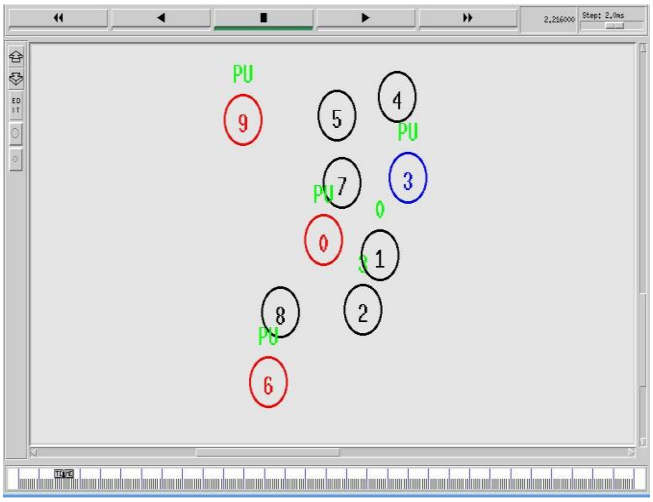


Figure 4: Network with 10 nodes at random locations.

Figure 3 and 4 illustrates the slot occupancy by secondary users for 10 nodes, where the number of nodes can be varied later for performance measurement. Here we can see the occupied slots by each secondary node that is competing for the channel. Nodes 0,3,6,9 are the primary nodes and nodes 1,2,4,5,7,8 are secondary nodes. Node 2 and node 4 are considered as higher priority nodes. These 2 nodes have got more slots than rest of the nodes as they are considered as higher priority nodes. The primary nodes 0,6,9 are busy and node 3 is free so the secondary user which has a slot time at that particular time uses the primary node 3 channel for the data transmission. Secondary nodes keep changing the channels for every attempt. In the below figure green font over the nodes represents the channel of primary user it had previously used.

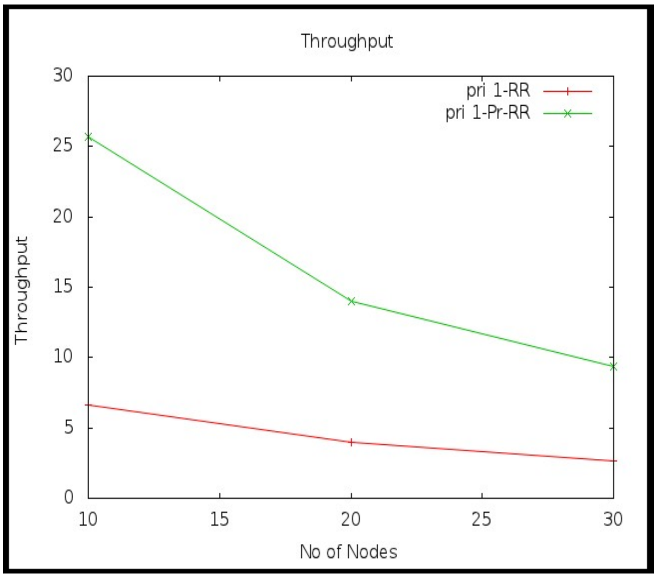


Figure 5: Throughput Versus no. of nodes for priority1 nodes

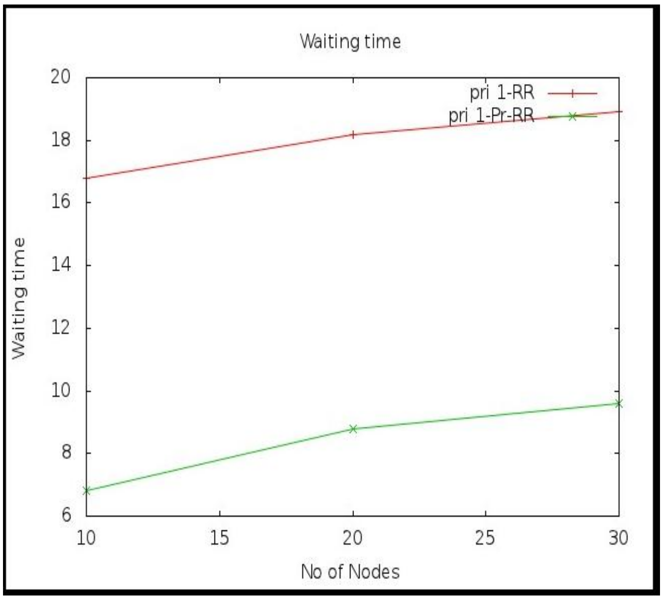


Figure 6: Waiting time Versus no. of nodes for priority1 nodes

Figure 5, 6, 7 and 8 shows graphs representing Throughput versus number of nodes and waiting time versus number of nodes for priority 1, priority 2 nodes respectively, from these graphs we can analyze that the throughput is high and waiting time is low for higher priority nodes in the proposed Priority based round robin TDMA protocol when compared to the existing Round robin TDMA.

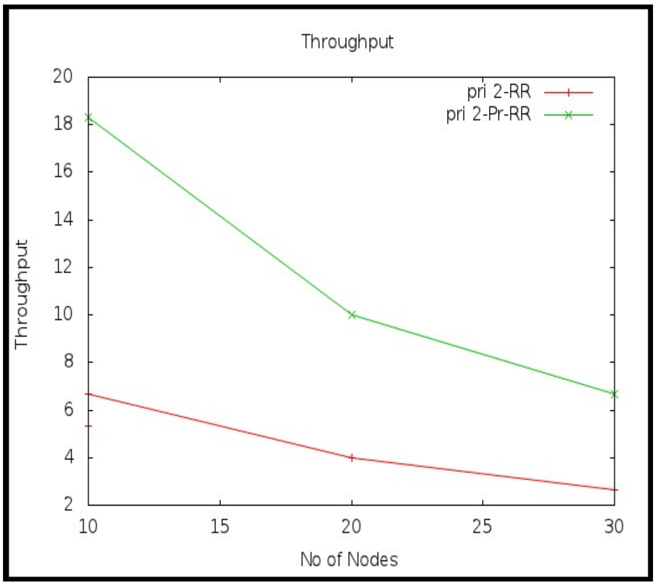


Figure 7: Throughput Versus no. of nodes for priority2 nodes

The performance improvement for the higher priority users is shown in the graphs. The throughput of the priority 1 users is almost 8% more than the throughput of the priority 2 users and the waiting time of the priority 1 users is almost 3% less than the waiting time of the priority 2 users. By observing this we can say higher priority users are satisfied with the priority based round robin Time Division Multiple Access.

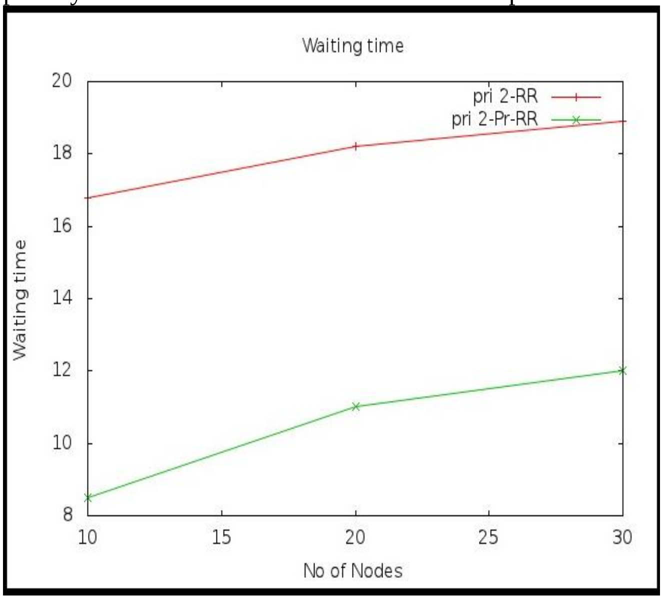


Figure 8: Waiting time Versus no. of nodes for priority2 nodes

5. Conclusion and Future Work

In this project, new class of MAC protocols based on cooperative learning that enables secondary stations to achieve and maintain perfect coordination is proposed. Our proposed MAC protocols are completely distributed, requiring neither any central control nor any exchange of control messages between secondary stations, fast, scalable. This protocol eliminates the defects of implementing round-robin TDMA. The proposed protocol achieve a priority based round robin Time Division Multiple Access schedule, where timeslots were split to the users according to their priority. The proposed protocol is designed to achieve high throughput by allocating more slots and decreasing waiting time for the secondary users with emergency data. The performance of the proposed PRRTDMA was evaluated using the NS2 network simulator and the proposed protocols shows improvement in performance by 20%-25% in terms of throughput and waiting time when compare to the existing RRTDMA protocol. In future, we can incorporate concept of PRRTDMA with the rendezvous scheduling

References

[1] H. Wang, H. Qin, and L. Zhu, “A survey on MAC protocols for opportunistic spectrum access in cognitive radio networks,” in Proc. Int. Conf. Computer Sci. Software Eng., 2008.
[2] T. V. Krishna and A. Dasa, “A survey on MAC protocols in OSA networks,” Computer Networks, vol. 53, no. 9, June 2009.
[3] J. Jia, Q. Zhang, and X. Shen, “HC-MAC: A hardware-constrained cognitive MAC for efficient spectrum management,” IEEE J. Sel. Areas Commun., vol. 26, no. 1, Jan. 2008.
[4] Q. Zhao, L. Tong, A. Swami, and Y. Chen, “Decentralized cognitive MAC for opportunisitic spectrum access in ad hoc networks: A POMDP framework,” IEEE J. Sel. Areas Commun., vol. 25, no. 3, Apr. 2007.
[5] Claudia Cormio and Kaushik R. Chowdhury, "A Survey on MAC Protocols for Cognitive Radio Networks", Ad Hoc Networks, no. 7, vol.7, pp.1315–1329, September 2009.
[6] Nhan Nguyen-Thanh, Anh T. Pham and Van-Tam Nguyen, "Medium Access Control Design for Cognitive Radio Networks: A Survey", IEICE Transactions on Communications, vol.E97-B, no.2, pp. 359-374, February 2014.
[7] Ian F. Akyildiz, Won-Yoel Lee, Mehmet C. Vuran and Shantidev. Mohanty, “Next Generation / Dynamic Spectrum Access/ Cognitive Radio Wireless Networks: a Survey”, Computer Networks Journal, vol. 50, no. 13, pp. 2127-2159, September 2006.
[8] T. Vamsi Krishna and Amitabha Das, "A Survey on MAC Protocols in OSA Networks", Computer Networks, vol. 53, no.9 , pp. 1377-1394, June 2009.
[9] Varaka Uday Kanth, Kolli Ravi Chandra and Rayala Ravi Kumar, "Spectrum Sharing In Cognitive Radio Networks", International Journal of Engineering Trends and Technology (IJETT), vol.4, no.4, pp. 1172- 1175, April 2013.
[10] Badr Benmammar, Asma Amraoui and Francine Krief, "A Survey on Dynamic Spectrum Access Techniques in Cognitive Radio Networks", International Journal of Communication Networks and Information Security (IJCNIS), vol.5, no. 2, pp. 68-79 , August 2013.

[11] J. Huang, R. Berry, and M. Honig, "Auction-based spectrum sharing," ACM J. Mobile Newt. Appl., vol. 11, issue 3, June 2006.
[12] Fu and M. van der Schaar, "Learning to compete for resources in wireless stochastic games," IEEE Trans. Veh. Technol., vol. 58, no. 4,2009.
[13] W. Zame, J. Xu and M. van der Schaar, "Cooperative learning and coordination for cognitive radio networks,".
[14] Rolla Hassan, Fadel F. Digham , Mohamed E. Khedr, "Priority-Based Scheduling for Cognitive Radio Systems".