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Enhanced Throughput for Cognitive Radio Networks Using Priority Based Scheduling With Backoff Algorithm

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Abstract: The concept of dynamic priority scheduling is used in cognitive radio networks to enhance the throughput and fairness of the network. Further backoff algorithm is used to reduce the collision during reservation of idle licensed channels.

Keywords: Cognitive radio, Backoff algorithm, priority scheduling, throughput.

I. Introduction

The fixed channel allocation in the communication systems leads to spectrum scarcity problem. So to reduce the problem we go for cognitive radio technique which uses unutilized spectrum in effective manner by constantly sensing and utilizing the available spectrum. Cognitive radio uses dynamic spectrum access (DSA) and opportunistic spectrum access (OSA). This access techniques identifies the unused radio spectrum and uses it opportunistically [1]. The cognitive radio networking involves two steps, in which first step is to identify the spectrum holes in licensed user's spectrum band. After identifying the spectrum holes, decision on optimal sensing, transmission time and proper coordination with other users for accessing the spectrum is made. Next step is to use the spectrum in effective manner. The throughput of cognitive radio networks can be maximized by frame structure [3].

The major characteristics of the MAC protocol are discussed in [4]. MAC protocol is used for better spectrum sensing and sharing .There are many challenges on designing MAC protocol, because they have to overcome three major problems as

- To limit interference on primary users during communication of secondary users.
- Synchronization between secondary users
- Hidden terminal problem.

There are various cognitive radio MAC protocols. The hardware-constrained cognitive MAC (HC-MAC) protocol [5], is used to conduct efficient spectrum sensing and make spectrum access decisions on considering hardware constraints. This protocol doesn't require network synchronization but the major limitation of this protocol is multichannel hidden terminal problem. The distributed spectrum-agile MAC protocol is a multichannel carrier sense multiple access (CSMA) -based protocol [6] which uses a dynamic channel selection algorithm. However this protocol requires network synchronization. The C-MAC protocol [7] uses rendezvous channel (RC) for coordinating nodes in different channels. But this protocol has problems in rendezvous channel availability and also requires network synchronization which makes this protocol more complex. The cognitive radio enabled multi-channel (CREAM) MAC [8] protocol overcomes the problem of hidden terminal problem and also this protocol doesn't require network synchronization. But the major issue of this protocol is communication overhead. In the self- scheduled MAC (SMC-MAC) protocol [9] used in our proposed method, the network synchronization is not required. This protocol is used for better co-operation among cognitive users to enhance the throughput. But the major limitation of SMC-MAC is fixed cycle time. And once the collision is detected in the contention interval, the users should wait till next cycle time to select the other contention slots. So the backoff mechanism has been applied to resolve this problem of contention among collided cognitive users and thereby increases the number of successful users. In the backoff mechanism, once the collision is detected, the collided cognitive users can once again select the contention slot in the same cycle time, and hence the users can transmit data during data transmission interval. In this mechanism, the contention interval is made flexible according to the number of collisions between collided cognitive users. By this backoff mechanism, throughput of cognitive radio networking is maximized. Further the dynamic priority scheduling concept is added to increase the number of packets sent by the individual cognitive user.

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II. EXISTING METHOD

In existing method, the SMC-MAC protocol is being used for sensing and sharing the unutilized licensed channels for better coordination among the cognitive users. In this protocol the cycle time is fixed. And once the collision is detected among the cognitive users during contention interval, the users cannot attempt to select the slot once again. The users will be given the next chance only in the next cycle time. So the collided users cannot transmit data during data transmission interval, hence reduces the number of successful cognitive users.

III. PROPOSED METHOD

In this paper, the back off mechanism is used for resolving contention among collided cognitive users to increase the number of successful cognitive users. Here once the collision is detected among the users during the contention interval, then the users again attempt to select the contention slot during the same cycle time. So they can transmit data during data transmission interval. So the successful users are increased and hence enhance the throughput of the cognitive radio network. The MAC protocol consists of control channel on which the users can share the sensing results. Each channel is divided into cycle time, Tcycle, which is further divided into four intervals as idle Tidle, sensing-sharing Tss, contention Tct and data transmission Ttr as shown in the figure.1(a).Further, the sensing-sharing and contention interval are divided into number of slots as shown in the figure.1(b).The number of slots in the sensing-sharing interval has to be equal to the number of licensed channels. For the Tidle and Tss, the cognitive users are tuned to control channel.

A. Sensing-sharing

Each cognitive users select a slot randomly from sensing-sharing interval and sense that particular channel. each users has sensing information of channel selected by it and by other users.

B. Contention

In contention interval, the cognitive users selects a slot randomly and if two users have chosen a same slot, then the collision is detected. After selecting the slot, source cognitive user sends CR-RTS frame to the destination cognitive user. The slot selection will be successful only if the source cognitive user receives the CR-CTS frame sent by the destination cognitive user. If the user fails to receive the CR-CTS frame then collision is detected. Once the collision is detected, the backoff mechanism is applied where the contention window size is increases hence increases the number of contention slots. Then the users again attempt to select a contention slot to reserve the unutilized licensed channel.

The source cognitive users sends list of available idle channels with CR-RTS frame to the destination cognitive user because there is a possibility that destination cognitive user location all those channels are not idle, so destination cognitive user sends list of selected idle channels/channel with CR-CTS frame, on which they will transmit data during data transmission interval. Once the cognitive user selects the contention slot during contention interval, it will switch cognitive node to that particular channel. And after that, on the selected channel if primary user signal is detected by the cognitive node, the node will stop its transmission to protect the primary user's transmission. The sensing-sharing is performed almost throughout the cycle time by the cognitive users. So sensing results are shared with other users to incorporate cooperation, and hence enhance the throughput of the network. The co-operation of six cognitive users is shown in the figure.1(a).

C. Data transmission

The cognitive users can transmit data only after selecting a slot successfully during contention interval. The data transmission interval T_{tr} is computed by subtracting idle time T_{idle}, sensing-sharing time T_{ss} and contention time Tct from cycle time T_{cycle}. This data transmission interval is used for computing throughput of the network. The maximum throughput of the network can be achieved only when all sensed idle channels are being used by the cognitive users. The maximum achievable throughput can be defined as,

$$Th_{max} = \frac{E[N] T_{trR}}{T_{cycle}}$$

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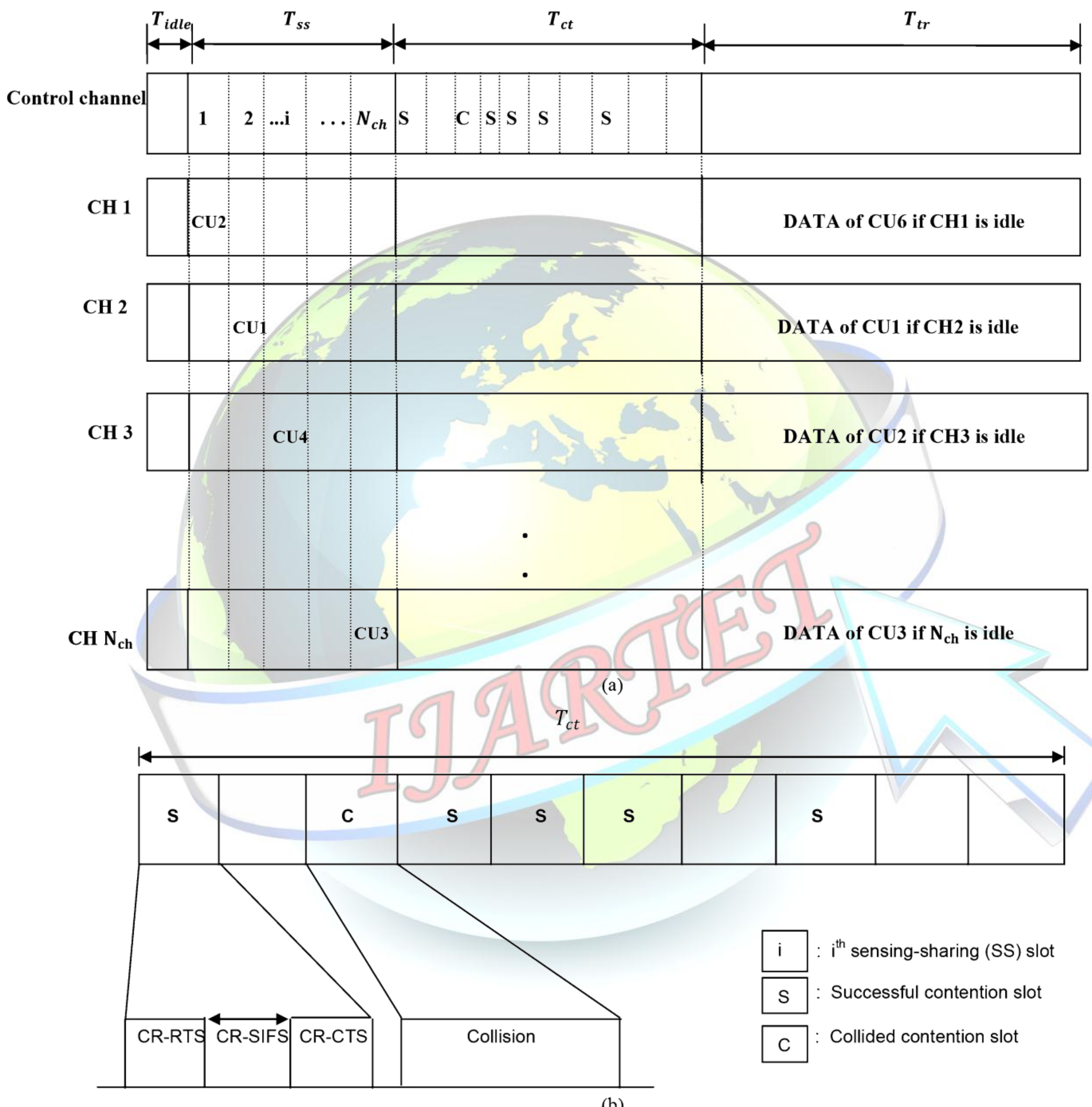

Fig. 1. (a) MAC protocol for distributed cognitive network. (b) Contention slot expansion of MAC protocol.

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Where, E [N] = Average number of Sensed idle channels.
R = Data rate
Ttr/Tcycle = Data transmission per cycle interval.

The throughput without backoff algorithm Thwo_bo is given as, minimum of the (Chidle×S) and average number of sensed idle channel.

$$Thwo\_bo = \frac{E[\min(chidle \times S, E[N])]TtrR}{Tcycle}$$

Where, Chidle = number of idle channels that cognitive user allowed to use.
S = number of successful cognitive users.

The throughput with backoff algorithm Thw_bo is given as,

$$Thw\_bo = \frac{N \times Chidle \times Ttr \times R}{Tcycle}$$

Where, N= number of successful users after backoff algorithm.

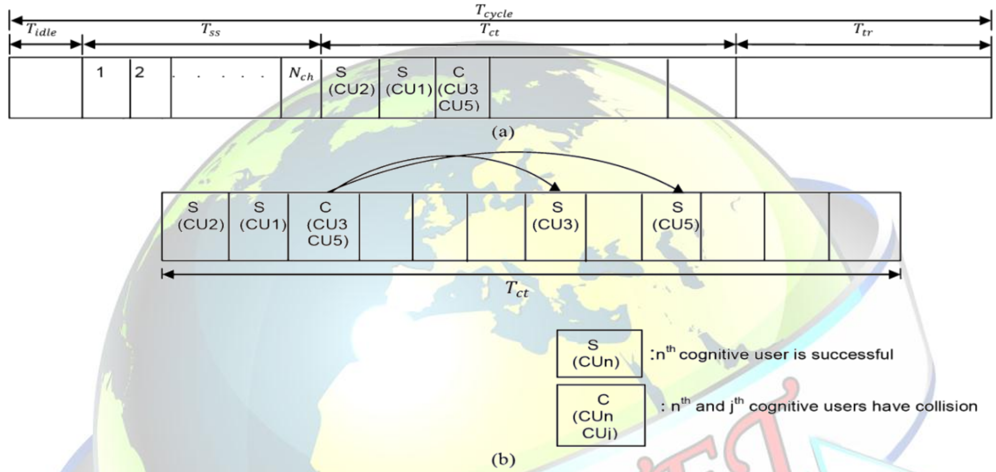

Fig. 2. Control channel structure (a) without the backoff algorithm during the contention interval and (b) with the backoff algorithm during contention interval.

D. Priority scheduling

The priority scheduling of a node is done to further achieve maximum and fairness among the users. Each node is assigned with priority and it can transmit data according to the priority. The priority can be based on various parameters.

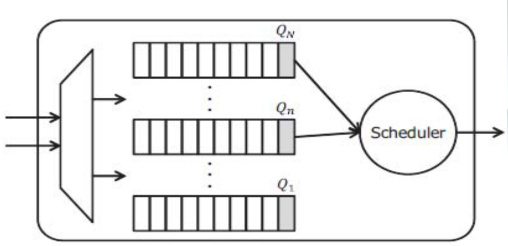

Fig 3. Multiple Priority Queues Scheduling Model

The proposed scheduling scheme aims to select data packet from N queues such that total number of transmitted packets is maximized while ensuring that their transmission duration does not exceed the transmitting time *Tt*.

In our model, time is divided into equal time slots which is further divided into two sub-slots.The length of first and second sub-slots are Ts and Tt, called sensing and transmitting time respectively. It is assumed that scheduler can assign data packets of secondary users at start boundary of each time slot but primary user can access channel whenever it has data to transmit. Whenever any data transmission request from secondary user arrives to scheduler, it first senses channel for Ts time interval, if channel is idle, it schedules data packets for secondary users according to their priorities.

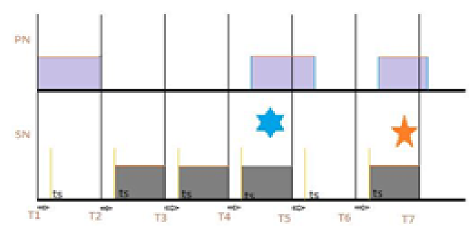

Fig 4. The Channel Access Scheduling Model for CR Users

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V. Simulation Results

The simulation results are given below.

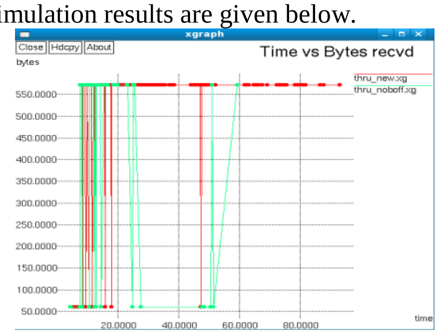

Fig.1. Throughput with and without Backoff algorithm.

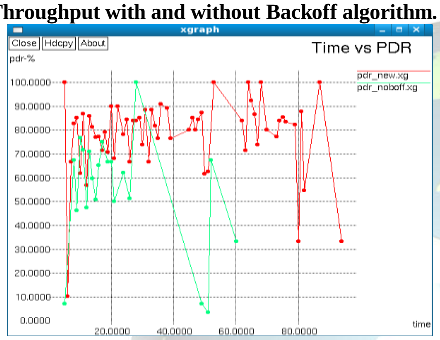

Fig.2. Packet delivery ratio with and without Backoff algorithm.

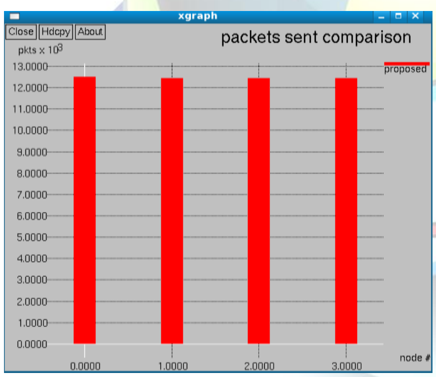

Fig.3. No of packets sent by nodes using priority scheduling

IV. Conclusion

In this paper, the self-scheduled multi-channel MAC protocol with backoff mechanism is been proposed with priority scheduling. In this method, the maximum throughput and fairness is attained for cognitive network by increasing the number of successful users. The successful users are increased by resolving contention using backoff algorithm during the contention interval. In proposed method, the maximum possibility of collision has been avoided and number of successful users are increased.

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