RANDOM ACCESS COOPERATIVE SPECTRUM SENSING IN COGNITIVE RADIO NETWORK

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Abstract - *Cooperative spectrum sensing increases the detection performance in a cognitive radio network, based on the number of sensing nodes. However, as the number of sensing nodes increases, the reporting overhead linearly increases. Such an approach has been first suggested in the packet reservation multiple-access (PRMA) technique, an adaptation of the reservation ALOHA protocol to the cellular environment. Contention based protocols, which limits their achievable throughput is the high number of packet collisions under heavy load of offered traffic. A key factor limiting throughput in such methods is that when a transmission is initiated, the full time and frequency resources of the channel are being used even though the sender have no knowledge if the transmitted packet will not encounter a collision. In case of collision the channel resources are wasted. There is group of medium access protocols that avoid some of the inefficiencies of the contention based protocols, by adding more control to the access method. They are called controlled random access methods. Two such protocols are described in this lesson: reservation ALOHA (R ALOHA) and polling. R-ALOHA is the example of distributed control random access scheme, poling is the example of centrally controlled random access scheme. Slots for the WSs reserved as per the current demand of the WSs. In the R-ALOHA scheme the control of the system is distributed among all users in the network. Because all reservation messages are heard by all users in the network, each user maintains information on the queue of outstanding reservations for all other users in the network as well as for its own reservation. When the queue length drops to zero, the system returns to the unreserved mode, in which there are reservation sub slots only.*

***Key Words*: R-ALOHA, Cognitive Radio(CR), primary Users(PU), Fusion Centre(FC).**

1.INTRODUCTION

Cognitive Radio (CR) enables the efficient use of limited spectrum by allowing secondary users (SUs) to access the licensed frequency bands of primary users (PUs). Fig 1 Spectrum sensing is a key element required to allow SUs to use vacant frequency bands in a CR network. Many signal detection techniques such as energy detection, matched filtering, and cyclostationary feature detection can be used to enhance detection performance in spectrum sensing . However, in practice, many factors, such as multipath fading, shadowing, and the hidden PU problem, may significantly affect detection performance. In cooperative spectrum sensing, each sensing node reports its sensing result to a fusion center (FC). The FC determines the presence of the PU by combining multiple independent sensing results from sensing nodes. Each sensing node performs local spectrum sensing and decides the presence of a PU by using a different detection threshold. Each sensing node reports its local decision to the FC and then the FC finally decides the presence of a PU by using hard combination (HC) methods (e.g., OR-rule or AND-rule). However, the SC method shows better sensing performance than HC methods at the cost of increased bandwidth of reporting channels. In cellular networks with multiuser diversity, various approaches have been studied to reduce the amount of the channel state information fed back by users. One approach is to quantize the observed channel state. An alternative approach is to allow users to report only if their channel state exceeds a threshold. In cellular networks with multiuser diversity, a base station finds one user who has the best channel condition among multiple users, for every frame. Contrastively, in the CR networks with cooperative spectrum sensing, an FC combines multiple sensing information reported from sensing nodes. Hence, previous multiuser diversity schemes with limited feedback in cellular networks cannot be directly applied to the CR networks.

1.1 RELATED WORK

Spectrum sensing is a major function of cognitive radio to sense the spectrum before using it to avoid interfering with the signals of the licensed users. Each SU implements a detection method such as matched filter detection [3], energy detection [4] and cyclostationary detection [5] to sense the PU signal. The SUs encounter several challenges such as signal attenuation, fading and shadowing when detecting the PU signal in the spectrum. Research issues which have been extensively studied in co – operative spectrum sensing include detection methods, collaborative SU's and FU's rules[8]. It does not address the reporting channel or reporting issues, in which SUs send their detection report to the FC. The reporting phase has been considered in a scenario with noise. In cellular networks with multiuser diversity, various approaches have been studied to reduce the amount of the channel state information fed back by users. Contrastively, in the CR networks with cooperative spectrum sensing, an FC combines multiple sensing information [1] reported from sensing nodes. Hence, previous multiuser diversity schemes with limited feedback in cellular networks cannot be directly applied to the CR networks. The OR voting rule [6] in their analysis to maximize a utility function as a weighted sum of capacity and energy expenditure.

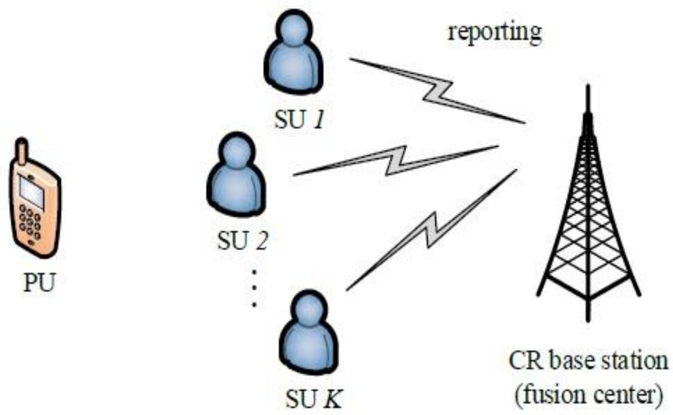

Fig -1: Cognitive Radio Sensing and Reporting

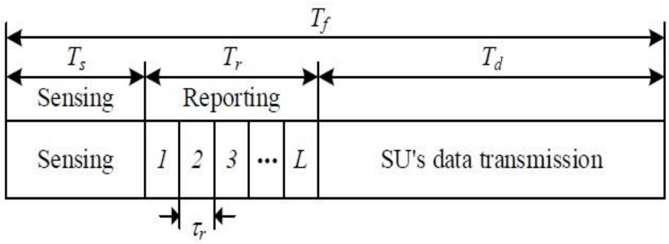

Fig -2: Frame Structure

2. REPORTING CHANNELS BASED ON R-ALOHA

The system has two modes of operation: unreserved mode and reserved mode. In the unreserved mode, the time axis is divided into short equal-length sub slots for making reservations. Fig:3 Users transmit short reservation requests in the reservation sub slots. After transmitting a reservation request a user waits for positive acknowledgment (ACK). The reservation acknowledgment advices the requesting user where to locate its first data packet. The system then switches to the reserved mode.

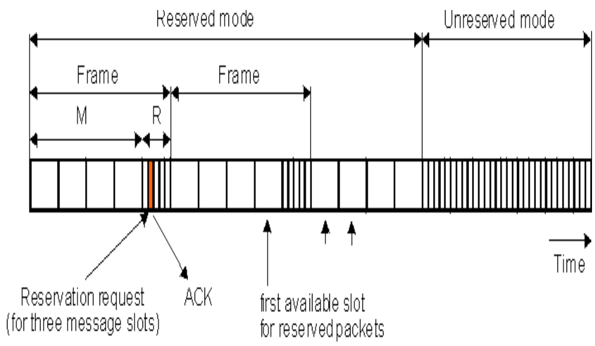

Figure -3: Frame structure of Reservation Aloha

In the reserved mode the time axis is divided into fixed-length frames. Each frame consists of M+1 equal-length slots of which the first M slots are used for message transmission (message slots) and the last slot is subdivided into R short reservation sub slots used for reservation. A sending user that has been granted a reservation sends its packets in successive message slots, skipping over the reservation sub slots when they are encountered. When there are no reservations taking place, the system returns to the unreserved mode.

METHODOLOGY

Maximize throughput

The maximum throughput

Occurs at G(n) = 1

If we knew m, n, and qa we could pick qr

so that

G(n) = (m − n)qa + nqr = 1 qr = 1 − (m − n)qa/n

Slotted Aloha

Departure rate = Prob of 1 transmission in a slot = Ge−G

Maximum departure rate occurs at:

d/dG (Ge−G) = e −G − Ge−G = 0 G = 1

Maximum departure rate = e −1 ≈ 0. 368

At the maximum departure rate: Pr(empty slot) = e −G = e −1 ≈ . 368

Pr (successful x mission) = Ge−G = e −1 ≈ . 368

Pr (collision) = 1 − e −G − Ge−G ≈ 1 − 2*. 368 = . 264

S = Ge−2G for un slotted Aloha and S = Ge−G for slotted Aloha

Average Delay

The average number of times a source transmits is G S

The average number of times a source retries, when there is an equilibrium point, is R = (G/S − 1)

$R_{unslotted}$ = e 2G − 1

$R_{slotted}$ = e^{G} − 1

At G = G_{max}, R = e − 1, for both systems

If the average time between retries is W, the average delay is T = 1 + R (1 + W)

2.1 EXPERIMENTAL RESULT

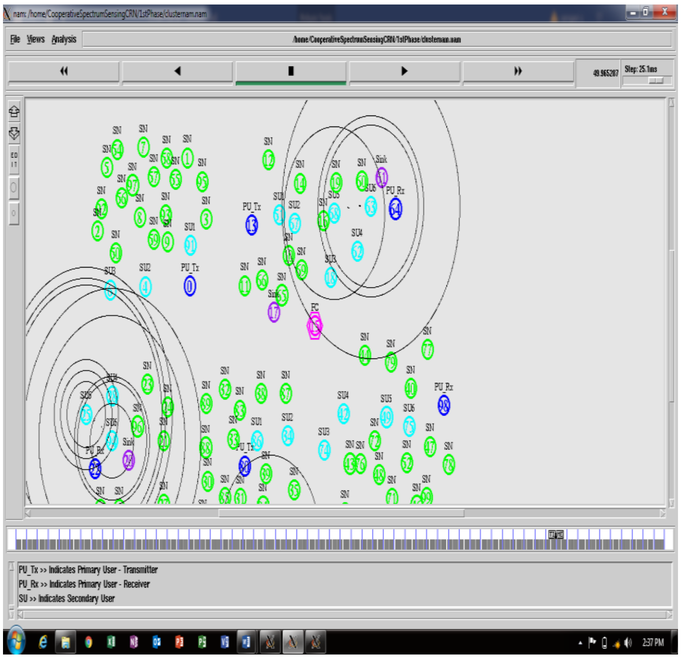

Figure -4: Starts transmission using R-Aloha

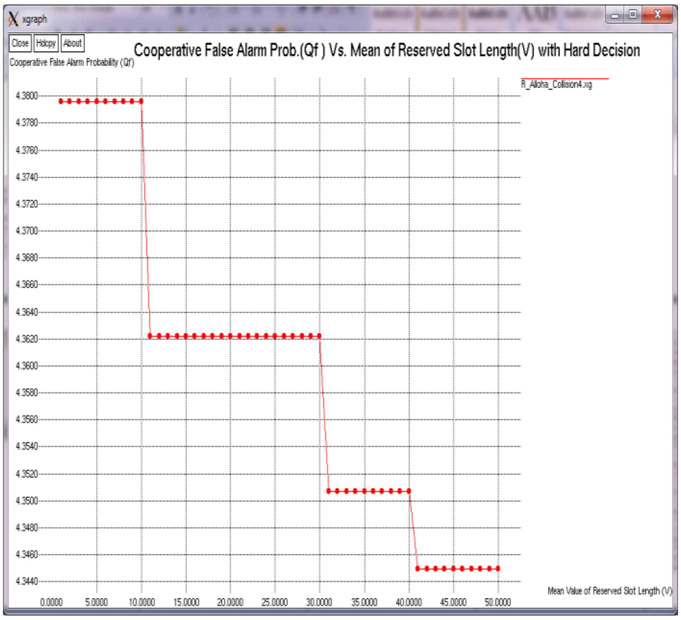

Figure -5: Cooperative False Alarm prob.(Qf) Vs Mean of Reserved Slot Length(V) with Hard Decision

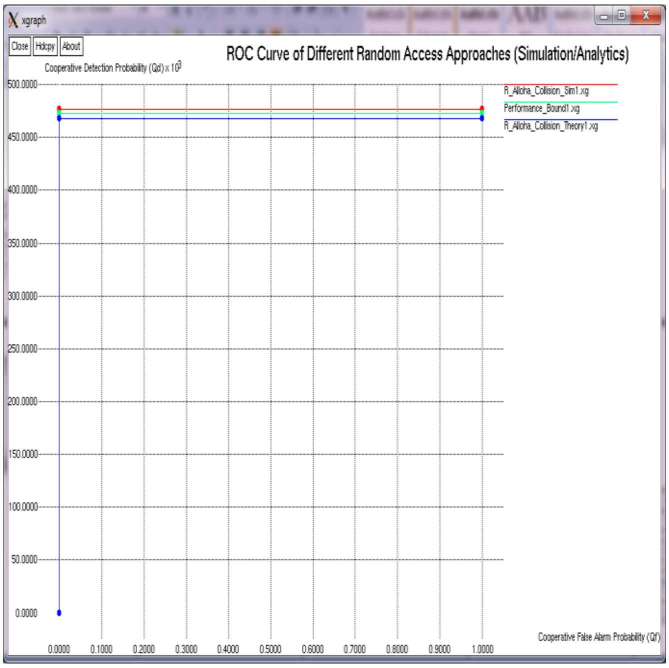

Figure -6: ROC Curve of Random Access Approaches

In Fig -5, cooperative false alarm probabilities Qf versus the numbers of reporting slots Nr is presented. Sensing performance of all protocols improve with increasing Nr and the cooperative performance varies. It is important to notice that, with limited number of reporting slots, good cooperative spectrum sensing performance can be obtained. For example, with R-Aloha with collision, we achieve approximately 2% cooperative false alarm probability when Nr = 10. From the above Fig -6, the performance of an ideal scenario in which all SUs' individual reports are collected perfectly at FC. cooperative false alarm probability (Qf) cooperative detection probability (Qd) performance bound R–Aloha (collision/theory) R–Aloha (collision/simulation). The simulation results match well with theoretical analyses.

3. CONCLUSIONS

A reporting channel design approach for cooperative spectrum sensing cognitive radio networks. This reporting channel design approach is based on random access protocols, including R-Aloha. This approach is utilized to reduce channel assignment complexity in any fixed assignment reporting channel design. Analytical evaluations and performance comparisons are performed considering R-Aloha (perfect/imperfect capture, collision) and hard versus soft fusion rules. With various R-Aloha design parameters and hard/soft fusion rules, it is shown that good cooperative spectrum sensing performance is achieved with limit number of reporting slots. It is also observed that, in general, R-Aloha performs better than previous approaches in providing effective reporting channels. Future work to increases the throughputs "original" frames generated at all nodes of a contention-based network (ALOHA, CSMA, etc.) per unit time.

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