Broadcasting in Dynamic Spectrum Access Networks

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ABSTRACT

Dynamic spectrum access network or cognitive radio network technology has been well studied more than a decade and numerous precious works have been proposed. Nonetheless, none of the existing works provides broadcasting mechanism for cognitive radio networks that operate on multichannel environments. Therefore, in this paper, we propose a mechanism that provides how to broadcast a message on multichannel cognitive ad hoc networks.

1. INTRODUCTION

A cognitive radio (CR) network normally includes primary users (PUs) that are licensed to use the specific channel and secondary users (SUs) or cognitive users which are typically not licensed to utilize the channel. The beauty of CR technology is allowing the secondary users to access the licensed channel without any harmful interference with primary users' operations [1]. In general, SUs detect the free or idle potions of a channel and access the channel. The availability of channels is determined by primary user activities, which change dynamically in frequency, space and time; therefore, the set of available channels for each SU might also change dynamically [4]. Therefore, at a given time, users may operate on different channel independently as shown in figure-1.

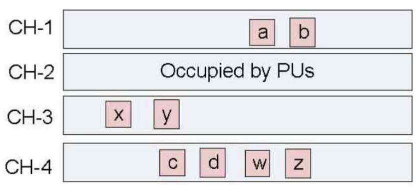

Figure.1. Users are operating on different channel independently.

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The problem is, in this situation, how to broadcast a message to all users that are currently dwelling on different channels. As we know, broadcasting is essential in many applications such as delivering multimedia messages, route discovery etc [2]. However, no existing protocol for cognitive radio network addresses this problem. This is the main inspiration for us in developing mechanism that enables broadcasting in multichannel cognitive radio ad hoc networks.

2. BROADCASTING IN MUTICHANNEL ENVIRONEMNT

A. System model

We assume the network type is ad hoc and no centralized coordinator. There are m available channels, $M = \{CH_1, CH_2, \ldots, CH_m\}$. We also assume that there are N numbers of nodes in the network and nodes are randomly distributed on CHs. The channel condition is ideal which means there are no hidden terminals and nodes (SUs) are within the transmission range of each other.

B. Messages Broadcasting

When a node receives a broadcast message from upper layer applications, it broadcasts immediately by embedding a counter (r) with the message. Any neighbor that receives the broadcast message checks the counter and if the counter is non-zero, it will retransmit the message after decreasing the counter by one. If a node receives the same message with different counter value, the counter value will be updated with lower value. The message will be retransmitted until its counter reaches to zero.

Since nodes are randomly distributed on different channels independently. If a node transmits the broadcast message on a channel, let say CH_i , only portion of the neighbor nodes, which dwelling on CH_i, will receive it. However, the message should be broadcast on every channel at least once in order to be delivered to all neighbors. Therefore, neighbor nodes participate on message retransmission as describe below.

When a node has to broadcast a message, it transmits on the current CH_i with counter, r, and some neighbor node which dwelling on CH_i will receive it. When a neighbor receives the broadcast message on CH_i, first, it chooses one of the CHs, $CH_j \in M$, randomly. Then, it switches to CH_j and retransmits the message after decreasing r by one. Neighbor nodes on CH_j perform the same way. They choose one of the CHs randomly and transmit the broadcast message and so on. A node can participate more than once for retransmission. For example, if a node receives the same message after transmitting, and if the counter is non-zero, it will participate again by retransmitting the message. Fig.2 shows the message broadcasting in multichannel environment.

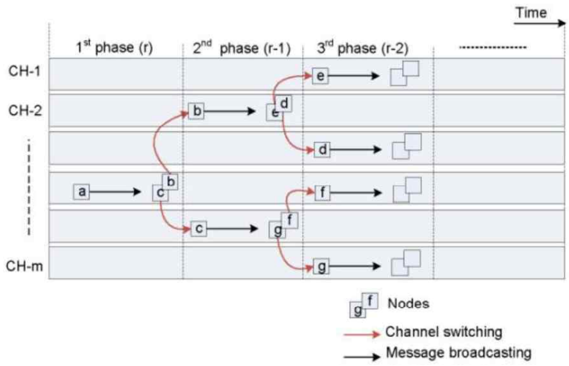

Figure.2 Massage broadcastings mechanism

C. Selecting the Counter Values

It is not straight forward to set the counter for the messages. Let say, a node transmits a message successfully on CH_i and all neighbor nodes on CH_i receive it. Then each node chooses one of the CHs randomly for transmission. Consider the worst case, suppose all nodes on CH_i choose the same channel ($CH_j \in M, i \neq j$) and switch to the CH_j for the transmission. Then, there will be at most one retransmission on CH_j in the second phase. Again, all nodes choose the same channel ($CH_k \in M$, $k \neq j, i$) and there also will be only one retransmission on CH_k in the third phase and so on. In order to transmit the message on every CH, the counter value should be m, since m is the total number of CHs.

Consider again for the best case as neighbor nodes choose different CHs for transmission. For example, node a chooses CH_k and b chooses CH_j, $where\ k \neq j$ as shown in Fig.2. Therefore, in the second phase, there will be n retransmissions on n different CHs, where n is the average number of neighbor nodes on CH_i and it can be estimated as $= \frac{N}{m}$. Again, if the nodes that receive the broadcast message choose totally different CHs, there will be $min(n^2, m)$ retransmission on $min(n^2, m)$ different CHs and so on. Thus, the messaged will be transmitted on every CH within $\log_n m$ phases. Then we can choose the counter value for broadcast message transmission as

$$\lceil \log_n m \rceil < r \leq m. \quad (1)$$

We ran a simulation to show the message dissemination rate based on the r value and the number of neighbor nodes on each CH. We assign the number of channels as $m=6$. Fig.3 (a) shows the portion of CHs that the nodes choose to transmit and (b) shows that the ratio of total users that currently dwelling on the selected CHs. In other words, it shows the portion of users that receive the emergency message.

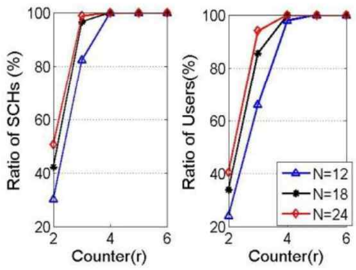

Figure.3. (a) Potion of SCHs that chosen for retransmission and (b) ratio of users that receive the message based on the r value.

3. CONCLUSION

We have presented a broadcasting mechanism for multichannel cognitive radio ad hoc networks. This work enables message broadcasting in multichannel environments without using a dedicated common channel [3]. In our future work, we will do detailed analysis for the proposed mechanism.

4. REFERENCE

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