# Token Based Control Packet Dissemination in Cognitive Radio Network

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**Abstract**

Cognitive radio network is opportunistic spectrum access network and it allows the secondary users to share the licensed bands with primary users or spectrum owners. The spectrum utilization depends on the information exchanging among users. The control information should be exchanged before any transmission is initiated. In this paper, we propose token based control packet dissemination mechanism. Necessary information is embedded in a token. The token is delivered to every secondary user and the user can get the information of all members in the network by capturing the token. This eliminates the need of control packets exchange procedure.

## I. Introduction

In cognitive radio network, control information exchanging among users is vital important. Channel selection and negotiation for data communication is done by control information exchanging among users. Generally, the information is embedded in control packets and these are exchanged via a channel which is available for every user. Most of MAC protocols for cognitive radio assume the existence of that channel and it is called Common Control Channel (CCC) [1][2]. All users use this CCC for control packets exchanging and it introduces control channel saturation problem when number of users in the network is increased [1]. It may also lead to single point failure if the CCC is broken in any case.

Moreover, whenever a user has data to send and wants to initiate communication with any other user, it needs to negotiate with intended receiver by exchanging necessary control information on CCC [3]. After negotiation has been done successfully on control channel, data communication can be accomplished on other data channels. It may cause unnecessary control packet overheads.

### A. Related Works

The authors of [4] proposed token based control channel protocol for cognitive radio network. In their proposal, every node is equipped with two radios and one is always tuning on the control channel to capture the token. After capturing the token, node can initiate data communication on other channels with second radio or data radio. Although, their proposal can significantly reduce control packet overheads, it is difficult to coexist with primary users since nodes dominate a channel as a CCC. If primary user appears and occupies the CCC for data transmission, it will cause single point failure.

Many MAC protocols for cognitive radio without using CCC have been proposed. Frequency hopping mechanism is one of the major approaches to overcome the control channel problems. Major challenging of this approach is constructing tight synchronization among users to follow the common hopping sequence. In [5] and [6] , authors tried to relieve synchronization by assigning independent and distributed hopping sequences to each node. However, a node needs a sufficient time to find intended receiver whenever it has data to send and it is called time to rendezvous (TTR).

In this paper, we proposed a token based control packet dissemination mechanism. Necessary information is delivered with token to every secondary user (SU) in the network.A SU can get a token from its predecessor [7]. After getting the token, SU can decide for channel selection and data communication according to the information from the token. The SU modifies the token by adding its own information and delivers to its successor. After token travels one round, with another words, one loop is completed, every SU gets the information of each user in the network.

## II. Control Packet Dissemination

### A. Token Format

Token is just a control packet which includes all necessary information. The token format is presented in Fig.1. The major information embedded in token is about available channel list and individual information of each SU.

- *Available channel* list describes the list of channels which are not currently used by any other SUs (nodes)[1]and primary users (PUs). Whenever primary users' activities are detected on one of these channels, it will be modified.

Individual information of all SUs is embedded in *information field*.

- *Home channel* is the channel for node to stay when it has no data to send. It is also used for receiving data and token.
- *Status field* indicates if the node is free or busy. If node has data to send, it sets its status field as busy and else it will be set as free.
- *Receiver's ID* field is used to describe the receiver of the current data communication.
- If a node has data to send, it estimates the necessary time for data communication and it will be described in *NAV field*. Other nodes can know that how long it will be busy by checking its respective NAV field.

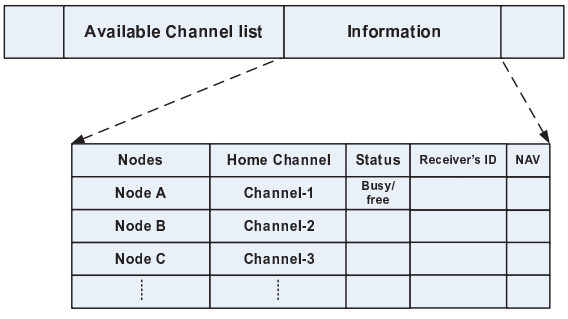


Fig. 1. Token packet format

### B. Information Dissemination

We assume that nodes are deployed on different channels. All nodes monitor the primary users' activities by sensing all the channels when they are not sending or receiving any data. A node generates a token and

[1]From now on, the terms, node is used for secondary user (SU).

integrates necessary information in it. Node defines the available channel list according to its sensing results and chooses one of them to use as a home channel. If node has no data to send, it shall stay on home channel and wait for receiving data and token. This information will be embedded in the token and node will deliver it to its successor. At the very initial sate of the network, node may need to switch one channel after another to find its successor.

When a node gets the token from its predecessor, it will choose one channel from the channel list to use as home channel and modify the channel list. If it has data to send to a node which has already embedded its information to the token, it will set the status filed as busy and describe necessary time for data communication at NAV field. The receiver ID will also be described in receiver's ID field. After delivering the token to its successor, node shall switch to the receiver's home channel and perform data communication. As soon as data communication is accomplished, it will switch back to its home channel and wait for the token or data. It cannot perform any data communication until it receives the token again.

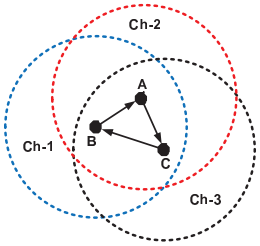


Fig. 2. Nodes are deployed on different channels and token is delivered to one node after another

Fig .2 shows as an example. In Fig.2, node B, A and C choose the channel 1, 2 and 3 as their home channels respectively. Node B generates the token and adds necessary information. The token is delivered to node A. Node A gets the token from its predecessor, node B. If A has data for B, it sets the status field as busy and defines NAV value. Node B is receiver of A's upcoming data communication and it will be described in receiver's ID field. After A delivers the toke to C, it switches to B's home channel, channel 1 and performs data communication. Node C knows that A and B are busy with data communication and it waits NAV value to communicate with these two nodes. After waiting NAV value, node C delivers the token to node B and node B gets the information about node A and C. Therefore, after one loop is complete, the necessary information for all nodes has been delivered.

### C. Token Back-up Procedure

Network stability is depending on the token and if a node malfunctions while it is holding the token, it might not be able to deliver the token to its successor. Therefore, the network will be broken in case of single node failure. A back-up procedure for token is considered to prevent this failure. It has already predefined that only one node has the right to generate the token to prevent the use of multiple token in the network [7]. This node estimates the necessary time for one loop of the token and calculates the timeout after delivering it. If the node does not receive its token within this timeout it will generate new token with new serial number. If it receives the old token after delivering the new one, the old one will be deleted.

### D. Major Challenge

The major challenge is multi-hop network scenario. In multi-hop network, token might not travel in logical ring topology. Therefore, it will be difficult to estimate the necessary time for one loop of the token. Moreover node may get the unnecessary information, for example, information of two or three hop neighbors and the available channel list might be vary according to the positions of the nodes.

## III. Discussion

The token packet travels among nodes with logical ring topology and the performance of the network depends on how often a node captures the token. According to the proposal, a node can capture the token only once par one round of token. With another words, node can perform only one data communication per one round of token. Necessary time for one round of token is depending on token and data packet size, transmission rate, processing delay and number of nodes, etc [4].

As an example, necessary times for one round of token according to the number of nodes are estimated by using Matlab. It is assumed that all nodes are transmission range of each other, which means all nodes are one hop neighbors. The token and data packet size are defined as 32 and 256 bytes respectively with transmission rate, 1 Mbps. Propagation delay is neglected since all nodes are one hop neighbors. First, we estimate the minimum time $T_{min}$ for one round of token. Token is delivered to one node after another without awaiting any NAV, which means no node has data to send. Second, we assume that all nodes have data to send and before delivering the token, nodes have to wait NAV value and it will be the maximum time $T_{max}$. Fig.3. shows the minimum and maximum time for one round of token according to the number of nodes.

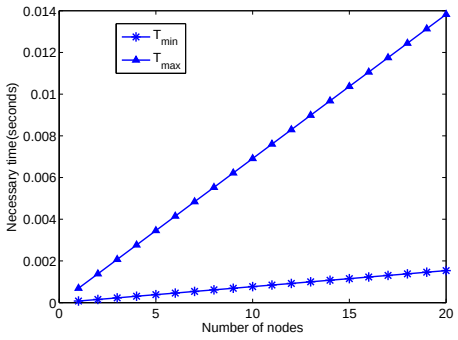


Fig. 3. Minimum and Maximun time for one round of token

## IV. Conclusion

We proposed token based control packet dissemination mechanism for cognitive radio network. According to the proposal, node can get all necessary information by capturing the token just one time. It can eliminate control packet exchange procedure. As a future work, we will consider for multi-hop network and the reliability of the token.

## V. Acknowledgements

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## References

[1] T. V. Krishna and A. Das, "A survey on MAC protocols in OSA networks," *Computer Networks*, vol. 53, no. 9, pp. 1377–1394, June 2009.

[2] J. Jia, Q. Zhang, and X. Shen, "HC-MAC: a hardware constrained cognitive MAC for efficient spectrum management," *IEEE Journal on Selected Areas in Communications 26 (1) (2008)*, pp. 106–117.

[3] J. So and N. H. Vaidya, "Multi-channel MAC for ad hoc networks: handling multi-channel hidden terminals using a single transceiver." Proceedings of the 5th ACM international symposium on Mobile ad hoc networking and computing (MOBIHOC), May 2004.

[4] C. Mazc and F. Buzluca, "A token based control channel protocol for cognitive radio networks." 24th International Symposium on Computer and Information Sciences, 2009. ISCIS, 2009, pp. 703–708.

[5] C. Cormio and K. R. Chowdhury, "Common control channel design for cognitive radio wireless ad hoc networks using adaptive frequency hopping," *Ad Hoc Network doi:10.1016/j.adhoc.2009.10.004*, 2009.

[6] L. DaSilva and I. Guerreiro, "Sequence-based rendezvous for dynamic spectrum access." IEEE DySpan, 2008, pp. 1 –7.

[7] M. Ergen, D. Lee, A. Puri, and P. Varaiya, "Wireless token ring protocol," *IEEE Transactions on Vehicular Technology*, pp. 1863–1881, 2004.