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Various Common Control Channel Assignment Schemes in CRNs: A Survey

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Abstract
Cognitive radio technology makes the unlicensed user to use the licensed band in opportunistic manner. By using licensed band in intelligently way for solving the problem of shortage of radio bands and optimal utilization of licensed band there is the requirement control channel (CCC). Control channels are used for exchanging control information about the new available channel for data transmission. When the primary user is detected or decline of QoS of currently being used channel by cognitive user then there is need of the common control channel to move on a new available channel. These channels are required to sense the free channel, to transmit the control information for channel synchronization between sender and receiver. It is challenging aspect of CRNs to provide the proper coverage of CCC that the problems of data packet loss or termination of connection can be reduced. In this paper various control channel assignment schemes are described.

Keywords
Common Control Channel (CCC), Media Access Control (MAC), Cognitive Radio Networks (CRNs), Primary Users (PUs).

1. INTRODUCTION
Cognitive radio allows to cognitive users (unlicensed users) to use the licensed band in opportunistic way for addressing the problem of radio spectrum scarcity and utilization of licensed radio bands. It implements the idea of spectrum sharing which permits the cognitive users to share free licensed band intelligently without disturbing primary user's communication in the course of cognitive radio phenomena. In cognitive

radio networks there must be channel synchronization between transmitter and receiver upon which channel data will be transmitted to avoid the dada packet loss.

A common control channel in CRNs does the various operations such as make the connection between transmitter and receiver, detection of other neighboring cognitive users [1], [2].We can define the control channel in a number of ways such as a dedicated frequency band [3] or a time slot in a time division multiple access systems. And a frequency hopping sequence can be a common control channel. In an intelligent cognitive radio, availability of the spectrum shows the both spatial and temporal variations due to primary user activity. That's why, there is no assurance that a specified frequency band will be accessible for transferring the control signals. We refer this is the problem of allotment of the common control channels for controlling purpose.

In the cognitive radio networks common control channels assignment is done in basic two ways static and dynamic channel allocation algorithms. In this paper we will discuss the various control channel assignment algorithms. There are numbers of challenges in the cognitive radio networks to implement the common control channel algorithms. Some of major issues are robustness to primary user activity, and security to protect the control channel from jamming attack [10]. It is the major issue of cognitive radio networks over which many researchers have been working and they have purposed various common control assignment methods which are described in remaining portion of this paper.

2. VARIOUS COMMON CONTROL CHANNEL ASSIGNMENT SCHEMES

The categorization of common control channel design is the easy way to know the control channel assignment schemes in CR networks which are shown below:

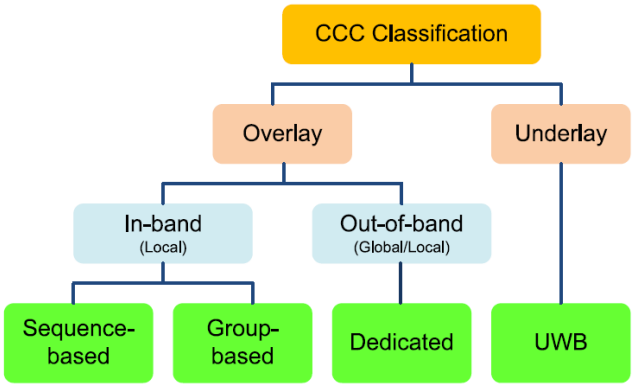

Fig. 1 Categorization of CCC design [7].

2.1 Overlay

In overlay based CCC scheme, the CCC is permanently or for the short term allocated of the spectrum not used by the primary user. When the allocated common control channels are affected by primary user's activity then cognitive radio users has to leave the control channel and create the connection over a new common control channel.

2.1.1 Out-of-Band

In this scheme, licensed or unlicensed band can be used like a common control channel to establish connection between sender and receiver, node co-ordination and synchronization. It helps to maintain the signaling overhead which will increase the performance of the cognitive radio media access protocol. Due to this, most of the cognitive radio network protocols use unlicensed common control channel. If we use the unlicensed dedicated common control channel it may be cause of interference with other communications like networks like Bluetooth which will degrade the performance of CR networks [11]. Also, transmit on single dedicated common control channel will be subject to security attacks like control channel jamming and Denial of service attacks (DoS) which can jeopardize the entire cognitive radio network with single point of failure [11]. Thus, designing common control channel through out-of-band technique has number of issues with such as security attacks, and interference with other technologies.

2.1.2 In-Band

In this common control design scheme, different intervals of time are used to transmit the data and control messages [7]. Currently, sequential and group based CCC design is proposed for node co-ordination and synchronization. In sequential based network setup, CR nodes have to first sense free channel list and scan each and every channel to find the common channel which takes long time.

2.2 Underlay

In underlay scheme, same radio band can be used by both primary user and cognitive radio users as a control channel. Control messages are transmitted in low power by using short pulses by using spread spectrum phenomena, which are transmitted over a high bandwidth. Because if transmit the control information over large bandwidth then it does not disrupt the communication of primary users. Even though, cognitive radio control messages and primary user data can be transmitted concurrently in a licensed spectrum.

3. MAIN COMMON CONTROL CHANNEL DESIGN SCHEMES

3.1 Dynamic CCC assignment using Swarm Intelligence

Swarm intelligence CCC scheme is purposed to dynamically find and handle control channel in CRNs that does not require explicit messaging and synchronization of clocks of both sender and receiver [4]. It is circulated, in-band and flexible design which handle the problem of primary user movement. Cognitive radio user chooses the best available free channel as CCC when primary user return back over that channel [10]. In addition, if numbers of control channel are less then it becomes easy to maintain. Moreover its benefits, but there is a problem in swarm intelligence common control channel scheme it requires high maintenance mainly in the presence of fast changeable primary user activity.

3.2 Cluster based CCC assignment

In this scheme the common control channel in cognitive radio networks are based on the time and the space-altering spectrum slots. A cluster-based common assignment scheme has been purposed that defines we can assign different control channel in different clusters in the cognitive radio networks [3]. We make the cluster by dividing the CRNs and the common control channel from the every cluster is chosen from the free channels. If the each cluster has large common free channels then it is beneficial such as (i) cognitive user can move to a new control channel if the current channel occupied by a primary user, (ii) it becomes cooperative sensing easier[3]. And to handle the situation when spectrum opportunities are highly heterogeneous a new algorithm designed which is known as Spectrum-Opportunity Clustering (SOC). This technique provides the solution to PU activity problem. The major disadvantage of this scheme is that, to handle signal exchange between the clusters, it needs high control and it is very difficult to synchronize the nodes in the clusters.

3.3 Hybrid CCC based Media Access Control Protocol

To improve the performance in the cognitive radio networks with respect to the synchronization among the nodes of the cognitive radio networks and to handle hidden terminal problem, a hybrid CCC based scheme has been purposed [11]. It provides solution to avoid collisions due to hidden terminal in multi channel network, reduce the time for set of connections of network, robust to primary user activity and provides protection against intruders. In hybrid common control based media access protocol provides solution for above issues of CRNs to improve the performance of cognitive radio-MAC protocol. It is combination of two spectrum band one is 902 MHz and other is 420 MHz which is a Television White –space spectrum band. Both bands are collectively used as a CCC for exchanging the control

signal between sender and receiver and for dynamic primary user activity [11].

3.4 Synchronized MAC Protocol

It has been purposed to keep away from the need of the dedicated control channel and also sort out the problem of hidden terminal in multi-channel. In this scheme we divide the total time in to fixed-time intervals [12]. And it is defined at the initial state which time slot will be used by the cognitive radio users for transmitting the control information. A dedicated common control channel has many disadvantage, one major drawback is the wastage of radio spectrum. Secondly, a control channel can be overburden when cognitive user increases [6]. Also, it becomes vulnerable to denial of service attack. The synchronized media access protocol is a slotted protocol. It collaborate the control channel contact together with standard vacant data channel [8]. A time slot can works like a channel, over which control and data can be transmitted. It also provides the solution to problem of saturation of common control channels and jamming. The main drawback of SYN-MAC scheme is when a primary user occupies the control slot then it blocks the control channel operation.

3.5 Sequence based Rendezvous Common Control Channel Design

In sequence based CCC assignment scheme control channel are allocated according to a sequence which can be a random sequence or a predefined channel hopping sequence. These sequences are constructed by taking the permutation of available control channel and choose best one from them. A cognitive radio user can use the different sequence for different neighboring user and it possible as well that neighboring users may be use different hopping sequence. Through sequence-based rendezvous scheme, it is possible to: (i) create an upper limit to the time to make contact , (ii) establish a priority order for channels in which rendezvous occurs; (iii) reduce the expected TTR as compared to random rendezvous. In this scheme the sequences are pre-defined in order to visit the available control channels that reduce the time required to make the contact with receiver in minimum time. Basically the purpose of this method by using the particular sequences which are constructed in such a manner to minimize expected time-to rendezvous to find the best available control channel. If the numbers of available channels are large, then it takes long time to find a adjoining node on a channel for control information exchange [7].But there is a problem in sequence based CCC assignment scheme that the order is predefined and is not adjustable to new control channel opportunities.

3.6 Adaptive Multiple Rendezvous Control Channel assignment

It solves the problem of multiple rendezvous CCC scheme which is static in nature. In this design the sequences can be chosen dynamically for handling the issue of the interference with primary user. It achieves the high performance by changing the hopping sequence when a primary is detected. If we compare it with sequence based rendezvous scheme it does not require strict synchronization. In simple terms it becomes easy to understand that, it exploits the frequency hopping spread spectrum technique in which transmitting channel changes over a particular time slice or according to a pseudo random sequence. Similarly, this scheme is implemented in same fashion to avoid the interference with other control channel and also provide primary users activity robustness. But there is a problem in this scheme is the average time to rendezvous may not be limited, cause of this time required to create common control channel link may be long. This happens when available channels are large [7].

4. CONCLUSION

To address the problem of common control channel assignment various designs has been purposed by various researcher and computer scientists. We have mentioned some of them. Each and every design algorithm has own pros and cons. But the thing is that according to particular cognitive radio networks we have to choose optimal common control channel assignment scheme that it becomes easy to cognitive radio user to sense the free available channel, exchange the control information related to channel tuning and reduce the interference problem with other licensed(primary user) and non-licensed(cognitive radio) users.

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