

A Survey on Sequence Creation in Cognitive Networks

^[1] Bhargavi G ^[2] Vidyasagar K N ^[3] Bharathi SH
^{[1][2][3]} Department of Electronics and Communication

REVA Institute of Technology and Management, VTU, Yelahanka, Bengaluru-560064

^[1]gopalacharbhargavi@gmail.com, ^[2]vidyasagarkn@revainstitution.org, ^[3]bharathish@revaistitution.org

Abstract: Intelligent (Cognitive) radio networks have a large communication spectrum. This is dynamic in nature. This leads to the necessity for main central channel where two nodes can talk to each other and conclude on the parameters for information exchange between each other, for this they need to meet on a pre-decided channel to communicate, this channel where the decisions are made should be decided by making use of the full available spectrum. In order to reduce collisions and also to make use of the entire available spectrum, a protocol must be devised. ETCH (An efficient channel hopping based MAC layer protocol) is proposed for communication establishment between cognitive radio networks. Two other protocols, Synchronous-ETCH and asynchronous-ETCH, assuming the presence of global clock synchronization and one without the assumption of existence of a global clock respectively.

Keywords—Cognitive, channel-hopping, wireless, rendezvous, dynamic spectrum access, global-clock synchronization

I. INTRODUCTION

Intelligent (Cognitive) radio networks have a large communication spectrum. This is dynamic in nature. This leads to the necessity for main central channel where two nodes can talk to each other and conclude on the parameters for information exchange between each other, for this they need to meet on a pre-decided channel to communicate, this channel where the decisions are made should be decided by making use of the full available spectrum. In order to reduce collisions and also to make use of all the available spectrum, a protocol must be devised. ETCH (An efficient channel hopping based MAC layer protocol) is proposed for communication establishment between cognitive radio networks. Two other protocols, Synchronous-ETCH and asynchronous-ETCH, assuming the presence of global clock synchronization and one without the assumption of existence of a global clock respectively.

COGNITIVE radio (CR) technology has enabled DSA (Dynamic Spectrum Access), which is an efficient solution to the spectrum scarcity issue. DSA allows secondary unlicensed users to access to the licensed spectrum initially allocated for the primary users, if the spectrum is not being used by the licensed primary users. In Cognitive Radio networks, communication rendezvous is the first step for a pair of CR nodes (i.e., secondary users) to establish the connection with each other. A pair of CR network nodes wishing to communicate should first agree on certain control information, such as data transfer

channel and data transfer rate, before they can start the data communication. The channel on which the nodes negotiate to reach the agreement is called the control channel. Communication rendezvous for two nodes is to establish a control channel between them. The CCC based approach, where a well-known channel is designated as the control channel for all nodes, suffers from the channel congestion problems and is vulnerable to jamming attack. Also, this approach cannot be applied in Cognitive networks because the control channel itself may be occupied by the licensed user and hence become unavailable to the unlicensed user. The CH (channel hopping) approach, by contrast, increases control channel capacity by utilizing a broader range of spectrum. With this approach, all idle nodes hop on a set of sequences of channels that are assigned for the purpose of control information exchange (rendezvous channels). When two nodes wishing to communicate hop to the same channel, that channel will be utilized as the control channel between the two nodes. The time that it takes for a pair of nodes to establish the control channel is called “time-to-rendezvous,” or TTR in short.

The Channel Hopping-based communication rendezvous protocol in Cognitive Radio networks should have the following features. First, every pair of nodes should have chance to meet each other periodically with a specific interval. Second, any pair of nodes should be able to meet each other on every possible rendezvous channel. Otherwise, a pair of nodes would not be able to communicate if the channels on which they rendezvous are occupied by the primary users, even though there are still available. Third, all the channels should have the same

probability to be utilized as control channels. Otherwise, those heavily used channels will have higher load, and thus more collisions. Furthermore, if a Channel Hopping sequence is heavily using a certain channel, nodes hopping on that particular sequence will lose contact with other nodes if the heavily used channel is occupied by the licensed or primary user. Besides the above mentioned three required features, a beneficial feature of CH-based protocols is the ability to exploit spectrum diversity, which is one of the most salient benefits offered by Cognitive Radio networks, in communication rendezvous. However, the existing CH-based solutions fall short on satisfying either the required or the beneficial features. Therefore, ETCH, a set of Channel Hopping-based communication rendezvous protocol that are suitable for Cognitive networks are proposed.

ETCH (Efficient channel hopping for communication rendezvous) contains two main protocols, SYNC-ETCH (Synchronous) & ASYN-ETCH (Asynchronous), which target two different scenarios depending on the availability of global clock synchronizations. SYNC-ETCH is a synchronous protocol that efficiently exploits the spectrum diversity in a way that every rendezvous channel can be utilized as a control channel in each hopping slot. In SYNC-ETCH, while achieving the same goal, two CH sequence construction algorithms are put forward: the 2-phase CH sequence construction & 1-phase sequence construction. These algorithms are complementary in design. The single-phase algorithm guarantees that all the rendezvous channel can have the same probability to be utilized as control channels. The drawback of the single-phase algorithm is that it requires the total amount of rendezvous channels to be not an even number (i.e. Odd number). The two-phase Channel Hopping sequence construction algorithm can be applied to Cognitive Radio networks with an arbitrary number of channels for rendezvous, but it tries to satisfy (but cannot guarantee) the third required feature mentioned earlier. ASYN-ETCH, on the other hand, does not assume the presence of a global clock. Compared to the existing solutions, ASYN-ETCH is able to take advantage of spectrum diversity by using all the channels available for rendezvous as control channels.

II OBJECTIVE

The objective of this paper is to provide a solution to the dynamic spectrum allocation problem which itself suffers from not being able to take full advantage of all the available spectrum at the same time.

III PROBLEM DESCRIPTION

Designing a communication rendezvous protocol that can take advantage of all spectrum that is available at

the same time is of high importance, because it lessens load on control channels, and thus further reduces chances of collisions. The problem of designing CH-based communication rendezvous protocols in Cognitive Radio networks by considering all relevant metrics and requirements is Formulated and provide an in-depth analysis about the principles of designing this type of protocol is provided

IV PROPOSED SYSTEM

Two protocols are proposed, Synchronous-ETCH, which is a synchronous protocol assuming CR nodes can synchronize their channel hopping processes, and Asynchronous-ETCH, which is an asynchronous protocol not relying on global clock synchronization. And an optimal synchronous protocol for communication rendezvous in Cognitive Radio networks is proposed. The optimality of this protocol lies in that its average time-to-rendezvous is shortest under the premise that all the rendezvous channels should be utilized in every hopping slot. This approach achieves good time-to-rendezvous while greatly increasing the capacity of the Cognitive Radio network at the communication setup stage. And a novel asynchronous protocol that enables two Cognitive Radio network nodes to rendezvous without the existence of global clock synchronization mechanisms is included. This protocol achieves better time-to-rendezvous and traffic throughput than the existing schemes.

V ALGORITHMS

Algorithm 1 Rendezvous Scheduling

Input: A set of $2N$ empty CH sequences, $U = \{S_0, \dots, S_{2N-1}\}$, each of which has $2N - 1$ slots
Output: $2N - 1$ different rendezvous schedules of U : $D_0, D_1, \dots, D_{2N-2}$

- 1 Initialize $D_0, D_1, \dots, D_{2N-2}$ to be empty;
- 2 **for** $sl \leftarrow 0$ to $2N - 2$
- 3 $T \leftarrow U \setminus \{S_{2N-1}\}$;
- 4 **for** $i \leftarrow 0$ to $N - 1$
- 5 $a \leftarrow$ the smallest subscript in T ;

Algorithm 2 Asynchronous CH sequences Construction

Input: N rendezvous channels: C_0, \dots, C_{N-1} (N is prime)
Output: $N - 1$ final CH sequences: S_0, \dots, S_{N-2}

- 1 **for** $i \leftarrow 0$ to $N - 2$
- 2 $A_i[0] = 0$;
- 3 **for** $j \leftarrow 1$ to $N - 1$
- 4 $A_i[j] = (A_i[0] + j(i + 1)) \bmod N$;
- 5 **for** $i \leftarrow 0$ to $N - 2$
- 6 **for** $j \leftarrow 0$ to $N - 1$
- 7 $subSeq_i[j] = C_{A_i[j]}$;

VI CONCLUSION

The aim was to design a communication rendezvous protocol that could take advantage of all the available spectrum at the same time and alleviate the load on the control channels and thus reduce the probability of collisions. ETCH, efficient channel hopping based communication rendezvous protocols for CR networks including Synchronous-ETCH (Both single and two phase) and Asynchronous-ETCH which assumes the presence of Global clock synchronization and one which doesn't make any assumptions respectively. Asynchronous-ETCH is able to make a pair of nodes rendezvous without being synchronized. ETCH approaches are successful in overcoming the drawbacks of the existing systems and also achieve the goal.

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