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Ant Colony System Based Control Channel Selection Scheme for Guaranteed Rendezvous in Cognitive Radio Ad-hoc Network

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***Abstract*—Achieving fast Time to Rendezvous (TTR) on a common coordination channel in an Ad-hoc network remains a contemporary issue in Cognitive Radio (CR) research. In this paper, we present a new channel hopping algorithm for the selection of a control channel in a heterogeneous, spatial, and time varying spectrum environment, with no pre-existing infrastructure such as an access point or a base station. We adopt the use of the bio-mimicry concept to develop a swarm intelligence based mechanism, which will guide nodes seeking to initiate communication, in selecting a common control channel within a bounded time. Closed form expressions for the upper bound of TTR and Expected TTR (ETTR) were derived for various network scenarios. We provide a theoretical analysis of the TTR and ETTR of our algorithm, and show that our algorithm provides a TTR within order *O (M)* as compared with Generated Orthogonal Sequence (GOS) and Channel Rendezvous Sequence (CRSEQ) of order $O(P^2)$. The algorithm further provides an improved performance in comparison to the Jump-Stay and Enhanced Jump-Stay Rendezvous Algorithms. We also provided simulation results to validate our claim of improved TTR.**

I. Introduction

Several spectrum surveys conducted across the globe reveal spectrum under-utilization as opposed to scarcity. The major cause of this pseudo scarcity of spectrum is the current paradigm of allocation technique known as the "Command and Control Technique (CCT)". CCT is exposed to limitation, as every radio technology must have a predefined and distinct spectrum for communication. CCT has failed to identify under-utilized bands. The trending solution is the use of unlicensed devices by secondary users (SU) in these underutilized bands opportunistically. The Federal Communication Commission (FCC) recently adopted this solution. The enabling technology for opportunistic spectrum usage is the Cognitive Radio (CR) technology.

CR, is defined as a radio capable of identifying its spectral environment and able to optimally adjust its transmission parameters to achieve an interference-free communication channel. In CR technology, Dynamic Spectrum Access (DSA) is made feasible. However, spectrum access by opportunistic user (SU) in CR must avoid co-tier and cross-tier interference, accurately detect spectrum and make decisions, and guarantee Quality of Service.

Several MAC protocol design schemes have been proposed to suit multichannel CR network for centralized architectures such as IEEE 802.22 and Dynamic Spectrum Access Protocol. However, few have been designed for distributed network also known as Ad-Hoc Network. Ad-Hoc network has zero form factor due to the absence of a central coordinator such as an access point or a base station, this has added to the complexity of developing a suitable MAC for CRAHN in addition to CRs spectrum heterogeneity, spatial and time varying spectrum availability [1]. The introduction of fixed or preselected common control channel (CCC) in MAC protocol design has remained the favourite solution in most works, however, this technique leaves more to be desired. The fixed CCC is exposed to control channel jamming, coverage limitations and it is not always robust to PU activities. To this day the most favoured solution is the implementation of a dynamic CCC (DCCC) for CRAHN [2] [3]. DCCC facilitates a variety of operations from transmitter-receiver handshake, neighbour discovery, channel access negotiation, topology change and routing information updates, to the cooperation among CR users. DCCC in some text is implemented as channel hopping technique [4].

In this work, we develop an Ant Colony System (ACS) based control channel selection scheme. By ACS we make reference to the mimicry of pheromone laying behaviour of real ants to find the shortest route between their nest and a food source. ACS technique is popular in literature as Ant Colony optimization. In this paper, we construct a channel hopping algorithm which will reinforce channels with best characteristics in the solution pool for selection as our control channel. We showed that by employing our algorithm we have improved on time to rendezvous. By rendezvous, we refer to the process of convergence which occurs when each SU node seeking to communicate with another must first converge on a common channel to establish a link.

The concept of node convergence on a common channel in CR networks has gained tremendous attention in recent years. Channel hopping (CH) is one such technique where communicating CR nodes hop across different available bands.

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