Dynamic Control Channel MAC for Cognitive Radio Ad-Hoc Network: Ant Colony System Implementation

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***Abstract*—In this paper, we demonstrated a new approach for the optimal selection of control channel in an Ad-Hoc Cognitive Radio (CR) environment using the ant colony system (ACS). Critical examination of the existing control channel selection schemes reveal breaches. Our algorithm reduces the complex objective of selecting control channel from an overtly large spectrum space, to a path finding problem in a graph. We use pheromone trails, proportional to channel reward, computed based on received signal strength on channel, channel availability and commonality of channel to guide the construction of a ranking scheme for control channel selection. Simulation results reveal ACS as a feasible solution for optimal dynamic control channel selection.**

I. Introduction

Dynamic Spectrum Access (DSA) is a critical function of Cognitive Radio and has formed an area of recent research interest. This interest ranges from developing robust broad band sensing techniques, to co-tier and cross-tier interference issues among Secondary Users (SUs) and Primary Users (PUs or licensed users), in addition to improving Quality of Service (QoS) with respect to channel access. With the aim of improving channel access, this paper presents a proposed efficient MAC protocol for enhancing access coordination in CR DSA based Ad Hoc networks using a Swarm intelligence based optimization technique. By swarm intelligence, reference is made to the mimicry of pheromone laying behaviour of real ants to find the shortest route between their nest and a food source, generally referred to as the Ant Colony System (ACS).

Generally, CR MAC should support interference control. This interference control involves collision avoidance for PUs, and collision avoidance among SUs [1], [2]. In this regard, several multichannel MAC protocol designs have been proposed for the coordination of SUs in CR centralized network architectures such as the 802.22 and Dynamic Spectrum Access Protocol (DSAP) [3]. However, in terms of Cognitive Radio Ad Hoc Network (CRAHN), certain issues such as zero form factor, spectrum heterogeneity, spatial and time varying nature of typical spectrum continue to limit the development of suitable MACs for such distributed multichannel networks [4].

With respect to known solutions, fixed or preselected common control channel (CCC) techniques for MAC protocol design have been proposed to address these challenges. However, this has opened up more challenges such as control channel security, robustness to PU activities, control channel coverage and control channel saturation [5]. Recently, the most patronized solution is the use of dynamic CCC (DCCC) for CRAHN [4], [6]. DCCC facilitates a variety of operations from transmitter-receiver handshake, neighbour discovery, channel access negotiation, topology change and routing information updates, to cooperation among CR users [4], [7]. It was noted that DCCC in some texts is typically linked to the concept of channel hopping CH [6]. But in this paper, the use of ACS as a channel ranking algorithm to rank channel sets detected by an SU is proposed. This ACS approach combined with the hopping sequence developed in [8] forms a selection scheme for the selection of control channel.

The use of ACS methods for coordination and organisation of network routing parameters have been observed in literature, an example is the AntNET. Also in [9] Dorigo and Gambardella employed ACS in solving the travel salesman problem. By drawing similarities, this technique was adopted for achieving the goal of coordination among CRAHN nodes. In this paper, CRAHN nodes were deployed randomly amidst PU presence in an overlay spectrum sharing modes. SUs detect spectrum holes, transmit on these spectrum holes and prepare a list of ranked spectrum hole information array (SHIA). SHIA is then employed in guiding nodes toward rendezvous on a CC. The long-time goal is to prepare SHIA which will guide nodes toward rendezvous. The concept of ACS was adopted, as pheromone trails are deposited on channels of quality paths.

Some related works have been shown in literature in respect of DCCC design scheme. Some notable CCC designs can be found in [4]. However, with respect to techniques which implement a DCCC selection scheme, and an ACS scheme, we take a look at some closely related designs. In [10] Chen *et al* addressed control channel assignment problem by employing the use of Hello beacon messages as pheromone trait to rank channels, this expedites the control channel selection process. In their work, the channel ranking was based on