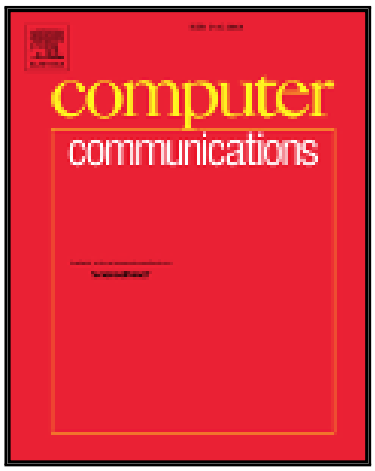

Energy Aware Cluster based Routing Protocol over Distributed Cognitive Radio Sensor Network

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Energy Aware Cluster based Routing Protocol over Distributed Cognitive Radio Sensor Network

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***Abstract*—Cognitive radio sensor network (CRSN) is a combination of wireless sensor network (WSN) and opportunistic spectrum access technology. It involves the issues related to energy and dynamic spectrum inherited by WSN and cognitive radio network (CRN) respectively. CRSN poses research challenges in designing an efficient topology control for communication in network. In this paper, we propose an Energy Aware Cluster based Routing Protocol (EACRP) for CRSN that jointly considers both the energy and dynamic spectrum challenges. Reported schemes for CRSN suffer from high frequency of re-clustering due to PU activities and are energy inefficient. The proposed scheme employs a self-organized distributed clustering to obtain less average node power by producing the optimal number of clusters. To mitigate the effect of PUs' activities, our proposed scheme forms clusters having more number of common channels and employs the concept of cooperative sensing in selecting the data channels for intra-cluster communication. To enhance inter-cluster connectivity, EACRP selects gateway nodes having more energy, closer to sink node and more number of common channels with neighboring nodes. Furthermore, a cluster-head (CH) rotation mechanism is employed that picks the CH based on nodes' residual energy values, available channels, neighbors and distance to the sink in order to have longer network lifetime. Upon detection of an event, the EACRP aims to route the event data through an energy efficient and stable path from source node to the sink node. On performance evaluation, we found that EACRP outperforms in terms of end-to-end packet delay, node energy consumption, packet delivery ratio and stability of selected gateway nodes than considered competitive approaches.**

***Index Terms*—Cognitive radio; wireless sensor networks; dynamic radio environment; event-driven communication; clustering; routing protocol; energy consumption.**

I. Introduction

With the trend of Internet of Things (IoT), number of connected devices in the networks are increasing gradually leaving the ISM (Industrial, Scientific, and Medical) bands overcrowded whereas the licensed bands often go underutilized. In order to overcome this spectrum scarcity challenge, a new paradigm has evolved which is known as cognitive radio [1]. In cognitive radio, the transceivers possess spectrum sensing capability and make use of licensed channel opportunistically while avoiding interference to licensed users or primary users (PUs) and the transceivers with such capability are known as secondary users (SUs).

Cognitive radio sensor network (CRSN), a wireless sensor network (WSN) with sensor nodes having enabled cognitive radio capabilities is a promising solution in the era of IoT. In CRSN, sensor nodes can detect the unoccupied channels in the licensed bands by spectrum sensing, determine communication channel by spectrum decision and change their operating channels by spectrum hand-off when PUs arrive on the communication channel. With these capabilities, nodes collaborate with their neighboring nodes in order to deliver event data from source node to the sink node in multi-hop fashion in such a dynamic spectrum environment.

Despite addressing the dynamic spectrum challenges by CR functionalities, CRSN also imposes energy and hardware limitation issues adapted from WSN. The existing solutions for WSNs do not consider CR functionalities and thus do not address dynamic spectrum challenges. On the other hand, the solutions proposed for CRN do not take into account energy and hardware challenges. Hence, we need to find new methods to address both the energy and CR challenges. As CRSN has been receiving interest from the research community lately and hence there is much more work to be done in this area. Recent existing works focus on clustering, connectivity and path formation[2][3].

Clustering is one of the most prominent research fields in sensor networks which means combining the nodes in groups to manage the system topology in order to attain increased system stability. There are several reported works on clustering for WSNs and wireless ad-hoc networks [4], [5], [6], [7], [8]. In the existing schemes, clustering divides the whole network in self-organized clusters where every cluster is controlled by one of the cluster member, namely, cluster head (CH). The CH acts as a central entity of a cluster and aggregates the data collected from the other member nodes of the cluster before forwarding it to the next node in the path to sink. The clustering schemes for WSN elects CH based on nodes' residual energy [9]. These clustering schemes cannot be used for CRSN as in these networks two nodes can be in same cluster only when they have atleast one common available channel. However, this alone does not ensure the stability as re-clustering occurs due to the dynamic radio environment.

In this paper, we propose an energy efficient and distributed event-driven cluster based routing approach that aims to make CRSN more robust to PU activities. To adapt the features of CRSN, a routing protocol for CRSN is utilized that routes the event samples from the event detecting nodes to the sink