

Chapter 12

A Backbone Formation Protocol Using Minimum Spanning Tree in Cognitive Radio Networks

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ABSTRACT

Numerous research articles exist for backbone formation in wireless networks; however, they cannot be applied straightforward in cognitive radio networks (CRN) due to its peculiar characteristics. Since virtual backbone has many advantages such as reduced routing overhead, dynamic maintenance, and fast convergence speed, the authors propose a backbone formation protocol in CRN. In this chapter, a backbone formation protocol is proposed using the concept of minimum spanning tree. The protocol is based on non-iterative approach, thus leading towards limited message overhead. The proposed algorithm first forms the minimum spanning tree, and second, the nodes having more than one neighbor are connected together to form the backbone.

INTRODUCTION

Recently, due to advent of new application areas and tremendous popularity of social networks, the number of network devices has proliferated creating huge demand for wireless spectrum. Thus, the spectrum scarcity has become problem of central interest to industry as well as research community. Moreover, the unlicensed spectrum band, ISM band (2.4GHz range) have been exhausted due to escalated use by the ad hoc networks, e.g. Wi-fi hotspots, wireless mesh networks, and mobile ad hoc networks in various applications, such as environmental monitoring, battlefields surveillance, and commercial usage. Furthermore, the ISM band is affected by the interference created by household appliances and electro-

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mechanical infrastructure. On the other hand, it has also been observed that licensed (reserved) spectrum such as TV white spaces are not being used effectively. As per Federal Communications Commission (FCC) estimate, the licensed spectrum utilization varies between 15% to 85% (Akyildiz, Lee, Vuran, & Mohanty, 2006). Note that the utilization of licensed spectrum is low also due to current spectrum allocation policies (Li, Liu, Li, Liu, & Li, 2013). The huge demand for the spectrum and inefficient spectrum usage has motivated FCC to approve the opportunistic use of licensed spectrum such as TV white spaces (Nekovee, 2009). Consequently, a new network paradigm has emerged, called cognitive radio network.

The CRN is a promising technique to boost spectrum utilization in wireless networks. The spectrum holder node is called primary user (PU). However, PU may not constantly occupy the entire owned (licensed) spectrum. Thus, the nodes that do not own any spectrum get opportunity to use the part of spectrum (channels) unused by PU. Such opportunistic user node is called secondary user (SU). However, SU node must vacate the channel on detecting PU appearance in that channel. In fact, CRN is the network of SU nodes only. The concept of CRN was first introduced by J. Mitola (Mitola & Maguire, 1999) in 1999 to utilize the radio spectrum in opportunistic manner. In article (Akyildiz et al., 2006), two architecture of CRN is discussed: 1) cognitive radio ad hoc network (CRAHN), and 2) infrastructure based CRN. In infrastructure based CRN, a base station exists which controls SU communication and manages the spectrums. Further, CRAHN has two types of network: 1) cognitive radio sensor network, and 2) cognitive radio mobile ad hoc networks. In CRAHN, SU node senses the available channel without interfering to PUs; however, it switches to another channel in case PU appears. Thus, CRAHN is quite challenging environment as compared to mobile ad hoc networks.

RELATED WORKS

The virtual backbone is a powerful technique for routing in wireless networks. Therefore, numerous research articles have been published towards backbone construction; however, we mentioned here only the techniques that are adaptable in cognitive radio networks (Alzoubi, Wan, & Frieder, 2003; Basagni, 1999; Wu & Li, 1999). These techniques are based on connected dominating set formation, which do not address the node mobility. There are some other research articles (Bandyopadhyay & Coyle, 2003; Youssef, Youssef, & Younis, 2009). These techniques are cluster based backbone formation which can't be applied straightforward due to their limitations related to spectrum management and mobility. Also, in mobile ad hoc networks (MANETs), many research articles (Akyildiz, Lee, & Chowdhury, 2009; Amis, Prakash, Vuong, & Huynh, 2000; Baker & Ephremides, 1981; Bao & Garcia-Luna-Aceves, 2003; Chatterjee, Das, & Turgut, 2002; Chiang, Wu, Liu, & Gerla, 1997; Kawadia & Kumar, 2003; Lin & Gerla, 1997; Srivastava & Ghosh, 2002; Yeh, Hsieh, & Li, 2012) exist for backbone formation. However, these techniques do not address challenges such as spectrum management, and link failure due to PU appearance. Some protocols (Celik & Kamal, 2016; Jiang, Cui, & Chen, 2009; Shirke, Patil, Kulkarni, & Markande, 2014; Yilmaz & Tugcu, 2015) have been proposed for clustering in CRN, which focus on energy consumption based parameters such as energy consumption minimization, throughput maximization, reducing communication overhead, and delay. In CRN, a limited number of articles (Dai, Wu, & Xin, 2013; Kumar & Singh, 2018a, 2018b; Wen-Jiang, Di, Wei-Heng, & Nian-Long, 2011) have been proposed towards backbone formation. These techniques follow the iterative approach to form clusters first, and next, cluster heads are connected to construct backbone. Since, these techniques are based on iterative approach; they suffer high message overhead. We can also design non-iterative algorithm

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