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Multi-sector multi-range control for self-organizing wireless networks

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ABSTRACT

In this paper, we propose a distributed multi-sector multi-range (MSMR) control algorithm for supporting self-organizing wireless networks. The algorithm enables us to reduce the unnecessary coverage with fine-tuned range control and also to increase the network-wide capacity with enhanced spatial reusability. The proposed algorithm discovers neighboring nodes within the maximum transmission range at every node, divides its transmission area into multiple non-overlapping angular sectors of a given degree, chooses the home sector for each neighboring node according to its relative position, and constructs a spanning subgraph per sector by determining appropriate transmission range to maintain connectivity. Since the range control influences on network connectivity directly, we prove in the first place that the proposed algorithm preserves both network-wide and local connectivity as far as both connectivity exist in the network that uses the maximum transmission range. In order to investigate the performance of the proposed algorithm, we implemented it in the ns-2 simulator, and performed an extensive set of simulation study in comparison with other transmission range control schemes. The simulation results indicate that the proposed scheme is superior to other schemes with respect to the network-wide throughput and its normalized value per energy in various simulation configurations. In specific, the algorithm achieves *minimally one order and maximally two orders* of magnitude improvement in those performance evaluations. The improvement becomes more salient as the number of nodes increases and is immune to traffic type, network size, node distribution, or node density.

1. Introduction

In self-organizing wireless networks, which are usually found in sensor networks (Dressler, 2008; Akyildiz et al., 2002), community wireless networks (Microsoft Research), or Femto-cell networks (Claussen, 2007; Ho and Claussen, 2007), the participating nodes spontaneously devise impromptu network, flock together in the network, decide optimal transmission range, adjust connectivity according to link status, device failure and performance degradation, respond to node mobility, and satisfy application requirement. Since self-organization can enable communication networks to work autonomously based on local information, which excludes humanitarian intervention (i.e. it does not require any global coordination) and network-wide knowledge to achieve network-wide goals, such as prolonging network-life time, improving network capacity, mitigating interferences, and building resilience to hostile wireless environment, self-organizing networks have been drawing much attention in wireless community. Recently mobile operators have started to exploit self-organizing techniques and framework in the deployment of Femto cell-based residential services in order to extend their service coverage indoors, which are alternative ways to deliver the benefits of *Fixed Mobile Convergence* (Claussen, 2007; Ho and Claussen, 2007).

Even though there are several important attributes necessary to realize self-organizing networks (which will be discussed in Section 2), the transmission range control has higher priority than any other component owing to the following reasons: (i) it decides the direct connectivity to neighboring nodes and thus the node degree (the number of neighboring nodes) at each node (Alzoubi et al., 2003); (ii) it determines the target area from which local status information, such as frame delivery ratio, SINR or network congestion degree, is collected; (iii) it saves the energy consumption since it calculates optimal transmission power necessary to maintain connectivity to neighboring nodes (Jones et al., 2001), and consequently influences on the network lifetime; (iv) it increases the network capacity (Gupta and Kumar, 2000) by allowing simultaneous transmissions with non-intrusive transmission range; (v) it mitigates MAC-level contention by reducing the number of contending nodes in the proximity of transmitting node (Narayanaswamy et al., 2002). These reasons actually motivate us to focus on transmission range control.

In this paper, we present a distributed self-organizing transmission-range control algorithm, `multi-sector multi-range (MSMR)`, in order to self-organize and maintain optimal connectivity at each node. The `MSMR` discovers neighboring nodes for every node u, based on a collection of announcements within the maximum transmission range, and divides the transmission area of the node u

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