Chapter 2.8
Energy-Efficient Scalable Self-Organizing Routing for Wireless Mobile Networks

Melody Moh
San Jose State University, USA

Xuquan Lin
Echelon Corporation, USA

Subhankar Dhar
San Jose State University, USA

ABSTRACT

The instant deployment without relying on an existing infrastructure makes the mobile ad hoc networks (MANET) an attractive choice for many dynamic situations. An efficient MANET protocol may be applied to other important emerging wireless technologies such as wireless mesh and sensor networks. This chapter proposes a hierarchical routing scheme that is scalable, energy-efficient, and self-organizing. This chapter presents a new algorithm: the Dynamic Leader Set Generation (DLSG). This algorithm dynamically selects leader nodes based on traffic demand, locality, and residual energy level, and deselects them based on residual energy. Therefore, energy consumption and traffic load are distributed throughout the network. The network also reorganizes itself surrounding the dynamically selected leader nodes. Time, space, and message complexities are formally analyzed; implementation issues are also addressed. Incorporating the IEEE 802.11 medium access control mechanism including the power saving mode, performance evaluation is carried out by simulating DLSG and four existing hierarchical routing algorithms. It shows that DLSG successfully extends network lifetime by 20-50% while achieves a comparable level of network performance.

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INTRODUCTION

A mobile ad hoc network (MANET) is a temporary network formed dynamically by wireless mobile hosts without a pre-setup infrastructure. Unlike in a traditional infrastructure-based wireless network where each host routes packets through an access point or a mobile router, in MANET each host routes the packets and communicates directly with its neighbors. MANET may be viewed as a general network model that is applicable to other emerging wireless network technologies such as wireless mesh networks and sensor networks.

Since MANET offers much flexibility than traditional wireless networks, its demand and potential applications have rapidly increased. It is excellent for highly dynamic situations such as military operations, disaster recovery including its healthcare needs, and ad-hoc teleconferencing. In the near future it may also be applied to vehicular ad-hoc networks and countless forms of social gatherings.

Growing along with the demand is the research challenges in designing efficient MANET protocols. There are several major factors to be considered. Firstly, as its demand is rapidly rising, so is the number of mobile hosts shared a MANET. Secondly, since MANET is designed to work without an existing network infrastructure, it needs to adapt dynamically to the changing network topology. Yet, the third critical factor to be considered is energy; mobile hosts usually rely on limited battery power. Thus, it is vital that a MANET protocol be scalable, energy-efficient, dynamic, and self-organization/self-healing (Banerjee and Misra, 2002; Chen and Gerla, 2002; Pei et al., 1999; Royer, 2004; Sivakumar et al., 1999).

To address the *scalability* issue, this paper focuses on hierarchical routing, as hierarchy makes a routing protocol scalable. We investigate hierarchical routing based on the idea of dominating sets (DS). Minimum connected dominating sets (MCDS) and its variations have been used for hierarchical routing in MANET such that nodes in a DS form a virtual backbone and are responsible for routing packets through the entire network. Both DS and MCDS and their use in MANET routing will be described further in the Related Studies section.

To address the *energy efficiency* issue, we study energy awareness of these dominating-set based routing algorithms. Most existing works have mainly focused on heuristics for finding a small dominating set (since MCDS is NP-complete) and evaluating the size of dominating sets and the message costs. We incorporate IEEE 802.11 medium access control (MAC) schemes, with power saving mode (PSM) (IEEE, 1999), into these routing algorithms and assess them in terms network lifetime, throughput, and delay.

To address the *dynamic* issue, we propose a new algorithm, *Dynamic Leader Set Generation (DLSG),* which dynamically selects leader nodes based on traffic demand, locality, and residual energy level. As a result, the network lifetime is greatly increased.

Finally, to address the *self-organization, self-healing* issue, the new algorithm DLSG not only dynamically selects new leaders; it further follows a threshold mechanism, such that a leader node may de-select itself when its energy level falls below some threshold. The network therefore re-organizes itself around new leaders. Furthermore, a simple self-healing mechanism is also suggested (in Section 3.2.4).

The rest of the paper is organized as follows. Section 2 gives a broad overview of related work on energy-efficient routing. In section 3, we present our proposed algorithm DSLG. Performance evaluation of our algorithm is discussed in section 4. We discuss conclusions on section 5.