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A scalable routing scheme with group motion support in large and dense wireless ad hoc networks

Floriano De Rango [a,*], Mario Gerla [b], Salvatore Marano [a]

[a] D.E.I.S. Department, University of Calabria, 87036 Calabria, Italy
[b] Computer Science Department, UCLA, Los Angeles, CA 90095, United States

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Abstract

This paper presents a scalable routing protocol for very large and dense ad hoc networks. The scalability of ad hoc networks is becoming an important issue due to the increasing number of applications in a distributed environment, the great number of mobile nodes involved into communication and wide speed range in which the mobile nodes can move. It is important to offer scalability in terms of network size, traffic load and mobility speed. The proposed protocol, called Geo-LANMAR, inherits the same advantage of LANMAR protocol in terms of group motion support and traffic load scalability and it reflects also the behaviour of geo-routing protocols such as GPSR. Geo-LANMAR is based on the idea of Terminodes routing for the forwarding scheme: long-distance geo-forwarding and low-distance table-driven routing. Its updating scheme, instead, is similar to the Hazy Sighted Link State Routing (HSLS) through a spatial and time update rate differentiation: frequent update rate for short distance and lower update rate for long distance. Performance evaluation of Geo-LANMAR has been lead out and a comparison in terms of throughput, average end-to-end delay and control overhead has been conducted against other well-known protocols such as LANMAR, GPSR and AODV. Geo-LANMAR results scalable in terms of traffic load, mobility speed, number of nodes and number of groups.

Keywords: Geo-LANMAR; Geo-routing; Scalable; HSLS; GPSR; Terminodes routing

1. Introduction

As mobile networking continues to experience increasing popularity, the need to connect large numbers of wireless devices will become more prevalent. Network scalability is a critical issue in routing protocols for ad hoc networks. It is important to guarantee good scalability properties to open systems or dynamic networks when the number of nodes, the traffic load and mobility rate increase.

Many scalable approaches have been proposed [1–13], which are based on either table-driven forwarding or geo-forwarding techniques. More specifically, in order to reduce the control overhead and to find a path from source toward destination, geo-routing inspired schemes such as GPSR [2] have been proposed. Geo-routing

* Corresponding author.
E-mail addresses: derango@deis.unical.it (F. De Rango), gerla@cs.ucla.edu (M. Gerla), marano@deis.unical.it (S. Marano).

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uses the positions of routers and a packet's destination to make packet forwarding decisions [1]. By keeping state only about the local topology, geo-routing scales better in per-router state than shortest-path. Independently, good scalability results were also recently reported by the Landmark Routing Protocol (LANMAR) [12], using a totally different approach exploiting group mobility and hierarchical routing. A novel approach based on the long-distance geo-forwarding and the local link-state routing has been recently proposed and it is called Terminodes Routing [10].

This paper, according with recent advances in the ad hoc networking routing and scalability issues, presents a novel routing scheme called Geo-LANMAR, that is based on the basic idea of LANMAR and Terminodes Routing [10,11]. The proposed protocol makes use of the group motion support of the LANMAR routing through the clustering algorithm until *k-hop* to elect the cluster-head (landmark node), and it applies also the geo-routing scheme for long distances. Differently from Terminodes Routing, a novel concept of Location Group Area (LGA), that represents the area associated to the group is introduced [17,18] and an optimised link-state routing called Hazy Sighted Link-State (HSLS) Routing [13] is applied to maintain the locations of LGAs. The routing adopted in the local scope has been the OLSR protocol [14]. A basic advantage in comparison with Terminodes Routing is the capability to make geo-forwarding without the need of the Location Server. The Geo-LANMAR, in fact, as well as explained in the next section, through the link-state routing HSLS can get the position info of the destination LGA where the destination node resides through the only knowledge of the destination address.

The proposed protocol presents good scalability properties in respect of the number of nodes, groups, traffic load and mobility rate. It is more scalable than LANMAR routing. An asymptotic analysis is realised according with the work in [19,20] and some rules that bind the project parameters with the number of groups and group size are obtained. Simulation campaigns are assessed and the Geo-LANMAR protocol has been compared with GPSR, AODV [21] and LANMAR.

The paper is organised as follows: Section 2 presents a brief overview of other scalable routing strategies proposed in literature; the basic idea of Geo-LANMAR protocol is introduced in Section 3; an asymptotic analysis of Geo-LANMAR is realised in Section 4; Section 5 offers the performance evaluation and simulation results; finally conclusions are summarised in Section 6.

2. Related work

Due to the lack of commercial applications for the ad hoc network technology, it is impossible to predict what the "killer app" will be and the scale in which it will be used. Because of these reasons, the networking technology developed today must be scalable to accommodate a potentially larger number of users in the near future. Due to the potential applications of ad hoc networks to traffic scenarios, the technology must also be scalable to networks of rapidly moving nodes. In this context, a lot of protocols have been proposed in literature in order to address the scalability issue in terms of traffic load, network size (number of nodes in the network) and speed motion. In the following a set of scalable protocols are presented. Some of them use the link-state routing, opportunely adapted to become more scalable in the ad hoc scenario, other protocols make use of the geo-coordinates to reduce the routing table size, other ones apply hybrid routing strategies and further routing schemes adopt the hierarchical nodes organization rather than flat structures. Among these protocols we recall:

- OLSR is an optimisation of a pure link state protocol for mobile ad hoc networks [14]. It reduces the size of control packets: rather than overall links, it declares only a subset of links with its neighbours who are its *multipoint relay selectors*. Then it minimises flooding of this control traffic by using only the selected nodes, called multipoint relays (MPRs), to diffuse its messages in the network. Only the multipoint relays of a node retransmit its broadcast messages. This technique significantly reduces the number of retransmissions in a flooding or broadcast procedure.
- FSR introduces the notion of multi-level fisheye scope to reduce routing update overhead in large networks [15]. Nodes exchange link state entries with their neighbours with a frequency that depends on the distance to the destination. FSR is a LS-like protocol but it, when the network size increases, reduces the update message frequency because it is time and bandwidth consuming. The reduction of routing update overhead