Analyzing the Effect of Node Density on the Performance of the LAR-1P Algorithm

Hussein Al-Bahadili, Petra University, Jordan
Ali Maqousi, Petra University, Jordan
Reyadh S. Naoum, Middle East University, Jordan

ABSTRACT

The location-aided routing scheme 1 (LAR-1) and probabilistic algorithms are combined together into a new algorithm for route discovery in mobile ad hoc networks (MANETs) called LAR-1P. Simulation results demonstrated that the LAR-1P algorithm reduces the number of retransmissions as compared to LAR-1 without sacrificing network reachability. Furthermore, on a sub-network (zone) scale, the algorithm provides an excellent performance in high-density zones, while in low-density zones; it preserves the performance of LAR-1. This paper provides a detailed analysis of the performance of the LAR-1P algorithm through various simulations, where the actual numerical values for the number of retransmissions and reachability in high- and low-density zones were computed to demonstrate the effectiveness and significance of the algorithm and how it provides better performance than LAR-1 in high-density zones. In addition, the effect of the total number of nodes on the average network performance is also investigated.

Keywords: Flooding Optimization Algorithms, Location-Aided Routing Scheme 1 (LAR-1), Mobile Ad Hoc Networks (LAR-1P), Probabilistic Algorithm, Pure Flooding, Route Discovery

INTRODUCTION

A mobile ad hoc network (MANET) is a self-configuring infrastructureless network of low-battery powered mobile devices (nodes) connected by wireless links. Each node in a MANET is free to move independently in any direction, and will therefore change its links to other nodes on the network frequently (Al-Bahadili, 2012). Each node usually acts as a router forwarding traffic unrelated to its own use. One of the main challenges in building a MANET is equipping each node to continuously maintain the information required for efficient and reliable traffic routing (Land, 2008).

The data packets in MANETs are forwarded to other mobile nodes in the network through reliable and efficient dynamic routing protocols, which are part of the network layer software (Land, 2008). These protocols are responsible for deciding which output route a packet should be transmitted on. Dynamic routing protocols

DOI: 10.4018/jitwe.2012040102
(e.g., the dynamic source routing (DSR), ad hoc on-demand distance vector (AODV), zone routing protocol (ZRP)) consist of two main phases; these are: route discovery and route maintenance.

Route discovery is used when a source node desires to send a packet to some destination and does not already have a valid route to that destination; in which the source initiates a route discovery process to locate the destination. It broadcasts a route request (RREQ) packet to its neighbours, which then forward the request to their neighbours, and so on until the expiration of the packet. During the forwarding process, the intermediate nodes record the address of the node from which first copy of the broadcast packet is received in their routing tables. Once the RREQ reaches the destination, it responds with a route reply (RREP) packet back to the source through the route from which it first received the RREQ. Otherwise, if the RREQ packet expired before reaching its destination, then the node, at which it expires, sends a route error (RERR) packet back to the source to initiate a new route discovery process.

Pure flooding is the earliest, simplest, and most reliable mechanism proposed in the literature for route discovery in MANETs (Bani-Yassein & Ould-Khaoua, 2007; Bani-Yassein et al., 2006). Although it is simple and reliable, pure flooding is costly where it costs $N$ transmissions in a network of $N$ reachable nodes. In addition, pure flooding results in serious redundancy, contention, and collisions in the network; such a scenario has often been referred to as the broadcast storm problem (BSP) (Tseng et al., 2002).

A variety of flooding optimization algorithms have been developed to alleviate the effects of BSP during route discovery in MANETs aiming at reducing the number of redundant retransmissions without significantly affecting network reachability. Examples of such algorithms include the LAR-1 (Ko & Vaidya, 2000; Belong & Camp, 2004) and probabilistic (Al-Bahadili, 2010a; Haas et al., 2006) algorithms.

The performance of the LAR-1 algorithm significantly suffers from the large number of redundant retransmissions in high-density networks (zones) (Ko & Vaidya, 2000). In contrast, the probabilistic algorithm usually provides excellent performance in high-density zones, by appreciably reducing the number of retransmissions with almost no effect on network reachability. Of course, that is subject to proper retransmission probability ($p_t$) adjustment (Bani-Yassein & Ould-Khaoua, 2007; Bani-Yassein et al., 2006; Al-Bahadili, & Kaabneh, 2010).

A new algorithm combining the LAR-1 and probabilistic algorithms called LAR-1P was proposed in Al-Bahadili (2012). In this algorithm, when receiving a RREQ, an intermediate node within the request zone rebroadcasts RREQs with dynamically adjusted $p_t$. In a low-density zone; a node is assigned a high $p_t$ (close to unity), so that the algorithm behaves like LAR-1, while a reasonable $p_t$ is assigned to the node in a high-density zone, which means the algorithm behaves like the probabilistic algorithm. In that way LAR-1P combines the best of the two algorithms.

The simulation results in Al-Bahadili (2012) demonstrated that for a uniform random node distribution in specific network area and for a certain simulation setup, LAR-1P reduces the number of retransmissions with slight reduction in reachability. Furthermore, LAR-1P can provide better average performance if the route discovery process is performed more often in high-density zones than in low-density zones.

This paper analyzes in details the performance of the LAR-1P algorithm through a number of simulations using the network simulator (MANSim) (Al-Bahadili, 2010b). First, the effect of node density (total number of nodes on the network divided by the network area) on the performance of LAR-1P is investigated and compared against other algorithm, such as pure flooding, dynamic probabilistic, and LAR-1. Second, for a certain node density ($4 \times 10^4 \text{ node/m}^2$), the effects of zones nodes densities on the performance of LAR-1 and LAR-1P algorithms are investigated.
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