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Impact of Varying Node Velocity and HELLO Interval Duration on Position-Based Stable Routing in Mobile Ad Hoc Networks

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Abstract

Wireless networks have evolved considerably in the recent years thanks to the advancement of technology that has made devices more portable, smarter, and more energy efficient. In particular, Mobile Ad hoc Networks (MANETs), that are formed without any centralized infrastructure, have received a lot of attention as they can be used in many real life applications. Yet, compared to static wireless networks, less academic research has been done on MANETs, especially when all the nodes are in continuous movement. In particular, we consider MANETs that broadcast HELLO messages at regular time intervals in order to maintain dynamic neighborhood information. The range of velocities of the nodes and the HELLO message interval duration can significantly affect the performance of routing protocols in MANETs. In this work, we study the effect of varying these two main characteristics on the performance of MANETs in terms of delivered packets and packets delivery ratio that reflect routing paths stability. We present a comprehensive experimental analysis of the effect of such variations on three position-based stability-oriented routing protocols, namely, Greedy-based Backup Routing (GBR), LEARN-based Backup Routing (LBR), and GBR combined with a Conservative Neighborhood Range (GBR-CNR).

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1. Introduction

In the recent years, the use of smart devices capable of wirelessly communicating and sharing information has become part of the daily routine practiced by millions of people. To build such wireless networks, a lot of attention has been given to Mobile Ad hoc Networks (MANETs) where mobile nodes assure the communication within the network without the presence of a centralized infrastructure. One of the limiting factors of Mobile Ad hoc Networks (MANETs) using traditional message exchange is the inability to transmit and receive at the same time slot or frequency simultaneously. Therefore, since every node is responsible of managing its own communication and discovering its surrounding nodes, to achieve maximum throughput, appropriate algorithms should be established

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in order to reduce network traffic caused by control messages used to maintain link information and to establish connections. In particular, we consider MANETs that broadcast HELLO control messages at regular time intervals in order to maintain neighborhood information including node positions to allow for position-based routing. It has been shown [1,2] that the duration of the HELLO message interval significantly affects the performance of MANETs. In addition, when constructing a communication path between a source and a destination, the source node starts by broadcasting a Route-Request (RREQ) control message in order to ask the nodes that are in its communication range to respond with relevant information such as their positions, velocities, orientations/directions of movement, etc. The same process is then repeated with next-hop nodes to complete a path to the destination node. In addition to the effect of the HELLO message interval, mobility is an important aspect that should be taken into consideration when when designing routing protocols for MANETs as their impact on the performance should be evaluated [3,4].

Meghanathan [5] proposed a beaconless node velocity based stable path (NVSP) routing protocol for MANETs where they conjecture that the stability of NVSP routes could be further improved if the route discovery procedure is modified to use only links involving slow moving nodes. Yassein *et al.* [6] proposed to study the effects of network density and network mobility scheme based on Velocity Of Node (VON). However, VON uses a fixed threshold regardless of network status. Oliveira *et al.* [7] considered MANETs under the Random Waypoint mobility model. They investigated the relationship between the transmission frequency of the HELLO messages and the sensing timer expiration value with the network nodes mobility. They showed that he transmission frequency of the HELLO messages and the expiration value of the sensing timer truly depends on nodes mobility.

In this paper, we extend previous work [1] to study the combined effect of varying node velocity as well as HELLO interval duration on the network performance. The effect of such variations are studied using the position-based stability-oriented routing algorithms: Greedy-based Backup Routing (GBR) [8]; LEARN-based Backup Routing (LBR) [9]; and GBR combined with a Conservative Neighborhood Range (GBR-CNR) [10]. The rest of this paper is organized as follows. We provide brief details of related stable routing protocols in Section 2. Section 3 discusses the impact of the interval duration between periodically transmitted HELLO messages and varying maximum node velocity. The performance evaluation and results are given in Section 4. Finally, concluding remarks are made in Section 5.

2. Routing Environments and Models in MANETs

When modeling a MANET, routing is a critical component that should be properly managed since its performance is very sensitive to the network topology, nodes velocities and available bandwidth. Indeed, routing protocols should find paths efficiently while maintaining tolerable network performance in terms of packets delivery rate and similar metrics. Thus, we should first define a network model of a MANET and introduce appropriate routing algorithms.

2.1. Network Model of MANETs

A MANET can be modeled using a graph $G = (V, E)$ where V represents the set of nodes/vertices and E represents the set of links/edges. Each edge represents a link between two nodes currently within the transmission range that, for this work, we assume to be the same for all nodes [11] (the resulting graph is termed a Unit Disk Graph (UDG)). We denote the set of neighbors of a node v_i by $N(v_i)$. A path of length n between a source node S and a destination node D is denoted by $(S = v_0, v_1, v_2, \ldots, v_n = D)$ where $v_i \in V$ and $v_i \in N(v_{i-1})$. In multi-path routing, the path which is used as the first choice when transmitting from the source to the destination is called the primary path. In MANETs, it is generally assumed that nodes have unique identifiers and their geographic position can be tracked using a Global Positioning System (GPS) and/or Location Service (LS) [8]. We assume the nodes are arranged in a two dimensional $2D$ Euclidean space such that G is a geometric graph. We also assume that all nodes broadcast their positions to their neighbors using HELLO messages at regular intervals (also called beacon messages).

2.2. Position-based Routing

There are two main categories of routing on ad hoc networks, namely, topology-based routing and position-based routing. Topology-based routing protocols use link information available from the network to determine a route between the nodes [12,13] whereas position-based routing protocols use the nodes positions to determine routes [14]. In