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Smart Partial Flooding Routing Algorithms for 3D Ad Hoc Networks

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Abstract

Mobile ad-hoc networks (MANETs) become an essential part of the current wireless communication infrastructure, thus efficient routing protocols takes an important consideration of the current research. In Geographic-Based routing algorithms, nodes use the location information about nodes to take routing choices. Current geographical routing algorithms usually address the routing environment in 2D space. However, in real life, nodes could be located in 3D space. In this paper, we propose two 3D geographical routing algorithms that uses the advantage of the high delivery rate of the flooding algorithms and the low overhead of the progress-based routing algorithms. The first algorithm (Progress-SGFlooding) uses geographical routing to progress as much as possible to the destination, if its not possible, a partial flooding is used over a sub-graph extracted locally. The second algorithm (Progress-SGFlooding-Progress) used geographical routing to progress to the destination, if the progress is not possible, a partial flooding is used over a sub-graph for one step only and then the algorithm goes back to the geographical routing. We evaluate our algorithm and compare it with current routing algorithms. The simulation results show a significant improvement in delivery rate up to 100% compared to 70% and a huge reduction in overall traffic around 60%.

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Keywords: MANET; geomatric graph; ad hoc network; geographical-based routing.

1. Introduction

Wireless networks became an essential part of todays communication infrastructure. Such networks are usually modeled by mobile ad-hoc networks (MANETs). MANETs consist of a set of wireless mobile hosts that can communicate with no physical backbone infrastructure. Communication is based on radio propagation; two nodes can communicate directly if they are within the transmission range of each other[14]. To communicate with nodes outside the transmission range, multihop routing is used employing the nodes in between to forward packets. Since mobile ad-hoc networks may change their topology often and because of the resource constraints, routing in such networks is difficult. In the last couple of decades, several routing algorithms have been suggested to address the multihop routing problem; each is based on different assumptions and theories. These routing algorithms can be classified to two main

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basic types [15]: flooding-based routing [1,10] and progress-based routing [4,8,9]. In flooding-based routing, when a packet reaches a node, it forwards that packet to all its neighbors. This can usually find the shortest path between two nodes. However, it can be difficult for these routing protocols to work with large MANETs because of the huge traffic and overhead that can be created around the network. Geocasting based Location-Aided Routing (LAR) [10] is an example for this strategy.

In progress-based routing, the node having a packet forwards it to one of its neighbors according to some heuristic, Greedy [2] and Compass [11] routing algorithms are considered as progress-based routing algorithms [11,3].

Current routing algorithms usually address the routing environment in 2D space. However, in real life, nodes could be located in 3D space. In this paper, we propose two 3D geographical routing algorithms that uses the advantage of the high delivery rate of the flooding-based algorithms and the low overhead of the progress-based routing algorithms. The first algorithm (Progress-SGFlooding) uses geographical routing to progress as much as possible to the destination, if progress is not possible, a partial flooding is used over a sub-graph extracted locally. The second algorithm (Progress-SGFlooding-Progress) used geographical routing to progress to the destination, if the progress is not possible, a partial flooding is used over a sub-graph for one step only and then the algorithm goes back to the geographical routing.

The rest of the paper is organized as follows. In Section 2, we define the network model and survey previous work. In Section 3 we give a detailed description of the new routing algorithms. We present simulation results to prove the much enhanced performance of the proposed methods in comparison with existing techniques in Section 4. Section 5 summarizes our results.

2. Model and background

Usually MANET is modeled using a geometric graph, which is a graph embedded in a d-dimensional Euclidean space such that its vertices are points with coordinates and its edges are straight-line segments. The set of n wireless hosts is represented as a point set S in R^3, each point has a geometric location. All network hosts have the same communication range of r, which represented as a sphere volume of radius r. We define the $dist(u, v)$ as the Euclidean distance between the points u and v, $dist(u, v) = \sqrt{(u_x - v_x)^2 + (u_y - v_y)^2 + (u_z - v_z)^2}$. Two nodes are connected by an edge (undirected) if the Euclidean distance between them is at most r. The resulting graph is called a unit ball graph (UBG). The routing task is to find a path from the source node s to the destination node d. Local information is used to determine how to route the packet. We are interested in the following performance measures for routing algorithms: **Delivery rate:** the percentage of times that the algorithm succeeds in delivering its packet. **Path dilation:** the average ratio of the length of the path returned by the algorithm to the length of the shortest path in the UBG. **Overhead:** the average ratio of number of nodes participate in the routing process to the number of hops in the shortest path.

2.1. Routing Algorithms

In geographical-based routing protocols, we assume that a node knows its geometric location which can be acquired using GPS, the location of all neighbors using periodical exchanged hello message, and the location of the packet destination which can be learned using location services [6,13]. Routing protocols for MANETs depends on several issues, for example, the network topology, the information available during routing process at each node, and the characteristics of backbone network that could be used to define a heuristic to find a route efficiently. In this subsection we review some representative geographical routing algorithms that are closely related to the new proposed algorithms: **(1) 3DGreedy routing:** a node forwards the packet to its neighbor that minimizes the remaining distance to the destination. This is repeated until the destination node is reached. In many cases this routing algorithm may fill to deliver the packet to the destination when a local minimum node is reached (a node that has no neighbor closer to the destination). **(2) 3DCompass routing:** a node forwards the packet to its neighbor that minimizes the angle formed between the current node, next node, and destination. This is repeated until the destination node is reached. As in 3DGreedy routing, this algorithm may suffer from the local minimum when the nodes enter an infinite loop of sending to each other without making progress to the destination. **(3) 3DLAR [10]:** This algorithm also uses the position information of nodes to restrict the flooding process during the route discovery phase. The node holding the packet forwards it to all neighbors that are located in a cube as follows: (1) With the available information of the destination