A Greedy Location-Aided Routing Protocol for Mobile Ad Hoc Networks

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Abstract: - In this paper, we propose an efficient greedy location-aided routing (GLAR) scheme to improve the efficiency of location-aided routing (LAR) scheme for mobile ad hoc networks (MANETs). In this scheme, we first decide a baseline, which is the line between the source node and the destination node, for route discovery. The request packet is broadcasted in a request zone based on the baseline to determine the next broadcasting node. The neighboring node with the shortest distance to the baseline is chosen as the next broadcasting node. Thus, we can find a better routing path than LAR scheme to reduce the network overhead. Simulation results show that the proposed GLAR scheme outperforms LAR scheme.

Key-Words: - Expected zone, Global positioning system, Location-aided routing, Mobile ad hoc networks, Request zone.

1 Introduction
A mobile ad hoc network (MANET) is a dynamically reconfigurable wireless network that does not have a fixed infrastructure [6]. Many routing protocols have been proposed for MANETs to achieve efficient routing [2, 3, 4, 5, 7, 8, 9].

In general, the routing protocols of MANETs can be divided into two classes: table-driven proactive routing protocols and on-demand reactive routing protocols. In table-driven routing protocols, such as OLSR [2] and DSDV [8], every node continuously maintains the complete routing information of a network. When a node needs to forward a packet, a route is readily available. In on-demand routing protocols, such as DSR [3] and AODV [9], mobile nodes maintain path information for destinations only when they need to contact the source node or relay packets. The source node will issue a search packet and transmit the packet using the flooding technique to look for the destination node.

Recently, many routing protocols in MANETs use the global positioning system (GPS) [1] for assistance, such as zone-based hierarchical link state (ZHLS) [7], location-aided routing (LAR) [4], and full location-aware routing protocol (GRID) [5]. The coordinates of each node can be known by using GPS. Furthermore, the route discovery process can be completed by mathematically calculation to determine the routing path. Thus, the routing protocols can reduce the overhead amount effectively.

In this paper, we propose a routing scheme that uses the global positioning system (GPS) to improve the efficiency of location-aided routing. In this scheme, we first decide a baseline, which is the line between the source node and the destination node, for route discovery. The request packet is broadcasted in a request zone based on the baseline to determine the next broadcasting node. The neighboring node with the shortest distance to the baseline is chosen as the next broadcasting node.

The rest of this paper is organized as follows. Section 2 presents the preliminaries of this work. The proposed scheme is developed in Section 3. Experimental results are given in Section 4. Finally, Section 5 presents conclusions.

2 Preliminaries
In this section, we first introduce the expected zone and the request zone. Then we present the location-aided routing (LAR) protocol [4].
2.1 Expected Zone and Request Zone
We assume that a source node $S$ needs to find a route to destination node $D$. We also assume that node $S$ knows the position of node $D$ at location $P$ at time $t_0$ and that the current time is $t_1$. If node $S$ knows the velocity of node $D$, then the extent that node $D$ moves about can be anticipated by the formula $v(t_1 - t_0)$.

We also assume that node $S$ needs to determine a route to node $D$. $S$ utilizes broadcasts to deliver packets. The request zone should embrace the expected zone. When $S$ is not embraced in an expected zone of $D$, $S$ needs to deliver packets to $D$ by way of a path that involves many other nodes. Furthermore, these nodes are not in the expected zone, either. Therefore, the request zone must embrace additional ranges.

2.2 Location-Aided Routing (LAR)
In this section, we introduce the location-aided routing (LAR) protocol [4]. As shown in Fig. 1, LAR uses a request zone that is a rectangle. Suppose that the source node $S(x_s, y_s)$ knows the location of node $D(x_d, y_d)$ at time $t_0$. At time $t_1$, the source node $S$ initiates a new route in order to discover the destination.

Furthermore, we assume that if $S$ knows the velocity of $D$, node $S$ can point to an expected zone at time $t_1$. Then the radius of the expected zone is $r = v(t_1 - t_0)$ and the center is located at $D(x_d, y_d)$.

The LAR scheme determines a request zone. This request zone contains the source node $S$ and the expected zone. The sides of the rectangle are parallel to the $x$-axis and the $y$-axis. The source node $S$ depends on the expected zone to determine the four corners of the request zone. Node $S$ includes their coordinates with the route request message transmitted when the route discovery is initiated. When a node receives a route request, it discards the request if the node is not within the request zone. For instance, if node $I$ receives the route request from another node, node $I$ forwards the request to its neighbors because it is located in the request zone. However, when node $J$ receives the route request, node $J$ discards the request, as node $J$ is not within the request zone.

3 Greedy Location-Aided Routing (GLAR)
In this section, we propose a greedy location-aided routing (GLAR) scheme to improve the efficiency of location-aided routing (LAR) scheme. In the proposed scheme, the request packet can be broadcasted in a request zone based on the baseline that is the line between the source node and the destination node. The baseline is used to determine the next broadcasting node. The next broadcasting node will be chosen as close as possible to the line of sight. An example of a baseline is shown in Fig. 2.

We assume that the source node is $S(x_s, y_s)$ and that the destination node is $D(x_d, y_d)$. Based on the LAR scheme, we assume that we already know the coordinates of $D$. Then we can determine the baseline by using the following equation.

$$ (x_d - x_s)(y - y_s) - (y_d - y_s)(x - x_s) = 0 $$  \hspace{1cm} (1)
The route discovery process is initiated whenever a source node needs to communicate with another node for which it has no routing information in its table. Every node maintains two separate counters: a node sequence number and a broadcast ID. The source node initiates route discovery by broadcasting a route request (RREQ) packet to its neighbors. The RREQ packet format is shown in Fig. 3.

![Fig. 3. RREQ packet format.](image)

The route discovery process is described as below. First, the source node broadcasts the RREQ packet. After the neighboring nodes receive the RREQ packet, the neighboring nodes will decide whether they are in the request zone and reply with a route request revise (RREQ_R) packet to the transmitting node. The RREQ_R packet format is shown in Fig. 5. The transmitting node will compare the $VDIST$ of all neighboring nodes. Then the transmitting node will decide the next broadcasting node to be the node with the shortest distance to the baseline. Furthermore, the $DIST$ of each candidate node for the next broadcasting node is larger than that of the current broadcasting node. This guarantees that the node chosen as the next broadcasting node will always be far from the source node. In the following, we introduce two parameters of the GLAR, $DIST$ and $VDIST$. An example of $DIST$ and $VDIST$ is shown in Fig. 6.

$DIST_A$: The distance between the source node and node $A$.

$VDIST_A$: The distance from node $A$ to the baseline.

As shown in Fig. 6, when node $A$ receives the RREQ from source node $S$, node $A$ will calculate the distance between the source node and itself, denoted as $DIST_A$. Moreover, node $A$ will calculate the distance from the node to the baseline, denoted as $VDIST_A$. We assume that the baseline is $ax + by + c = 0$. Then $VDIST_A$ can be obtained from the following equation:

$$VDIST_A = \frac{ax_A + by_A + c}{\sqrt{a^2 + b^2}}$$

![Fig. 4. RREP packet format.](image)
The steps of route discovery are described below.

Step 1: First, source node S broadcasts a RREQ packet to its neighboring nodes. The source node S will compare DIST and VDIST of all neighboring nodes. Then the neighboring node which is the nearest to the baseline will be chosen as the next broadcasting node.

Step 2: We assume that node N has been chosen to be the next broadcasting node. Node N keeps broadcasting the RREQ packet to its neighboring nodes. Suppose that the neighboring nodes are node A and node B. Node N will compare the DIST of node N (DIST_N) with the DIST of node A (DIST_A) and with the DIST of node B (DIST_B), respectively. We assume that the DIST of node A and node B are greater than that of node N. In addition, if the VDIST of node A is smaller than that of node B, the neighboring node A will perform the succeeding actions. This ensures that the RREQ packet will proceed further away from source node S. If the above-mentioned conditions are all met, repeat Step 2. When the destination node D receives a RREQ packet, destination node D sends a RREP packet to the source node S along the decided path.

Let us consider an example, as shown in Fig. 7(a). Node S broadcasts a RREQ packet to its neighboring nodes, and it is observed that the neighboring nodes of S, such as nodes A, B, C, and E, are all in the request zone. When the four nodes receive the RREQ packet, the four nodes will reply with a RREQ_R packet to the transmitting node.

The transmitting node will compare the VDIST of all neighboring nodes. Suppose that node A is found to be the nearest node to the baseline SD. Then node A will continue broadcasting the RREQ packet. As shown in Fig. 7(b), to meet the requirements of route discovery, node A will keep broadcasting the RREQ packet and find the node that is nearest to the baseline.

4 Simulation Results
In this section, we will compare the performance of the proposed GLAR with that of LAR using the results from our simulation experiments. We first made some assumptions on the parameters of the
system architecture in the simulations. The simulation modeled a network in a 600 m \times 600 m area with 30 mobile nodes. The speed of each mobile node was assumed to be 20-80 km/hr. The radio transmission range was assumed to be 100 m. The random waypoint mobility model [3] was employed in our simulations. Each node randomly selects a position and moves toward that location with a speed between the minimum and the maximum speed. Once it arrives at that position, it stays for a predefined time. After that time, it re-selects a new position and repeats the process. The simulations have been run for 600 s.

Fig. 8 shows the control overhead of GLAR and LAR with different speeds. The control overhead of GLAR is lower than that of LAR. The reason is the same as that given above. In general, both the control overhead of GLAR and LAR increased when the speed increased. The reason is that when the speed of the mobile nodes was faster, there was more of a chance that the related routes would break. In addition, the number of rebroadcasts would increase. Therefore, the control overhead was higher.

Fig. 9 shows the route lifetime of GLAR and LAR with different speeds. Both the lifetime of GLAR and LAR decreased when the speed increased. The reason is that when the speed of the mobile nodes was faster, there was more of a chance that the related routes would break.

Fig. 10 shows the packet delivery rate of GLAR and LAR with different speeds. The packet delivery rate of LAR was larger than that of GLAR when the number of mobile nodes increased. The reason is the same as that given above. In general, both the packet delivery rate of GLAR and LAR decreased when the speed increased. The reason is that when the speed of the mobile nodes was faster, there was more of a chance that the related routes would break.

5 Conclusions
In this paper, we proposed an efficient greedy location-aided routing (GLAR) scheme that improves the efficiency of location-aided routing (LAR) scheme. In this scheme, we first decide a baseline, which is the line between the source node and the destination node, for route discovery. The request packet is broadcasted in a request zone based on the baseline to determine the next broadcasting node. The neighboring node with the shortest distance to the baseline is chosen as the next broadcasting node.

We compare the performance of GLAR and LAR. In our simulations, we conducted the routing overhead, the route lifetime, and the packet delivery rate with different mobility speeds. Simulation results show that the proposed GLAR outperforms LAR. GLAR can reduce the number of route discovery packets and increase the average route lifetime.
References: