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A New Packet Forwarding Algorithm in Geographical Location Based Mobile Ad Hoc Routing Protocol

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Abstract: - The packet forwarding algorithms in the existing geographical location based Ad Hoc routing protocols consider only one factor that influences the performance of the routing protocols. Therefore, the performance of these protocols is not good enough. In this paper, we present a new packet forwarding algorithm—Universal Weighted Greedy (UWG) algorithm, which takes two factors into account. The two factors are the distance of next hop and destination, and the angel that the next hop deviates the beeline between source and destination node. The algorithm has good universality and can improve the routing performance because the two considered factors are critical factors for routing. In the following paper, first the design principle of geographical location based Ad Hoc routing protocol is introduced and the packet forwarding algorithms in some typical routing protocols are reviewed. Then the principle of the UWG algorithm is elaborated. We simulate the UWG algorithm and determine the parameter scope when the performance of the routing protocol is optimal.

Key-Words: - Mobile Ad Hoc network, geographical location based routing protocol, packet forwarding algorithm, universal weighted greedy (UWG) algorithm, LAR, DREAM.

1. Introduction

A "mobile Ad Hoc network" is an autonomous system of mobile nodes connected by wireless links. The nodes are free to move randomly and organize themselves arbitrarily; thus, the topology of the network may change rapidly and unpredictably [1]. These mobile nodes do not have special user management and configuration; every node is not only a host but also a router that can forward packet to its neighbor nodes. Ad Hoc network is also called multi-hop network and self-organized network.

Compared with other infrastructure-based wired networks, Ad Hoc network has the following distinct characteristics [2]: 1.Dynamic topologies; 2.Bandwidth-constrained and variable capacity links; 3.Energy-constrained operation; 4.Limited physical security. Due to these characteristics, the routing for Ad Hoc network is very important and the traditional routing protocol used in Internet cannot satisfy the requirement. Therefore, many routing protocols have been suggested for mobile Ad Hoc network. In general, the design principle for Ad Hoc routing can be divided into two categories. One is based on network topologies, the typical routing protocols include DSR [3], AODV [4] and OLSR [5] etc.

Another design principle is based on the nodes' geographical information. This kind of protocols are called geographical location based routing protocols. In these protocols, a mobile node gets its geographical information in the form of 3D coordinate by location system such as GPS [6].

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When a source node wants to send packets to a destination node, the source node must first get the destination node's geographical information, then make routing choice and forward the packets based on the geographical information of destination and neighbor nodes. The geographical location based routing protocol consists of two important parts. One is the location management system that provides the storage and query function of geographical information. The other is the packet forwarding algorithm, which chooses the next hop for a packet after having the geographical information of destination and neighbor nodes. In this paper, we mainly discuss the packet forwarding algorithm in the geographical location based routing protocol.

2. Related Work and Our Research Focus

DREAM [7] and GPSR [8] are the most typical geographical location based Ad Hoc routing protocols. They adopt different packet forwarding strategies.

In DREAM protocol, the destination node has an expected zone. The expected zone and the source node form a scope of direction angle [$\vartheta - \alpha$, $\vartheta + \alpha$]. When a source node wants to send a packet to destination node, it must choose a node in the scope of direction angle as the next hop node. And so are other forwarding nodes. The packet forwarding algorithms in DREAM can be called restricted directional flooding algorithm.

The packet forwarding algorithm in the GPSR protocol is called greedy packet forwarding algorithm. In GPSR, every node broadcasts the HELLO packet to its neighbor nodes periodically, thus every node stores the geographical information of its neighbor nodes. When a certain node wants to forward packet, it chooses the neighbor node closest to the destination node and closer than the forwarding node to the destination as the next hop.

The algorithms above sometimes cannot satisfy the routing request. For example, the algorithm will not work if there are no nodes in the direction of destination in DREAM. [8]describes the routing failure case in GPSR, where there is a path existed between the source and destination node, but no forwarding route can be found using the greedy algorithm. In order to solve the above problems, we present a new packet forwarding algorithm — Universal Weighted Greedy Algorithm. It can avoid the above problem and improve the performance of the routing protocols to a certain extent.

3. Universal Weighted Greedy (UWG) Algorithm

3.1 The Factors Considered by UWG

The universal weighted greedy algorithm considers two factors, not only the distance between destination node and next hop but also the angle that the forwarding path deviate the beeline **L**. **L** is the beeline between source and destination node.

Since the topology of the Ad Hoc network changes frequently and randomly, the availability and stability of wireless links between mobile nodes are relative low compared with that in other networks. Thus the reachability of packets is the most important issue needs to be considered. The greedy packet forwarding algorithm, which chooses the node closest to destination as the next hop, make the packets can get to the destination through as fewer hops as possible. The fewer hops that the packets pass through, the more possibility the packets can get to the destination and the less delay the packets experience. Hence, the distance to the destination node is a very important factor that should be taken into account in packet forwarding algorithms. Based on this consideration, many geographical location based Ad Hoc routing protocols adopt the greedy packet forwarding algorithm such as GPSR, GLS [9] and MSGPR [10] etc. Practically, the greedy packet forwarding algorithm is a simple and effective method.

The other factor is the angle that the forwarding path deviate the beeline between the source and destination node **L**. According to the well-known axiom that the distance of the beeline between two nodes is the shortest, if all forwarding nodes are on the beeline **L**, the spatial distance that the packet travels is the shortest. Because this is impossible in practice, we hope that all forwarding nodes should distribute around **L** as close as possible. This can decrease the spatial distance that the packets travel and therefore can improve the effect of the packet forwarding algorithm.

3.2 The Principle of UWG

The mobile nodes in the Ad Hoc network can obtain their geographical information by location system. Otherwise, every node broadcasts the HELLO packet periodically. Thus every node in the network can store the geographical information of their neighbor nodes carried in the HELLO packets. When a source node wants to send a packet to a destination node, it can query the destination node's geographical information through the location management system. The source node must encapsulate the geographical information of source and destination node in the packet to make the forwarding node can choose the next hop according to UWG algorithm.

The process of UWG algorithm is as follows:

(1). The forwarding node chooses a neighbor node i and calculate the distance between node i and destination node denoted as $D_{i.}$

(2). The angle between K and L $\alpha_{i.}$ is calculated, where K is the beeline between node i and the source node.

(3). The distance D and angle α for all other neighbor nodes are calculated. And the maximum distance MaxD and angle Maxα is selected.

(4). For the neighbor node i, the combination weight of distance and deviation degree W_i is calculated, namely $W_i=p*D_i/MaxD+q*\alpha_{i.}/Max\alpha$. Here, the parameter p and q are the weight coefficient. The more important the factor considered in the UWG algorithm the bigger the weighting coefficient. Note that the coefficient p and q must satisfy p+q=1.

(5). For all other neighbor nodes of the forwarding nodes j,k,…..,n, the combination weight W_j, W_k, …….,W_n are calculated.

(6). The neighbor node with the least combination weight W is chosen as the next hop.

3.3 The Characteristics of UWG

Compared with other packet forwarding algorithms in the geographical location based routing protocols; the UWG algorithm has the following unique characteristics:

(1). The UWG algorithm considers multiple factors that dominate the performance of the routing, and therefore can improve the performance of the routing protocol essentially.

(2). The UWG algorithm avoids the disadvantages of other packet forwarding algorithms to a certain extent. Both the greedy packet forwarding and the restricted directional flooding algorithm can experience routing failure. For example, in case there are no nodes in the direction of destination node in DREAM, no route can be found using the corresponding algorithm. There exist also cases that no suitable nodes can be found using the normal greedy packet forwarding algorithm. The UWG algorithm chooses the next hop based on the combination weight of each neighbor node. It is not restricted in one special scope, so it do not exist routing failure.

4. Simulation Results and Analysis

The two parameters p and q in the UWG algorithm are the coefficients representing the weight of two factors influencing routing. In different network topologies and environments, p and q may have different value, which means that the two factors have different importance to the routing performance. In this section, we determine the scope of the parameter when the routing performance is optimal in different network environment and topologies through simulation. We simulate the UWG algorithm in case of different node average distribution density (D_{ave}) and maximum moving velocity (V_{max}).

4.1 Simulation Environment

We have realized the UWG algorithm and simulated it in the J-Sim [11] simulation environment. J-Sim includes full simulation of IEEE 802.11 physical and MAC layer. We placed N nodes in a simulation region with 2000*2000 unit distance. And the node's moving direction is randomly distributed in (0, 2π). The nodes' moving velocity is between 0 and V_{max}. The simulation time is 100 unit time. We establish the TCP data stream between some nodes and examine the following parameters as the evaluation to the performance of the algorithm: the congestion window in TCP source (cwnd), the maximum sequence number of packets received in TCP sink (seq) and the throughput of TCP sink (throughput).

4.2 Simulation Analysis

4.2.1 The Relationship between the Performance and the Average Node Density D_{ave}

First of all, we analyze which factor has greater influence on the algorithm performance in case of different D_{ave}. Assume that Vmax=1.0 and we placed different number of mobile nodes in the simulation region. Since p + q =1, we let p={0.1, 0.2, 0.3, …, 0.9} respectively. We determine the scope of p by analyzing the simulation result when the algorithm performance is optimal.

We simulate the UWG algorithm when the total node number N=6, 20, 30, 50, 80, 100 respectively. We found that the change of parameter p and q does not influence the algorithm performance when D_{ave} is very small. With further simulations we confirm that when N<=18, i.e., D_{ave}<=$0.5*10^{-5}$, the change of parameter p and q does not have any influence on the performance. From the simulation result, when N=20 and 30, p={0.1,0.2,0.3…0.9}, a majority of the value of the evaluation parameters are basically the same. Thus we do not need to estimate the scope of p to make the algorithm performance optimal. However, when N=50 and 80, the plotting of evaluation parameters are almost different under different p. Nevertheless, the difference is not obvious enough to determine the scope of p, although the difference of evaluation parameters under difference p is bigger than that N=20 and 30. But in case of N=100, only the simulation result of p={0.7, 0.8, 0.9} are the same, and the algorithm performance is optimal. As Fig.1 and Fig.2 illustrate the simulation result when N=100. Here we can see that only when p={0.7, 0.8, 0.9} the value of seq is maximum but the cwnd is very small.

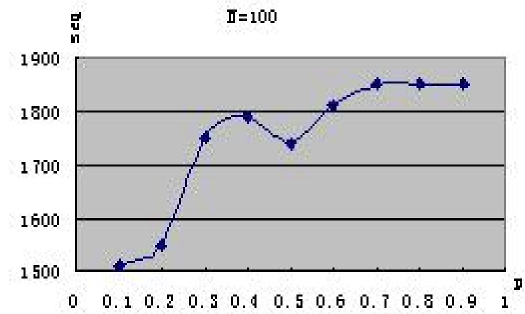

Fig.1: Simulation result of seq under different p.

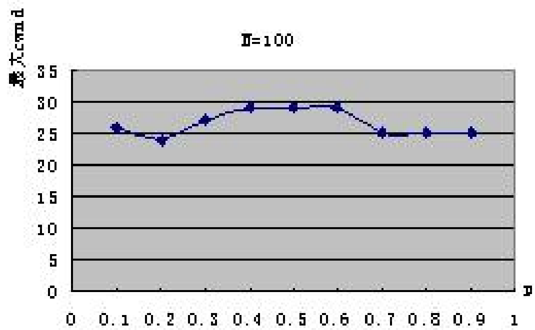

Fig.2: Simulation result of cwnd under different p.

From the above simulation result, we can see that with the increase of D_{ave}, the parameter p and q has more influence on the performance packet forwarding. This means that the UWG algorithm is more efficient in the environment with relative high D_{ave}. When V_{max}=1.0 and D_{ave}<$0.5*10^{-5}$, the change of parameter p and q does not have much influence to performance of the UWG algorithm. Because when the D_{ave} is very small, the forwarding node's neighbor nodes are few and even maybe only one. No matter what the packet forwarding algorithm is adopted, the next hop calculated is the same. Table1 summarizes the simulation result. It can be seen that with different D_{ave}, the distance between next hop and destination node plays the major role in choosing the next hop.

Table 1:The simulation result with different $D_{ave,}$ N=6

N	Simulation result	Optimal weight coefficient p, q
<18	Performance has no change	Any value satisfying p + q=1
20	Simulation result is all the same except p=0.1	Any value satisfying p + q=1
30	The simulation result of p= {0.2,0.3,0.4} are basically the same. p={0.7,0.8,0.9} is also	Any value satisfying p + q=1
50	Different p different simulation result.	Any value satisfying p + q=1
80	Different p different simulation result.	Any value satisfying p + q=1
100	The simulation result of p={0.7,0.8,0.9} are basically the same and optimal.	p={0.7,0.8,0.9}

4.2.2 The Relationship between the Performance and the Maximum Moving Velocity V_{max}

In this section, we analyze which factor has greater influence on the algorithm performance under different V_{max}. Assume that N=6, and the nodes have different V_{max} in the simulation region. Since p + q =1, we let p={0.1, 0.2, 0.3, …, 0.9} respectively. We determine the scope of p by analyzing the simulation result when the algorithm performance is optimal.

We simulate the UWG algorithm when V_{max} =1, 5, 10, 17. Assume that V_{max} =1.0 is comparative to the natural walking velocity and V_{max} =17 is comparative to the automobile's velocity of 60km/h. The simulation result is that when V_{max} =1 and 5, the change of parameter p and q almost does not have any influence on the routing performance. Further simulation results reveal that until N>6 the change of parameter p and q does not have much influence to algorithm performance. When V_{max} =10, the plotting of the evaluation parameters are all different under different p. And with the increase of p, the routing algorithm performance tends to optimal. From the simulation results we can see that the algorithm performance is almost the same and optimal when p={0.7, 0.8, 0.9} as shown in Fig.3. When V_{max} =17, with the increase of p, the algorithm performance tends to optimal. And when p={0.8, 0.9}, the algorithm performance is almost the same and optimal, as shown in Fig.4.

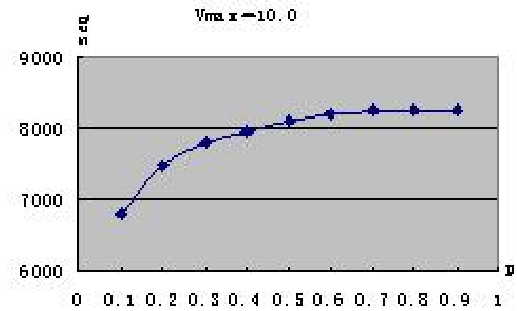

Fig.3: Simulation result of seq under different p

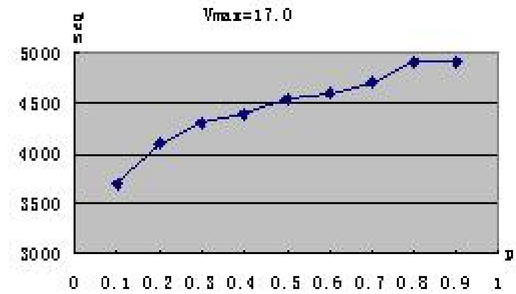

Fig.4: Simulation result of seq under different p

From the above simulation results we can see that when N=6, in case of V_{max} <=6, the change of parameter p and q almost does not have influence on the performance of UWG algorithm. That is because when D_{ave} is very small and the moving velocity is not big enough to make the node closer with each other, the number of the forwarding node's neighbor node is few, thus the choice of next hop is simplex. When 17>V_{max}>7, with the increase of p, the algorithm performance will gradually tends to simulation result. We can see that when the mobile optimal. And the algorithm performance is almost the same when p={0.7,0.8,0.9}. Table2 summarizes the node have different V_{max}, the distance between the next hop and the destination node also plays a major role in choosing the next hop.

Table 2: The simulation result with different $V_{max,}$ N=6

Vmax	Simulation result	Optimal weight coefficient p, q
<6.0	Performance has no change	Any value satisfying p + q=1
10.0	Different p different simulation result. With increase of p, performance tends to optimize.	p={0.7,0.8,0.9}
17.0	Different p different simulation result. With increase of p, performance tends to optimize.	p={0.8,0.9}

5. Conclusions and Future Works

In this paper, we present a new packet forwarding algorithm for the geographical location based Ad Hoc routing protocols. UWG algorithm takes two factors affecting the performance of routing protocols into account, and can avoid failures in selecting the next hop and has better performance. In addition, the scope of the parameter p and q in UWG is determined through simulation. From the value of p and q when the performance of the routing protocols is optimal, we can see that the distance between the next hop and the destination node plays a major role in choosing the next hop. However, we cannot ignore another important factor.

The node density D_{ave}, the maximum moving velocity of nodes V_{max}, and the transmission capability of wireless links of nodes .etc can all change the topology of Ad Hoc networks. Under different topology environments of Ad Hoc networks, the two factors in the UWG algorithm may play different roles. That means the scope of the parameter p and q should different in different topology environments when routing performance is optimal. So far, we have only studied UWG in two different topology environments and the other network environments should also been studied.

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