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A self-adapting greedy forwarding algorithm for MANETs

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Abstract: As the population application of GPS, some greedy forwarding algorithms based on geographic information for MANETs (mobile ad hoc networks) are proposed in recent years. These algorithms have been well-designed from different aspects to improve its performance. On the basis of analysis of these algorithms, this paper presents modified methods to address some issues of GPSR (greedy perimeter stateless routing): dynamically adjusting the time interval of sending beacons according to the radio transmission; not only considering the distance between each neighbor and the destination, but also the neighbor node surviving ratio. Some relevant algorithms are described in the paper as well. The simulation results show the improved routing algorithm excels GPSR markedly in terms of delivery ratio and routing overhead while the transmission range is larger or the motion velocity of nodes is greater.

Keywords: MANET; Routing algorithm; Greedy forwarding; Beacons; Neighbor node surviving ratio.

1. Introduction

As the population application of GPS, many routing protocols based on geographic information are developed. These protocols solved the problem of poor efficiency in traditional MANETs routing protocols successfully. In this category of routing protocols, the mobile nodes get its neighbors location information and IP address information by the sent beacons periodically; and then create the data base of neighbor information; every intermediate node chooses the most appropriate neighbor node to forward packets to the destination adopting greedy algorithm. The existing greedy algorithms include GPSR, NC (nearest closer) [2,3], DIR (directional routing) [4-6] and so on. However, there are common defects in the current most study on the routing protocols based on geographic information: (1) the motion velocity is too slow, in MANETs, the mobility of nodes is one of its majority characteristics, in the low speed procedure or pause procedure, the success ratio of packet forwarding is higher than in fast procedure, and the communication pause times are decrease. On the contrary, the success ratio of forwarding of the high-speed node is low. (2) The stop time is long. In the most modes, the stop time reflects node mobility. In, the performance of static nodes is much better than that of mobile, the long stop time means more nodes are static. Nevertheless, this phenomenon doesn’t fit with the mobility feature of MANETs.

Based on the analysis of existing greedy algorithm, this paper presents an improved self-adapting greedy forwarding routing (SGFR). This algorithm integrates the transmission range and the neighboring nodes existence time, which simulates MANETs more reality, especially in the fast mobility and short stop time MANETs to reach better routing performance.

2. The greedy forwarding algorithm based on geographic information

2.1. Beacon exchange algorithm

Periodically, each node transmits a beacon to the broadcast MAC address, containing only its own identifier (e.g., IP address) and position. I encode position as two four-byte floating point quantities, for x and y coordinate values. To avoid synchronization of neighbors' beacons, as observed by Floyd and Jacobson, I jitter each beacon's transmission by 50% of the interval B between beacons, such that the mean inter-beacon transmission interval is B, uniformly distributed in [0.5B, 1.5B].

Upon not receiving a beacon from a neighbor for longer than timeout interval T, a GPSR router assumes that the neighbor has failed or gone out-of-range, and deletes the neighbor from its table. The 802.11 MAC layer also gives direct indications of link-level retransmission failures to neighbors; I interpret these indications identically. I have used T ---- 4.5B, three times the maximum jittered beacon interval, in this work.

2.2. Greedy forwarding algorithm

Under GPSR, packets are marked by their originator with their destinations' locations. As a result, a forwarding node can make a locally optimal, greedy choice in choosing a packet's next hop. Specifically, if a node knows its radio neighbors' positions, the locally optimal choice of next hop is the neighbor geographically closest to the packet's destination. Forwarding in this regime follows successively closer geographic hops, until the destination is reached.

3. SGFR

3.1. Study and analysis on the beacon exchange algorithm

In, the shorter the time interval between two beacons, the more the success ratio of packet delivery. However, the routing overhead is increased. In order to reduce routing overhead effectively, proposed a beacon exchange algorithm: adjusting the beacon sending frequency according to the node motion velocity, which not only insures the packet delivery ratio, but also decreases the routing overhead, and it meets wonderful results. proposed a detect approach based on Bloom filter. The approach can test whether a given node has moved out its networks to reduce unnecessary routing overhead. adjusts the sending time interval according to the stop time of nodes, which can also decrease routing overhead and lessen the network whole overload.

On the basis of analysis above, this paper proposes the time interval of sending beacons should be determined according to the node transmission range. The bigger the transmission range of a node is, the longer its neighbors remain in its transmission range; on the contrary, it is shorter. In GPSR, I select a proper time interval Boptimal according to the success rate of packet delivery and routing overhead. In SGFR, I set the new time interval as Bnew=Rnew/Roptimal*Boptimal, where Rnew denotes the transmission range of nodes, Roptimal represents the transmission range corresponding to Boptimal in GPSR. Bnew is set to the time interval of sending packets in SGFR, which can keep the success rate of packet delivery and routing overhead to be an acceptable level.

3.2. Study and analysis on the forwarding algorithm

The mobility of nodes is a curial property of MANETs. In GPSR, the time interval of sending beacons is fixed; therefore, the neighbor node location information can't update timely, which result in the success rate of packet forwarding decreasing. In GPSR, the node closest to the destination is selected as the next hop, which is simple, efficient and easy to operate. However, the node closest to the destination is the farthest one to the source. In wireless communication, the farther the transmitting distance is, the more serious the signal distortion is. As a result, the lose rate of packet is greater.

NC [2,3] has proposed a forwarding strategy: the forwarding node selects a closet neighbor as the next hop to decrease the possibility of temporary communication blindness, however, which increases the number of hops and the data transmission delay. DIR [4, 5, 6] selects the neighbor node as the next hop, which form a least angle whose vertex is the destination with the source, the destination. Yet, this algorithm may generate loop. proposed a greedy forwarding algorithm based on the motion velocity of nodes; while selecting the next hop, the forwarding node chooses the slowest speed node from its neighbor node set which are closer to the destination than the forwarding node. The algorithm has some flaws in real scene: the node motion velocity doesn't vary continuously; the speed calculated according to geographic location is the average value in certain time interval, not the current speed. presented multi-path routing on demand searching from QoS perspective, which selects a optimal route that meets the bandwidth request from multi routes. considered the route selecting from energy saving aspect. All of the above routing strategies select the next hop from the neighbor list based on different metrics, so the performances are different.

Based on the analysis above, this paper puts forward a new selecting method: the forwarding node chooses the next hop according to the neighbor node's geographic location and its neighbor surviving rate (NSR). NSR is the number of those nodes that still keep connecting with current node after a period of time to the number of all nodes that has communicated with the current node. The detailed implementation steps are as follows. The field of NSR is inserted into the beacon packet, and its length is set to 4 bytes. Meanwhile, the neighbor node list of all neighbors is added a NSR property. While selecting the next hop, the node with the greatest NSR in the neighbor node set is chosen. In this way, the probability of the packet successfully forwarded once more will increase notably, especially in high motion velocity MANETs, for NSR reflect the relative motion between the current node and its neighbor node. The greater the NSR is, the more stable the current node and its neighbors are, and the success rate of forwarding packet is larger while the packets are forwarded.

Suppose an intermediate node m receives a packet p sent from the source S to the destination D, and then the forwarding algorithm of node m is described below. (1) m gets the coordinate value of destination D from the packet header, and calculates the distance Dism between m and D; (2) m calculates the distance Disa between the destination D and each of its neighbors, and compares it with Dism. If Dism＞Disa, the corresponding neighbor node is added to the set N; (3) m finds out the node n with the greatest value of NSR from the set N; (4) m transmits the packet ton.

4. Simulation and analysis

In order to analyse the performance of SGFR deeply, I adopt the network simulation software NS-2 to implement SGFR. I focus on the average success rate of packet forwarding and routing overhead of the two algorithms SGFR and GPSR.

4.1. Simulation environment parameters

Simulation environment for the proposed protocol consists of four models: network model, channel model, mobility model and traffic model. These models are discussed below.

Network model: The MANET in the simulation environment is generated in an area of 1500×300 square meters. It consists of 50 number of mobile nodes that are placed randomly within the square area.

Channel model: Radio propagation range r for each node changes dynamically, depending upon transmitted power level of a node. For the convenience of comparison, r is set to 100m, 200m and 300m successively. IEEE 802.11b distributed coordination function (DCF) with the RTS/CTS mechanism was used as the MAC layer protocol. The radio interface was modeled as a shared-media radio with a nominal bit rate of 2Mbps.

Mobility model: Nodes move in an unobstructed plane. Motion follows the random waypoint model: a node chooses a destination uniformly at random in the simulated region, chooses a velocity uniformly at random from a configurable range, and then moves to the destination at the chosen velocity. Upon arriving at the chosen waypoint, the node pauses for a configurable period before repeating the same process. In this model, the pause time is set to 10 seconds. The velocity was chosen randomly between Vmin and Vmax, which are set to [0,10] and [10,20] respectively.

Traffic model: The UDP protocol is used in the transport layer. There are 20 pairs of Constant Bit Rate (CBR) data flows in the network layer. The source and the destination of each CBR flow are randomly selected and not identical. Each flow does not change its source and destination throughout the simulation. Each source transmits data packets at a rate of four 512-bytes data packets per second. According to the experience of simulation experiments, the HELLO beacon interval is set to 3 seconds, i.e., Boptimal is set to 3.

In all of these simulations, the initial value of NSR is set to 1. And then, every node calculates NSR every 30 seconds to prepare for forwarding packets. The node motion velocities are set in two ranges and the radio transmission range are set for 3 values, so there are 6 simulation environments. The ongoing time of each simulation is 900 seconds in every environment, and repeat for 5 times. The final result is the average of the 5 times. The main simulation parameters are listed as table 1

Table 1. Parameters of the simulation

Number of nodes	50
Rate of channel(Mbps)	8
region(m^2)	1500*300
Pause time(s)	10
Velocity(m/s)	[0,10], [10,20]
radio radius(m)	100, 200, 300
type of operation	CBR
CBR flows	22
Generation rate of packet	2
Length of packet(Byte)	512
simulation time(s)	900
NSR interval(s)	30

4.2. Simulation results and analysis

In the environment as above, the two protocols GPSR and SGFR are modeled respectively in terms of success rate of packet delivery and routing overhead, which are described in figure 1 and figure 2 respectively as below.

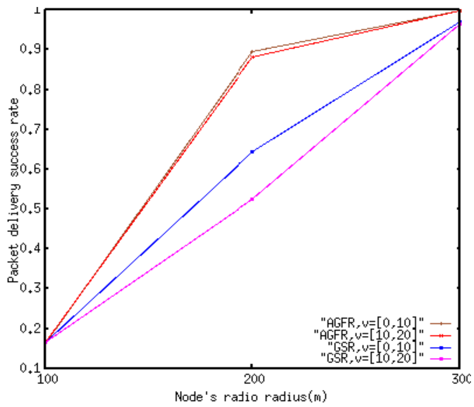

Figure 1. The effect from transmission range and motion velocity on the success rate of packet delivery

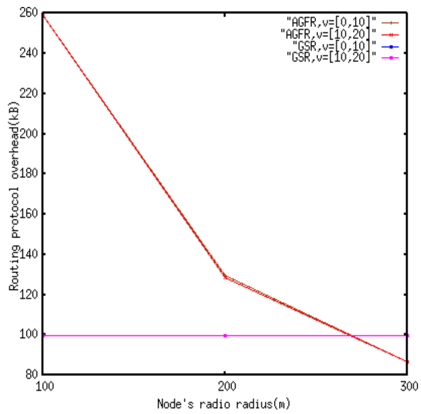

Figure 2. The effect from transmission range and motion velocity on the routing overhead

From Fig.1, we can see that the packet delivery success rates are roughly equal when the radio range of nodes is very small, which is because that the neighbor nodes of each node are very rare and the packet delivery success rate is mainly decided by the number of neighbor nodes. While the radio range reach about 200 meters, the packet delivery success rate of SGFR is greater than that of GPSR obviously. In this situation, the numbers of neighbor nodes of each node are reach certain quantiy. And the packet delivery success rate mainly depends on the next hop while the packet is forwarded. But the effect of velocity on SGFR is very little whereas on GPSR is obviously. When the radio range reach about 300 meters, the rise extent of the packet delivery success rate of GPSR is little greater than that of SGFR, which is because there are lots of neighbor nodes of each node. So the selectable range of GPSR is increased substantially while GPSR chooses the next hop. The packet delivery success rate of SGFR is greater than that of GPSR obviously as the node motion velocity increases and the radio range amplifies.

In Figure 2, when the radio range is 200 meters and the interval slot time of sending beacons are set to 3 seconds, the overhead of SGFR is greater about 30 percent than that of GPSR. The cause is that the beacons of SGFR plus a field NSR, which occupies 4 bytes. Also, we can see, in figure 2, the overhead of GPSR almost does not affected by the node motion velocity and radio range. However, the overhead of SGFR declines rapidly as the radio range increases. Meanwhile, the node motion velocity does not impact the overhead of SGFR. Thus, SGFR is more suitable for those networks where the node radio range is fairly wide.

5. Conclusions

In the paper, I put forward a novel routing protocol based on geographical information SGFR, which adjusts the time slot interval dynamically by the node radio range and integrates the neighbor node surviving ratio to select the next hop. According the simulations, I reach the results: while the node radio range is much wide and node motion velocity is much rapid, the superiority of SGFR is obvious than GPSR. However, the overhead of SGFR is increased than GPSR while sending the beacons, which is insignificant under the circumstances that the hardware performance is developed rapidly.

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