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Prediction based Greedy Perimeter Stateless Routing Protocol for Vehicular Self-organizing Network

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Abstract. PGPSR (Prediction based Greedy Perimeter Stateless Routing) is based on and extended the GPSR protocol to adapt to the high speed mobility of the vehicle auto organization network (VANET) and the changes in the network topology. GPSR is used in the VANET network environment, the network loss rate and throughput are not ideal, even cannot work. Aiming at the problems of the GPSR, the proposed PGPSR routing protocol, it redefines the hello and query packet structure, in the structure of the new node speed and direction information, which received the next update before you can take advantage of its speed and direction to predict the position of node and new network topology, select the right the next hop routing and path. Secondly, the update of the outdated node information of the neighbor's table is deleted in time. The simulation experiment shows the performance of PGPSR is better than that of GPSR.

1. Introduction

Vehicular ad hoc network (VANET) [1] is used in automobiles that installed with vehicle chips, intelligent systems, wireless communication devices, GPS and other information technologies. The purpose is to let the vehicle communicate with each other and share information. It is one of the basic research of unmanned driving. VANET is also a branch of wireless ad hoc network, which has the characteristics of fast moving speed and rapid topology change. How to select routing effectively to send packets from source nodes to target nodes is the focus and core of network research. VANET routing protocols are divided into two types: Based on geo - Location Protocol and link - based stability. Based on link stability, routing protocols such as AODV and DSR need to find routing before sending data, which is not suitable for fast changing and high-speed mobile network topology, and has large routing overhead and delay, and out of date routing problems. This paper mainly discusses the geo location protocol.

Based on geographic location, GPSR (Greedy Perimeter Stateless Routing for wireless networks) [2] was proposed by Karp et al in 2000, then related routing protocols were also proposed. GPSR consists of two modes, namely greedy forwarding mode and peripheral forwarding mode. Greedy forwarding mode selects the nearest node from the destination node as the next hop. When the greedy mode fails, the peripheral forwarding mode uses the right hand rule to forward the packet until the destination node receives the packet. When node B suffers from local optimization (routing holes), it uses peripheral mode forwarding, sometimes even when using the right hand rule, it cannot transmit data packets to the destination node. To this end, Naumov et al. Proposed storage - packet forwarding, intermediate nodes will be stored until the next hop node when forwarding it [3]. STAR (Spatial and Traffic-Aware Routing for vehicular systems) [4] require nodes maintain a neighbor table and a traffic flow table is used to construct a weighted directed graph. STAR is better than GPSR in performance, however, it wastes more network bandwidth than GPSR and has a longer time delay. The node of high speed motion may delay or lose the beacon information, which makes the vehicle density information inaccurate and leads to routing failure. In addition, in SSTAR, the density of the vehicle is only dense or sparse in two states, and the accuracy is low. In 2007, Moez Jerbi et al [5] proposed routing protocol GyTAR (improved Greedy Traffic Aware Routing protocol), according to the various sections of the vehicle density in real time step by step to obtain dynamic packet forwarding under an anchor. The caching and forwarding mechanism is adopted when packet forwarding falls into local optimum. GyTAR requires extra hardware and services to extract the traffic density information in real time, which limits the application scenario. Song Limin and others put forward an improved AODV routing protocol based on location information, which used the middle node to recalculate the forwarding angle, so that the middle node near the target node could preferentially forward the routing [7], which has a large routing cost.

2. PGPSR

2.1. The Basic idea of PGPSR

Based on the characteristics of ad hoc network and the existing problems of location based protocol, this article modified the GPSR protocol, Prediction based Greedy Perimeter Stateless Routing (PGPSR) is proposed. The main idea of PGPSR is adding the direction of motion and speed to the periodically broadcasting information of nodes. Before the broadcast packet is received, during this time (Δt), the direction of motion and speed of nodes are used to predict the new position of nodes in next time slice. So it can select the best route with rapid changes in VANET. For example, in Figure 1, the source node A sends data to the target node F in the t_0 network topology diagram. In Figure 2 shows the real network topology (but not updating) duringΔt. GPSR protocol select the next hop node of node A is B. Obviously B is not the best next hop node, this is mainly because of during Δt, GPSR is still using the topology of the t_0 to select the next hop, but the actual topology is shown in Figure 2. The error of select the next hop node will lead to packet circles, so that the packed even cannot reach the target node, and network delay packet loss rate is high. In order to improve the accuracy of GPSR routing, and to reduce the loss rate and transmission delay, we can reduce the information updating cycle. It may be effective but not obvious enough. On the contrary, it will increase the routing overhead of the network, that is, the normalized routing overhead. PGPSR routing protocol for new direction and speed of motion in updating the node information, does not receive the topology of nodes using the t_0 update before grouping, calculate a t node position and new network topology, a greedy algorithm is used to select the right next hop node C other than node B, though A→C → D→F to the destination node. PGPSR effectively reduces the error rate and transmission delay of the next hop routing and improves the network throughput.

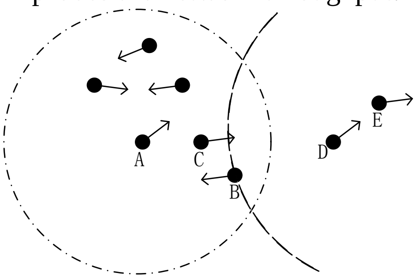

Fig 1. Topology of the network in t_0

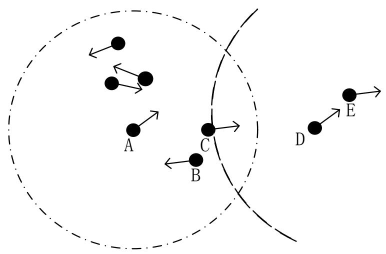

Fig 2. Topology of the network in t_1 without update

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2.2. Structure of the packet

The PGPSR packet:

(1) Hello data packet. Each node periodically uses the packet format to encapsulate the node information and broadcast it to the adjacent nodes. After receiving the neighbor nodes, the neighbor table is updated. The structure of hello packet is shown in Fig. 3. Type_: type of the packet, X_: abscissa, Y_: ordinate, seqno: sequence number, speed: speed of the node, Mov_dir: move direction, size: size of the packet.

type	X_	Y_	seqno	speed	Mov_dir	size

Fig. 3. The structure of hello data packet

(2) Query data packet. Each node periodically uses the packet format to encapsulate its node information, and uses flooding method to transmit node information to all nodes in the network. The format is as shown in Figure 4. TS_: the time stamp.

type	X_	Y_	Ts_	hops	seqno	speed	Mov_dir	size

Fig. 4.The structure of query data packet

(3) Data packet. This packet is used to complete the encapsulation and transmission of data. During the transmission process, data is transmitted to the target node by greedy algorithm (Greedy Forwarding) and planar graph traversal. Its format is shown in Figure 5: SX_: source node abscissa, SY_: source node ordinate, DY_: destination node abscissa, DX_: destination node ordinate.

type	Mode_	SX_	SY_	DX_	DY_	Ts_	speed	Mov_dir	size

Fig. 5. The structure of data packet

2.3. Flow chart and algorithm

The flow chart of PGPSR is shown in Fig.6. PGPSR receive packets from the top or bottom layer. If the packet is from the top layer, it will finish the packet encapsulation. Otherwise it will determine whether the packet is HELLO packet or QUERY packet, and call the corresponding receiver. If not, it will predict the location of neighbor nodes, and using a greedy algorithm to find the next routing hop.

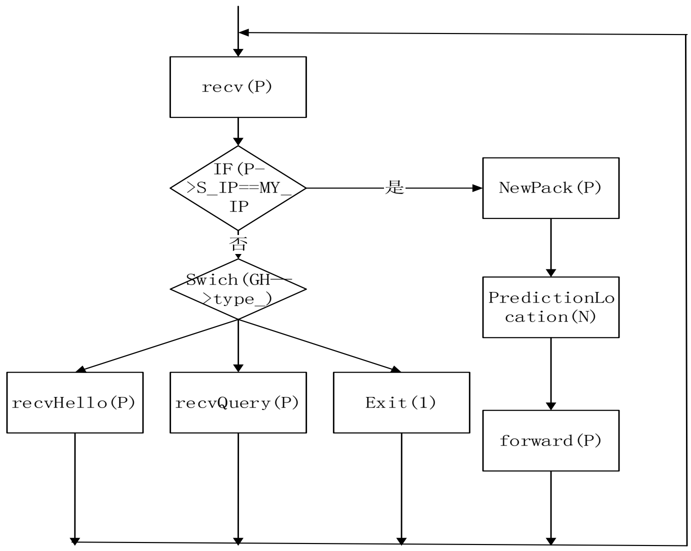

Fig. 6 The flow of PGPSR

Table 1 Functions

Function Name	Function
recv(P)	Receiving packet P from the higher or lower layer
NewPack(P)	Encapsulation packet P
recvHello(P)	Receiving Hello packet
recvQuery(P)	Receiving Query packet
PredictionLocation(N)	Predict locations of neighbor nodes in GPSR neighbor table
forward(P)	Forwarding packet P

One of the key point of PGPSR protocol is searching the best next hop from neighbor table. The following algorithm is used to maintain it to ensure the accuracy and effectiveness of neighbor table.
The algorithm of GPSR neighbor maintaining:

(1) Send hello packets: each node calls the algorithm periodically by interval time t, and uses GPS information to calculate its motion direction and speed, complete the encapsulation of hello packets and broadcast hello packets to adjacent nodes.
(2) The neighbor node receives the Hello packet, the neighbor node table update information: GPSR neighbor receives a Hello message, using the source address searching neighbor node list. If the node information has existed, it will update the information and resets the timer, otherwise it will add the node to the neighbor list.
(3) A node with a zero timer is deleted from the neighbor node.
(4) Call step 1by interval time t.

The algorithm of GPSR_sinlist table maintenance algorithm in target candidate nodes：

(1) Each node periodically calls this algorithm, completes the encapsulation of query packets with node information, and sends the packet to all nodes in the network by flooding method.
(2) When the neighbor node receives the query data packet, it traverses the GPSR_sinlist table of the target candidate node according to the node ID. If it can be found, it updates and reset the timer, otherwise it will add the node to the GPSR_sinlist table. The neighbor node continues to broadcast the query packet.
(3) GPSR_sinlist reset the timer. Neighbor nodes whose timer is zero will be deleted.
(4) Call step (1) at intervals of t。

Data forwarding algorithm：
Greedy forwarding: With source node and the target node, using the formula 1 to calculate the new position of all GPSR neighbor nodes inΔt. Formula 2 is used to calculate the distance from the new position to the target node. If the location of new neighbor node in wireless communication range of the node, select the target node with the minimum distance as the next hop nodes, otherwise changed into the plane forwarding model.

$$\begin{aligned} x_{t1} &= \Delta t * S * \cos(\theta) + x_{t0} \\ y_{t1} &= \Delta t * S * \sin(\theta) + y_{t0} \end{aligned} \quad (1)$$

$$dis_{A,B} = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2} \quad (2)$$

Plane forwarding algorithm: RNG and GG are two kinds of the plane type. The new neighbor nodes are calculated by using formula 1 and formula 2. The next hop node is obtained by using RNG or GG algorithm according to the newly constructed plan map.
RNG type algorithm:
N=PredictionLocation(N)
for all v ϵ N **do**{**for all** w ϵ N **do**{if w == v **continue else if** PredictionDis(u,v) > max[PredictionDis(u,w),PredictionDis(v, w)]{eliminate edge (u,v) **break**}}}

3. Simulation Experiment

We use NS-2[8] to simulate the PGPSR protocol, and compare it with GPSR. The simulation scene is

20000m * 100m and two-way 6 lanes highway, as shown in Figure 7. As shown in Figure 8, the vehicle speed is distributed randomly in [10m/s and 40m/s], and the location and lane of vehicles are randomly generated in two directions. The simulation is shown in table 2. In order to verify the reliability of the experimental data, the number of nodes in each class of nodes is randomly generated by 50 different topological structures, and then their average values are obtained. The performance indexes such as throughput, transmission delay and normalized routing overhead are compared.

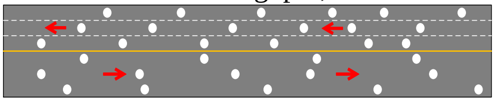

Fig. 7. Real scenes in highway

Fig. 8. Simulation scene in NS-2

Table 2 Setting of experimental simulation parameters
Simulation parameters

Experimental parameters	Parameter setting
Simulation platform	NS-2
Simulation object	Highway with 6 lanes
Routing protocol	PGPSR、GPSR
MAC protocol	802_11Ext
Simulation scene	10000m*400m
Communication link	3
Transmission distance /m	500m
Packet size /Byte	1500Byte
Number of nodes	[20,300]
Simulation time /s	50s
Transmission rate /Kb	1000kb/s
Simulation lane and direction	Bi-directional, 6 Lanes
Node moving speed	[10m/s,40m/s]Random
Queue Type	PriQueue
Queue length / packet	50

(1) Throughput: Throughput is used to evaluate the performance of the network. It is the amount of data received by the destination node in the unit time without packet lost. As shown in Figure 9, the PGPRS throughput is much higher than GPSR at a fixed transmission rate. This is because the next hop routing selected by GPRS protocol is not all the best routing, or even because the node moves quickly to select the wrong route, resulting in a large number of packet losses, affecting its throughput. PGPRS uses node direction and speed to predict node location, and combines greedy forwarding, which is more effective, reliable and reliable in selecting next hop routing, reducing loss rate and improving throughput. The experiment shows that PGPSR has a higher spit amount than GPSR, almost 2 times as much as GPSR.

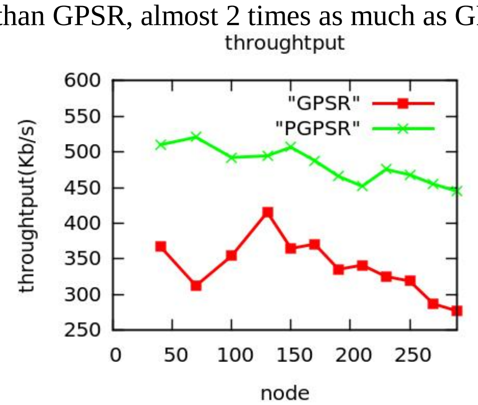

Fig. 9. Throughput

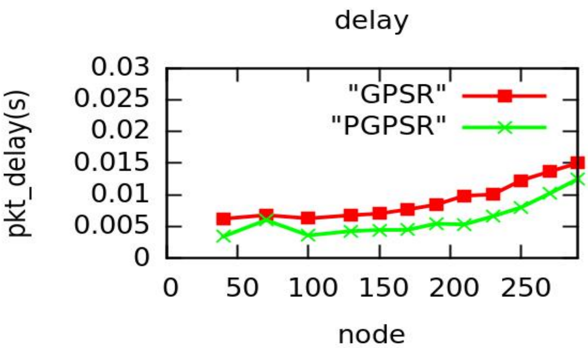

Fig.10. Transmission delay

(2) Transmission delay: it is the amount of time form the packet is send to the time that the packet is receive by the target node. The smaller the transmission delay, the more effective the packet

forwarding path is, the lower the loss rate. As shown in Figure 10, PGPSR has a smaller transmission delay than the GPSR, and the performance is better than that of GPSR. This is mainly because PGPSR is more effective than GPSR's routing path. Even though every node in PGPSR needs to predict and calculate neighbor nodes, it increases the processing delay of nodes.

(3) The normalized routing overhead is used to measure the ratio of how many routing overhead is required to send a data packet. Normalized routing overhead is used to measure routing overhead, and the more efficient it is, the more efficient the routing protocol is. As shown in Figure 11, PGPSR is similar to GPSR routing overhead.

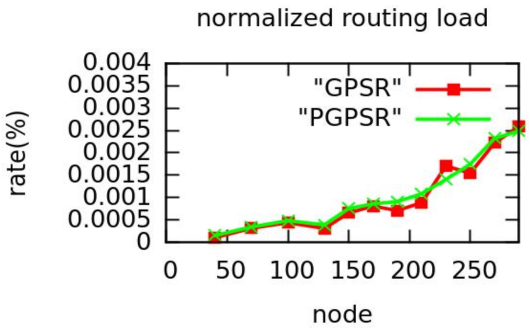

Fig.11. Normalized routing load

4. Conclusion

In vehicle ad hoc network complex nodes change high-speed mobility and network topology (VANET), PGPSR uses the node speed and direction to predict the position of next time node and uses greedy algorithm to select the next hop routing, the network overhead, the throughput and delay performance indicators are better than the GPSR protocol. It also proves that our idea is effective and suitable for high speed mobile ad hoc network.

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