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AN ENERGY-EFFICIENT ROUTING FOR VEHICULAR AD HOC NETWORKS USING REAL-TIME PERCEPTION OF NODE INFORMATION

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Abstract-Integrating recent years' results and analyzing the VANET (Vehicular ad hoc networks), taking the important role of mobile nodes into account a vehicular opportunity route based on real-time information (VORI) is proposed. VORI uses mobile nodes to collect real time area information, and construct hot area for best inter-area selecting with the information to help delivery message. VORI is consisting of node position query and data transmission. The limited query reduces the number of query copies within the net, and with dynamically selecting hot area message delivery works well.

Index terms: VANET, VORI, mobile nodes, real time, query copies.

I. INTRODUCTION

Progress of science and technology developments of the 21st century is no longer limited to the impact on the efficiency of industrial production, and it has begun to go deep into the People's Daily life, consumption and entertainment [1]. The tide of building smart planet and wisdom city has been widely welcome and accepted in many countries. As an important part of the internet of things, the main content of smart city, research on VANET accepts great attention [2, 17-18].

In opportunistic networks, the routing protocol is mainly centered on the route to the node to node location-centric routing, data-centric routing and mobile-centric routing of several classes. In the node-centric routing full use of radio and computing ability of each node to build messaging and network topology, such as a typical route Epidemic routing [3], and then the Epidemic routes are optimized by the concept PREP introduced for the weights [4]. In addition, the class also considers the type of routing nodes divided optimized for message transmission, and the performance of on-board routing node based on the delay was analyzed in [5], and it was proposed a delay optimization allocation algorithm to maximize the data transmission between nodes in [6]. Many researchers consider the use of distributed real-time information, and Cheng P C et al. [7] proposed a distributed routing protocol based on the vehicle network real-time information, and routing algorithms can be effectively used to provide periodic node characteristics to achieve data connectivity transmission[8].

In location-centric routing mobile node can be well balanced the instability caused by network topology, as much as possible to avoid requiring the use of a fixed message forwarding path, and consider the use of the weight (such as physical distance), e.g. GPSR [9] always delivers the message from the node to the destination node closer direction. GeoDTN+Nav takes into account the influence of the directional motion of the vehicle brought studied and routing design [10]. Zhu X l et al. [11] takes into account the impact of the vehicle and the direction of movement brings forward the implementation of the opportunity. To the location of the center of the routing nodes often uses GPS to obtain the current location decision support, and its advantage lies in the implementation of real-time information calculated based on the nodes without the need to maintain the global routing table. Now more routes begin to consider using more roads GIS topology information, and VADD [12] will depend on the type of road routes into the intersection mode, straight pattern and destination mode, and on three different types of road design forwarding mode.

Recent more studies consider VANET routing scheme combining node mobility and vehicle routing design, and the features of social networks is given by the study in [13, 19, 20]. RMR takes into account the use of regional reliability problems [14, 21], and many structural approaches such as [15] and [22] have considered the properties of the vehicle after the vehicle as obstacles to test their impact on vehicular ad hoc networks, as well as taking into account the hotspot problem.

The rest of this paper is organized as follows: Section 2 describes the existing algorithms of vehicular ad hoc network and the proposed algorithm is introduced. We give the deals in experiment analysis in Section 3. Later, a conclusion is drawn in Section 4.

II. DESCRIPTION OF THE ALGORITHM

2.1 System assumes

VORI routing protocol was described in this paper without any prior knowledge of the surrounding environment information, and only the aid of GPS is ready access to their own position and the transmission path through completing self-organization between vehicles. In this paper, to realize fast flooding first restricted queries to determine the location of the destination node followed by the transmission data directed convergence. Overall speaking, dynamic message routing gradually is closer to the target area, and the specific details of the route, and the optimal routing method is based on the information and calculations for each mobile node itself forward data collected in real time. Given the roadside station may occur unavailable, and the trajectory of the mobile node is very difficult to follow the law, and therefore in the "intermediate stations" and "ferry people" used to take periodic check on all the way to dynamically obtain speed data transmission and improve the success rate of transmission. We hope to make full use of computing and storage capacity of the mobile node so that the neighboring nodes always know their information, as well as some information about the dynamic node storage area in the region [16-18].

Most vehicles today are equipped with GPS navigation systems. GPS system has a function to receive location information for free that is not affected by the basic geographical environment.

It is assumed that the use of GPS can obtain real-time location information to assist in routing establish directional transmission and message. Many proposed routing algorithms obtain information on the city and the road topology information by means of roadside station to forward the information, because in the larger urban roads approaching natural disaster would have been a huge broken ring and can not be used, and the information base may also be destroyed. So this program has some not feasible. On the other hand, information base as a special node can dynamically query to get information without having to be known.

2.2 Fast limited flooding query

Distance between nodes should first determine the location of the query by asking flooded road style. The simplest way is using the query of the Epidemic Routing type. But the way in a sense will be a waste of a energy and storage capacity, and it may also cause congestion. The proposed router took periodically querying and waiting for getting each other's position. If a small amount of messages were transmitted through the first position confirmation that could pass the message to the destination node, and feedback information becomes a transmission confirmation message.

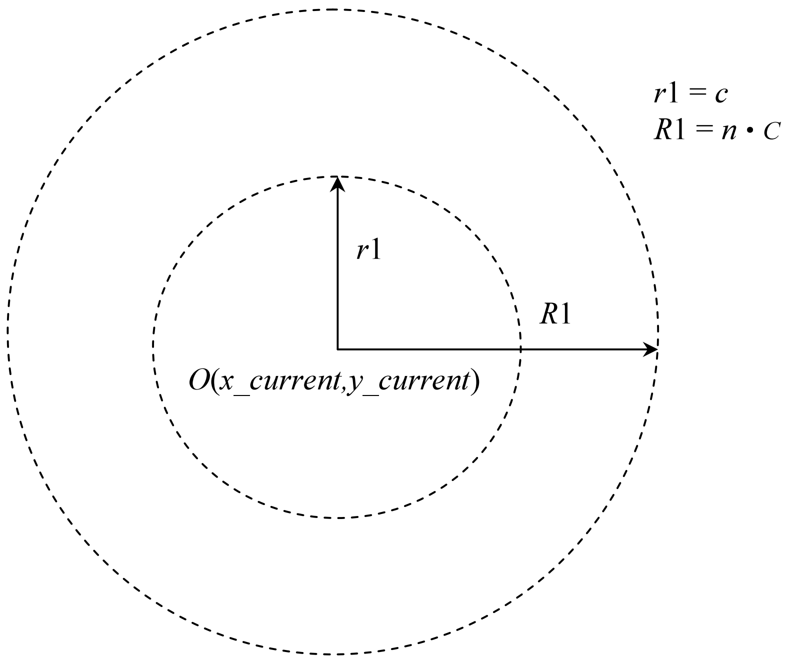

Fig.1. Description of node region

To facilitate discussion, we assume the node region and hot spots region in this work. The defined region of the node is as follows: each node can maintain a communication center *O*, and $R1$ is the radius of a circular area. In this region, the coordinates of the center *O* is (*x_current*, *y_current*) which is the current GPS position coordinates of the nodes. The radius $R1$ of the region is $n \cdot c$ where *c* is the vehicle's own wireless communication capabilities and *n* is the number of hops. The above parameters are initialized with certain values, and the node according to its own learning control change of the value. As shown in Fig.1.

Hops *n* is given initializing certain value as $n = 5$. The value of *n* is automatically adjusted according to the successful message transmission time as Equation (1):

$$\begin{cases} n = n+1, request\_time > n * T\_\lim \\ n = n-1, request\_time < n * T\_\lim \end{cases}. \tag{1}$$

*T*_lim is defined as:

$$T\_\lim = \frac{R1 + c}{\bar{v}}. \tag{2}$$

Where $\bar{v}$ is the average speed of the nodes in the region which can be easy to calculate, and $R1$ is the radius of the area of the vehicle itself which is the vehicle's own wireless communication capabilities.

Suppose node A may be the source node or the intermediate node, and a message of the cache is broadcast according to the need. The broadcast message on the intermediate node has the coordinates of an intermediate node comprising, after the second broadcast node A of the one-hop neighbor nodes will receive the message. Suppose node B receives the broadcast message, and it first checks whether it is the destination node. If the node B is the destination node, it must send a feedback message to the source node; otherwise proceed with the calculation.

Node B checks whether its own cache nodes have the news, and if there will be a message directed broadcast. For any news, set a tolerable life time, in this time, as long as there is a need to broadcast news, when the tolerable time runs out decreasing execution times news broadcast. If the distance between the intermediate node B and other intermediate nodes is less than or equal to the area between the radius of B, and the node B receives the message and storage and then directed broadcast; otherwise, B receives the message and uses their own coordinate message to update the routing table at the same time, and the original routing information is preserved which is broadcasted by B later.

In directed broadcast system, the node and the intermediate node broadcast message in the same direction to reduce the amount of copies of the message and the energy expenditure of nodes as shown in Fig.2.

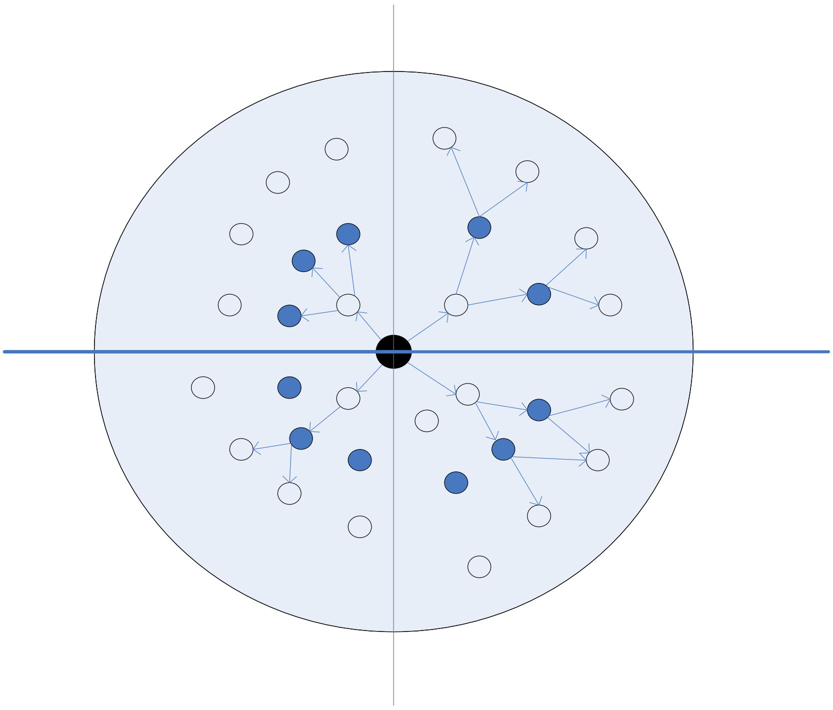

Fig.2. Directed broadcast system

As shown in Fig.3, the node A_3 in the communication radius of node A_0 can receive the message which node A_0 broadcast, then node A_3 directly broadcast this message to node A_3 ' in same direction.

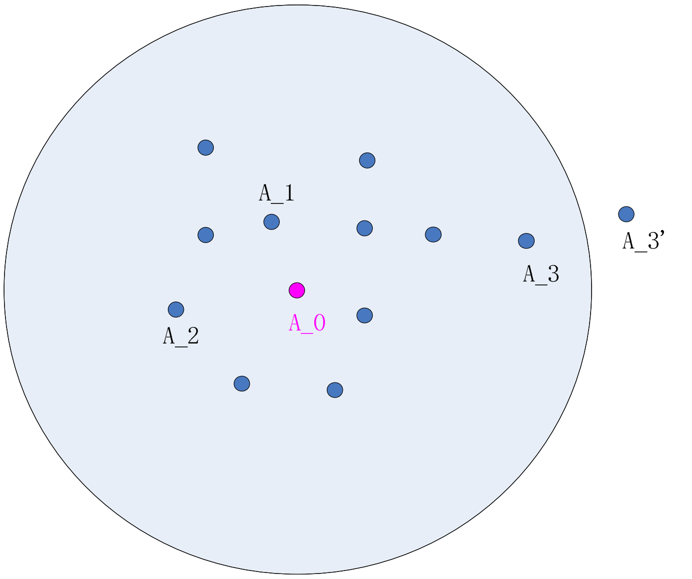

Fig.3. An example of directed broadcast system

2.3 Regional information collection and storage

All of nodes aren't always transmitting message at all times. Nodes can periodically broadcast message to exchange their information such as location, speed, direction and neighbor node list. The collected information is stored on the node, and the node can know its coordinates and radius of region. When a node knows the distribution of other nodes in its region, the node can build a local temporary stabilization diagram and run the routing algorithm for message transmission.

The neighbor nodes of node can update their real-time neighbor link table. When a node receives the broadcast message of its neighbors, the node can know the real-time topology information around it. According to the received broadcast message, the node will decide whether to update the new neighbor node list.

Through the exchange of information periodically, a node can know the distribution of velocity density of their small domains of the vehicle. With these limited local real-time information, the node can establish local link list and define the region.

When the source node want to send the message to the destination node, the source node can use GPSR routing message transmission or by some local routing information transmission. The node carry out local information transmission algorithm to choose the intermediate region close to the objective area as the middle region of the message transmission.

2.4 Hot region

Each node maintains its own a region and the one-hop neighbor information. The node can get the location of the destination node by quickly limited inquiry, and dynamically query intermediate hot region to transmit messages.

Hot region is defined the number of nodes which must meet the certain value N_lim shown in formula (3):

$$n \geq N\_\lim, R^{'} = R + c, N\_\lim = \frac{(2R^{'})^2}{\pi c^2} = \frac{4(n+1)^2}{\pi}. \quad (3)$$

For each hot region, we need to maintain the appropriate information as shown below:

1) $coord$: coordinates of center.

2) R: radius of hot region.

3) ρ : the node density in the region.

4) $\bar{v}$: average speed of nodes in the region.

5) *time*.

6) *life*: survival time of the hot region.

The life is defined as:

$$life = \frac{R+c}{\bar{v}}, \bar{v} = \frac{1}{num\_node}\sum v\_node\_i, \quad (4)$$

where the *num_node* is the number of nodes in the hot region, and *v_node_i* is the speed of each node in the hot region.

For detecting the new hot region, and the nodes first check own cache using equation (5),as follow:

$$Dis < \frac{R\_new + R\_temp}{2}, Dis = |coord\_new - coord\_temp|. \quad (5)$$

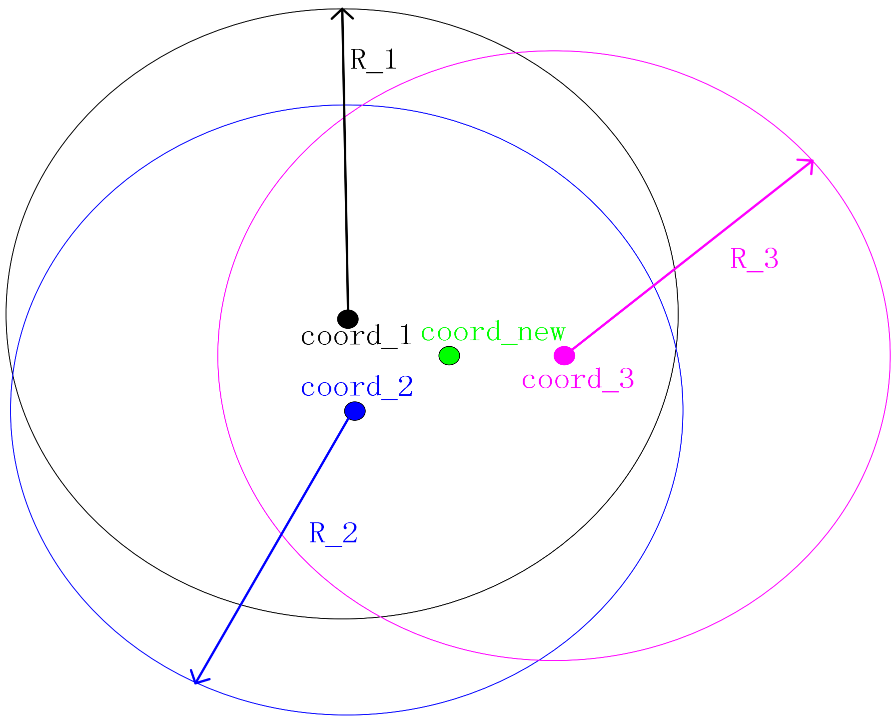

Fig.4. Update of hot region

Where *R_new* is the radius of the new hot region, *R_temp* is the radius of the hot region in the cache, *coord* is the center coordinates, *Dis* is the center distance for the two regional centers, the *coord_new* is calculated as shown in Fig.4.

2.5 Information feedback and re-transmission

When the source node obtains the feedback message from the destination node, nodes can better search the middle region for the directional message transmission. If the source node or intermediate node will choose hot region with the same direction of target node region to transmit message, the node can use equation (6),as follow:

$$check = \rho + \frac{Ds - d}{Ds - temp}, \tag{6}$$

where ρ is the number of nodes within the region, $Ds - d$ is the distance between the region of the source node(intermediate region) and the center of region of destination node, and $Ds - temp$ is the distance between the region of the source node(intermediate region) and the center of region of available next-hop node. As shown in Fig.5, this is a selection of hot region in a 45 degree range as possible options in order to choose the middle region with higher density of nodes for reliable communication.

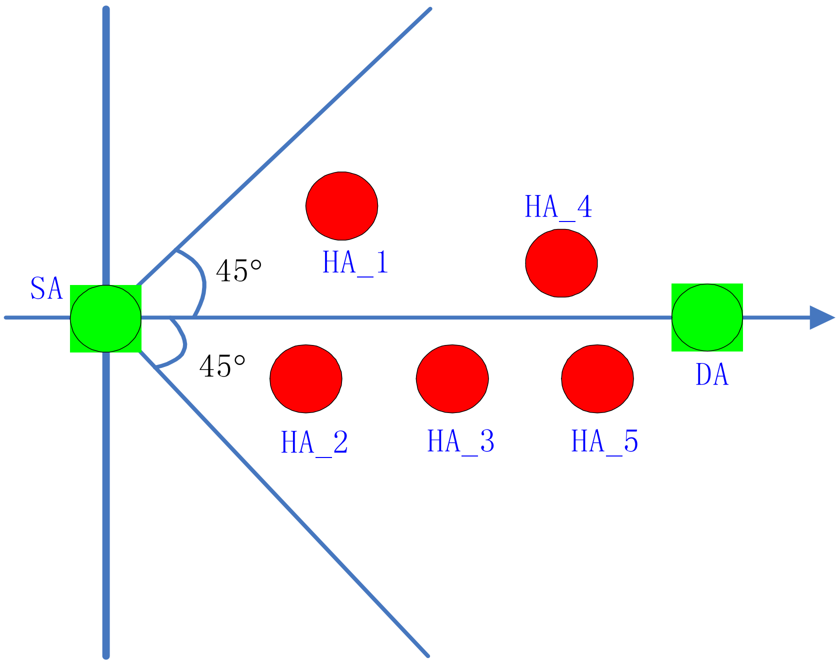

Fig.5. Selection of hot region

If a hot region shall be used as the candidate region, the angle calculation for judgment is given as:

$$\theta = \arccos \frac{\overrightarrow{ST} \bullet \overrightarrow{SD}}{\left|\overrightarrow{ST}\right| \bullet \left|\overrightarrow{SD}\right|}, \tag{7}$$

where, S is the center of the region of the source node, D is the center of the region of the destination node, T is the center of the region of old next-hop node of the source node which is stored in the cache of the source node. If $\theta \le 45^0$, the hot region is a candidate region for the next step and the node can calculate the value of *check*.

If a node get the value of *check*, the node will determine the next message forwarding direction. Node S maintains a neighbor nodes list and knows the next-hop node *N_next*. When S is forwarding data, the control time *time_ctrl* is defined as:

$$time\_ctrl = \frac{Ds - N\_nest}{\overline{v_s}}. \tag{8}$$

If the node *N_next* receives the message from node *S* within the *time_ctrl*, node *N_next* will send the feedback for confirmation and recalculate the forward direction. If the *S* does not receive the feedback from *N_next*, *S* will start the message forward again.

As shown in Fig.6, the source node A_0 maintains a neighbor nodes list by which the node A_0 knows that the node A_k is in its communication range. The destination node A_k' is not in the communication range of the source node A_0, and node A_0 must rely on the intermediate nodes such as the node A_k to forward message to the node A_k', because . Within the time *time_ctrl*, if the node A_k receives the message which A_0 send, the node A_k will update the information in its cache and calculate the middle area to obtain the next-hop node for message forward. Furthermore, the node A_k will send a feedback to A_0 for confirmation. Within the time *time_ctrl*, if the node A_0 does not receive the feedback from A_k, the node A_0 immediately retransmits message to requery the next-hop node.

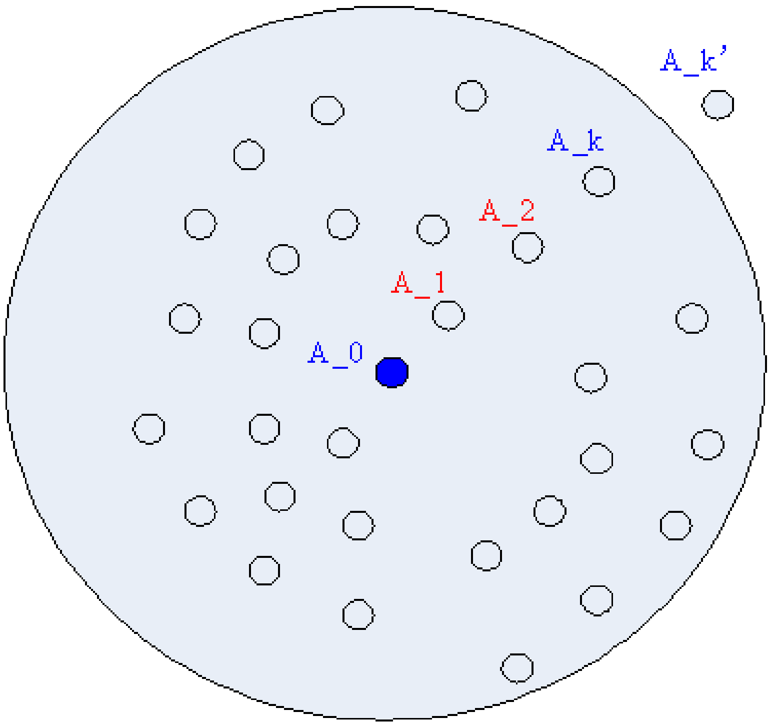

Fig.6. Communication between nodes

III. EXPERIMENTAL RESULTS AND ANALYSIS

The node can transmit and receive the message with other nodes, and .The routing algorithm is executed in each node as follow:

Start

The first step: process and broadcast the Hello packet.

The second step: monitor the HELLO packet which neighbor node send.

The third step: build or update the stable neighbor node list.

The fourth step: if a message needs to be forwarded, enter the fifth step to judge; otherwise, jump to the sixth step.

The fifth Step: determine the message is the routing message for forwarding data or feedback message for confirmation.

The sixth step: monitor the message from neighbor node. If the message has been received formerly, drop the message; otherwise, store the message in the queue waiting for forwarding or broadcasting.

The seventh step: if the control time run out, go to the first step to process and broadcast the Hello packet or rebroadcast feedback message.

End

In the local routing, nodes need to maintain some information such as the neighbor node list, hot region, the queue which store broadcast packet, and the queue which store forward packet.

We define the function MessageManageGenerator which manage the message, the pseudo code is shown as follows:

```
static int msg_ctrl=0;
if(++ctrl/3)
  create new Message(HELLO);
else
  create new Message(EVENT);
```

In the routing class, we override the message receiving method and transmitting method:

```
checkReceiving(Message msg)
{
   check message type;
   if HELLO msg
    refresh neighbor and hot region;
   else if EVENT msg
    StoreToForwardQueue();
```

```
}
startTransfer(Message msg)
{
   check(hot_region) and check(neighbor);
   transmit();
}
```

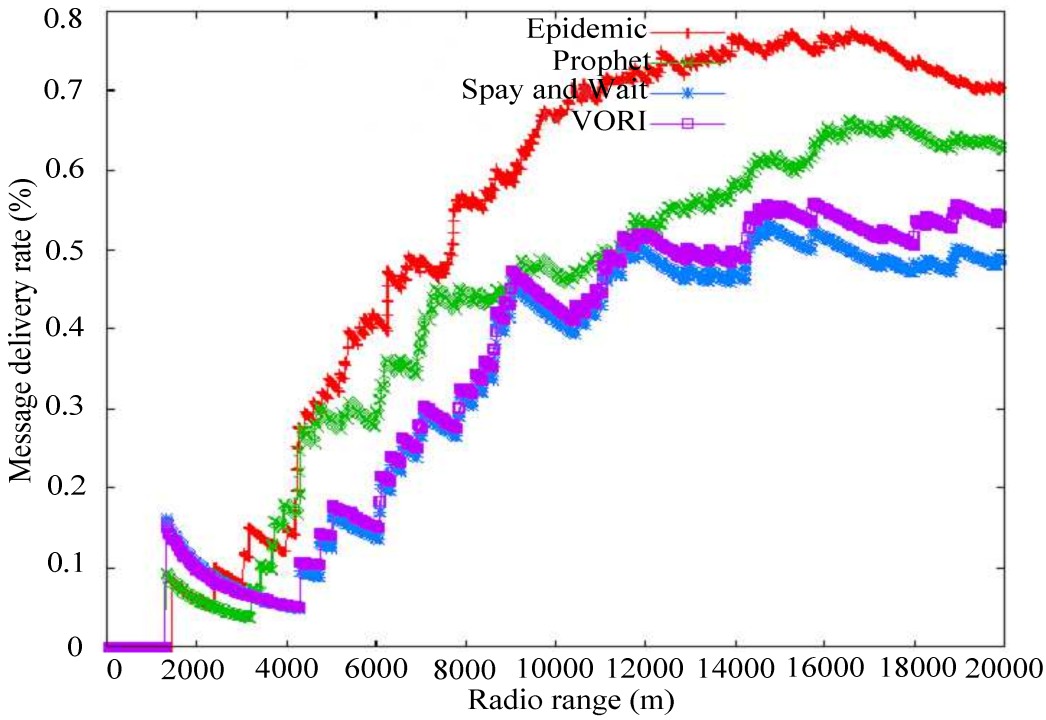

Fig.7. Comparison of message delivery rate

We simulate the proposed VORI algorithm. In the experiment we use a city map, and the size is 10000 * 8000 meters. We set up two kinds of mobile nodes representing the bus, taxi or private vehicles, and moving speed is set to 35km/h-50km/h , 40km/h-60km/h. The former moving model uses Map Based Movement, and the latter moving model uses Working Day Movement. The message cache on node is set to 9M. The node transmission speed is set to 256Kbps, and TTL of the message is set to 1300s. The nodes use GPS function to know their location.

In the same settings, the results of simulation were compared the proposed VORI algorithm with the classical routing algorithm such as Epidemic algorithm, Prophet algorithm, Spay and Wait algorithm. We use the metrics such as message delivery rate, cumulative delay probability, average buffer time, average number of hops and average overhead ratio to compare the proposed VORI algorithm with the algorithms mentioned above.

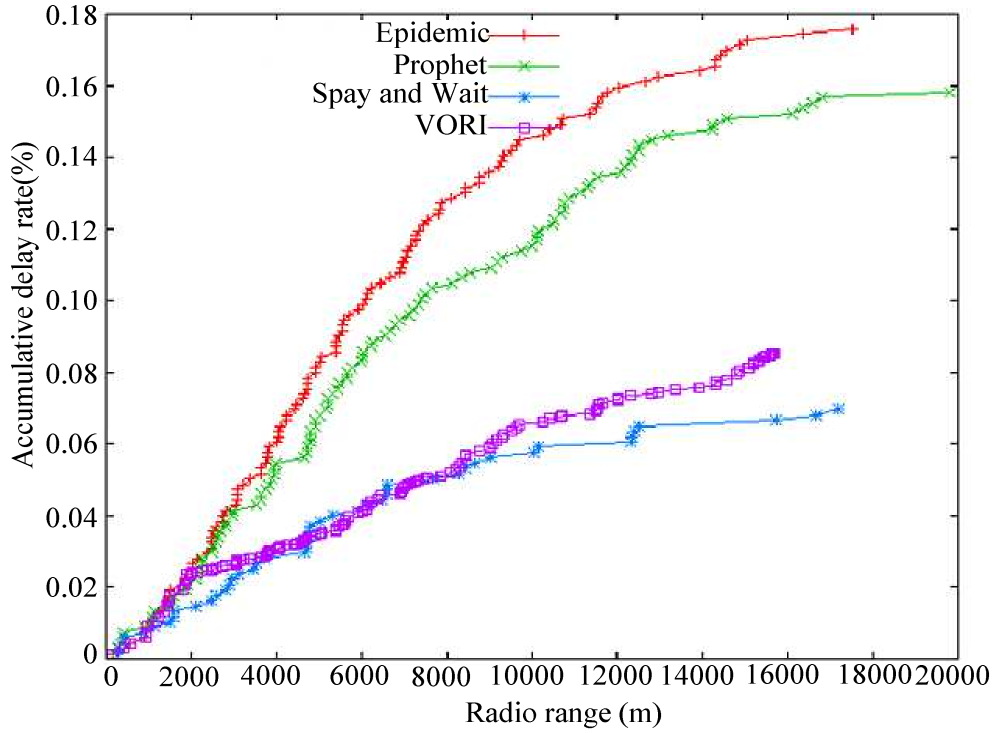

Fig.8. Cumulative delay probability statistical comparison

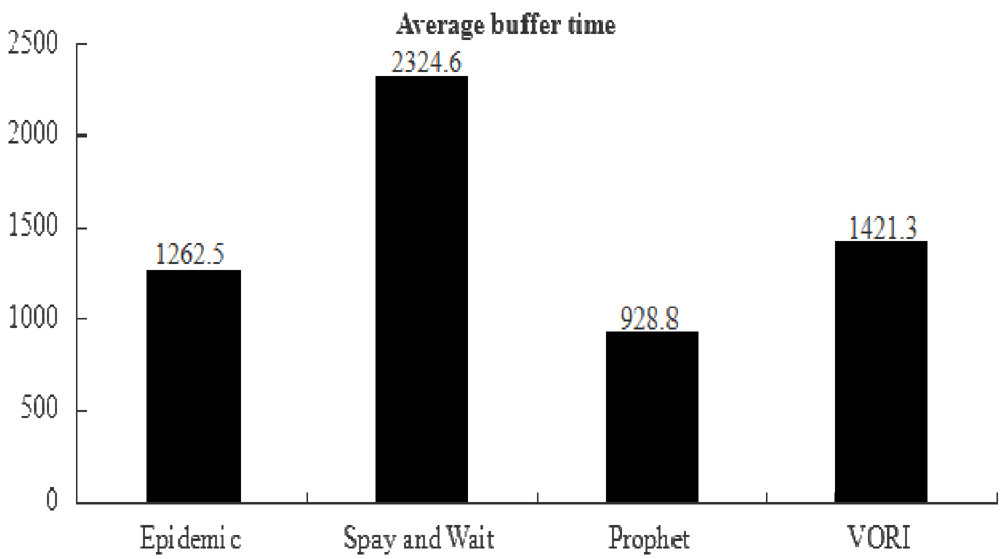

Fig.9. Comparison of average buffer time

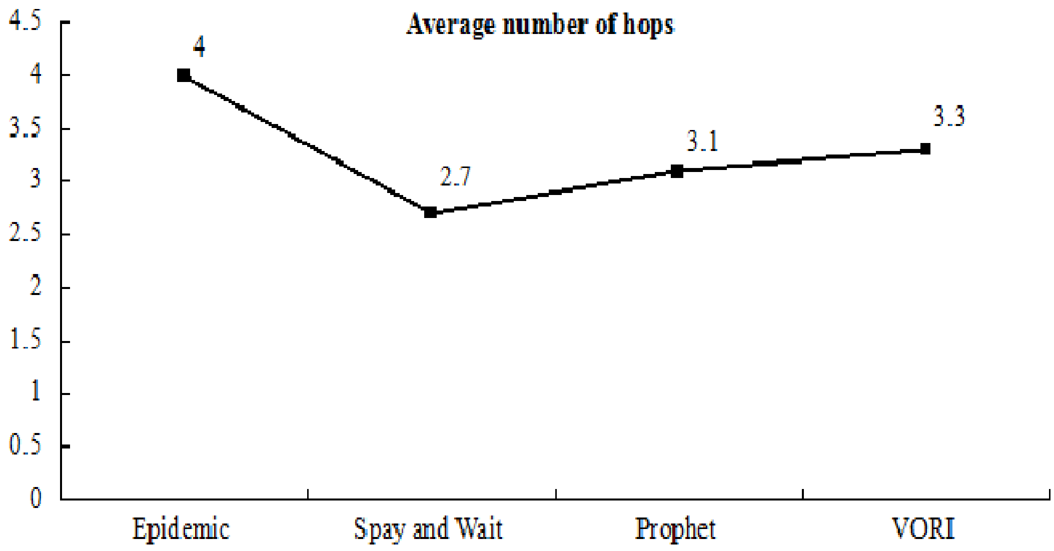

Fig.10. Comparison of average number of hops

Fig.7 illustrates the message delivery rate of VORI algorithm, in comparison to Epidemic algorithm, Prophet algorithm, Spay and Wait algorithm. The message delivery rate of VORI is less than Epidemic and Prophet. The message delivery rate of VORI is close to Spay and Wait algorithm from 0 to 12,000, and it has a little higher than Spay and Wait algorithm in the other values.

Fig.8 shows cumulative delay probability of message transmission of VORI algorithm, in comparison to Epidemic algorithm, Prophet algorithm, Spay and Wait algorithm. The growth delay rate of VORI algorithm significantly is lower than Epidemic and Prophet, and it is close to Spay and Wait algorithm from 4,000 to 9,000, and it is slightly more than Spay and Wait algorithm.

Fig.9 illustrates that the average buffer time of VORI algorithm is close to Epidemic algorithm, and it is more than Prophet Algorithm. On the whole, the performance of VORI algorithm is at the level of the middle class.

As shown in Fig.10, the average number of hops on the VORI Algorithm is close to Prophet Algorithm, and it is more than Spay and Wait algorithm.

As shown in Fig.11, the average overhead ratio of VORI algorithm is close to Spay and Wait algorithm, and it is far less than Epidemic algorithm and Prophet Algorithm. The VORI algorithm effectively utilizes the HELLO packet to exchange messages between the nodes to maintain the neighbor node list and build dynamic local network topology. We can see that that the VORI algorithm as a routing algorithm has certain advantages, but its the performance need to be improved further.

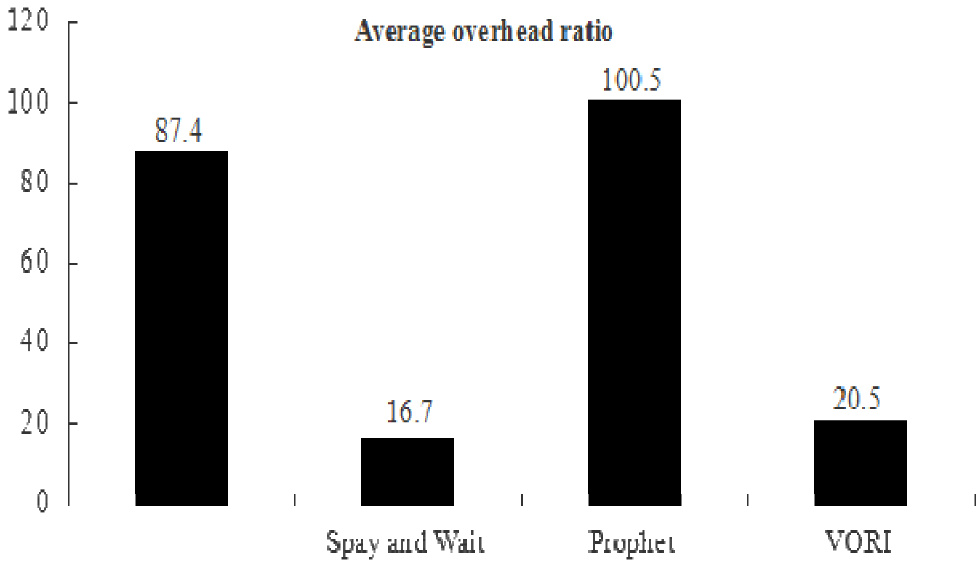

Fig.11. Comparison of average overhead ratio

IV. CONCLUSION

In this paper, the VORI algorithm is proposed which can maintain the state of the neighbor nodes by real-time perception. The VORI algorithm effectively utilizes the HELLO packet to transfer messages between the nodes, and it maintains the neighbor node list and build dynamic local network topology. The result of simulation shows that the VORI algorithm is energy-efficient. In the further, we will improve the VORI algorithm.

ACKNOWLEDGMENTS

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