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AN ANALYTICAL COMPARISION OF VARIOUS ROUTING PROTOCOLS IN VANET

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Abstract: A number of ad hoc routing protocols of vehicular ad hoc network (VANET) have been proposed and evaluated based on mobile ad hoc network (MANET) routing protocols. Although a large number of routing protocols have been developed in MANET, the VANET has different environments such as highly dynamic topology, frequently disconnected network, hard delay constraints for safety-related application, and various communications environments (e.g., highway or urban traffic scenarios). Therefore, development of a suitable routing protocol that considers these characteristics of VANET should be needed. In this paper we describe and comparing the Stable Routing, Connectivity-Sensed Routing and A Lightweight Neighbor-Info-Based Routing in VANET.

Keyword: Routing, Protocol, VANET, V2V, V2I.

I. INTRODUCTION

Vehicular ad hoc networks (VANETs) are an instantiation of mobile ad hoc networks (MANETs). Numerous routing protocols (e.g., [1–7]) for VANET have been proposed based on MANET routing protocols. Generally, MANET routing protocols have the main requirement to improve network performance to achieve minimal communication time with minimum consumption of network resources. Although a large number of routing protocols have been developed in MANET, a VANET routing protocol has different requirements [8] compared with the MANET routing protocols because the VANET has particular network environment as follows. A topology of the VANET usually changes due to high speed of movement between vehicles. A network could also be frequently disconnected by the same reason. The VANET is usually operated in two typical communication environments such as highway and urban traffic scenarios.

Due to the special environment in VANET, it cannot have a widely applicable routing algorithm.The typical algorithm in VANET, such as GSR routing protocol, involves each node storing the neighbor lists, topology table, next hop table, and distance table. All of them maintain the state information of adjacent nodes and choose the appropriate router according to the location and topological information. In small network with high mobility and limited bandwidth, the performance of transmission is good However, it requires the node to maintain the network topology. And with the increase of network size, the routing information that needs to be exchanged will increase exponentially. Another type of algorithm, such as the GPSR [5, 11], is based on position. It depends on the overall geographical location information search system. It cannot work without GPS.

Along with the fast development of VANET application, for example, the safety application and infotainment application, more and more promising applications and the cost effectiveness of VANETs constitute major motivations behind increasing interest in such networks. Except for driving the development of VANETs, those applications are calling for more reliable network connectivity as well.

The issue of intermittent connectivity becomes rather vital. Therefore, designing specific routing protocols for urban scenario is more and more significant. Many works have been researching on that problem. When intermittent connectivity happens, one of the most adopted repair strategies is carry and forward [7] strategy: a moving vehicle stores the packet when it cannot find its next hop until a valid vehicle appears in its transmission range. Besides, [1] studied the multipath routing scheme, which can also improve the packet delivery to some extent. To further improve the reliability of packets delivering, opportunistic routing [3] strategy was put forward and studied.

II. DISTANCE-BASED STABLE ROUTING DECISION SCHEME

We present the broadcasting scheme and the stable route decision scheme for urban inter vehicle communication. In this paper, our proposed scheme is focused on using vehicle to vehicle (V2V) communication in urban areas, without any support by using vehicle to infrastructure (V2I) communication. We assume that the communication protocol between the vehicles is IEEE 802.11p [13], and the transmission range is 200 m. The IEEE 802.11p based communication device is equipped with the global positioning system (GPS) or another global navigation satellite system (GNSS) for each vehicle. These devices have geographic information such as map and periodically send HELLO messages (i.e., beacons) announcing their information to their neighbors. Therefore, every vehicle can acquire the neighbor vehicle information, (e.g., position,

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speed, moving direction) in its neighborhood area. The proposed scheme is based on distance-based broadcasting method using the distance between vehicles based on information of vehicle's position. As the POVRP, every node periodically broadcasts the HELLO message that contains its own position and retains information of its neighbors' position within a single hop. The proposed scheme is designed to effectively disseminate RREQ packets and select stable forwarding node in the intersection.

Broadcast Scheme for Urban Inter vehicle Communication.

On the legacy distance-based broadcast method, the sender transmits a broadcasting packet. Then, the receivers wait to rebroadcast it as soon as their own waiting time is expired. The waiting time is shorter for more distant receivers. When one of the receivers rebroadcasts the received message in advance, other nodes do not rebroadcast the same message and then discard it. Though one of receivers which has the Short waiting time fails to rebroadcast, another receiver which has long waiting time would try to rebroadcast when its own waiting time is expired. Equation (1) shows the basic waiting time on distance-based broadcasting method [13, 15, 16]:

Waiting Time = −MaxWT/ $Range \cdot d$ + MaxWT, (1)

where MaxWT: maximum waiting time, $Range$: radio range, and d: distance between vehicles.

In order to explore a destination node, a RREQ packet is disseminated from a source node by multi hopping broadcast until it arrives at the destination node. Although density of vehicles is enough to relay a RREQ packet, it does not ensure that a routing path is successfully established in urban area because RREQ packets should disseminate toward all directions at intersections. However, the influence of obstacles to the dissemination of packets should be considered

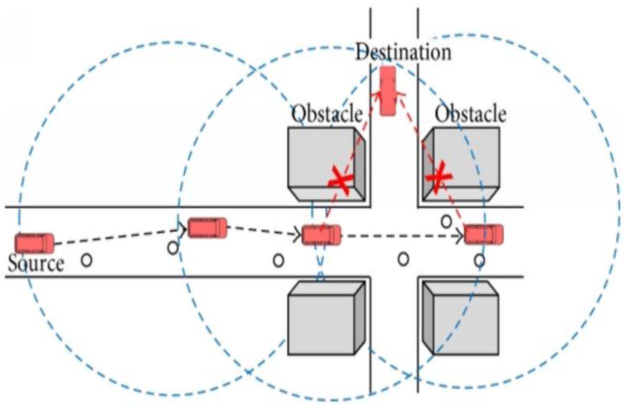

Figure 1: Unsuccessful routing path setup due to obstacles in urban area.

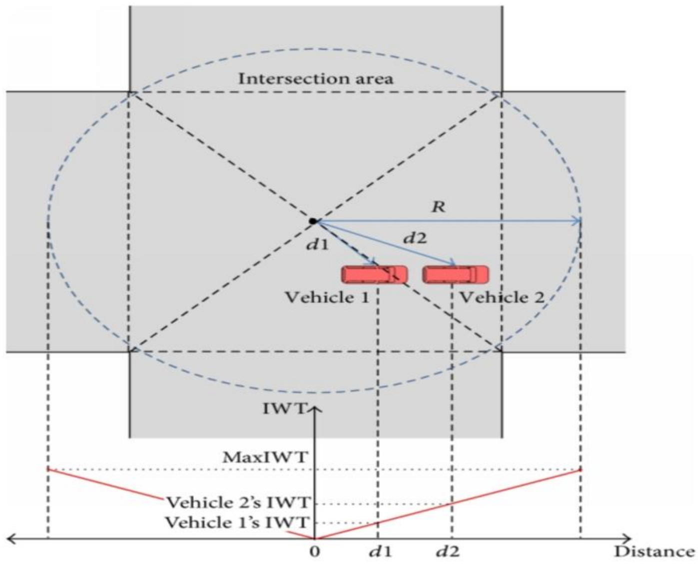

Figure 2: Calculation of the waiting time within an intersection.

In order to effectively disseminate RREQ packets toward all directions of intersection, the proposed scheme sets up shorter intersection waiting time (IWT) within intersection area than other waiting times out of intersection area. The value of IWT depends on a distance between vehicle's position and the center point of the intersection and is set below the maximum intersection waiting time (MaxIWT). A vehicle has shorter IWT than others when it is located closer to the center of the intersection as described in Figure 2. The reasons are to decrease the probability of packet collisions in the intersection and reduce an influence by obstacles surrounding an intersection. The center point of the intersection area can be calculated based on the center point of the dotted square described in Figure 2. The dotted square means the largest square where borders of all roads are extended inside an intersection. It can

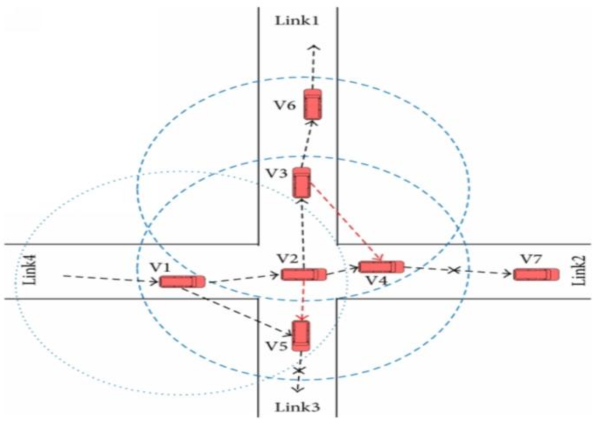

Figure 3: Problems of distance-based method in urban area.

be applied for asymmetric intersection patterns as well as T- junctions. The radius (R) is defined as the longest vertex of the square from the center point of the intersection area:

$$\text{IWT} = \text{MaxIWT}/R \cdot d\,\text{junction} \quad (\text{where } 0 \leq d\text{junction} \leq R), \quad (2)$$

Where IWT: intersection waiting time and $d$junction: distance between the vehicle and the center point in the intersection.

The IWT is calculated based on a radius of the intersection (R) and a distance between the vehicle's position and the center point in the intersection ($d$junction) as denoted in (2). The maximum value of IWT may be set to Max IWT when a vehicle is located on a border of the intersection area. The minimum value of IWT may be set to zero when the vehicle is located on the center of the intersection area.

III. CONNECTIVITY-SENSED ROUTING PROTOCOL

CSR is an intersection-based protocol. Different from those traditional intersection-based protocols, CSR takes advantages of computing power and tries to guarantee that the forwarder selects a road segment which not only brings progress to the destination, but also is with better connectivity. In this section, we will introduce our proposed CSR protocol in detail. Then we implement simulations by NS2 [10] and VanetMobisim [9].

1. Problem Statement. Nodes in VANETs move in specific patterns which are restricted to roads and, as a result, they are not distributed evenly any more. Traditional geographic routing protocols which only consider distance progress and vehicle density will suffer serious intermittent connectivity and will fail to deliver the packets in such a case. Figure 5 shows such network situation. The red path indicates the message routing path of GPCR and GPSR. The vehicles V1 and V2 cannot find the next hop within transmission range and finally the packets will be dropped. Traditional routing protocols face great challenges. Driven by the need to tackle such a problem, we propose CSR protocol.

2. Assumption. Along with the development of computer technology and embed system, the vehicle equipment is competent to execute high-speed calculation. Thus, more completed parameters can be taken into consideration in order to design a better-performing routing protocol.

Hardware. We assume that current technology can satisfy those hardware and software requirements on communication. That is, all vehicles are equipped with communication devices for wireless communication. Besides, vehicles are also equipped with GPS devices for positioning.

Negligible Vehicle Movement. Message propagation is instantaneous with respect to vehicle movement, and this assumption is supported by experiments in [9]. In thatwork, it takes 110 ms to transmit a message of 73 bytes with a device

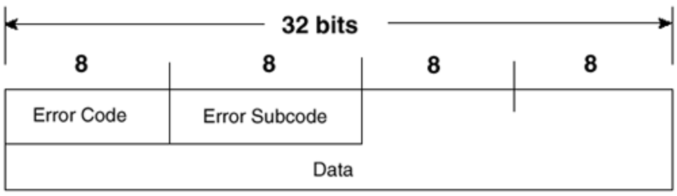

Figure 4: Notification message format

Whose transmission rate is 3.6 kb/s. If the transmission range is 500m, then a message can propagate as far as 5000mfor 10 hops, about 1.1 s. During that short time, the vehicles' flowing in and out of a certain road segment can be ignored.

3. Design Solution. In CSR protocol, we design a new method for an intersection forwarder to weigh the different intersections. As has mentioned above, [11] presents an intersection-based protocol GyTAR; it gives a score formula $(i) = \alpha \cdot f(T_i) + \beta \cdot (D_i)$, where T_i is traffic density and D_i is the curve metric distance (adjusted with road topology). Let us analyze the situation in Figure 5; we can obviously find that though traffic density on segments R1 and R3 is higher than that in segment R4, according to most intersection protocols in which traffic density and distance are major measuring factors in this case, the source car will choose I2 or I3 as its temporary destination and will forward data packet to vehicles on relevant segments. However, we can see that the distribution of vehicles is more uneven, which will cause intermittent connectivity. In our protocol, network connectivity is taken into consideration. Though traffic density in R4 is lower, the advantages in network community render segment R4 chosen. Therefore the packets will be successfully delivered following the red path.

4. Collection of the Vehicle Geographic Information. As has been discussed above, a forwarder located at an intersection needs to evaluate connectivity of adjacent roads by utilizing the vehicle geographic information. In CSR, such information is broadcasted by the infrastructure located at the intersection. Naturally, there is a question how to collect that vehicle geographic information. In academia, there are studies [10, 11] utilizing on-the-fly process to collect the information including average number of neighbors and one hop delay. There are two reasons why we do not use it .The first one is timeliness. When a vehicle arrives at an intersection, the information it obtains is probably from some time ago because the network quality also frequently changes. Second, the on-the-fly collection process needs an extra overhead, which will not only burden the network, but also incur an increase of collision probability, especially when raising the sending rate of on-the-fly packet to improve the timeliness.

In CSR, we assume this problem is treated by other highly real-time technical methods, for example, by electronic eyes which have been equipped at intersections combined with image processing, road sensors, or infrastructure affording relay in the future 5G [12].

5. Packet Format Design. In Figures 6 and 7, PI means the packet ID, T means the time starting sending this packet, and

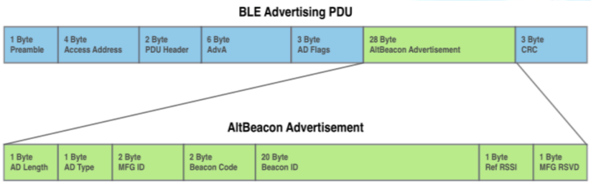

Figure 5: Beacon packet format

In Figure 4, for the notification message broadcasted by the intersection infrastructure, RI is the road ID and VP is the vehicle position. Particularly, in Figure 5, beacon packet contains MA (My Address, i.e., the current vehicle address), DA (Destination Address), and DI (Destination ID). The address is expressed by x coordinate and y coordinate in planar areas. Considering that too much payload will increase the burden of network, CSR restrains hello packet to a smaller size as possible. As a result, beacon period is able to be set to less than 1 s short and, thus, the geographic information will be more up-to-date. Infrastructures located at intersections can give needed geographical location information. How can these packets be used in CSR? In the following we will give a detailed description.

6.WorkingMode. According to the current vehicle's different position, CSR works in two modes: segment mode and intersection mode.

7.Segment Mode. When a packet travels on a road segment, the segment mode will work. In this mode, a forwarding vehicle transmits a data packet to its neighbor as far as possible. Such a method is called greedy scheme; though this scheme is not a standard so far, it is really adopted by the literature. If the forwarding vehicle does not have an available next hop, carry and forward strategy will be used as a repairing strategy.

8. Intersection Mode. If a data packet travels at an intersection; that is, a vehicle receives a data packet and finds itself at an intersection, then the CSR protocol goes into intersection mode. We call the vehicle that is in charge of selecting intersections and forwarding packets a coordinator.

In this mode, the coordinator sends request to the intersection for notification message; the intersection then sends notification message which contains needed information to the coordinator. Then the coordinator will calculate cost of all the adjacent intersections; the intersection with the smallest cost will be selected as the next temporary destination, and then the vehicle node at the intersection forwards data packets to its neighbor which is on that segment; Figure 10 illustrates such a situation. Particularly, in order to avoid the occurrence of routing loop, CSR increases the cost of the current segment to a large degree. By this way, packets will not be forwarded back to the current segment again. Thus, issues of routing loop will be averted. How to select a proper segment? In the following part, we will describe our designed intersection selecting scheme, called MMC.

IV.CONCLUSION

A VANET routing protocol has different requirements compared with the MANET routing protocols because the VANET has particular network environments. In this paper, we have proposed the enhanced distance-based VANET routing protocol and have applied two major approaches which are themultihop broadcast scheme for fast and reliable packet dissemination in the intersection and more stable route decision scheme based on the prioritized adaptive waiting time using a relative distance and a relative velocity between vehicles in order to select the stable relay node. We believe that network connectivity is a significant guidance to improve the routing protocol. Driven by the need for improving reliability of information transmission in urban VANETs, we present a stochastic analysis model to analyze the connectivity.

A Lightweight Neighbor-Info-Based routing protocol for taxi-calling application. it analyzes scenes of taxi-calling application and studies the differences between the common vehicle application scene and the taxi-calling application scene. Secondly, it proposes the routing information maintaining algorithm based on position prediction which performs better reliability. Thirdly, a self-network forming method for taxi-calling application is drawn up.

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