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An Efficient Routing in Urban Vehicular Ad Hoc Networks

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Abstract

VANET is a highly mobile wireless ad hoc network that is targeted to support road safety, traffic monitoring and other applications. The node communication is easy to break due to the high mobility of vehicles and the road layout. In this paper, we propose an efficient routing based on static node assistance. The static nodes are fixed in each intersection. Each static node stores information of other static nodes in path. The routing takes static nodes as backbone nodes and vehicles as relay nodes between static nodes. The static nodes are selected dynamically and sequentially, and they are chosen according to the delay that packets are forwarded from the current static node to the candidate one. The vehicular relay selection between two static nodes considers the link stability as the parameter. Simulation results show performance improvement comparing with performance of other existing routing approaches.

***Keywords**: VANET, Static Node Assistance, Vehicle Communication*

1. Introduction

By equipping vehicles with on-board wireless transceivers, the newly emerged vehicular ad hoc network enable vehicles on the road to wirelessly communicate with each other and to the roadside gateways for Internet access using the exclusive DSRC (dedicated short-range communications) radio spectrum. Over this new paradigm of networking, a variety of novel and exciting media applications, such as instant message, video streaming and social networking, *etc*., can be delivered to fleet travelers on the road to make their trips more efficient and enjoyable. This increasing importance has been recognized by major car manufacturers, governmental organizations, and the academic community. In the U.S., the Federal Communications Commission has allocated 75 MHz of spectrum at 5.9 GHz for dedicated short-range communications. An increasing number of car manufacturers are equipping vehicles with onboard computing and wireless communication devices, in-car sensors, and the global positioning system (GPS) in anticipation of the deployment of large-scale vehicular networks. A number of attractive applications that are unique for the vehicular setting have emerged [1]. VANET can be used for issuing driver alerts during specific events like potential traffic jams, hazardous road conditions (slippery road warning), or accidents (to avoid multi-car collisions). Apart from road safety applications, VANET is useful for other applications, including (1) info-mobility (weather information, gas station or restaurant location, city leisure information, tourist information, *etc*.). (2) Mobile e-commerce (advertisements or announcements of sales information). (3) Infotainment and interactive services (Internet access, distributed games, chats, music downloads, *etc*.).

The proposed routing must be adaptable to a highly dynamic topology of vehicles. This is a challenging task in VANET due to the following issues: (1) High mobility of the

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vehicles leads to frequent link breakages, which cause end to end routing unsuitable. In the case, if two cars are driving in opposite directions, the link will last only for several seconds. (2) Due to the random mobility of the vehicles, it is difficult to maintain the hop length uniformly.

The major focus of this paper is to provide a robust routing in urban environments. We consider a scenario where several ITS (Intelligent Transportion System) applications are deployed in a city scale, for both car-to-car communication services and value-added infrastructure-based ITS services. To guarantee efficiency to different applications, several important issues have to be tackled, the link is easy to break, road constrains the movement of vehicle, the topology of the VANET changes rapidly and so on. VANET is frequently disconnected because that the movement of vehicles is constrained by the roads causes many topology holes in the network. We focus on the design of a robust routing with static-node assistance. We take into account surviving the path that has been found for a period of time. Indeed, most VANET/ITS applications rely on multi-hop data delivery.

The rest of the paper is organized as follows. The related work is introduced in Section 2. The network model and problem statements are introduced in Section 3. The detailed description of our routing is in Section 4. In Section 5, we evaluate our proposed approach by simulation. We conclude our work in Section 6.

2. Related Works

Due to the high mobility of nodes and the constraint of road in VANET, some traditional routing protocols, such as AODV [2], DSR [3] are not suitable to VANET. Geograph- ical routing protocols, Geographic Source Routing (GSR), greedy perimeter stateless routing (GPSR) [4] use any nodes that ensures progress toward the destination as forwarding node. But, sometimes they cannot find any forwarding node. So, the packet will be stored in the forwarding node. In [5], the authors propose a lightweight proactive source routing (PSR) protocol. PSR can maintain more network topology information than distance vector (DV) routing to facilitate source routing, although it has much smaller overhead than traditional DV-based protocols. Utilizing the vehicles trajectory obtained from the navigation system, Feng proposed TaDB [6], a Trajectory-assisted Delay-Bounded Message Delivery Algorithm. To choose delivery route within delay constraint while minimizing transmission cost, TaDB uses a Cluster-Aware Link Delay Model to estimate link delay for both the Carry and the Forward strategies on each road segment. TaDB also leverages the vehicles planned trajectory to estimate its future location. Liang developed two algorithms[7], namely, the delay-inferred forwarding (DIF) algorithm and the probability-inferred forwarding (PIF) algorithm. The basic idea of DIF and PIF is to find the optimal forwarding path by minimizing the expected delay and by maximizing the expected probability, respectively, in the hop graph that is defined in their paper.

Yanmin Zhu *et al* [8] developed greedy algorithms for base station deployment. By mining a large dataset of real vehicular GPS traces, they show that there is strong regular- ity with vehicle mobility. With this important observation, they formulated a new objective of maximizing the expected sensing coverage. This takes random vehicle mobility into account and exploits the regularity in vehicle mobility. Ruob- ing Jiang [9] proposed a novel coverage graph to maintain collected trajectories of all the encountered vehicles and their most update timing information so that the extended coverage capability of each vehicle can be estimated. Their idea is to measure vehicles coverage capability and forward packets to those vehicles with higher probability to success- fully deliver the packets. Mershad *et al* [10] introduced a system that takes advantage of the Roadside Units (RSUs) that are connected to the Internet and that provide various types of information to VANET users.

Some other studies employed to help message delivery in [11] [12]. Fu *et al* formulate the V2V (vehicle to vehicle) data forwarding problem as a novel multi-objective Markov Decision Process (MDP)[11]. They exploit the vehicle trajectory information and traffic statistics to estimate the parameters of the MDP. Seh Chun Ng *et al* [12] developed an analytical model with a generic radio channel model to fully characterize the access probability and connectivity probability performance in a vehicular relay network considering both one-hop (direct access) and two- hop (via a relay) communications between a vehicle and the infrastructure. The paper [13] mines the extensive data sets of vehicular traces from two large cities in China, *i.e*., Shanghai and Shenzhen, through conditional entropy analysis, the authors find that there exists strong spatiotem- poral regularity with vehicle mobility. By extracting mobility patterns from historical vehicular traces, they develop accu- rate trajectory predictions by using multiple order Markov chains. Based on an analytical model, they theoretically derive packet delivery probability with predicted trajectories. They then propose routing algorithms taking full advantage of predicted probabilistic vehicular trajectories. Jeonghee *et al*[14] provide intersection-priority based RSU placement methods to find the optimal number and positions of RSUs for the full distribution providing with a maximal connec- tivity between RSUs while minimizing RSU setup costs. they propose three optimal algorithms: greedy,dynamic and hybrid algorithms.

Meneguette *et al* [15] developed a seamless flow mobility management architecture based on vehicular network ap- plication classes with network-based mobility management. Their goal is to minimize the time of flow connection exchange in order to comply with the minimum requirements of vehicular application classes, as well as to maximize their throughput. Robert Lasowski *et al* [16] introduced the idea of Beaconing as a Service approach which follows two core aspects. First, control the beacon rate intelligently with respect to a real benefit of a message transmission e.g. a vehicle detects a potential collision situation. Second, utilize the overall communication bandwidth, which is divided into several communication channels. Emmanuel Baccelli *et al* [17] provided a full analysis of the information propagation speed in bidirectional vehicular delay tolerant networks such as roads or highways.

Nianbo Liu *et al* [18] proposed the idea of ParkCast, which doesnt need investment, but leverages roadside park- ing to distribute contents in urban VANET. Such a col- laborative design paradigm exploits the sequential contacts between moving vehicles and parked ones, implements se- quential file transfer, and reduces unnecessary messages and collisions, and then expedites content distribution greatly. The secure and intelligent routing (SIR) protocol [19] is proposed to transmit the data in a quickest path through the authenticated vehicles. Sending the data in a most connected path with less link connection problem enhances the system performance and selecting the authenticated vehicles in this quickest path protects the system from the malicious attacks.

3. Network Model and Problem Statements

3.1. System Model

We consider a VANET that consists of two parts: the set *V* of all the moving vehicles and the set *SN* of all the static nodes. This paper assumes that each vehicle node is equipped with GPS device, which enable them to acquire its own position and velocity. Vehicles can determine the position of their neighboring intersections through preloaded digital maps, which provide a street-level map. The static nodes are set in each intersection. The real-time traffic information about related streets is sent to the specified static node by vehicles. The source node has known the position of the destination for making a decision to route.

We assume that the deployment of *SN* is given and the locations of the *SN* are fixed. The position of a vehicle is changing over time. When the distance between two nodes (two nodes $\in$ *SN* or *V*) is smaller than the transmission range, the two nodes can communicate with each other. Each vehicle generates data packets over time. We consider unicast data delivery, *i.e*., each packet *pa* has a single source, $s(p_a)$, and a single destination $d(p_a)$.

3.2. Problem Statements

The goal is to find a path from the source of each packet pa to its destination. The route for pa, denoted by Rp, is essentially a sequence of relays that can be a vehicular node or a static node. ri stands for a relay node.

Rp = $<r_0, r_1, \ldots, r_i, \ldots, r_k>$, $r_i \in V \cup SN$.

Apparently, $r_0 = s(p_a)$ and $r_k = d(p_a)$.

The path that has been found in a VANET is very fragile. The change of vehicles movement direction may lead the path to break. To solve this problem, we present a static-node-assisted routing. When the path has been found, each static node stores the information of other static nodes in the path. The path that takes static nodes as backbone nodes and vehicles as the relay nodes between two static nodes can be survived.

In addition, if the target zone is in the transmission range of static node in the path, any vehicle within the transmission range of static nodes can forward data packets through the path during the period. Therefore, the method can increase the Packet Delivery Ratio and decrease the End-to-End Delay of packets.

4. The Routing Design

4.1. Static Nodes Selection

The real-time road information of the related streets is sent to the specified static node by the leaving vehicles. The information mainly consists of the velocity, the direction, the position and the number of vehicles. Let *density(sn,* sn_j*)* stand for the density of vehicle between the *sn* and sn_j, and *Csn_neighbor_SN* stand for the neighbor static node collection of the current static node. Let *Csn* be the current static node that needs to forward a packet.

Once the current node needs to forward a packet, it will estimate these delay time that packets are forwarded from the current static node to the candidate static nodes. The one that has the minimum delay will be chosen as the next relay static node.

Let sn_i be the static node *i*. The sn_j is the neighbor static node of the sn_i. The delay that packets are forwarded from sn_i to sn_j can be calculated according to the following formula[20].

$$T(sn_i, sn_j) = w(sn_i, sn_j) + t(sn_i + sn_j) \tag{1}$$

Here, the $w(sn_i, sn_j)$ is the wait time that the packet are stored in the current static nodes until the packet are forwarded to one vehicle. The $t(sn_i, sn_j)$ is the time that the packet is forwarded from sn_i to sn_j by road L_{ij}.

Let λ be the reach that vehicles run into the road L_{ij}. So,

$$\lambda = speed(sn_i, sn_j) \cdot density(sn_i, sn_j) \cdot \tag{2}$$

Here, $speed(sn_i, sn_j)$ stand for the average speed of the vehicles in the road L_{ij} and $density(sn_i, sn_j)$ stand for the density of the vehicles in the road L_{ij}. So, $w(sn_i, sn_j)$ can be calculated according to the following formula.

$$w(sn_i, sn_j) = 1/\lambda = 1/(speed(sn_i, sn_j) \cdot density(sn_i, sn_j)) \tag{3}$$

The $t(sn, sn_j)$ will be calculated considering the density of road, the average speed of vehicles in the road, the length of road. The function that calculates $t(sn_i, sn_j)$ shown as follow,

$$t(sn_i, sn_j) = f(density(sn_i, sn_j), speed(sn_i, sn_j), length(sn_i, sn_j)) \quad (4)$$

If there are very small amounts of vehicles in the road, the delay $t(sn_i, sn_j)$ can be calculated as $t(sn_i, sn_j)=length(sn_i, sn_j)/speed(sn_i, sn_j)$. The $speed(sn_i, sn_j)$ is the average speed of the current vehicle. If there are enough vehicles to forward packets, $t(sn_i, sn_j)$ will be very small.

We assume that the deployment of *SN* is given and the locations of the *SN* are fixed. The map can be modeled as a graph G(V, E). Let V be the collection of the static node and E be the collection of the road. Let $T(sn_i, sn_j)$ be the weight of the road L_{ij}. So, we can estimate the delay matrix of the graph. When the source node and the destination node are determined, SNAR can select the next static node based on the delay matrix.

The current node selects its next relay static node by applying Algorithm 1.

Algorithm 1. The current static node Csn selects its next relay static node

```
Input: sn, sn_neighbor_SN,   density(sn_snj),
         speed(sn_snj);
Output: opt_sn;

opt_sn=Φ;
T_sn[]=Φ;
success=0;
min_delay=0;
index=0;
if (success==0) then
   for each neighbor static node snj ∈
        sni_neighbor_SN
        do T_sn [j]=w(sn, snj) + t(sn, snj)
   end
   for each T_sn
   do select the minimum delay of the T_sn[index];
   end
  if (min_delay!=0) then
     success=1;
     opt_sn=snindex;
     break;
   else opt_sn=Φ;
end
return opt_sn;
```

4.2. Packet Dissemination Between Two Static Nodes

Once the next relay static node has been selected, a link-stability calculation is adopted to determine the next vehicular relay. The vehicle that has the maximum link-stability value will be selected to the next relay node. If there are the same link-stability values in candidates, the forwarding vehicle randomly chooses one as the next hop. The current node selects its next relay by applying Algorithm 2. Each vehicle maintains a neighbor collection, is denoted by *v_neighbor_C*, in which the real-time information of each neighbor vehicle is recorded. This collection is built and updated through Hello messages periodically exchanged by all vehicles. *stability_v_v*$_j$ stand for the link stability between *v* and *v_neighbor_C*. Figure 1 shows that the current node selects its relay node.

```
Algorithm 2. The current node v selects its next
relay node
----------------------------------------------------
input : v_neighbor_C, v
output: opt_v

stability_v_vj[];
success=0;
max_stability=0;
index=0;
if(success==0) then
   for each element k in v_neighbor_C do
     calculate the stability between v_neighbor_C[]
and v;
   end
   for each stability_v_vj do
     select the maximum one of the
stability_v_vj[index];
   end
   if (max_stability!=0) then
      success=1;
      opt_v= v_neighbor_C[index];
      break;
    else opt_v=Φ;
end
return opt_v;
```

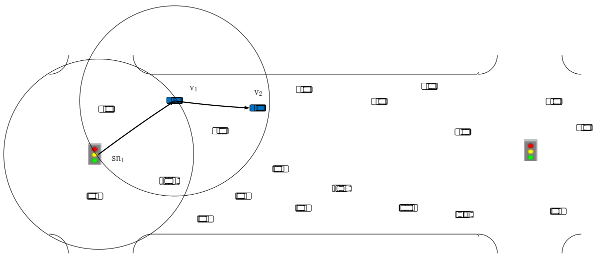

Figure 1. The Current Node Selects a Vehicle as the Next Hop

4.3. The Link Stability Calculation

Define the link stability is the probability that the link is active in a given time. If the link L_i is active at t_0, let $r(L_i,t_0, \Delta t)$ be the link stability that the link L_i is active at $t_0+\Delta t$.

Usually, when vehicles freely drive, the distribution of the time headway is the exponential distribution [21]. When the speeds of the vehicles in the traffic flow are supposed to be uniform, the distribution of the space headway will have the same distribution as the time headway. Thus, the distribution of the distance d between vehicles is expressed by the exponential distribution.

$$f(d) = \lambda e^{-\lambda d} \quad (5)$$

Where λ represents the traffic density in vehicles per kilometer.

Let R be the max radio communication range. The probability $F(R, \lambda)$ that a vehicle exists within the communication range R is expressed as

$$F(R,\lambda) = P(d < R) = \int_0^R f(d)d_D = 1 - e^{-\lambda R}$$

(6)

Consider m vehicles on a single-lane road of length L. The m cars determine m-1 inter-vehicle segments. The probability that there is continuous radio connectivity between vehicles along the road is equal to the probability that there are m consecutive vehicles driving at distances of less than *R*, which can be calculated as

$$P(\lambda, R, m) = \prod_1^{m-1} F(R,\lambda) = (1 - e^{-\lambda R})^{m-1}$$

(7)

Where m-1 could be approximated by the integer value of L/R.

Figure 2 depicts the probability of continuous radio connectivity as a function of λ (the average number of vehicles per kilometer) for different road lengths. The max radio range is set to 250 m. As seen in the figure, when the density λ increases, the probability of connectivity noticeably improves. For example, for a road of length L =5R (1250 m), we have a good connectivity (Pr =0.96) from λ =10 vehicles/kilometer. Furthermore, when we have a traffic density of 12vehicles/kilometer, we have a probability of continuous connectivity almost equal to 1 for the different street lengths.

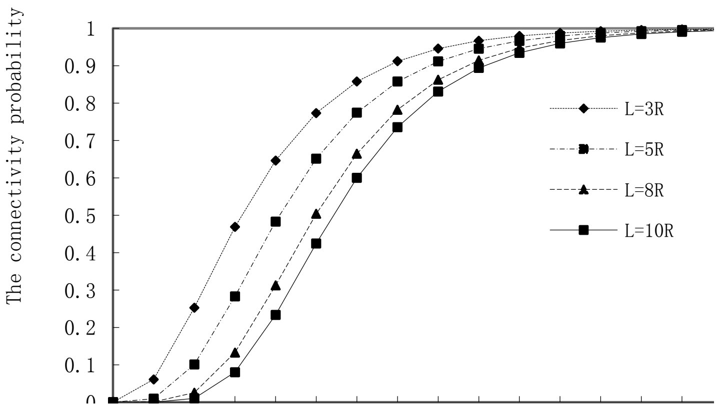

Figure 2. The Connectivity Probability Over Density

We denote the probability density function (PDF) and cumulative distribution function (CDF) of the gap distribution respectively, $f_g(x) = \lambda e^{-\lambda x}$, $F_g(x) = 1 - e^{-\lambda x}$. Where λ=σ/Ev, σ denotes the mean arrival rate of vehicles at the street. Ev denotes the average speed of vehicles at the street.

The probability that there are n nodes in the interval (0, L] is a Poisson point process,

$$P(X = n) = \frac{(\lambda L)^n}{n!} e^{-\lambda L}$$

(8)

d(s, n1) denotes the distance of node s and node n1 and R denotes the max radio transmission range. The solid circle in Figure 4 is a circle with radius R and s as center. The node n1 is the node which is nearest to the destination in the radio transmission range of node s in Figure 4. d(n1,n2)>R, So, node n1 can continue to forward the packet to another node n2 when there is at least one relay node in the radio transmission range of node n1. The probability that there is at least one node within the distance d(n1,x) is

$$P = 1 - P(X = 0)$$
$$= 1 - e^{-\lambda \cdot d(n_1, x)}$$
(9)

Here, x is the assumption relay node, and $d(n_1,x)<R$.

If the probability that there is at least one relay node within the distance d(n1,x) is p0, we get the min of the distance of node s and node n1,

$$d(n_1, x) > \frac{\ln(1 - p_0)}{-\lambda}$$
(10)

So, the time that n_1 can communicate with n_2 is $\Delta t = \frac{R - d}{\bar{v}}$, $\bar{v}$ is the relative velocity of the two vehicles. The link stability $r(L_i, t_0, \Delta t) = p_0$.

Figure 3 show the connectivity probability that there is at least one node within different distance to node s.

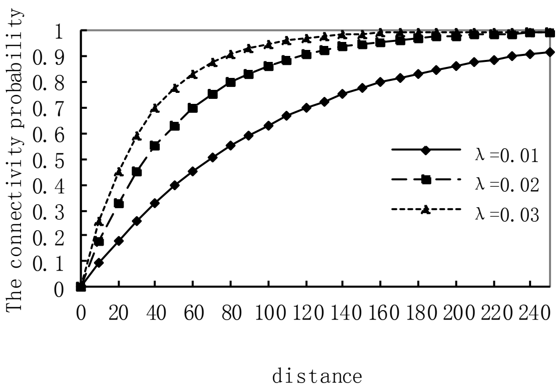

Figure 3. The Probability that there is at Least One Node within Different Distance to Nodes

5. Simulations

In our simulations, we performed a set of experiments for simulation area which has 12 streets. The simulation parameters are given in Table 1. We mainly compare Our Routing with GSR (Geographic Source Routing) and LAR (Location-Aided Routing) in two metrics: delivery ratio and average end to end delay.

Table 1. Simulation Parameters

Parameter	Value
MAC Type	IEEE 802.11 DCF
Channel Capacity	2Mbps
Traffic Model	15CBR connections
Channel type	Wireless
Weight factors(α,β)	(0.5,0.5)
Simulation times	600seconds
Simulation area	4000m*4000m
Number of static nodes	36
Number of roads	12

Number of vehicles	40
Average node speed	36km/hr
Data Packet Size	512bytes
Transmission range	200m

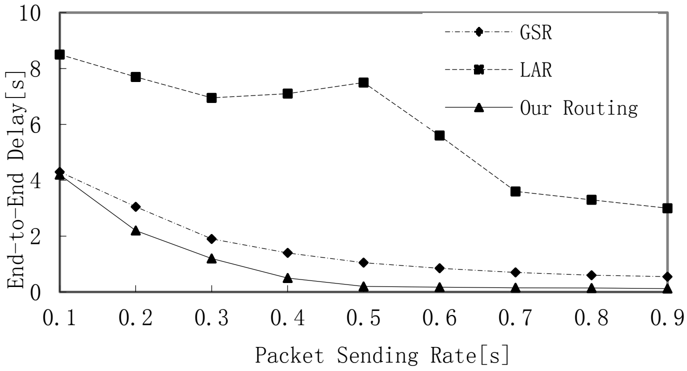

Figure 4. End-to-End Delay Versus Packet Sending Rate(40 Nodes).

End-to-End delay: As shown in Figure 4, Our Routing achieves a lower end-to-end delay than GSR and LAR in all configurations. This is because in Our Routing, the route is progressively discovered when relaying data packets from the source to the destination and not need to keep track of an end-to-end route before sending data packets. In contrast, GSR and LAR use a route discovery mechanism that causes longer delays.

The delay of LAR is higher than GSR because packets whose delivery was suspended are stored in the buffer longer than in GSR's suspension buffer. Indeed, thanks to its more appropriate choice of routes, GSR uses its recovery mechanism less often and for smaller periods of time compared with LAR.

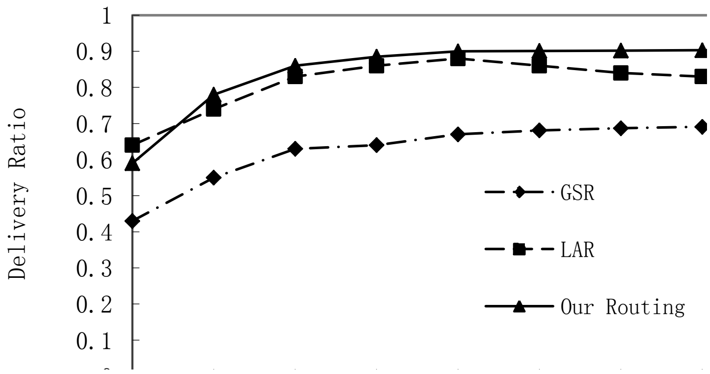

Figure 5. Delivery Ratio versus Packet Sending Rate (40 nodes).

Packet delivery ratio: Figure 5 shows that Our Routing achieves the highest packet delivery ratio for almost all packet sending rates. This is mainly because in Our Routing, the path is progressively determined, following the road traffic density and the urban environment characteristics. Hence, a packet will successively move closer toward the destination along streets where there are enough vehicles to provide connectivity. On the other hand, in GSR, a complete sequence of waypoints is computed before the packet is originally transmitted by the source and without considering the vehicular traffic. Consequently, some data packets cannot reach their destination due to a lack of connectivity on some sections of streets.

LAR has a much higher delivery ratio than GSR. This is because with local recovery, packets that encounter the local optimum can be rerouted and delivered instead of being dropped. The increase in packet delivery ratio is more significant in the case of lower node numbers where the local optimum is frequently encountered.

6. Conclusion

We presented a study of routing in urban vehicular networks. We proposed a solution to the problems of the failures of links and extensively evaluated it. The main contribution of this work lies in the efficient routing that takes into account adopting a link stability based to forward packets between two static nodes. However, path dependant features like load balance and channel competition have not been considered. Our future work is to incorporate these factors into routing decision to enhance the performance.

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References

[1] J.Nzouonta, N.Rajgure, G.Wang, and C.Borcea, "VANET routing on city roads using real-time vehicular traffic information", IEEE Transaction on vehicular Technology, 58, 7**(2009)**, pp.3609-3626.
[2] C.E.Perkins, E.M.Royer, "Ad hoc on-demand distance vector routing", Proc. 2nd IEEE Workshop Mobile Computer System. Application, **(1999)**Feb, pp. 90-100.
[3] D.B.Johnson , D.A.Maltz, "Dynamic Source Routing in ad hoc wireless networks", Mobile Computer, 353, 5**(1996)**, pp. 153-161.
[4] B.Karp and H.Kung, "GPSR: Greedy perimeter stateless routing for wireless networks", Proc. 6th Annu. Int. MobiCom, **(2000)**Aug, pp. 2315- 2319.
[5] Zehua Wang, Yuanzhu Chen, Cheng Li. "PSR: A Lightweight Proactive Source Routing Protocol For Mobile Ad Hoc Networks", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, 63, 2**(2014)**, pp.859-868.
[6] Xiaojun Feng, Jin Zhang, and Qian Zhang, "Trajectory-Assisted Delay-Bounded Routing with Moving Receivers in Vehicular Ad-hoc Networks", Proceedings of the Nineteenth International Workshop on Quality of Service, ACM, **(2011)**Jun, pp.1-3.
[7] Mingjiong Liang, Zhiguo Zhang, Cong Liu, and Li Chen. "Multihop-Delivery-Quality-Based Routing in DTNs", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, 64, 3**(2015)**, pp.1095-1104.
[8] Yanmin Zhu,Youchen Bao,Bo Li, "On Maximizing Delay-Constrained Coverage of Urban Vehicular Networks", IEEE Journal on Selected Areas in Communications, 30, 4**(2012)**, pp.804-817.
[9] Ruobing Jiang, Yanmin Zhu, "Coverage-aware Geocast Routing in Urban Vehicular Networks ", 2012 IEEE 26th International Parallel and Distributed Processing Symposium Workshops & PhD Forum (IPDPSW) , **(2012)**May, pp.2522-2525.
[10] Mershad K. , Artail H.,"A Framework for Secure and Efficient Data Acquisition in Vehicular Ad Hoc Networks", IEEE Transactions on Vehicular Technology, 62, 2**(2013)**, pp.536-551.
[11] Maocai Fu, Xin Li, Fan Li, Xinyu Guo, Zhili Wu. "TMODF: Trajectory-based Multi-objective Optimal Data Forwarding in Vehicular Networks", IEEEE International Performance Computing and Communications Conference, **(2014)**, pp.1-8.
[12] Seh Chun Ng, Wuxiong Zhang, Yu Zhang, Yang Yang, Guoqiang Mao, "Analysis of Access and Connectivity Probabilities in Vehicular Relay Networks", IEEE Journal on Selected Areas in Communications, 29, 1**(2011)**, pp.140-150.
[13] Yanmin Zhu, Yuchen Wu, Bo Li, "Trajectory Improves Data Delivery in Urban Vehicular Networks", IEEE Transactions on Parallel and Distributed Systems, 25, 4**(2014)**, pp.1089-1100.
[14] Chi Jeonghee , Jo Yeongwon , Park Hyunsun , Park Soy- oung, "Intersection-priority based optimal RSU allocation for VANET", 2013 Fifth International Conference on Ubiquitous and Future Networks (ICUFN*)*,**(2013)**, pp. 350-355.

[15] Meneguette Rodolfo Ipolito, Bittencourt Luiz Fernando, Madeira Edmundo Roberto Mauro, "A seamless flow mobility management architecture for vehicular communication networks" , Journal of Communications and Networks, 15, 2**(2013)**, pp.207-216.
[16] Robert Lasowski, Claudia Linnhoff-Popien, "Beaconing as a Service-a novel service -oriented benconing strategy for vehicular ad hoc networks", 2012 IEEE Communications Magazine, 50, 10**(2012)**, pp.98-105.
[17] Emmanuel Baccelli, Philippe Jacquet, Bernard Mans, Georgios Rodolakis, "Highway Vehicular Delay Tolerant Networks: Information Propagation Speed Properties", IEEE Transactions on Information Theory, 58, 3**(2012)**, pp.1743-1756.
[18] Nianbo Liu, Ming Liu, Guihai Chen, Jiannong Cao, "The Sharing at Roadside: Vehicular Content Distribution Using Parked Vehicles", 2012 Proceeding IEEE INFCOM, **(2012)**Mar, pp.2641-2645.
[19] Sourav Kumar Bhoi, Pabitra Mohan Khilar. "SIR: a secure and intelligent routing protocol for vehicular ad hoc network", IET Networks, 4, 3**(2015)**, 185-194.
[20] Yong Ding, Li Xiao, "SADV: Static-Node-Assisted Adaptive Data Dissemination in Vehicular Networks", IEEE Transac- tions on Vehicular Technology, 59, 4**(2010)**.
[21] H. Inose and T. Hamada, Road Traffic Management. Tokyo, Japan: Sangyo-Tosho, **(1972)**.

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