Intelligent Traffic Scheduling Algorithm Based on Hybrid Differential Evolution Strategy

Hao WU

Nanjing Communications Institute of Technology, Nanjing Jiangsu, 211100, China

***Abstract* — The traditional wireless ad-hoc routing protocol is difficult to apply to VANETs because of the rapid movement of VANETs node as well as the dynamic topological structure, therefore we propose a hybrid traffic-aware routing protocol (HT-AR). The weight of section is evaluated through collecting real-time traffic information. The density of road node and network flow is integrated by hybrid traffic information. Optimal routing is selected according to the weight of each section and then reliable and stable routing is established. Function node is selected through effective mechanism at junction and traffic information is integrated through function nodse. Our simulation results show that compared with traditional geographic routing protocol, the proposed HT-AR program has made great improvement in both data transmission rate and network throughput performance.**

Keywords- junction; vanet, geographic routing; traffic information; intelligent traffic

I. INTRODUCTION

As an important component of intelligent traffic, VANETs（Vehicle Ad hoc Networks）realizes various applications[1] of accident early warning, driver assistance, road traffic information checking as well as Internet access service etc efficiently through vehicle to vehicle communication as well as vehicle and roadside facilities communication. VANETs plays an important role in accident early warning, ensuring traffic security, traffic management, passenger amusement and providing comfortable and safe driving environment for users, which is expected to become one of the classic applications of internet of things[1,2].

II. HT-AR

A. Hypothesis

The algorithm proposed in this paper is based on following hypothesis:

(1) All nodes in internet is equipped with GPS device, who can attain accurate position information of themselves; at the same time, all nodes are with wireless communication device, any of two nodes can communicate with each other within their communication range;

(2) Before source node sending data to target node, attain position information of target node and neighbor node through position service.

(3) The node in internet can attain street information, including a) topological structure of road; b) ID and position of junction; c) ID and length of road.

B. HT-AR Basic Concept

(1) Related information of neighbor node

The node periodicity of HT-AR program broadcasts "HELLO" message to neighbors, so that the neighbor nodes can attain the real-time information of surrounding nodes. The format of HELLO message is as shown in picture 1. Source node communication attains the timely information of neighbor nodes and selects the best transfer node.

TABLE 1. HELLO MESSAGE FORMAT

RoadID	Location(x,y)	At junction (Y or N)	TTLJ or Channel load

In which RoadID is the road number of this node and Location(x,y) is the location of the node. At junction(Y or N) refers to whether this node is at junction. If the node is at one junction, then the last column of table 1 is the residence time TTLJ of this node at crossroad, or else, the last is the road congestion time Channel load where node locates.

Each node needs to maintain neighbor information table and the format is as shown in table 2. When node receives "hello" message from other nodes, it will extract data from "hello" message to store in the neighbor information table.

TABLE 2. FORMAT OF NEIGHBOR INFORMATION STORAGE

NodeID	RoadID	Location(x,y)	At junction	TTLJ or Channel load	Time stamp
2	0012	(123.56,452.56)	Y	23s	9.0
4	0003	(128.56,432.43)	N	0.6	14.0

(2). Routing discovery

Definition: $G=(V,E)$ graph theory representation of node logical relationship, V and E are point set and edge set respectively. Establish routing stage, regard junction as point V and each road as edge E, each edge has their own weight. For the given two points, HT-AR can find the best routing route. At the beginning of data transmission, the source node needs to establish routing. According to the position of node, the establishment of routing has two situations.

First, node is at the non-junction. When node on the road receives a data packet, first it needs to check the destination of this packet, if the node is not the destination node of this packet, and then the node will find the following transfer node according to the destination of data packet. If a transfer node can be found successfully, send the data packet to the

DOI 10.5013/ IJSSST.a.17.40.20

ISSN: 1473-804x online, 1473-8031 print

transfer node. If can't find the transfer node, then adopt buffer storage and transfer until find the next node.

Second, node is at the junction. When the node at junction receives the data packet, it will check the destination of this data packet. If the node is not the destination of this packet and then check if this is the first time for the packet to arrive at this junction. If it is the first time, re-calculate the routing of this data packet immediately and then find the best transfer node. If can't find the next transfer node, and then recalculate the routing and continue to find the next transfer node.

(3) Selection mechanism of function node

It needs to deploy function node at each junction as the leader node (LN) of this junction, which is responsible for collecting real-time traffic information from neighboring roads periodically. LN is mainly responsible for the following three tasks:

1) Collect neighbor road traffic and network flow information timely;

2) Calculate the weight of road according to collected information and algorithm;

3) Allocate weight data of the located road to neighbor junctions.

In the paper, it divides the states of node into four categories based on different situations of nodes, which include sleep, monitor, compete and spread. The four states can make mutual transformation according to different input information.

When the node is not at junction, it enters into sleep state. Its state changes into monitor once the node enters junction. To monitor if LN exists at this junction, the node at monitor needs to set a countdown timer of T_m second. LN allocates the latest weight information packet WIU to neighbor nodes periodically, if not receive weight information packet WIU (Weight Information Update) within T_m, it means there is no LN at the moment and the node enters into compete state. If node receives WIU within T_m, and then the node is at monitor state and need to reset the current timer.

The node in compete state needs to set T_c countdown timer and compete the LN position with other nodes in compete state. T_c is calculated with formula (1).

$$T_c = \max\left(T_c^{th}, 1/\lceil TTLJ / \Delta t \rceil\right) + rand() \tag{1}$$

In which T_c^{th} is the upper limit of T_c. $rand()$ is the function of producing random number for reducing the probability of different nodes setting the same T_c. $\lceil \cdot \rceil$ is down take integer. Combining $TTLJ$, Δt is used to designate the countdown time of each node.

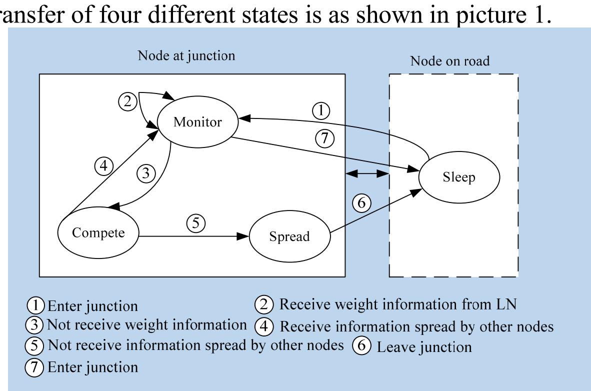
It can be learnt from formula (1) that, the bigger $TTLJ$, the smaller corresponding T_c. After T_c timing, node sends request message to neighbor to compete for new LN and enters spread state at the same time. Once node in compete state receives request message from other nodes, it will stop countdown timer and transfer into supervision state at the same time.

All LN nodes enter into spread state. LN collects road information periodically and broadcasts to neighbor nodes. When LN needs to leave junction, it needs to choose one node at junction to inherit its position, which is to be the LN of next round. Select LN preferably through the value of $TTLJ$ and the node with the biggest value of $TTLJ$ will be selected to inherit node. The bigger of $TTLJ$ value, the longer it stayed at junction. $TTLJ$ can be calculated with formula (2):

$$TTLJ(t) = \frac{D(t)}{V(t)} \tag{2}$$

In which, $D(t)$ is the route of node leaving junction and $V(t)$ is the speed of node.

After selection of inheritance node, the node will leave junction, at the same time enter into sleep state. The inheritance node will enter into spread state accordingly. The transfer of four different states is as shown in picture 1.



Picture 1. Node state transfer

(4) Implementation of LN task

It can be learned from above analysis that LN has three tasks must be accomplished, which are collecting traffic information, evaluating road weight and broadcasting weight information.

A. Collecting traffic information

To collect real-time traffic information, LN needs to transfer traffic information collection data packet (TIC). The format of TIC is as shown in table 3. Traffic information implies two kinds of information, one is the density of node on road and the other is congestion information of network flow, which is expressed by road load.

TABLE 3. TIC FORMAT

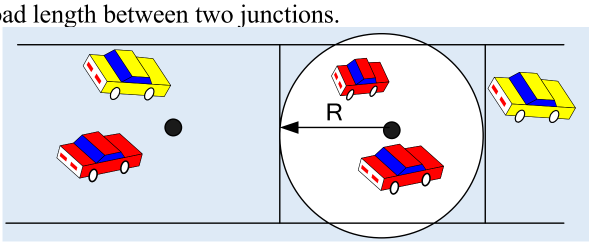
Junction ID (Source)	Junction ID (Destination)	Time stamp	Segment ID	Number of Nodes	Channel Load

In which, two columns of JunctionID are source junction and destination junction. Numbers of Nodes is the node quantity of one section. Segment ID is the segment number of road. Time stamp is producing TIC packet stamp. Channel Load is the road load.

In addition, HT-AR segments the road between two junctions with the communication range R of node. Divide based on formula (3):

$$N_{seg} = \left\lceil \frac{L}{2R} \right\rceil \quad (3)$$

In which N_{seg} is the number of segments and L is the road length between two junctions.



Picture 2. Road division picture

During information collection, try to transfer each TIC packet to the center of each road. For this, select the node with the shortest distance to center as the transfer node for each transfer. The node receiving TIC packet will add node density and road load information into TIC packet, and then transfer to the next node. When the destination node receives TIC packet, it will copy this TIC packet and send to source LN.

When evaluate the channel load of section, let each node to detect its surrounding traffic situation and calculate the load attained by their detection, as shown in formula (4).

$$\text{Channel Load(n)}=\text{T}_{busy}(n)/\text{T}_{\text{measure}}(n) \quad (4)$$

In which $\text{T}_{\text{measure}}(n)$ is the time of node n in detecting road and $\text{T}_{\text{busy}}(n)$ is the busy time of the road.

Numerous nodes detect the busy time of section together. Channel Load_i of the whole road is calculated with formula (5):

$$\text{Channel Load}_i = \max \text{Channel Load}(n) \quad n \in N_i \quad (5)$$

In which, $i \in N_{seg}$. N_i is the node quantity of this section i .

B. Evaluate road weight

When evaluate road weight, use Dijkstra algorithm to calculate the shortest route. After LN receiving TIC packet, it will calculate the road weight Wei_{road} based on formula (6). After LN calculating the weight of each section, store the weight of each road into weight information table, whose format is as shown in table 4.

$$Wei_{road} = \begin{cases} 1-\left(\sum_{i=0}^{N_{seg}} N_i / L_i\right) / N_{seg}, \text{if } \forall CL_i \le CT_{th} \\ 1-\left(\sum_{i=0}^{N_{seg}} N_i / L_i\right) / N_{seg} + C_1, \text{if } \forall CL_i > CT_{th} \\ C_1, \quad \text{otherwise} \end{cases} \quad (6)$$

In which, L_i is the length of the section. C_1 and C_2 are two constants and $C_1 > C_2$. CT_{th} is the threshold value of road.

TABLE 4. WEIGHT INFORMATION TABLE

Junction (From)	Junction (To)	Weight	Time Stamp

C. Broadcast road weight information

LN spread road weight information to nearby junctions in the form of broadcasting and the format of broadcast information packet is as shown in table 5. After source node attaining the weight of each section, select the road with the smallest weight as the transfer route of date packet.

TABLE 5. SECTION WEIGHT INFORMATION TABLE

Junction (From)	Junction (To)	Road Weight

III. SIMULATION AND PERFORMANCE ANALYSIS

To evaluate the VANETs performance of proposed routing, make simulation for HT-AR, GSR[5] and GyTAR[9]. Select these two protocols to make comparative simulation and the main reasons are: GSR is representative protocol not considering about traffic information; GyTAR is representative protocol which makes traffic information to assist routing and supports carry forward technology. Adopt Network Simulator 2.31 as simulation platform. Simulation scene adopts the model of TraNS[9]. The specific parameters of this simulation is as shown in table 6.

TABLE 6. SIMULATION PARAMETERS

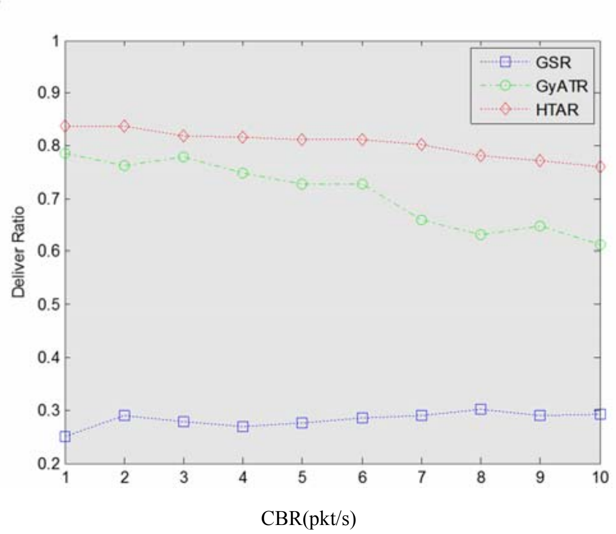
Simulation area	3000m x 2000m
Wireless communication range	250m
NS2 MAC Protocol	IEEE 802.11
Size of data packet	128 bytes
Vehicle speed limit (m/s)	30
CBR Speed	1-10
Hello Message broadcast cycle (s)	2
Quantity of vehicles	400
Quantity of junctions	40
Simulation time (s)	200

To better analyze the performance of HT-AR protocol, this paper makes protocol analysis of delivery ratio of data packet (delivery ratio), average delivery delay (Delay) and network cost. The delivery ratio of data packet is the ratio between data packets sent by source node and data packets received by destination node, as shown in (7). The average delivery delay is needed average time for delivering date packet from source node to destination node. Network cost is the sum of product between the produced data packet in network and its pass hop count during protocol operation for realizing the delivery function of data packet, which includes position service data packet, traffic information data packet as well as routing maintenance data packet etc[10].

$$Deliver\,Ratio = \frac{Numbers\,of\ \ received\ data\ packet}{Numbers\,of\ \ sent\ data\ packet} \tag{7}$$

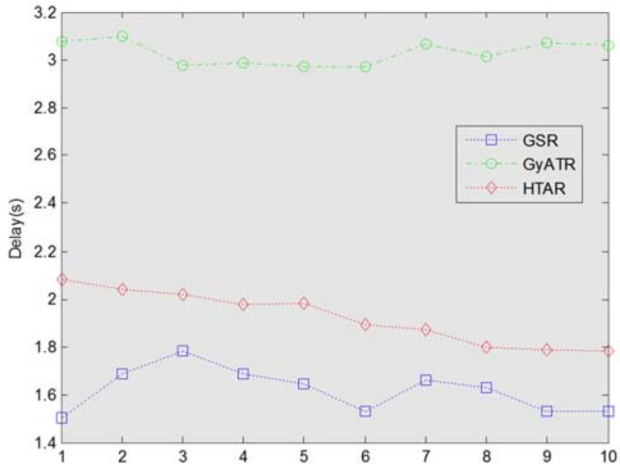
This paper has made simulation analysis for the changing situation of data packet delivery ratio, average delivery delay and the change of internet cost with the changes of CBR speeds when the node quantity is 400.

Picture 3 describes the changing curve of data packet transfer ratio with the changing of CBR speed. It can be learned from picture 3 that with the increasing of CBR speed, the transfer of data packet presents a decreasing trend. Compared with GSR and GyATR, HT-AR is with very high data packet transfer rate, which is mainly because that HT-AR fully considers about the real-time information of traffic, the probability of transfer road breaking decreases, data packet transfer ratio increases and can achieve at about 85%. However, the GSR protocol does not consider about the traffic flow information fully, serious data packet loss happened during network partition and the data packet delivery rate is extremely low. GyTAR protocol considers about the local traffic information on road during data transfer and its data packet transfer rate is higher than GSR, however, as it only considers about local traffic information but no the traffic information of whole network, so the data packet transfer rate is lower than HT-AR.



CBR(pkt/s)

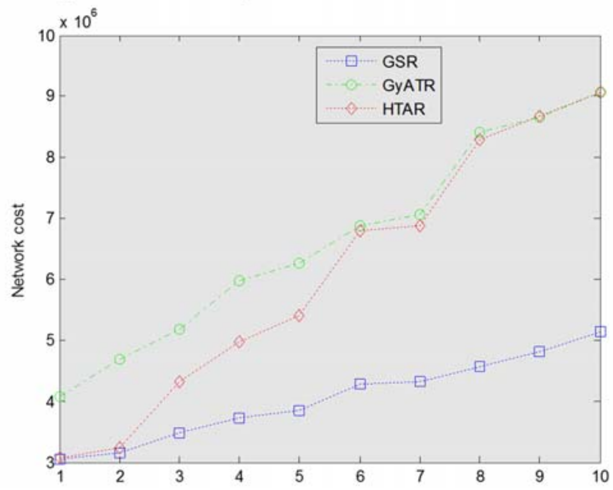
Picture 3. Changing situation of delivery ratio with CRB



CBR(pkt/s)

Picture 4. Changing situation of average transfer delay with CBR

Picture 4 has explained the influence of CBR on average transfer delay. Comparisons among these three protocols have shown that GSR is with the smallest time delay, which is mainly because the data packet is always transferred to destination node from the shortest transfer route. However, HT-AR and GyATR adopt wireless transfer and storage transfer and there is no big difference in the average delay of data packet. Compared with GyATR, HT-AR considers about the global traffic information, selects the road with dense node, makes full use of wireless transfer function and its delay is lower than GyATR.



CBR(pkt/s)

Picture 5. Changing situation of network cost with CBR

As shown in picture 5, with the increasing of CBR speed, the network costs of three protocols increase accordingly. Because GSP protocol is simple, it is with low complexity, the smallest network cost and slow increasing range. Compared with GSR, GyATR and HT-AR protocols are relatively complicated and the network cost also increase synchronously.

IV. CONCLUSION

This paper has proposed routing protocol for VANETs based on the characteristics of VANETs, which attains the real-time information of traffic through setting function node. Set one function node LN at each junction and LN is responsible for collecting real-time traffic information. Divide the road into sections based on the communication range of vehicle, LN calculates the weight of each section and spread this information to neighbor node as well as nearby junctions. To adapt to the dynamic characteristics of topological structure of VANETs, LN integrates the node density as well as the loading information of each section into traffic information. Therefore, the node can select the best transfer node and make the routing path stronger and more stable. At the same time, select LN through setting countdown timer to reduce network cost. The simulation results has shown that the data packet transfer ratio of HT-AR can reach 85%, average transfer time is less, not higher than 2 seconds, and network cost is related to similar protocols and there is no obvious increase.

ACKNOWLEDGMENTS

The high level talents scientific research project “Advanced public transportation system”.

REFERENCES

[1] Wang T, Song L, Han Z. Coalitional Graph Games for Popular Content Distribution in Cognitive Radio VANETs[J]. IEEE Transactions on Vehicular Technology, 2014, 62(8):4010-4019.

[2] Cheng N, Zhang N, Lu N, et al. Opportunistic Spectrum Access for CR-VANETs: A Game-Theoretic Approach[J]. IEEE Transactions on Vehicular Technology, 2014, 63(1):237-251.

[3] Cheng N, Zhang N, Lu N, et al. Opportunistic Spectrum Access for CR-VANETs: A Game-Theoretic Approach[J]. IEEE Transactions on Vehicular Technology, 2014, 63(1):237-251.

[4] Fonseca E, Festag A. A Survey of Existing Approaches for Secure Ad Hoc Routing and Their Applicability to VANETS[J]. Social Science Electronic Publishing, 2015.

[5] Singh K D, Rawat P, Bonnin J M. Cognitive radio for vehicular ad hoc networks (CR-VANETs): approaches and challenges[J]. Eurasip Journal on Wireless Communications & Networking, 2014, 2014:49(4):2122-2135.

[6] Punal O, Pereira C, Aguiar A, et al. Experimental Characterization and Modeling of RF Jamming Attacks on VANETs[J]. IEEE Transactions on Vehicular Technology, 2014, 1(2):524-540.

[7] Resendez C, Boukerche A, Ramos H, et al. A Reactive and Scalable Unicast Solution for Video Streaming over VANETs[J]. IEEE Transactions on Computers, 2015, 64(3):614-626.

[8] Jinyu Hu and Zhiwei Gao. Distinction immune genes of hepatitis-induced heptatocellular carcinoma[J]. Bioinformatics, 2012, 28(24): 3191-3194.

[9] Liu, Y., Yang, J., Meng, Q., Lv, Z., Song, Z., & Gao, Z. (2016). Stereoscopic image quality assessment method based on binocular combination saliency model. Signal Processing, 125, 237-248.

[10] Jinyu Hu, Zhiwei Gao and Weisen Pan. Multiangle Social Network Recommendation Algorithms and Similarity Network Evaluation[J]. Journal of Applied Mathematics, 2013 (2013).

[11] Yishuang Geng, Jin Chen, Ruijun Fu, Guanqun Bao, Kaveh Pahlavan, Enlighten wearable physiological monitoring systems: On-body rf characteristics based human motion classification using a support vector machine, IEEE transactions on mobile computing, 1(1), 1-15, Apr. 2015

[12] Lv, Z., Halawani, A., Feng, S., Ur Réhman, S., & Li, H. (2015). Touch-less interactive augmented reality game on vision-based wearable device. Personal and Ubiquitous Computing, 19(3-4), 551-567.

[13] Jinyu Hu and Zhiwei Gao. Modules identification in gene positive networks of hepatocellular carcinoma using Pearson agglomerative method and Pearson cohesion coupling modularity[J]. Journal of Applied Mathematics, 2012 (2012).

[14] Jiang, D., Ying, X., Han, Y., & Lv, Z. (2016). Collaborative multi-hop routing in cognitive wireless networks. Wireless personal communications, 86(2), 901-923.

[15] Felice M D, Cerqueira E, Melo A, et al. A distributed beaconless routing protocol for real-time video dissemination in multimedia VANETs[J]. Computer Communications, 2014, 58(1):40-52.

[16] Wang M, Shan H, Luan T H, et al. Asymptotic Throughput Capacity Analysis of VANETs Exploiting Mobility Diversity[J]. IEEE Transactions on Vehicular Technology, 2015, 64(9):4187-4202.

[17] Jesudoss A, Raja S V K, Sulaiman A. Stimulating truth-telling and cooperation among nodes in VANETs through payment and punishment scheme[J]. Ad Hoc Networks, 2015, 24:250-263.

[18] Tsai J L. An improved cross-layer privacy-preserving authentication in WAVE-enabled VANETs[J]. IEEE Communications Letters, 2014, 18(11):1931-1934.

[19] De Felice M, Baiocchi A, Cuomo F, et al. Traffic monitoring and incident detection through VANETs[C]// Conference on Wireless On-Demand Network Systems and Services. 2014:4603-4606.

[20] Yang, J., Lin, Y., Gao, Z., Lv, Z., Wei, W., & Song, H. (2015). Quality index for stereoscopic images by separately evaluating adding and subtracting. PloS one, 10(12), e0145800.

[21] Lv, Z., & Li, X. (2015, November). Virtual Reality Assistant Technology for Learning Primary Geography. In International Conference on Web-Based Learning (pp. 31-40). Springer International Publishing.

[22] Feng, L., Lv, Z., Guo, G., & Song, H. (2016). Pheromone based alternative route planning. Digital Communications and Networks, 2(3), 151-158.