Vehicular Delay Tolerant Network Routing Schemes: A Review

IshwarpreetKaurGrewal, Dr. SandeepHarit
Department of Computer Science & Engineering
PEC University of Technology, Chandigarh

***Abstract*—Routing of data packets in vehicular adhoc network (VANET) is a challenge because of constant dynamic change in the network topology and dynamic nodes. Especially in case of sparse environments where there does not exist a continuous end-to-end connection from source to destination. Sparse environments like rural areas and hilly areas lack technological support in the form of infrastructure due to deployment difficulties or due to economic reasons. These areas usually do not have a high priority in governmental investments. Various delay tolerant network protocols have been proposed for sparse environment. These protocols use different ways to tackle the problems of connectivity in sparse environment. The method and parameters used in various techniques vary from each other. In the following paper a review has been done on various delay tolerant (DTN) protocols in VANET based on various parameters, environment used, technique etc.. DTN protocols such as delay based, direction based and distance based have been compared.**

***Index Terms*— Delay tolerant network, Routing protocols, sparse environment, VANETS, vehicle to vehicle communication.**

I. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) are special kind of Mobile Ad Hoc Networks (MANETs) that provide wireless communication among moving vehicles. VANET systems are gaining much importance recently pertaining to its various applications like traffic safety, driver assistance, entertainment information services and internet access. VANETs are the key networking technologies for future vehicular communication even in Intelligent Transportation System (ITS). VANETs are different from MANETs in certain features such as high mobility, dynamic topology etc. [1].

VANET aids in reducing the road mishaps and help in parting with the situation in case of an emergency.VANET routing can be done by two means: Inter-Vehicle Communication (IVC) and Roadside-Vehicle Communication (RVC).In IVCrouting is shared by vehicles and no external aid is required in the form of RSUs (Road side Units) i.e communication is infrastructure free**.** RVC systems on the other hand uses external aid i.e from RSUs and hence form a communication which is between vehicle and road side unit. The cost of such system would be high but it is expected to be more reliable than the IVC system.

They play a major role in creating safer roads by circulating among the vehicles, important information regarding traffic and road conditions in a timely manner. Apart from these VANETs circulate valuable real time information such as weather data, e-commerce, internet access and other infotainment applications to the users. Through VANETempowerapplications which can work control free and can be applicable in case of highway and urban applications. These applications will help the vehicles to sail without any aid from the driver. These applications though are yet to become practical. [2]

VANETs assume some of the attributes such as mobile nodes and self-organizing behaviour from MANETs. However, VANETs hold certain individual attributes such as highly mobile nodes, variable density of nodes, recurrent disconnections and a topology that changes dynamically. All these attributes make VANETs more challenging [3].It is a challenge to establish networks between vehicles and confirm a well-grounded, continuous and secure communication among the vehicles in motion. Routing in VANETs is a key concern because of the above reason.

Hence there is a need for a strong base routing protocols upon which other improvement can be done to enhance routing. Most of the protocols provide services supported through a wireless infrastructure. It may seem that infrastructure involvement provides better connectivity and results but the cost to setup such systems is very high. Especially in case of sparse environment whe re end to end connectivity is low, it seems feasible to deploy road side units but the cost and infrastructure maintenance and damage caused due to natural calamities can create a problem in the communication.

Network density is associated to traffic density, which is affected by location and time. For example, if we consider the traffic density in rural areas, it is quite low. Also, in case of urban environment i.e.in a highly populated area, the traffic density is low at night and moderate to high during the day. Namboodiri et al. [4] showed that in a highway environment it is likely possible that the moving vehicles setup connections with vehicles few hops away and hence communicate easily.Additionllay**,** a mobile vehicle can carry the packet and forward it to the next vehicle.Through relaying vehicles and carry and forward techniques, the message can be delivered to the destination without an end-to end connection for delay-tolerant applications.

Delay-Tolerant Networks (DTNs) are networks that sanction communication in case of weak connectivity environments like sparse where there is no end-to-end connectivity and face problems life high delay, high error rates, highly asymmetric data rate etc. So, DTNs emerge as a solution in these type of problems and provide ways to form a connection where there is no end-to-end connectivity.Vehicular Delay-Tolerant Networks (VDTNs) are DTNs where vehicles communicate with each other and with fixed nodes placed along the roads in order to communicate messages. Some of the prospective applications for these networks are the following: warnings regarding traffic conditions (unforeseen jams etc.),road accident notifications, weather data information (snow, ice, windy, foggy, rain), advertisements (parking spots, nearby hotels, fuel prices, etc.), vehicle collision escape warning, web or email access, or even mustering of information collected by other vehicles such as road defects, sideway fault etc.These networks work well for sparse environment such as rural areas where the nodes are small in number and the network is disconnected.

To deal with the frequent disconnection of nodes in the network DTN uses carry and forward strategy. In this strategy when a node cannot find any node in its vicinity to forward the packet it stores the packet information and forwards the same when an opportunity arises. Such networks play important role in harsh communication environments, like natural calamity, combat zone and road accidents etc. Despite high delay, the ability to communicate emergent information is of great value in such situations. Various DTN protocols include VADD, GPSR, epidemic routing, GeoOppsetc.

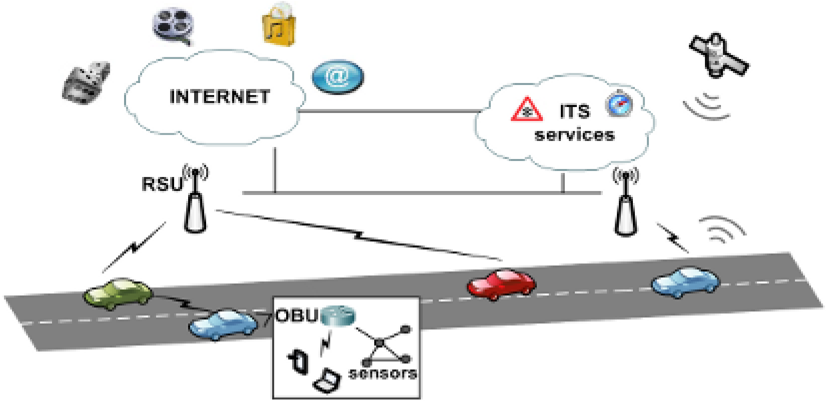

Figure 1. VANET architecture

II. LITERATURE REVIEW

Literature Review

Delay tolerant network protocols in vehicular environment can be classified as:

a) Distance based where the distance to the destination is taken into account i.e minimum distance to the destination becomes the next forwarding node.

b) Delay based where the minimum delay till the destination is taken into account i.e node which can forward the data with minimum delay to the destination is selected.

c) Direction based in which the direction of the destination is taken into account i.e sending in the direction of the destination is considered better.

d) Priority based where certain nodes have higher priority of packet forwarding based on certain conditions or historic data i.e a node being highly used in the past will have higher priority and packets will be replicated to this node.

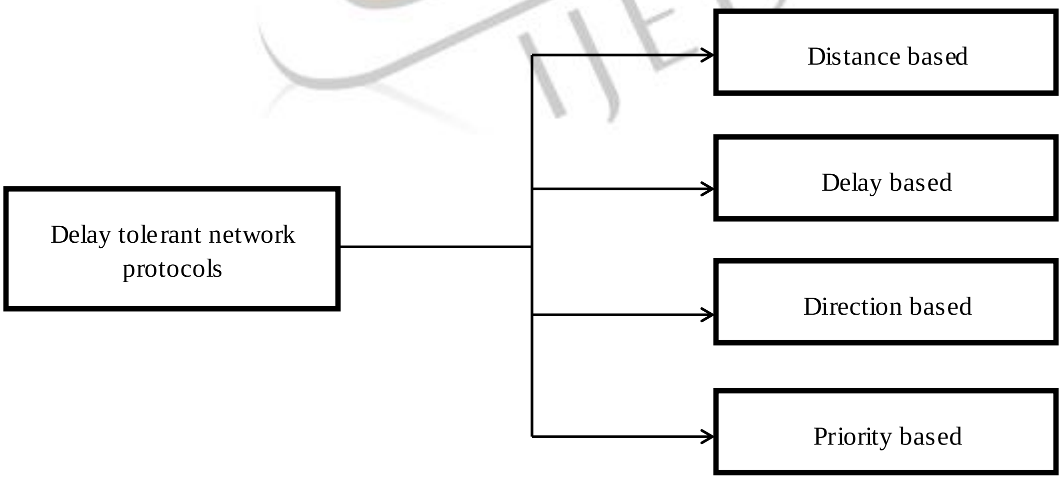

Figure 2.Classification of Delay Tolerant network Protocols in Vanet

A. Distance Based

DAER [5] is a distance based routing protocol designed for intermittently connected MANETs and VDTN. Authors have proposed a new protocol Distance aware epidemic routing to improve the bundle delivery ratio in conventional epidemic method. The data environment around shanghai was collected based on the SUV taxi services in shanghai. It was studied in realistic urban environment. The forwarding strategy used in DAER is store-carry-forward. In this strategy, when the link is broken, the intermediate nodes do not discard or decline the packets.Rather, they carry and save the packets and wait for a suitable node to forward packets. Hence a certain delay is expected but the probability of delivery of packets is high and hence this method has a better packet delivery ratio value. DAER was compared with Epidemic and Enhanced Epidemic methods which are the conventional methods. The result was that DAER performed better than other methods in case of both light and heavy load scenarios.

GeoDTN+Nav [6] is a hybrid routing protocol that includes a greedy mode, a perimeter mode and a DTN mode. The first mode is greedy mode where the packet is forwarded to the node closer to the destination, but problem arises when there is no node to forward packet and it has reached local maxima. The local maxima problem is solved by the perimeter mode which extracts packets lost in local maximum. But in certain cases the network is disconnected. It is mostly a case of sparse environment. So for this case DTN (delay tolerant network is used). Hence GeoDTN+Navis a routing protocol which uses all the modes accordingly to get the nest results. The overhead and the complexity are though more. The authors have compared it with GPCR and GPSR. GeoDTN+Nav perform better than both protocols in terms of packet delivery ratio. However, as described earlier, it is more complex and there is increased delay.

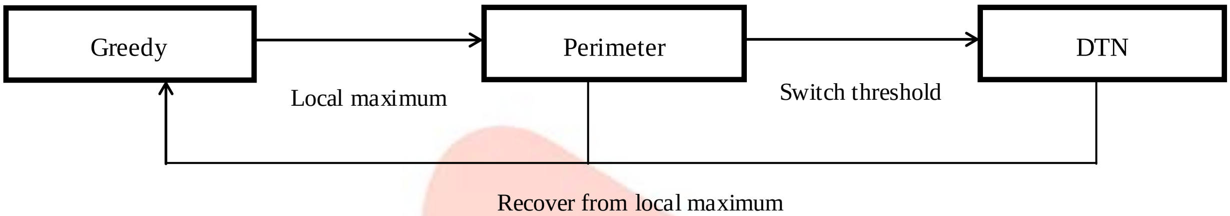

Figure 3. Switch between greedy, perimeter, and DTN mode.

In DARCC [7]the routing strategy works with the aim that a certain number of copies of the packets will be forwarded or replicated only to some suitable nodes.DARCC applies this concept of DTN routing to vehicular communication. DARCC discover whether it should transmit data to the suitable vehicle or not with the following two principles:

a) Data will be redirected to the vehicle that is closer to the destination if the location of the destination node or data node is available.

b) Otherwise,DARCC favours disseminating the data to a different direction to improve the probability of the data reaching the destination.Results shown by the authors define that DARCC performed better than epidemic and maxprop in terms of delivery ratio. DARCC still incurs little relay cost due to effective control of message replication.

B. Delay Based

GeOpps[8] Geographic routing is one of the most promising approaches for efficient routing, which takes into account the location information of the vehicle. It redirects the data bundle opportunistically towards the final destination vehicle location by utilizing the geo-location of the vehicles. The closest point where a vehicle carries the bundle is called nearest point and used to compute minimum estimated time of delivery (METD) as follows:

METD = time to nearest point + (remaining distance/average speed).

A vehicle with the lowest METD is the candidate bundle forwarder/carrier. GeOpps presumes that the bundle carrier always find another vehicle when it arrives at the nearest point.

The results conclude good performance in various scenarios in terms of delivery ratio, delay and overhead with respect to other protocols.

PBRS[9] uses the concept of relaying vehicle. Roadside units cannot cover all the area of communication and deploying large number of RSUs can increase the overall cost. So the concept of relaying vehicle is uses which carry the data along the line to the destination vehicle. For relaying the data packets between RSUs and vehicles typical researchers usually use the store and carry forward strategy.The RSU transmits its data to the incoming vehicles which enter its transmission range. So in these cases, suppose the RSU forwards and replicates the data to all the vehicles which come in its vicinity, a lot of duplicate packets are generated in the network.Therefore, PBRS proposed a decision-based scheme which makes RSUs determine whether or not to forward its data to a vehicle on the basis of certain criterion. PBRS performed better than GBRS (Greedy bundle relaying scheme).

FFRDV [10] is a unicast geographic routing scheme for VANET that provide improvement in DAER protocol by considering the vehicle's speed for fast forwarding of messages. Selecting of high speed relaying vehicle with long distance to destination can reach earlier in comparison to slow vehicle with short distance. The bundles ferrying procedure employed in FFRDV chooses ferries on the basis of their velocities.

GeoSpray[11] uses the principle of single-copy single-path GeOpps to perform multicopy multipath bundle routing approach.Multicopy routing schemes are famous for their high delivery ratios, low bundle delivery delays, and high overheads due to duplicated copies.Henceto limit the number of duplicates, GeoSpray selects the replication proposition of the spray and wait protocol. In the beginning it uses a multiple copy scheme, which disseminates limited copies of the bundle to exploit diverse paths.Later on,it shifts to a single-copy forwarding scheme. GeoSpray clears the delivered bundles from vehicles' storage by propagating the delivery information.Althoughthere is high replications overhead but it still manages to achieve a better delivery ratio than GeOpps.Nonetheless, this overhead is less than the epidemic protocol and is similar to spray-and-wait.

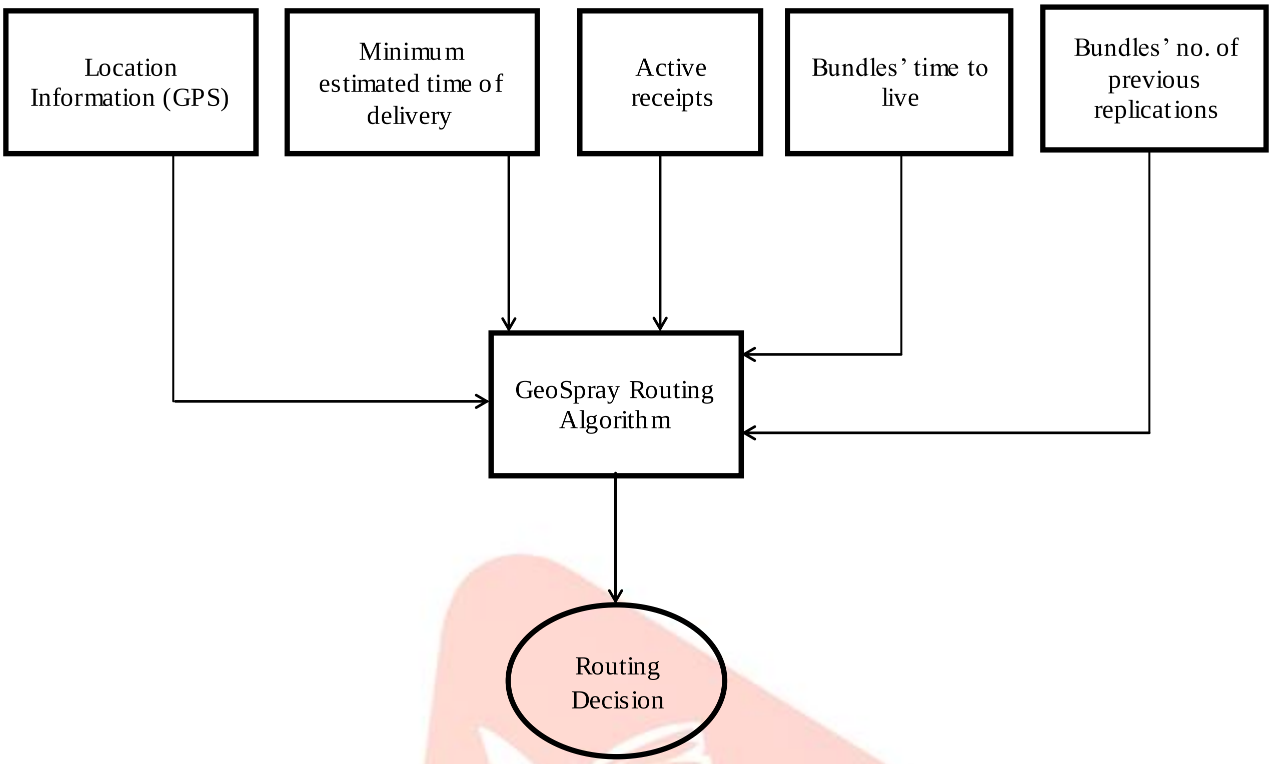

Figure 4.Routing control data-fusion model for GeoSpray.

C. Direction Based

VADD [12] is a protocol that uses both the delay and the direction of the destination. L-VADD (Location probe) was introduced which uses the nearest location in the direction of moving vehicle but could enter into loops. D-VADD i.e direction probe VADD was introduced to overcome the problem of loops. Hybrid VADD was further the hybrid of the above two approaches. Results shown proved that VADD performed better than GPSR and epidemic. VADD works well at intersections where the vehicle has to decide that in which direction should her next send the packets. So VADD is quite feasible to be implemented in case of sparse environment where there is no continuous connectivity available.

RUDTI (Roadside unit deployment traffic information) [13] uses an improved VADD version where RSUs are used at intersection to decide in which direction should the packets be sent to get optimal path and minimum delay. Results show that RUDTI performs better than VADD in terms of delivery ratio and delay. However there is a trade-off of the cost incurred to deploy RSUs.

D. Priority Based

In MaxProp [14] when two nodes communicate, they exchange packets in a specific order. If the node currently in contact is the destination node of some packets, these packets are transmitted first. Secondly, the routing information is exchanged which includes the estimated probability of meeting any node. The calculation of the probability is based on the number of encounters between two nodes. In the end, an acknowledgement of delivered data is transmitted.

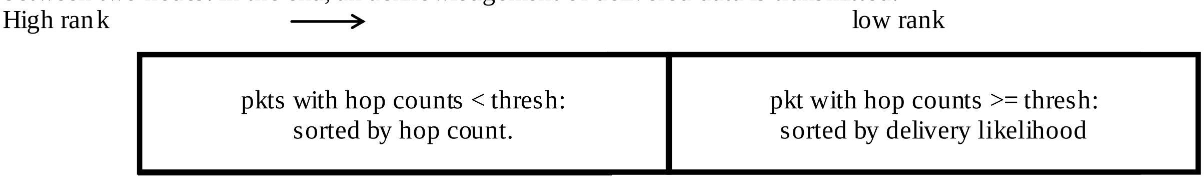

Figure 5.The MaxProp routing strategy.

III. COMPARITIVE ANALYSIS

The comparison is done on the following metrics:

1. Forwarding Metrics: Most of VDTN routing protocols utilize the store-carry and forward mechanism. Hence, these

protocols usually do not make any end-to-end path between source and destination vehicles. The forwarding metric is one of the most significant features for distinguishing routing protocols. Various protocols use different metrics such as delay, distance, density etc.

2. Forwarding Neighbour Selection Method: Based on the protocols' method to choose next neighbour to pass the packet the forwarding neighbour selection method can be classified as delay, distance, direction and priority based.
3. Infrastructure assistance: it defines whether the protocol uses infrastructure support or no. For sparse environment it is feasible if the protocol does not use the support of infrastructure. For urban scenario it does not affect the performance.
4. Environment scenario: It defines the environment on which the protocol works for i.e. urban, highway, rural etc.
5. No. of metrics used: These define the number of metrics used to forward the packet.
6. Computation Load: This is the overall overhead or complexity if the protocol. A protocol may give high performance but it maybe computationally very complex. So there is always a trade-off between the two factors.
7. Topology assumptions: These are the topological assumptions used in various protocols. The area, numbers of nodes, speed etc. factors also affect the performance of the system.
8. Target of scheme: This is the overall target to be achieved by the protocol. Whether it is to minimize delay, increase packet delivery ratio, to decrease the overall complexity etc.
9. Performance Results: These are the results they have compared with previous protocols.

Table I. Comparative analysis of the routing protocols reviewed

Routing Protocol	***Forwarding Neighbour Selection Method***	***Forwarding metrics***	***Infrastructure assistance***	***Environment scenario***	***No. of metrics used***	***Computation Load***	***Topology assumptions***	***Target of scheme***	***Performance Results***
DAER [5]	Distance Based	Neighbour Distance	no	Urban, highway	single	low	Mobility model from the real taxi GPS data collected from over 4000 taxis in Shanghai	improve the bundle delivery ratio within a tolerance of delay	Performs better than epidemic and advanced epidemic scheme
geo DTN + Nav [6]	Distance based	Neighbour Distance	no	Urban, highway	multiple	high	-	Improve geo-routing for sparse or partitioned networks	Geo-DTN+Nav outperforms GPCR and GPSR in packet delivery ratio
GeoOpps [8]	Delay Based	Path delay	yes	Rural, Urban	single	high	260,000 vehicles 15 km ×15 km area	Optimize delivery ratio, delay, and overhead	GeOpps is able to deliver nearly 98% of the packets, whereas Greedy and MoVe delivers 72% and 53% respectively.
PBRS [9]	Delay Based	Velocity-based	yes	Rural	single	low	20 km one way road vehicle; interarrivaltime:	Reduce packet replication	PBRS outperforms GBRS in terms of the mean transit

		probability					5–120 seconds		delay
FFRDV [10]	Delay Based	Neighbor Velocity, Path Distance	No	Urban	multiple	low	1500m × 1500m area; average speed of node 60 km/h	To reduce intermediate nodes	Performs better than DAER in both light and heavy load traffic
VADD [12]	Direction Based	Path Delay, Neighbor Direction	No	Rural	multiple	high	4000m × 3200m area; 24 intersections; 150-210 vehicles	To minimize overall delay	Performs better than epidemic and (GPRS with buffer) in case of delay and delivery ratio
DARCC [7]	Distance Based	Location of destination moving direction of nodes	Yes	Urban, Rural	single	low	100 vehicles in 3000m × 3000m area; each road has 4 lanes; average speed of node 60 km/h	Reduce packet replication	Perfroms better than DAER, Epidemic, MaxProp and GPSR
GeoSpray [11]	Delay based	Density of nodes and different data size	Yes	Rural, Urban	multiple	high	100mobile nodes with an average speed of 50 km/h city of Helsinki, time: 6 hrs	Optimised Routing with minimum delay	Better Delivery ratio than GeOpps but with more cost
MaxProp [14]	Priority Based	Hop count historical data	No	Rural	Single	low	30 Buses in 1502 miles; 60 days of trace	Gives priority to packets in buffer	
RUDTI [13]	Direction Based	Path delay, Neighbour direction	yes	Rural	multiple	high	600m × 300m rectangle area, average speed of node 30-60 kmph, 30-60 vehicles	Follow the minimum delay path	Better than VADD but costly.

IV. CONCLUSION

This article presented a survey of a number of proposed routing protocols for DTNs in VANETs. The major contributions of this article are the classification of different DTN routing protocols into three types based on their neighbor selection techniques and their evaluation on the basis of their characteristics. Most of these routing protocols are appropriate for metropolitan vehicular networks. These protocols use various packet-forwarding metrics to select next forwarding neighbor. Among all these protocols, VADD, GeOpps and FFRDV can provide better end-to-end delay, data delivery ratio and low network overhead in city environments because they include path information that leads to destination. PBRS can provide better results in highway scenario because it does not incorporate decision making at intersections.

The paper will help the readers, who are new to VANETs, to improve their understanding of this contemporary area. It will support them to peruse their research in an efficient manner. Research in DTN for VANETs is passing from the infant phase with several open issues that must be fixed for achieving full benefits of the field. The main goal of this work is the assessment and comparison of the contemporary research activities and to inspire the researchers in developing efficient and better protocols for DTN in VANETs.

REFERENCES

[1] Venkatesh, Indra. A and Murali. R, "Vehicular Adhoc Networks (VANETs): Issues and Applications", Journal of Analysis and computation, Vol. 8, No. 1, 2012, pp.31-46.

[2] Andrei Furda et al, "Enabling Safe autonomous driving in real-world city traffic using multiple criteria decision making", IEEE Intelligent Transportation System Magazine, SPRING 2011, pp. 4-17.

[3] S SManvi and M S Kakkasageri, "Issues in Mobile Ad hoc Networks for Vehicular Communication", IETE Technical Review, Vol. 25, No 2 March- April 2008.

[4] V. Namboodiri, M. Agarwal, and L. Gao, "A study on the feasibility of mobile gateways for vehicular ad-hoc networks," in Proc. VANET, Oct. 2008, pp. 66–75.

[5] Huang, Hong-Yu, et al. "Performance evaluation of SUVnet with real-time traffic data." *IEEE Transactions on Vehicular Technology* 56.6 (2007): 3381-3396.

[6] Cheng, Pei-Chun, et al. "GeoDTN+ Nav: a hybrid geographic and DTN routing with navigation assistance in urban vehicular networks." *MobiQuitous/ISVCS* 47 (2008).

[7] Lo, Wei-Zen, Jhih-SiaoGao, and Shou-Chih Lo. "Distance-aware routing with copy control in vehicle-based DTNs." *Vehicular Technology Conference (VTC Spring), 2012 IEEE 75th*. IEEE, 2012.

[8] Leontiadis, Ilias, and Cecilia Mascolo. "Geopps: Geographical opportunistic routing for vehicular networks." *World of Wireless, Mobile and Multimedia Networks, 2007. WoWMoM 2007. IEEE International Symposium on a*. Ieee, 2007.

[9] Khabbaz, Maurice J., Wissam F. Fawaz, and Chadi M. Assi. "Probabilistic bundle relaying schemes in two-hop vehicular delay tolerant networks." *IEEE Communications Letters* 15.3 (2011): 281-283.

[10] Yu, Danlei, and Young-BaeKo. "FFRDV: fastest-ferry routing in DTN-enabled vehicular ad hoc networks." *Advanced Communication Technology, 2009. ICACT 2009. 11th International Conference on*. Vol. 2. IEEE, 2009.

[11] Soares, Vasco NGJ, Joel JPC Rodrigues, and FaridFarahmand. "GeoSpray: A geographic routing protocol for vehicular delay-tolerant networks." *Information Fusion* 15 (2014): 102-113.

[12] Zhao, Jing, and Guohong Cao. "VADD: Vehicle-assisted data delivery in vehicular ad hoc networks." *IEEE transactions on vehicular technology* 57.3 (2008): 1910-1922.

[13] Jiang, Ji-Han, Shih-ChiehShie, and Jr-Yung Tsai. "Roadside Unit Deployment Based on Traffic Information in VANETs." *Intelligent Data analysis and its Applications, Volume I*. Springer International Publishing, 2014. 355-365.

[14] Burgess, John, et al. "MaxProp: Routing for Vehicle-Based Disruption-Tolerant Networks." *Infocom*. 2006.