A Comparative Study of Different Emerging Routing Protocols in VANET

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Abstract – Vehicular Ad Hoc Networks (VANET) is a special class of Mobile Ad Hoc Network (MANET) which provides communication between vehicles intelligently via vehicle to vehicle communication or vehicle to roadside communication. VANETs is an essential and emerging area of research in the field of Ad Hoc Networks. The main objective of deploying VANET is to improve the road safety and reduce the number of accidents. Existing routing protocols are not sufficient to meet all the issues in routing. To provide best routing protocol, it is necessary to make an analysis of routing protocols in VANET. This paper starts with the basic challenges of VANET and provides a detailed description of various existing routing techniques with its advantages and disadvantages. Finally, this paper discusses and compare the emerging routing protocols for VANET.

Index Terms – Intelligent transportation system (ITS), Zone of Relevance (ZOR), Geo Cast Routing, Position based Routing Protocol, OBU.

1. INTRODUCTION

Vehicular ad hoc network, consisting of a network of vehicles, moving at a relatively high speed, that communicate among themselves with different purposes, being the main purpose that of improving security on the road.

Vehicular Ad Hoc Networks are created by applying the principles of mobile ad hoc networks (MANETs) - the spontaneous creation of a wireless network for data exchange - to the domain of vehicles.

Vehicular Ad Hoc Networks. When principles of MANET are applied in domain of vehicles, they form VANETs. A generic term used to define VANETs is inter-vehicle communication (IVC). The vehicles are fitted with sensors. These sensors interact with the sensors of other vehicles or the infrastructure present outside.

A form of mobile ad hoc network, to provide communications among nearby vehicles and between vehicles and nearby fixed equipment, usually described as roadside equipment In VANETs, participating vehicles are equipped with set of wireless sensors and On Board Units (OBUs) to allow for possibility of wireless communication between the vehicles and their environs. These devices make each vehicle function as packet sender, receiver and router which enable the vehicles send and receive messages to other vehicles or road side units (RSUs) within their reach via wireless medium. These sets of wireless sensors, OBUs or some typical radio interfaces enable vehicles form short-range wireless ad hoc networks to broadcast kinematic data to vehicular networks or transportation authority's/agencies which process and use the data to foster traffic efficiency and safety on the motorways. VANET-enabled vehicles are fitted with the appropriate hardware which allows for acquisition and processing of location (or position) data such as those from global positioning system (GPS) or differential global positioning system (DGPS) receiver. The fixed RSUs are connected to the backbone network and situated at strategic positions across the roads to aid effective, reliable and timely vehicular communications.

RSUs are equipped with network devices to support dedicated short-range wireless communication using IEEE 802.11p radio technology. The possible vehicular communication configurations in intelligent transportation system (ITS) include vehicle-to-vehicle (or inter-vehicle), vehicle-to-infrastructure and routing-based (RB) communication .Vehicles can directly establish communication wirelessly with one another forming V2V communication or with fixed RSUs forming V2I communications.

These vehicular communication configurations rely heavily on acquisition of accurate and up-to-date kinematic data of both the vehicles and the surrounding environment with the aid of positioning systems and intelligent wireless communication protocols and access technologies for reliable, efficient and timely information exchange. Considering the network environment of VANETs with unreliable, shared communication medium and limited bandwidth [10], smart cross-layer communication protocols are required to guarantee reliable and efficient delivery of data packets to all vehicles and infrastructures (RSUs) within the vehicles' radio signal transmission coverage.

In VANET, the routing protocols are classified into five categories: Topology based routing protocol, Position based routing protocol, Cluster based routing protocol, Geo cast routing protocol and Broadcast routing protocol. These

protocols are characterized on the basis of area / application where they are most suitable.

1. Topology Based Routing Protocols

These routing protocols use links information that exists in the network to perform packet forwarding. They are further divided into Proactive and Reactive.

i) Proactive routing protocols

The proactive routing means that the routing information, like next forwarding hop is maintained in the background irrespective of communication requests. The advantage of proactive routing protocol is that there is no route discovery since the destination route is stored in the background, but the disadvantage of this protocol is that it provides low latency for real time application. A table is constructed and maintained within a n ode. So that, each entry in the table indicates the next hop node towards a certain destination. It also leads to the maintenance of unused data paths, which causes the reduction in the available bandwidth. The various types of proactive routing protocols are: LSR, FSR.

Merit

- Maintain an up to date network topology from each node to other nodes.
- No route discovery takes place to avoid delay.

Demerit

- Frequently update the routing table because of the high dynamic topology.
- Network traffic is increased.

ii) Reactive/Ad hoc based routing

Reactive routing opens the route only when it is necessary for a node to communicate with each other. It maintains only the routes that are currently in use, as a result it reduces the burden in the network. Reactive routing consists of route discovery phase in which the query packets are flooded into the network for the path search and this phase completes when route is found. The various types of reactive routing protocols are AODV, PGB, DSR and TORA

Merit

- Setup the link on demand

Demerit

- Searching delay is high for route discovery

2. Position Based Routing Protocols

Position based routing consists of class of routing algorithm. They share the property of using geographic positioning information in order to select the next forwarding hops. The packet is send without any map knowledge to the one hop neighbor, which is closest to destination. Position based routing is beneficial since no global route from source node to destination node need to be created and maintained. Position based routing is broadly divided in two types: Position based greedy V2V protocols, Delay Tolerant Protocols.

i) Position Based Greedy V2V Protocols

In greedy strategy and intermediate node in the route forward message to the farthest neighbor in the direction of the next destination. Greedy approach requires that intermediate node should possessed position of itself, position of its neighbor and destination position. The goal of these protocols is to transmit data packets to destination as soon as possible that is why these are also known as min delay routing protocols. Various types of position based greedy V2V protocols are GPCR, CAR and DIR

ii) Delay Tolerant Protocols

In urban scenario where vehicle are densely packed locating a node to carry a message is not a problem but in rural highway situation or in cities at night fewer vehicles are running and establishing end to end route is difficult. So in such cases certain consideration needs to be given in sparse networks. The various types of Delay Tolerant Protocols are MOVE, VADD, and SADV.

Merit

- Need of global route from source to destination hops are not required to be created and maintained.
- Route discovery delay is avoided.
- Beacon message at regular interval made the geographical position available

Demerit

- Fully dependent on Global Positioning System (GPS).

3. Cluster Based Routing

Cluster based routing is preferred in clusters. A group of nodes identifies themselves to be a part of cluster and an n ode is designated as cluster head will broadcast the packet to cluster. Good scalability can be provided for large networks but network delays and overhead are incurred when forming clusters in highly mobile VANET. In cluster based routing virtual network infrastructure must be created through the clustering of nodes in order to provide scalability. The various Clusters based routing protocols are COIN and LORA_CBF.

Merit

- Attempt to capture the mobility of VANET nodes by creating relatively stable clusters of vehicles for communication.

Demerit

- Increase the communication overhead by finding cluster head.

4. Broadcast Routing

Broadcast routing is frequently used in VANET for sharing, traffic, weather and emergency, road conditions among vehicles and delivering advertisements and announcements. The various Broadcast routing protocols are BROADCOMM, UMB, VTRADE, and DV-CAST.

Merit

- Used for safety related information.

Demerit

- Consume the large amount of network bandwidth.

5. Geo Cast Routing

Geo cast routing is basically a location based multicast routing. Its objective is to deliver the packet from source node to all other nodes within a specified geographical region (Zone of Relevance ZOR). In Geo cast routing vehicles outside the ZOR are not alerted to avoid unnecessary hasty reaction. Geo cast is considered as a multicast service within a specific geographic region. It normally defines a forwarding zone where it directs the flooding of packets in order to reduce message overhead and network congestion caused by simply flooding packets everywhere. In the destination zone, unicast routing can be used to forward the packet. One pitfall of Geo cast is network partitioning and also unfavorable neighbors, which may hinder the proper forwarding of messages. The various Geo cast routing protocols are IVG, DG-CASTOR and DRG

Merit

- Follows the principle of multicasting which reduce the chance of collision.

Demerit

- Deliver the messages to nodes within a geographical region.

CHALLENGES IN VANETS

We found that few challenges and open research issues exist in routing of VANETs which is the most important area for research today. These open issues and challenges in VANET routing such as driver's behavior, loss of signal, interferences caused by tunnels and high buildings have been discussed in this section.

Dynamic Topology and High Mobility:

Vehicles are the mobile nodes in VANETs and move according to the road pathways which restricts the mobility of the nodes. This causes the disruptions in communications and changing topology. For routing protocol development, we should traumatize dynamic topology. A solution to give effective information dissemination notwithstanding fast changing topology may be broadcast based communication.

Fault Tolerance:

Since a VANET has fast changing topology; several vehicles could enter or exit the network periodically. If during the communication, a node leaves the network, a new route should be created by the routing protocols to manage the network. This problem can be solved if the route failure is known in advance, this requires lot of updated information exchange leading to un-scalable communication.

Flexibility and Scalability:

Area decides the number of vehicles, for e.g. number of vehicles in rural area is low without road side units, it becomes difficult to maintain the network connectivity. For development of the road side units, large investments are required, therefore less power constraints can be used by increasing communication ranges with higher transmission power to form every node reach its destination without support of the roadside units. On the contrary, urban area is very large and crowded having a huge range of vehicles running. The routing protocols need to reduce the overhead and control of data packets as a larger number of vehicles need to communicate. It should provide safety communication rather than control overhead.

Delay Constraints and Real-time Transmission:

To deal with sudden occurring situations, drivers do not have enough time to respond as the information is distributed in the real time. If information is received on time, accidents can be avoided. Hence the routes are to be maintained and constructed for real time applications.

Security Enhancement:

Security [7] stands the most important and challenging issue in safety applications of VANETs. If no security is provided in routing protocols, a malicious node can enter the network and cause damage. This could lead in misleading of information which can be used by terrorists to trap innocent people as dead end tunnel. So in turn to protect the information; authentication, integrity and non-repudiation must be achieved such that there is no entry of any unauthorized vehicle into the network and no modification of the data packets is allowed during the communication. Hence, security is an important issue as future research area.

2. RELATED WORK

Landmark based routing using global real time traffic (LRRT) [2] was introduced to improve information system in urban traffic management system in VANET. It is a beaconless AP

assisted scheme. Global density information is available by sharing local density information between adjacent APs. Its demerit is vehicles in the network periodically update their locations and report to APs, while APs gather these real-time reports in their coverage in order to build local density table which needs to have high capacity data storage and it may leads to network congestion due to more number of periodic message. Another one is they have divided the road segment in uniform fixed size and at the center of each segment there is an AP. But in global aspect if we consider semi-urban or rural area it will be costly where less number of APs are enough for data transmission. Also it is assumed that vehicles are distributed uniformly which is not a real time situation. [2]

Unmanned Aerial Vehicle Assisted VANET Routing Protocol (UVAR) based on the use of vehicle density and the knowledge of vehicular connectivity in the street. Its advantage is that UAV collect information about traffic density on the ground and the state of vehicles connectivity, and exchange them with vehicles through Hello messages. More over UAV to place themselves so as to allow relaying data when connectivity between sole vehicles on the ground is not possible. Through vehicle to-UAV (V2U) communication, the overall connectivity between vehicles is improved and therefore the routing process is efficiently improved. Its disadvantage is that UAVs do not use GPS information during route discovery and data forwarding. There is no clear indication about the content of Hello messages except the road segment information and degree of connectivity. Also UAVs do not use GPS then they assumed that UAV and vehicle both are equipped with GPS.) As per the proposal UAV maintain and update a table of neighbors periodically for each road segment but they there is nothing about the length of the road segment. [3]

Moving Zone Based Routing Protocol (MOZO) is a moving-zone based architecture in which vehicles collaborate with one another to form dynamic moving zones so as to facilitate information dissemination. The advantage of proposed routing delivers messages in VANET via a self-organized moving zone based architecture formed using pure V2V communication which will reduce the exchange of messages to form a stable cluster. It will be advantageous if forming stable clusters of vehicles requires significant more message exchanges than simply delivering messages without using clusters, such clustering may not be useful in practice. Captain vehicle has the ability to estimate vehicle positions in the near future so that decisions (e.g., zone splitting, message routing) can be made without requiring constant location updates from member vehicles. Proposed protocol have some disadvantage like considered vehicle moves towards end otherwise towards starting point. But this cannot be always true because the vehicle can change their decision to go other destination other than the previous one. The vehicle, calculates a similarity score for each response received from the neighboring captain vehicles. Vehicle defining the similarity score based on average distance between the two vehicles whereas the direction can be a major factor. After selection of captain vehicle with the highest score the member vehicle sends a join request to the captain vehicle with the highest score and sends a join request to the captain vehicle. Direction is not there in join request which may hamper the stability of the moving zone. For moving zone maintenance they proposed zone splitting and zone merging. But for this purpose we need to select the new captain which will increase network overhead [4].

Cluster-Based Life-Time Routing (CBLTR) protocol, Intersection Dynamic VANET Routing (IDVR) protocol, and Control Overhead Reduction Algorithm (CORA). The advantages are In CBLTR (Cluster Based Life Time routing Protocol) eliminate the route discovery process and reduces the number of re-election process for new CH.) In IDVR protocol relaying of the packets done via CHs which may reduce the probability of the link failure. In CBR Protocol every CM have to send hello messages periodically which is an important issue that degrade the performance of any mobile and limited networks resources. Furthermore, the frequently exchanging of HELLO message negatively impacts the network performance. Proposed CORA algorithm presents a new design of hello messages by minimizing the number of parameters. The demerits of these three protocols are In CBLTR protocol the vehicle with the maximum LT is elected as a CH, then it remains as the CH till it arrives at the directional threshold point; this means there are no new election until the current CH arrives at the predetermined directional threshold point. If a CH change its velocity then abnormally then the LT value have to be changed (LT is based on the velocity of the vehicle) otherwise based on predefined LT value the cluster may lost its cluster head and communication will be hampered. Threshold distance is calculated dynamically based on the current CH velocity. Then LT which they considered predefined can be dynamic also. One more thing is that if we need to calculate LT periodically it will increase the computation time rather than communication.) If the cluster head (CH) remain same for long time it may reduce the message overhead but a cluster member (CM) which have better stability and connectivity with other CM in a specific time than a CH can improve the data communication. When the local CH receives a packet, it searches in its routing table for the candidate CHs that are located close to the destination regardless of the CH's direction whereas same direction vehicle can communicate with the destination vehicle for more time. In IDVR protocol relaying of the packets done via CHs which may reduce the probability of the link failure as well as if the CHs fail total communication will be down unless the new CH comes up. If more than one vehicle enters the cluster intersection zone at the same time after sending hello messages if they did not get the CHAD (cluster head advertising message) they will announce themselves as ICH means for one intersection there may be multiple ICH. As per CORA algorithm CH is capable to

calculate the candidate CH before leaving the cluster for which CH have to know the current location of all CM associated with this. This can be a big challenge to a CH because of high vehicle mobility, a nature of VANET [5].

Acute Position based Routing protocol (APR) for vehicular ad hoc networks (VANETs) which performs better when the number of vehicle increases on the road as compare to GPSR. There are some advantages of it as Acute Position Based Routing Protocol (APR) allows V2V and V2I communication. The demerit of this protocol is information messages are sent to each one-hop neighbor. If a node does not receive messages from one neighbor during a certain time period, then the link is considered down. Then low vehicle density will increase the chance of link failure. Also if a vehicle have a data packet and will not find the other vehicle or RSU to transfer this packet, it will carry the packet until it get suitable vehicle or a RSU. But that case message itself can lost its importance [6].

TABLE 1- COMPARISON AMONG ROUTING PROTOCOLS TYPES AND COMMUNICATION TYPE IN VANET.

Proposed Protocol	**Protocol Type**	**Communication Type**
LRRT	Position based routing protocal	V2V
MoZo	Cluster based routing protocal	V2V
UVAR	Topology based routing protocol	V2V, V2I
CBLTR	Cluster based routing	V2V
DSDV, DSR, AODV	DSDV: Topology based proactive routing	V2V
	DSR, AODV: Topology based proactive routing	
MDORA	Position Based routing	V2V, V2I
CBDRP	Cluster based routing	V2V
Improved GPSR	Position based routing	V2V
DAPBR	Position based routing	V2V

TABLE 2- COMPARISON BASED ON END TO END DELAY AND FORWARDING STRATEGY IN VANET.

Proposed Protocol	**Protocol Compared**	**End to end delay**	**Forwarding Strategy**
LRRT	LOUVRE, GSR	-	Greedy
MoZo	CBDRP, BRAVE	Average	Dijkstra algorithm
UVAR	IRTIV, VDLA	Less	Carry and forward
CBLTR	CBDRP, CBVANET, AODV-CV	-	Store and forward
DSDV, DSR, AODV	Each other	AODV DSR achieved similar performance DSDV : maximum delay	-
MDORA	AODV, GPSR-L, HLAR	Low	-
CBDRP	AODV, GPSR	Increase with distance	Store and Forward
Improved GPSR	GPSR	-	Greedy forwarding and intersection forwarding
DAPBR	GPSR	Decrease of no. of vehicle	Greedy Forwarding

3. CONCLUSION

In this paper, we present several routing protocols in VANET that may be a promising technology for intelligent transportation (ITS). The merits and demerits of the studied protocols are also described. The table1 and table2 shows the comparative analysis of all the above stated routing protocols. The domain of Vehicular Ad Hoc Network (VANET) and its related analysis are still in progression phases. This survey paper has given differences among major classifications of routing protocols. In this brief study on various VANET routing protocols; different related research issues and challenges/difficulties are represented that require more effort and research to address them.

REFERENCES

[1] James Bernsen, D. Mnivannan, "Unicast routing protocols for vehicular ad hoc networks: A critical comparison and classification", in journal of Pervasive and Mobile Computing 5 (2009) 1-18

[2] Wenjie Wang, Tao Luo, Ying Hu "Landmark-based routing using real-time urban trafficinformation in VANET" in 2nd IEEE International Conference on Computer andCommunications, 2016,pp-2193- 2197.

[3] Omar Sami Oubbati, AbderrahmaneLakas, NasreddineLagraa ," UVAR: An intersectionUAV-assisted VANET routing protocol" IEEE Wireless Communications and NetworkingConference-2016, **ISBN:** 978-1-4673-9815-2

[4] D. Lin, J. Kang, A. Squicciarini, Y. Wu, S. Gurung, O. Tonguz, "MoZo: A Moving Zone Based Routing Protocol Using Pure V2V Communication in VANETs", *IEEE Trans. Mobile Computing.*, 2016, [online] Available: 10.1109/TMC.2016.2592915, pp1-14.

[5] Ahmad Abuashour, Michel Kadoch, "Performance Improvement of Cluster-Based Routing Protocol in VANET" IEEE Access, Volume 5, 28 July 2017, DOI**:** 10.1109/ACCESS.2017.2733380, Pages- 15354 – 15371.

[6] Neha Goel, Isha Dhyani, Gaurav Sharma, "An Acute Position Based VANET Routing Protocol" International Conference on Micro-Electronics and Telecommunication Engineering (ICMETE), 201622-23 Sept. 2016, ISBN**:** 978-1-5090-3412-3, pp 139-144.

[7] Agrawal, A., Garg, A., Chaudhiri, N., Gupta, S., Pandey, D., and Roy, T.,Security on Vehicular Ad-hoc Networks (VANET): A Review PaperÃ¢Â€ Â•, International Journal of Emerging Technology and Advanced Engineering, Vol.3, Issue 1, 2013.