International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 4, April-2014, pp: (313-320), Impact Factor: 1.252, Available online at: www.erpublications.com

A Review paper for comparative study of different Routing Protocols in VANET

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Abstract: VANET (Vehicular Ad hoc Networks) is an emerging technology. The main application of VANETs are in ITS (Intelligent Transportation System) providing various applications such safety and non-safety related services. VANET is subclass of MANET (Mobile Ad hoc Network). Like MANET, VANET transmit its message to other nodes with the help of multi-hop relaying but dynamic topology change and high speeds of nodes creates a distinction from MANET. The fundamental component for the success of VANET (Vehicular Ad hoc Networks) applications is routing because it handles rapid topology changes and a distributed network efficiently and reliably. Although, there are several routing protocols available for MANET (Mobile Ad hoc Networks) but these routing protocols fails to fully address the specific needs of VANET especially in city environments (i.e. nodes distribution, high mobility of nodes, signals transmission blocked by obstacles, etc). In VANET intersection based protocols are required as vehicles tend to cluster at the intersection of roads. In this paper, the comparison between various protocols related to VANETs such as GPCR, STAR, VADD etc. are studied with tabular comparison.

Keywords: ITS, MANET, RSU, VANETS, V2I, V2V.

Introduction

Wireless communication has enabled many of the convenience in our lives and also increased our day to day productivity. VANET is also a wireless network and has tremendous impact on the area of inter-vehicle communication i.e. V2V (Vehicle to Vehicle), V2I (Vehicle to Infrastructure) communication and VANET. VANET are self organised networks built up from fast moving vehicles. VANET is also part of MANET and like it, it is also based on multihop relaying but high mobility of nodes, frequent network partition, constraints on roadways etc. impose high technical challenges to implement a high performance in VANET. VANET is a vehicle-to-vehicle or vehicle-to- road side units (RSU) network architecture that can deployed without relying on network infrastructure. The promising applications and cost effectiveness of VANETs constitute major encouragement behind increasing interest in such networks [1].

Topological structure of VANET is more dynamic when compared to MANET, where an end-to-end connection is usually assumed. Vehicular Networks are frequently disconnected depending upon vehicles density and speed of the nodes. The movement of vehicles is restricted on the layout of roads, which renders many topological holes in the network. The characteristics make the classical MANET routing algorithms such as AODV and GPSR [2] are inefficient for vehicular networks. These protocols do not solve the problems caused by the high speed vehicles and radio obstacles as well. High mobility leads to frequent broken routes in VANETs.

1.1 Needs of VANET

There are various needs of VANET such as:

- **Lack of connectivity:** There is need of connectivity between the fast moving vehicles as there is disconnection on high speed of vehicles.
- **Fast communication:** There is need of fast data communication while travelling ranging from safety to non-safety.
- **Safety:** There is need of safety on roads while travelling and to keep track of predecessor and the succeeding nodes to avoid accidents and track of their movement on the roads. This will help in the proper safety on roads related to driving.
- **Infotainment:** This includes all sorts of activities related to other than safety such as online gaming, data sharing related to music and other kind of activities in the day to day life.

1.2 Characteristics of VANET

- **High Mobility:** The nodes (vehicles) are highly mobile so there is need of implementing such type of algorithms that are capable of dealing on high speeds. The mobility of nodes imposes certain challenges in terms of connection maintenance while travelling with high speeds. Vehicles are moving with high speeds so they can't be more than 10s to 20s in the range of an infrastructure.
- **Dynamic Topology:** VANETs have high mobility so there topology changes from time to time in a succession of time. They tend to slow down at the intersection of roads and on straight road they are on high speed, hence topology changes frequently.
- **Predictable Movement:** As the roads are fixed in the city, so the movement of vehicles is rather predictable. Each vehicle is installed with Geographic Position System (GPS) and digital map through which it can easily predict the direction in VANET.

1.3 Applications of VANET

The two main applications of VANET are [3-5]

- **Safety:** These include those issues that are directly related to safety of passengers and drivers. These mainly include cooperative driving, accident avoidance, etc.

- **Non-Safety:** These are those issues which are directly related to entertainment and information. These mainly include traffic information, toll service, internet access, games, entertainment etc.

1.4 Architecture

VANET contains various types of mobile nodes such as vehicles. There are various RSU (Road Side Units) which act as connection provider to vehicles when they are not in range to other vehicles. The connection is maintained between Vehicle-to-Vehicle and Vehicle-to- Road Side Units.

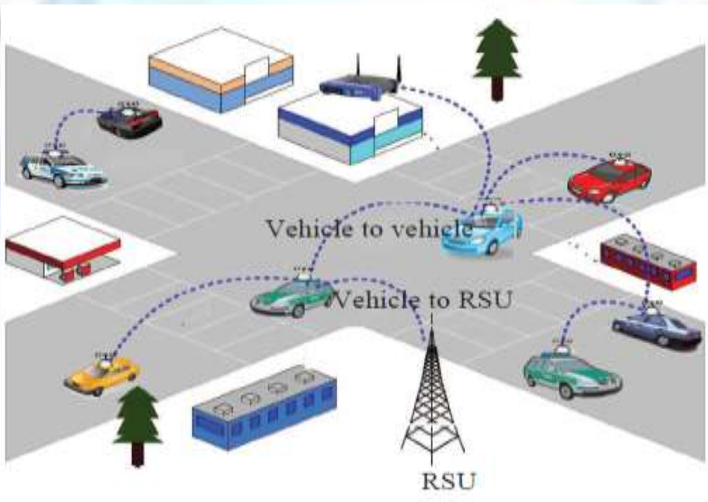

Figure 1: Overview of VANET [6]

2. Literature Survey

VANETs are self organised network built up from moving vehicles. They provide communication between V2V and V2I. The literature studied for the present dissertation work includes the study of different routing Algorithms, Data delivery Mechanisms and is presented in the following section.

2.1 Intersection Based Traffic Aware Routing in VANET

Vehicular Ad hoc Network provide efficient and reliable communication between Vehicles-to-Vehicles and between Vehicles-to-Road Side Units. In paper [6], Intersection based routing protocol has been proposed are highly reliable. When vehicles move on straight road, they move by greedy forwarding. RLFF (Red Light First Forwarding) ensures efficient routing in urban environment. It is assumed in RLFF that each vehicle is designed with GPS (Global Positioning System), digital map and each vehicle know its position, position of its neighbours and position of destination. RLFF is designed to work well on roads that are deployed with traffic lights.

RLFF works in two modes[6]:

2.1.1 Straight Mode: On straight road, the vehicles forward packets with Greedy forwarding**:** mechanism. In greedy forwarding when a node wants to send a message to destination, it checks whether the destination is reachable. If, yes, then the message ii forwarded directly. If the destination is not reachable then the node forwards the packets to the intermediate node which is near to destination than itself. RLFF uses perimeter forwarding mechanism as recovery mechanism to forward the packet to the node that is closer to destination.

2.1.2 Intersection Mode: When a packet reaches an intersection, it will check whether the red light segment near to destination is connected. If connected, the red light segment is used to forward the packet to destination.

2.2 Virtual Vertex Routing (VVR) Course-Based Vehicular Ad hoc Networks

In [7], proposes a novel Geographic routing protocol, Virtual Vertex Routing (VVR) which uses to solve the routing holes problem through the information of line. The concept of proximity of a vertex (or a virtual vertex) is introduced. An intermediate node in this proximity performs routing towards destination by Floyd Algorithm. For routing holes, the two countermeasures are : Greedy Routing(VVR-GR) and Face Routing (VVR-FR) which can guarantee packet delivery. The existing routing protocols experience routing holes problem frequently when node are placed only on straight lines because they perform greedy forwarding blindly without taking consideration about distribution of nodes into the network.

Basic mechanism of VVR routing is:

2.2.1 Initialisation: The shortest paths between all pairs of vertices in graph is calculated using Floyd Algorithm[8] having complexity $O(n^3)$ where n is number of vertices in the graph. The overhead is trivial because: (1) it is performed rarely only when the graph G is changed (e.g. new roads are added or existing roads are destroyed) and, (2) the number of vehicles on roads are smaller than number of nodes.
The source node (S) and destination node (D) are located on the source edge and the destination edge. Every edge has two vertices . Let s1 and s2 be two vertices of source edge and d1 and d2 that of destination edge. The S chooses the source vertex (srv Vtx) from s1 or s2 and the destination vertex (dst Vtx) from d1 and d2.

$$\text{Min}\{\text{dist}(S,s1) + \text{Floyd-path-dist}(si,dj) + \text{dist}(dj,D)\} \qquad \text{where } i,j=1,2$$

Where dist(a,b) is the Eucludian distance between a & b and Floyd-path-dist(x,y) is the distance of the shortest path, calculated by Floyd Algorithm between vertex x and vertex y.

2.2.2 Vertex change: VVR forwards the packet vertex-by-vertex .Once a packet arrives at a vertex, its intermediate destination is updated. The nodes that are in the closeness of geographical location of the vertex will serve as the virtual vertex. When a packet reaches a node in the proximity of VVR nextVtx, the forwarding node changes VVR.nextVtx to the next vertex of the shortest path toward VVR.dstVtx[7].
It has been shown that existing geographic routing protocols are not well suitable for VANET due to frequent routing holes problem. To solve this, VVR using the information of roads, rails, or courses with the help of navigator system embedded in vehicles are more suitable.

2.3 Intersection Based Routing for URBAN Vehicular Communication with Traffic Light consideration.

In paper[9], the impact of traffic lights in routing in Urban areas is proposed using new protocol called Shortest Path Based Traffic-Light Aware Routing (STAR). In this, the signals of traffic lights on the intersection, together with the traffic pattern govern how the packets is to be forwarded. STAR[9] is routing protocol designed for VANET in urban areas where traffic density is high, traffic light exist at intersections and vehicle may stop, slow and go. The location of each vehicle is available is equipped with GPS and digital map.

In STAR, the packets are forwarded greedy with carry-and-forward recovery[10-13]. If there is no connection then the packet is relayed toward the Green light segment that is closer to the destination. In fig.2, routing path would be
AB → BE → EH → HI, If BE and EH are connected segment.

For maintaining the segment connectivity each vehicles maintain periodically exchanged beacons or hello messages. Each vehicle approaching at intersection will broadcast its connectivity information which indicates whether or not, it can reach an intersection. These beacons are updated until it reaches to the other end of the segment. STAR which makes use of connected light segments for packets forwarding uses greedy forwarding plus carry and forward mechanism for recovery.

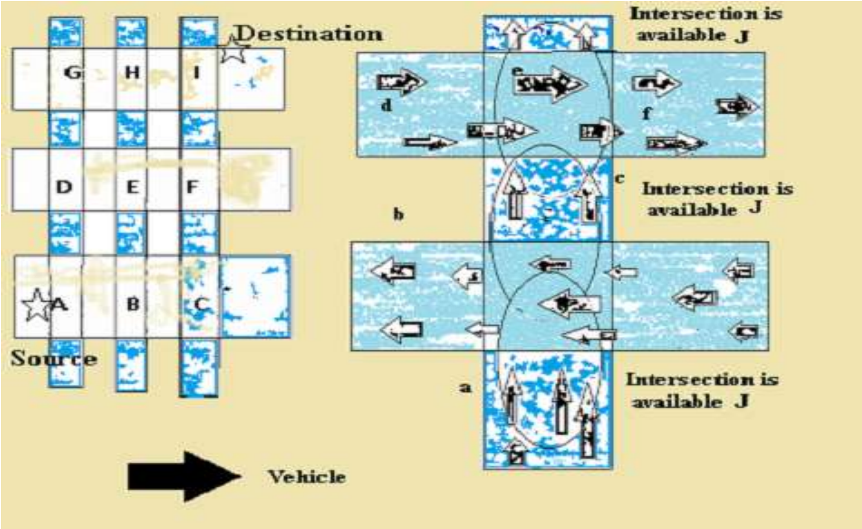

Fig. 2: Path selection under traffic light considerations [9]

2.4 An improved Vehicular Ad hoc Routing protocol for city environments

In [14], The MANET routing protocols are not suitable for VANET and fail to fully address the rapid topology changes and a fragmented network needs especially with city environments. Improved Greedy Traffic Aware Routing Protocol (GyTAR) suitable for city environments is proposed which has two modules :

(1) Dynamic selection of junction through which packets must reach to destination,

(2) An improved greedy strategy used to forward packets between junctions.

GyTAR considers that each vehicle in the network knows its own position with the help of GPS and the source node should know the current geographical position of the destination in order to make routing decision. The services are provided by Grid Location Service [14] and each vehicle knows the position of its neighbours using the digital maps which provides street level map and each vehicle knows the number of vehicles between the junctions.

2.4.1 Geographic Source Routing (GSR)[15] a routing strategy for Vehicular Ad hoc Networks in city environments. It combines position based routing with topological knowledge. GSR out performs than topology based approaches (DSR AND AODV) with respect to latency and delivery rate.

2.4.2 Anchor-based Street and Traffic Aware Routing (A-STAR)[16] is a position based routing strategy designed specifically for Inter Vehicle Communication (IVC) in a city environments. It features the novel use of city bus route information to identify anchor path of higher connectivity so that higher number of packets can be delivered to their destinations.

2.4.3 Greedy Perimeter Coordinator Routing(GPCR)[17] has deal with the challenges of the city scenarios. It does not require any global or external information such as static street map. It uses restricted greedy forwarding procedure i.e. choosing next hop, a coordinator node is preferred to a non-coordinator node even it is not closet to node to destination.

GyTAR uses real time traffic density information and movement prediction to route data in VANET. It uses geographical routing using map topology and vehicle density to effectively select the adequate junction so that packet must reach to destination.

2.5 VADD: Vehicle-Assisted Data Delivery in Vehicular Ad hoc Networks

In paper[18], Multi-hop data delivery is complicated in VANET because of high mobility and frequent disconnection. Due to this a new protocol Vehicle Assisted Data Delivery(VADD) protocol to forward the packet to the best road with lowest data delivery delay. It out performs in terms of delivery ratio, data packet delay and protocol overhead.

2.5.1 Location first probe (L-VADD)[18]: L-VADD tries to find out the closest contact towards that direction as next hop. The packet checks the next intersection using the priority assigned to each road where a smaller number has high priority. The packet carrier checks the outgoing direction from the highest priority. For a selected direction, the packet carrier chooses the next intersection towards the selected direction as the target intersection and apply geographical greedy forwarding towards target intersection to forward the packet . This process continues till selected direction has lower priority than carrier current direction.

2.5.2 Direction first probe(D-VADD) and Multi-path Direction First Probe (MD-VADD)[18]: Routing loop occurs because vehicles don't have an unanimous agreement on order of priority and they don't have any decision- to who should be carrier of packet. In D-VADD, the contact start moving towards the selected direction.MD-VADD increase the chances of finding the optimal direction, the packet carrier doesn't delete the packet from its own buffer until it is forwarded towards the direction of highest priority i.e. when D-VADD select a contact for next hop, it passes a copy of the packet to the selected contact and continues buffering the packet. It marks the packet as SENT and record dsent as the direction of the contact to which packet has just passed.

2.6 A Novel Location Based Service for Urban Vehicular Ad hoc Networks

In [19] proposed a Scalable and Effective Location Service called RSLS based on responsible sections (RS) which are intersections with traffic lights or bus stops. Vehicles in the RS acts as location servers to store the latest position of vehicles and provide location query service.

GLS [20] divides the network into hierarchy of square called quad-tree. Each node selects one node from every level of quad tree as a location server. HLS [20] partitions the networks into cells that group into region level by level.

2.6.1 Location Server Selection: RSLS firstly determines the corresponding RSes which the server are locating in [19]

2.6.2 Location Update: When a vehicle changes its position, it needs to transmit its latest position to all location servers in direct and indirect Responsible Sections.

2.6.3 Location Query: When vehicle U wants to communicate with V, U must know the position by transmitting query message to the server of V.

Scalable and Effective Routing Service called RSLS in which vehicles only locating in those areas of can act as location servers. These are formed on areas of crossroads with traffic light and main bus stops which has lower speeds or stops. RSLS focuses on the transmission of multi-media signals (MP3 Stream) between a static and mobile node.

2.7 Multicast Voice Transmission over Vehicular Ad-hoc Network: Issues and challenges

In Paper[21], The voice data that has been transmitting consist of several MP3 files containing various safety messages. All these message have been encoded at 192 kbit/s using LAME MPEG-I layer 3 encoder. VANETs have intrinsic characteristics such as interference and multipath effects which makes data forwarding more challenging[22-23]. A well known solution in the field of multimedia streaming such as dynamic retry, limit adaptation is used which has limitations on concurrent transmissions, high node density and mobility[24]. The other protocols such as dynamic routing algorithms[24] and IPv6 [25] are very useful in multimedia communication but not in single hop communication. In order to perform real time applications audio/voice multimedia streaming, a client-server software suite compliant with the standard RTP/UDP/IP protocol stack has to be implemented. MPEG-I layer 3 (MP3) fulfils the needs of low complexity and latency encoding and decoding. The various posterior packet retransmission techniques such as Automatic Retransmission request, a priori and scalable error protection techniques such as Forward Error Correction (FEC) are seen to reduce packet loss [26].

In this paper a transmission of MP3 streams in typical urban context are focused. The various solution for V2I connectivity ranging from software enhancements to use of omni-directional antennas. An optimised client server streaming software suite is developed for test results.

2.8 Mobile Cluster Assisted Routing for Urban VANET

In paper [27], a new mobile cluster assisted routing for scalable networks is proposed. High mobility and scalability are two vital issues are considered while aiming reliable data dissemination in a VANET. In real time scenario, Vehicular density at the road junction is higher than that of the roads. Vehicle Assisted Data Delivery (VADD) implemented predicable mobility by taking the traffic pattern and road layout into account.

2.8.1 Junction Mode: As a vehicle approaches a road junction, it switches to junction mode. The cluster in the direction of cluster is chosen to forward the packet. One of the vehicles in chosen cluster is elected as cluster head (CH) which collects data.

2.8.2 Cluster formation: The vehicles when disseminated at the junction are in range of one another and hence from this cluster one (preferably the centre node) of the vehicles is chosen as cluster head through which all cluster in the group can be contacted.

2.8.3 Cluster Head: Each moving cluster has its own cluster ID and it covers several vehicles. Cluster head is chosen for the mobile cluster where a count on vehicle nodes and static node becomes the input and cluster head is the output.

2.9 VANET- Challenges in selection of Vehicular Mobility Model

VANET is a wireless communication between Vehicle to Vehicle and Vehicle-to-Roadside infrastructure. VANETs have different challenges as compared with MANET. VANET has traffic, safety and user application based challenges which have some specific design requirements.

S. No.	Challenge Base	Challenge	Design Requirement
1.	Traffic Base Challenge	Highly Dynamic Vehicles Lesser Bandwidth Traffic jam, Traffic light and intersection of road (Emergency conditions)	Dynamic Topology Less flooding in network Good congestion control mechanism
2.	Safety Based Challenges	Breaching of Privacy Of Vehicles Government and authorities surveillance	User authentication and data authentication Balance in privacy and liabilities
3.	User application base challenges	Revenue Generation for funding VANET	Require flooding of information in the network

Table1: Challenges in VANET [28]

3. Comparison between different routing protocols of VANET

Table 2 : Comparison between different VANET protocols.

S. No	Protocol Proposed	Compared with protocol	Comparison parameters	Advantages	Disadvantages
1.	VVR[7]	GPSR, AODV	Delivery ratio, delay, normalized routing overhead	Solves the problem of routing holes problem	Success of packet delivery through edges is not guaranteed
2.	STAR[9]	GyTAR, GLS, VVR	Aggregate TCP throughput	Intersection based routing protocol used for urban areas	Less suitable for straight road
3.	GLS	GyTAR, STAR	Average delivery delay, CDF of delivery ratio	Useful on straight road communication	Not useful on intersection of roads
4.	GyTAR[14]	GSR, LAR	Delivery ratio vs. (a)packet sending rate and (b) Nodes number	Limits the control message overhead, uses concept of prediction	Requires the additional information of network
5.	GPCR[17]	GyTAR	Delivery ratio and throughput	Don't require any global and external information i.e. maps	While choosing next hop, a coordinator node is preferred rather than non-coordinator even if is not closet to destination
6.	GSR[15]	GyTAR, LAR	Routing Overhead vs no. Of nodes	Combines position based routing with topological knowledge	Requires additional geogra;hic information

7.	VADD[18]	D-VADD, MD-VADD, H-VADD, GPSR, Epidemic	Data sending rate for 150 nodes and 210 nodes	Support delay tolerate application in sparsely connected VANET	Uses predicable vehicle mobility which limited to traffic pattern and road layout
8.	RSLS[19]	HLS, GLS	Success rate vs velocity, success rate vs no. of vehicles	Is successful in terms of small and large scenarios in terms of success query rate	Not suitable for high speeds
9.	RLFF[6]	GPSR	Packet delivery ratio, delay and overhead	Suitable for both intersection and straight mode	Requires support from the traffic lights

4. Issues

There are several issues in VANET that needs to be addressed. Some of these are described as per below:

- **Handoff:** There is requirement of handoff in VANET since vehicles have high speeds and they almost remain 10s to 25 s within the range of the vehicles and Roadside units(RSU)
- **Safety:** There is requirement of safety in VANETs as there are several issues ralated to safety of vehicles and the person the roads. These include the cooperative driving and avoidance of accidents.
- **Energy:** The transmission of packets as well as the computation carried out at nodes, consumes a significant amount of energy. In some cases, such as battery operated wireless networks, the resources may be highly constrained where it is important to take into account the residual energy of a node while determining whether to exchange data during an encounter. So, the energy is an important issue in Vehicular Ad hoc networks that needs to be considered.
- **High Speed:** VANETs have speeds and they move around in the range of 60-90 Kmph. There is requirement of discovering those algorithm which will deal with nodes at such a high speed as existing protocols are not upto the mark.
- **Dynamic Topology:** The topology of the VANETs are changing at a short moment since they have high speeds .So, there is requirement of those routing protocols that will deal with such type of problem in systemic manner.

5. Future Work

This paper presents the comparison among the various existing protocol in VANETs with their pros and cons. The existing protocols are not upto the mark to deal properly with VANETs. There is still scope of development in this field for developing such type of protocols to deal with the high speed nodes. There is requirement of much better handoff techniques to deal with dynamic topology changing networks. Safety is much more emphasizing needs in the VANETs which require to deal with the much attention and drawing such type of algorithms to tackle this problem.

6. Conclusion

In this paper, the various routing protocols for VANETs are compared. Choosing the correct routing protocol and providing with appropriate simulation will improve the performance of routing protocols in VANETs. The various real life issues and applications are required to be properly implemented so that the applications of VANETs can properly implemented in the real life scenarios.

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