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A Survey on Topology and Geography based Routing Protocols in VANETs

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Abstract:

VANET [Vehicular Ad hoc Networks] is a new type of wireless communication which involves mobile ad hoc networks, Wireless LANs (WLAN), Cellular networks (3G/4G LTE) and WiMAX (IEEE 802.16)[1] to achieve road safety, vehicle to vehicle communication connectivity, un-intermittent internet connectivity, important alert messages and accessing infotainment and entertainment applications. VANETs play an important role in implementing Intelligent Transport System (ITS). Considerable research interest is shown by the academicians, researchers and industry to design an effective routing protocols in the VANETs to provide ubiquitous connectivity and efficient vehicle to vehicle and vehicle to road side unit connectivity to enable ITS. In this paper we attempt to classify the various topology and geography based VANET routing protocols.

Keywords: VANET, DSRC, ITS WAVE, Broadcast based routing, Data Fusion based routing, Bio-inspired routing

INTRODUCTION

Vehicular Adhoc Network (VANET) can be treated as an extension of Mobile Adhoc networks. In a VANET, each vehicle is equipped with an On Board Unit (OBU) to transmit and receive data with OBUs on another vehicles or access points on the road called Road Side Units (RSU) vehicular communication is essential for improving road safety and comfort through Intelligent Transport System (ITS). One of the essential requirement of the ITS is the deployment of cooperative wireless networks among the vehicles (V2V) and between vehicles to RSU (V2I). The application of ITS can be divided into following categories: Safety services, traffic management and User oriented services [2].

Characteristics of VANET:

VANETs can be differentiated from other kinds of adhoc networks with respect to dynamic topology, Frequent disconnected network, geographical type of communication, interaction with onboard sensors, various communication environments and hard delay constraints [2].

VANET Standardization [4]:

Dedicated Short-Range Communication (DSRC) [3][4] was introduced by the FCC (Federal Communication Commission) to support vehicle to vehicle and vehicle to Infrastructure communication. The standard supports nominal transmission range of 300m (up to 1000m), a data rate of 6 Mbps (up to 27 Mbps) and the maximum speed of vehicles up to 190 Km/hr (53 m/sec). DSRC is defined in the frequency band of 5.9 GHz on the total bandwidth of 75MHz with 7 channels. The Media Access Control and physical layer specification of DSRC follow IEEE 802.11p standard. Wireless Access in Vehicular Environment (WAVE) is the mode of operation in IEEE 802.11 compliance devices which in turn uses DSRC band. The wave covers IEEE 1609.1 (Wave resource manager) IEEE1609.2 (Wave Security services) IEEE 1609.3 Wave networking services IEEE 1609.4 Wave multi channel operation [5]. The WAVE stack is illustrated in Figure. 1.

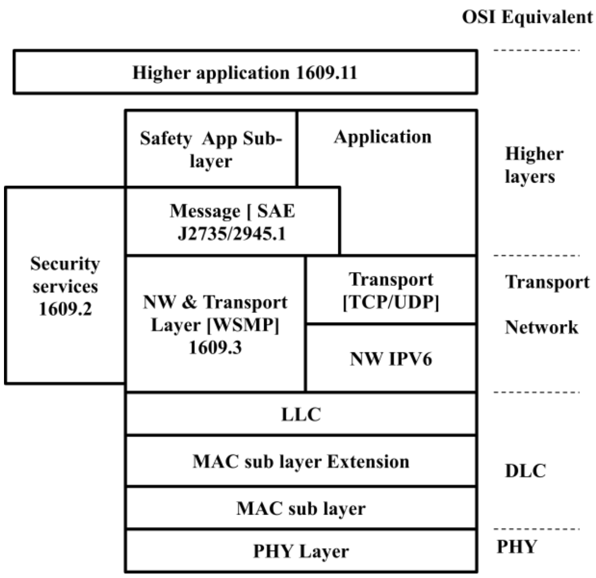

Figure 1: Protocol stack of WAVE

Routing in VANET:

Routing in VANET depends on many factors such as velocity, density and motion of vehicles etc.. The applications of routing in VANETS pertain to safety, transport efficiency and infotainment. Many of the MANET routing methods (AODV, DSR, and LAR) have been applied to VANETS. In this paper, we have categorized the summary of our survey on VANET routing protocols available in the literature.

The VANET routing protocol can be classified in to four categories depending on (a) Communication methods (b) Routing information (c) Bio-Inspired and (d) Diffusion based routing protocols as in Figure. 2. The communication methods based routing protocols are further classified in to (i) Broadcast (ii) Multicast and (iii) Unicast routing protocols[7] as shown in Figure-3. The routing information based protocols are further classified in to (i) Topology based and (ii) Positioned based routing protocols. Most of the broadcast based routing protocols use selective flooding [8]. The selective flooding based routing protocols are further classified in to (i) topology based (ii) cluster based (iii) table based (iv) location based (v) distance based and (vi) probability based routing protocols. The multicast routing protocols are divided in two categories viz (i) Cluster based and (ii) Geo-cast based protocols as shown in Figure. 3.

Similarly topology based routing protocols [8] are further divided into (i) proactive (ii) reactive and (iii) hybrid protocols as in Figure. 4. The position based routing methods are further sub-divided in to non-delay tolerant, delay tolerant and hybrid protocols as shown in Figure. 5. In [37] the authors classify the algorithms called 'Bio-inspired algorithms as shown in Figure .6.

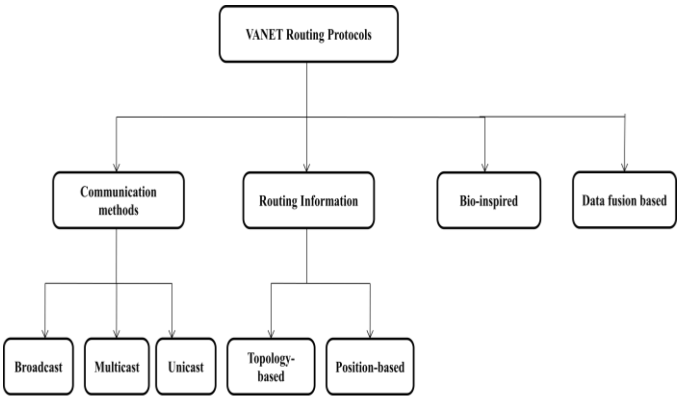

Figure 2: Classification of VANET routing protocols

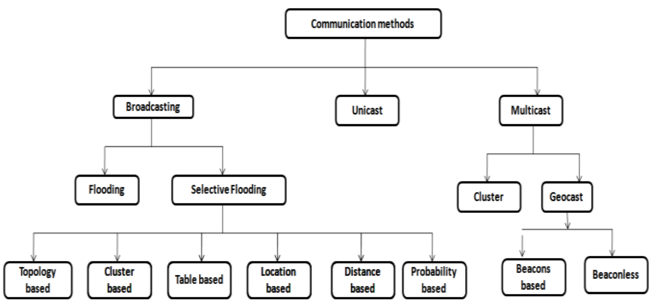

Figure 3: Classification based on communication methods

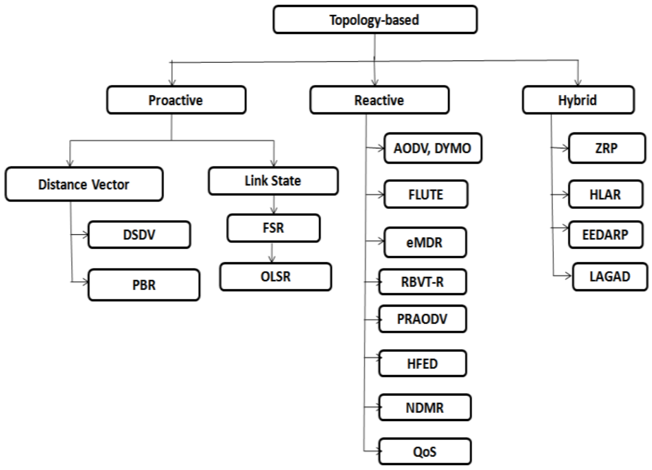

Figure 4: Classification of Topology based routing

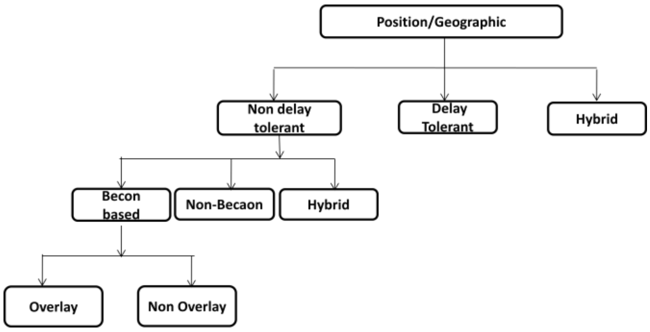

Figure 5: Classification based on position

In [37], the authors classify the class of algorithms called 'Bio-inspired algorithms as shown in Figure-6.

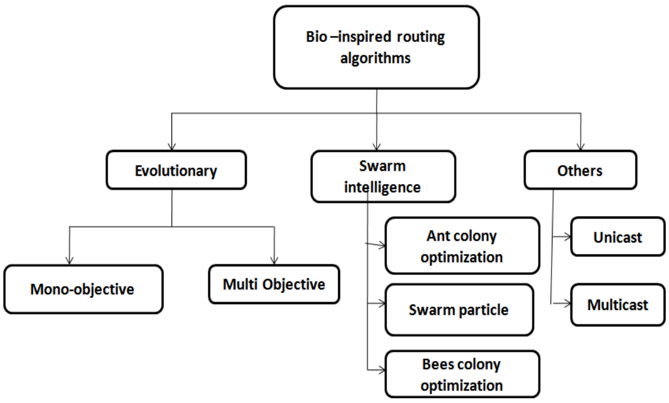

Figure 6: Classification of Bio-Inspired routing

Most of the routing protocols used in MANETS are used in VANETS also [9].

Routing Protocols:

The routing table which stores all link information is the basis for routing the packet from source to destination nodes. The routing information based protocols are classified in to four groups depending upon underlying implemented architecture. They are (i) Proactive (ii) Reactive and (iii) Hybrid and (iv) Predication based. Each node in a network maintains one or two routing tables which stores information of all neighbouring nodes; each entry in the table contains address of the next hop node used in the routing path to the destination node. Each node broadcast messages periodically to all other nodes to collect information about the neighbour nodes irrespective of whether the route is actually required or not. Any topology changes in the network will be immediately updated in the routing table. However these protocols cause additional communication overheads in the high mobility network. Proactive protocols depend upon shortest path algorithm to determine the route to be chosen. Two different methodologies are used to determine the route. (i) Link state information and (ii) Distance vector.

Rest of this paper is organised as follows. Section-2 and 3 present a comprehensive survey of topology and geographic based VANET routing algorithms. Section-4 addresses the challenges and issues of the above said schemes and section-5 presents the concluding remarks and future research directions on VANET routing.

ROUTING ALGORITHMS:

Prediction Based Routing Algorithm [PBR]:

Vinod Namboodiri et al.[10] proposed prediction based routing algorithm. Two important parameters of PBR protocol are location information and velocity information of vehicles on the route to the gateway. The prediction algorithm predicts when the route will break based on the above two parameters. The life time of the communication link depends on the direction of the moving vehicles. Hence the direction information is used additionally to predict the route. The PBR proactively creates new routes before they break. Prediction algorithm calculates the life time of the link and route and speed information. PBR protocol also differs from reactive protocols like AODV and DSR.

Fisheye State Routing [FSR]:

Guangyu Pei et al.[11] formulated FSR is hierarchical proactive link based routing protocol proposed by Kleinrock and Stevens. Each node maintains one list and three tables. They are neighbour list, topology table, next hop table and distance table. In addition to these, link weight function is used to determine shortest path based on specific metric. The nodes maintain a link state table from the information received from neighbouring nodes periodically. The table entries with largest sequence number are retained replacing small sequence number. No flooding was used here. Periodic table exchanges between nodes are similar to DSDV and Distributed Bellma-Ford (DBF) algorithm. Full topology map is kept in each node and only link states are exchanged rather than distance vector.

Destination Sequence Distance Vector Routing [DSDV]:

Teressa Longjam et al.[12] devised DSDV which is a proactive routing protocol and it is same as Routing Information Protocol (RIP), the only difference is DSDV has additional attribute sequence number in the routing table. The broadcasted routing information thus has the fresh sequence number, the address of the next hop, route metric, the new sequence number generated by the destination and the number of hops required to reach that destination. The fresh destination sequence number is used to decide that whether to forward the information again or not. This fresh sequence number is also updated to all the nodes while transmitting within the network.

Optimised Link State Routing [OLSR]:

Jamal Toutouh et al. [13] proposed OLSR. It is one of the classical routing protocols, the information about all possible routes to destination nodes will be updated in the routing table. ‘HELLO’, ‘TC’ (Topology control) and ‘MID’ (Multiple interface declaration) are the three types of messages which are exchanged between nodes to maintain the routing information. OLSR relies on flooding the control messages periodically using special nodes called ‘Multi Point Relays’ as per RFC3626[14]. The main advantage of the OLSR is best suited routing protocol for high density networks [13] OLSR is suited for application that require low latency in the data transmission especially security messages in VANETs [15] [16], Supports multi interface (Blue tooth, Wi-Fi, etc.) that acts as a gateway for other network infrastructures (Smart phone, RSUs, etc.)[13].OLSR does not require the high resource capabilities (Transmission range, bandwidth, directional antenna, etc.)[16].

Ad hoc On Demand Distance Vector Routing Protocol [AODV][RFC 3561]:

C. E. Perkins et al. [17] proposed this scheme. The Ad hoc On-Demand Distance Vector (AODV) routing protocol is meant for use by mobile nodes in an ad hoc network. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the adhoc network. It uses destination sequence numbers to ensure loop freedom at all times. AODV is experimented in six cars. AODV is unable to discover, maintain and update long routes in VANETs [3]. Three way handshakes to establish a connection between nodes is almost impossible.

Dynamic on demand routing protocol [DYMO]:

The DYnamic Manet On-demand (DYMO) routing protocol is intended for use by mobile nodes in wireless, multi-hop networks proposed by Chakeres et al.[18]. It offers adaptation to changing network topology and determines unicast routes between DYMO routers within the network in an on-demand fashion. In AODV, the information about target node and next hop is collected where as in DYMO, the route discovery process collects information about the source node and the intermediate nodes in the new path.

File Delivery over Unidirectional Transport [FLUTE]:

FLUTE protocol proposed by Carlos T. Calafate et al. [19] uses either broadcast or multicast for robust communication between source node and destination node and doesn't require bidirectional communication between them. It will work with any unidirectional communication such as Internet, Satellite, Wi-Fi, etc. FLUTE protocol depends on different Forward Error Correction schemes such as XOR, Reed-Solomon and Raptor codes. The file to be transmitted will be opened in binary mode and FDT (File Delivery Table) will be created by appending FLUTE headers. The encoded symbols with redundancy symbols are transmitted as FLUTE packets. In the destination node, reverse process will recover the file.

Enhanced Message Dissemination based on Roadmaps in real maps [eMDR]:

Francisco J. Martinez et al. [20], proposed this scheme which uses location and street map information to facilitate an efficient dissemination of warning messages. In this scheme, the vehicles operate on two modes, (i) Warning Mode and (ii) Normal Mode. Normal mode is default behaviour of the vehicle. When the vehicle encounters the dangerous condition, warning mode vehicles alert other vehicles by sending warning messages periodically about abnormal situations that could affect the traffic security and accident probability. The warning messages are sent with highest priority at the MAC layer. Comfort and infotainment messages are sent with low priority in normal mode. Normal mode vehicles enable the diffusion of these warning packets and periodically they also send beacons with non-critical information such as their positions and speed. Two algorithms are proposed in eMDR, one for sending and other for receiving. In sending mode, if the vehicle is in warning mode, the message is broadcasted. In receiving mode, if the message is warning and the distance between receiver and sender is greater than a threshold distance or the vehicles are in different locations, the message will be discarded. eMDR works well in urban scenario in which density of vehicle is high and surrounded by high rise buildings which absorbs radio waves.

Road Based Vehicular Traffic Reactive protocol [RBVT-R]:

RBVT-R is a reactive protocol [21] proposed by Josiane Nzouonta et al. creates on demand road-based routes by using connected road segments. These routes are depicted as the series of intersections which are stored in the data packet headers and will be used by intermediate vehicles to geographically forward the packets between the intersections. In route discovery phase, RBVT-R initiates a route discovery phase. The sending node creates a Route Discovery packet (RD) and the RD packets will be flooded using improved flooding mechanism. When a node receives a fresh RD packet, the node retains the packet for a period of time which is inversely proportional to the distance between the sending and receiving node. The receiving node creates Route Reply (RR) packet. The RR packet contains connected paths with the header information copied from RD packet. Between intersections, geographical forwarding is used to cover every available node on the path. When all the nodes between sender and receiver are connected, there is no need to store and forward. There will be broken link wherein the intermediate node carries packet for a specific time.

PRAODV and PRAODV-M:

Vinod Namboodri et al.[22] introduces two prediction based routing protocols which are variants of AODV. Both routing protocols use link state route life time estimates. PRAODV is same as AODV except that RREP packets are modified so that it includes velocity and location information. Every node that receives reply makes a link life time prediction based on its location and velocity information got from the RREP packet. Old predication value will be replaced by newly received reply packet. Both AODV and PRAODV use minimum hop count as the metric to choose between multiple paths for the same destination. The difference is that a new request is sent out just before the end of this predicted lifetime to construct a new route to the destination. PRAODV-M uses the path which has the maximum predicted value among multiple route options as metric unlike AODV and PRAODV which use minimum hop count. Simulation results show that there is slight improvement in the packet delivery ratio.

Hindering False Event Dissemination in VANETs with proof-of-work mechanisms [HFED]:

HFED was introduced by Esther Palomar et al. [23]. The main objective of this protocol is to hinder the dissemination of false event warning messages and limiting its undesirable consequences in the receiving node. The vehicle which sends Event Warning Messages (EWM) performs a computation and then attaches Evidence of computation to the EWM. The computation cost is called Proof Of Work (POW) which is used to discourage the dishonest vehicles from flooding the wrong messages. The EWM consists of type of event, location and time. EWM is broadcasted to nearby vehicles along with Event Warning Certificate (EWC). EWC is based on digital signature scheme which assures data authentication and confirms source authentication of the message. Vehicle's OBU and Hardware Security Module (HSM) is responsible for generating digital signature. RSU will produce POW to be sent to the nearby vehicles. Pre-puzzle type of POW is deployed in non interactive POW scheme and on demand POW puzzles are generated on demand POW scheme.

Node-Disjoint Multipath Routing [NDMR]:

In wireless networks, multiple paths are exposed to mutual interference or path coupling which reduces the packet delivery ratio and end-to-end delay. The packet delivery ratio can be improved if backup or secondary paths are established. If a node on one path is in the transmission range of a node on the other path, contention occurs. At most one node is allowed to transmit or receive at any time to a neighbour node. Thus, severe contention would cause reduced throughput and longer delay. The node-disjoint multi path routing [24], two paths are used for packet delivery. In the simulation, it is shown that multiple paths will improve the packet delivery ratio. The energy efficiency is higher in single path routing than NDMR without redundancy.

Multiprotocol Label Switching with QoS [MPLS-QoS]:

MPLS-QoS was proposed by Mahmood Fathy et al.[25]. The main objective of label switching networks was to bring those connection oriented benefits into a non connection oriented network. The MPLS was based on IP over ATM. Fast switching and virtual circuit mechanism of ATM for guaranteeing QoS, along with popularity and scalability of IP is the basis of MPLS. The routers forward packets by looking at the label of a packet, instead of searching in routing table to find the next hop. Attached labels causes the layer 3 functions separately from layer 2 functions like switching. Using Traffic Engineering, MPLS can determine the best route, which is not necessarily the shortest path. The vehicles send data through base station and create MPLS domain in wired domain. The protocol assumes that base stations are connected with wired Road Side back bone network (RBN). AODV is used for wireless routing protocol as it has less overhead and consumes less bandwidth.

Hybrid Location-based Adhoc Routing protocol [HLAR]:

HLAR [26] merged reactive routing and position-based geographic routing that uses all the available geographical position information. The protocol is so formulated to migrate to reactive routing as the location information degrades. In HLAR, the AODV protocol is modified with Expected Transmission Count (ETC) metric. The HLAR initiates route discovery on demand. If the source vehicle has no route to the destination, the position co-ordinates of both source and destination nodes are included in route request (RREQ) packet and the source nodes looks for nearest node to the destination node in its neighbour table. If nearest neighbouring node to the destination node is available, the RREQ is forwarded to that node. If the source node does not find closer neighbouring node, the RREQ packet is flooded to all the nodes. The RREQ packet contains TTL to avoid unnecessary flooding. Intermediate vehicles that participate in the data traffic are allowed to repair broken routes through the route repair packet (RRP). If an intermediate vehicle fails to locally repair a broken link, it sends a route error (RERR) packet to the source vehicle. A new metric, Overhead is introduced and three types of overheads namely, initiation overhead, maintenance overhead and beacon overhead to estimate the quality of link and to build up the neighbour table. The authors used Gaussian, Rayleigh and Uniform speed distribution and high way urban scenarios in simulation. In simulation it is established that HLAR has less overhead, lossy link and End-to-end delay compared to MTL (Minimum Traffic Load) and stand alone AODV-ETX.

End-to-end Delay Assessment And Hybrid Routing Protocol for Vehicular Adhoc Networks [EEDAHRP]:

EEDAHRP [27] estimates the End-to-End Delay assessment using total time spend on the route recovery process, number of hops, and propagation delay. The route discovery consists of two phases. If the destination node is in the neighbour list, RREQ will be sent by unicast and RREP will be send to the source. If the destination node is not available in the neighbour list, the second phase starts. In the second phase, the address of destination is multi casted from far nodes to near nodes. The far node address is used for restricting routing overhead in the next step. In the route discovery process parameters like number of overhead neighbour, number of overhead close neighbour and number RREP packets are used. For constructing neighbour list, nodes use ‘HELLO’ packets to update the list. After that the protocol behaviour is similar to reactive protocol. The authors claimed that EEDAHRP outperforms AODV with respect to average route discovery time, average end-to-end delay, average packet throughput and pocket loss.

Location-Aided Gateway Advertisement and Discovery Protocol for VANets [LAGAD]:

Introduced by Kaouther Abrougui et al., LAGAD [28] protocol allows gateway clients to discover nearby gateways. Gateways keep advertising themselves to their clients to permit client information about the route toward the discovered gateway without having to resort to reactive route discovery. Every vehicle using LAGAD protocol uses gateway table and routing table. Gate way discovery protocol is based on location information in the source vehicle. In the VANET model proposed by authors, given a set of gateways and assuming that each car and each base station is aware of its position, each gateway requester’s car discover nearby gateways and gain sufficient information to route packets toward the closest gateway while guaranteeing network scalability. The LAGAD protocol has unique characteristics for gateway discovery in VANETs such as (1) it is built on top of the network layer. (2) It uses channel diversity and (3) It is based upon a location-aided adaptation of the advertisement zone of the gateway. From the simulation results, the authors claimed that LAGAD has less overhead compared to proactive, reactive and hybrid protocols.

A Predictive Cross-Layered Interference Management in a Multichannel MAC with Reactive Routing in VANET:

The authors Peppino Fazio et al.[29] proposed a on demand routing protocol for multi radio environment. The objective of the scheme is to maximize the 'Average Signal to Interference Ratio' between communicating nodes. The authors designed three protocols viz, Interference aware routing scheme (IAR), Predictive IAR (PIAR) and Smoothed Predictive IAR (SPIAR). During path discovery procedure, in response to RREQ from source node, RREP packet gathers 'Signal to Interference ratio'(SIR) of the neighbouring nodes. The nodes with SIR greater that threshold will be included in RREP packet. The SIR value will be periodically refreshed and if it falls below threshold, the node initiates CREQ and CREP to dynamically switch to new channel. Since the instantaneous value of the SIR shifts due to fading, shadowing, Doppler shift etc., another method of finding route PIAR using adaptive filter theory is also proposed by authors. Third method Smoothed PIAR using Recursive Least Square algorithm is also suggested by the authors. The throughput, packet delivery ratio (PDR) decreases with number of nodes. The PIAR and SPIAR schemes present higher end to end delay as the scheme re-computes overall path. The network overhead increases as the number of node increases.

Table-1 presents a summary of various topology based protocols surveyed in this section.

Table 1: Comparison of Topology based protocols

Table-1 Topology based Routing Protocols									
Type of Routing		Path type	Environ ment	Scalability	Mobility	Packet Delivery Ratio	Latency	BW	Vehicle Density
Proactive	PBR [10]	-	-	-	-	High	Not Specified	High	Medium
	FSR[11]	-	-	-	-	Low	Not Specified	Low	Low
	DSDV[12]	-	-	-	-	Low	Not Specified	Low	Medium
	OLSR[13]	-	Urban	-	-	Medium	Medium	High	Low
Reactive	DYMO[17]	-				-	-	Low	Low
	AODV[18]	-	-	Scalable	Available	Low	-	Low	Low
	FLUTE[19]	Multi path	-	Not scalable	Low	Medium	Not specified	Low	Medium
	eMDR[20]	Multi path	Urban	Scalable	Available	High	Medium	Low	High
	RBVT-R[21]	-	Urban	Scalable	Available	Medium	Low	Medium	Medium
	PRAODV/PRAODV-M [22]	Multi path	-			Medium	Low	Medium	Medium
	HFED[23]	-	-	Scalable	Available	-	-	-	-
	NDMR[24]	Multi path				Medium	Medium	Medium	Low
	MPLS-QoS [25]	-	Urban	Not scalable	-	-	-	-	-
Hybrid	HLAR [26]	Single path	High	Scalable	Available	Medium	Low	Medium	High
	EEDAHRP [27]	-	-	-	-	Medium	Medium	High	Medium
	LAGAD [28]	-	-	Scalable	Available	Medium	Low	Not Specified	Medium

GEOGRAPHIC / POSITION BASED PROTOCOLS:

Geographic based protocols mainly depend on position data of the destination node. The position information of the destination node can be obtained from GPS and periodic beacon messages. Information thus got from maps, traffic light effect on vehicle distribution, prediction of direction of vehicle, inter vehicle link life time, prediction of speed, vehicle density, interference, heterogeneous transmission powers among vehicles and data delivery frequency are the important factors to be considered for selecting a route(s) and forwarding to the destination in multiple routes.

Greedy perimeter stateless routing for wireless networks [GPSR]:

In GPSR [30], the position information about the nodes is got from beacon packets. The algorithm consists of two methods. Greedy forwarding to the destination is applied with one hop neighbour till the message reached the destination. Greedy perimeter algorithm is applied where greedy forwarding fails. In the Greedy perimeter algorithm, the authors suggested right hand rule. The right hand rule says that when the destination is nearer to source comparing with other Neighbour – Destination distances there will be a network state called 'Local maximum'. If the local maximum state occurs, planar graphs such as Relative neighbourhood graph (RNG) and Gabriel Graph (GG) are constructed to eliminate the alternate long distance paths traversing counter clockwise direction. The main drawback of this approach is only planar graph can be constructed and packet delivery ratio is poor. The algorithm is not suited for urban scenario where the intersection of roads creates local loops.

A Trusted ROuting protocol for Urban Vehicular Environments [TROUVE]:

TROUVE [31] uses Co-operative Awareness Messages (CAM]) as per ETSI standard (Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service. The CAM messages are high frequency messages and stored in five containers. The additional format contains the Total Number of Front and Rear nodes (NFN, NRN), the Ratio of Trusted Front and Rear nodes (TFN/TRN), and the Minimum Trust in the Front and Rear (Min(TFN)/Min(TRN)). The protocol has two steps. In step 1, continuous real time trust and traffic estimation by all nodes in a distributed manner until nodes at junctions are reached. In step 2, routing messages though trusted and reliable route. A node is assumed to contain local information about neighbours and local intrusion system. From CAM messages, in-segment node information is collected and for in-junction nodes 'Segment weight' is computed. For in-segment nodes, data will be forwarded trusted stable neighbour nearest to the destination. For in-junction nodes, nodes in the most trusted segment is selected and message is forwarded. The average end to end delay and packet lost ratio is high when marginal number of vehicles are available. The algorithm is restricted to urban road scenario.

Comprehensive GPSR Routing in VANET Communications with Adaptive Beacon Interval:

In this scheme, Jia Li et al.[32] tried adaptive beacon interval instead of fixed beacon interval in GPSR. A factor called 'Coefficient of dependence' which is based on position, driving directions, data delivery frequency and number of nodes within two hop neighbour is derived from beacon packets. Existing beacon packet is modified to include counted beacon interval "T_{Beacon}" when the packet is generated. The authors assume exponential distribution functions to arrive density of vehicles, frequency of data delivery, message forwarding directions and number of hops for greedy forwarding for deducing Coefficient of dependence. From coefficient of dependence the beacon time is derived by weighted average considering minimum and maximum beacon time. In this approach when the nodes are close to destination the algorithm gives worst result. Similarly when either less or higher number of vehicular nodes are participating the performance of algorithm declines. The higher limit on the beacon interval is not suitable for vehicles moving at high speed. Additional beacons consume more bandwidth.

Stable CDS-Based Routing Protocol for Urban Vehicular Ad Hoc Networks [SCRP]:

In SCRP [33], method of routing is improved version of GPRS with respect to 'Local maximum' and load balancing with the ultimate aim of selecting routing path with minimum end to end delivery for non safety applications in urban scenario. SCRP develops stable back bones on road segments taking into account of vehicle's speed and spatial distribution of vehicles. The authors claim that the SCRP outperforms earlier traditional urban protocols such as GPSR, GyTAR [42] and iCAR [43] with respect to local maxima, node density, average end to end delay and packet delivery ratio. The disadvantage is large bandwidth consumption due to beacon packets, RSA packets and additional table construction. Routing of messages in different zones may face discontinuity if the synchronisation between articulation nodes between two zones fails.

A Greedy Traffic Light and Queue aware routing protocols in Urban Vanets [GTLQR]:

Greedy Traffic Light and Queue aware routing protocol [GTLQR] [35] is proposed by Yangyang Xia et al. is a scheme to prevent packet to topology hole and selection of relay node at the intersection of the node in the urban real world environment. Instead of beacon packets, the scheme uses periodic adaptive duration 'HELLO' packets to collect vehicle node and network in formations such as node position, node speed, direction of the node, queuing delay and distance prediction. This method of routing some time results in local maximum problem. Insuch situation, carry and forward strategy will be adopted by intermediate relay node. RSU estimates Street connectivity based on 'ON' time of the RED light , total time of the signal, length of the vehicle, average distance between the vehicles, number of lanes and number of vehicles. Intermediate neighbour node on the path will be determined from to reduce the number of hops. Neighbour priority index of intermediate destination along routing path will be determined from ratio of Signal to Noise Ratio of the intermediate destination node and queuing delay of the node. From source node to destination node the message will be greedily forwarded. If the destination is not visible, then one node at corresponding street with intersection will be selected as intermediate node. The packet delivery ratio is high and it is independent of speed of the vehicle and density of vehicle. But the end to end delay increases with number of traffic flows due to collision and queuing delay. This method cannot be used in remote hill area vehicular environment.

Cooperative Vehicular Content Distribution in Edge Computing Assisted 5G-VANET:

In [36], Guiyang Luo et al. proposed EDGE architecture which consists of two tiers. In the lower tier the Macro Base Stations (RSUs, OBUs and WiFi) co-operates with all vehicular nodes, communicate with each node for content requests of neighbours. The upper tier coordinates the all the base stations, schedules the network wide data caching and handling of unbalanced node. To cater rapid topology change and unbalanced load, the authors propose a "Multi-place Multi-factor" pre fetch scheme. Content can be pre-fetched into both infrastructure and mobile nodes and Content distribution is through graph theory based approach. Factors such as longer dwell duration of the vehicle, variation of traffic, road topology and point of interest [Petrol bunks, Hotels] are considered for content pre-fetching. Content pre-fetching based on machine learning and at MBS, it is based on predicted traffic flow. Content distribution is based on graph theory which has three phases. In phase-1, Neighbour nodes are identified by DSRC beacons in broad cast mode signal to noise ratio and channel capacity. In Phase-2, all OBUs will inform MBS about list of its current neighbours, the channel capacity of each neighbour's link and the identifiers of data items and uncached data items either with or without participation of RSUs. In Phase-3, greedy algorithm along with MWIS and scheduling algorithm CDEC [Cooperative Data dissemination in Edge Computing assisted 5G-VANET] are used for data dissemination. Security and privacy aspects of routing are not considered in this methodology.

Table 2: Comparison of Geography based protocols

Table-2 Geography Routing Protocols							
Type of Routing	Environment	Scalability	Mobility	Packet Delivery Ratio	Latency	BW	Vehicle Density
GPSR [30]	Not suitable for Urban	Not scalable	Available	Low	Medium	Medium	High
TROUVE [31]	Urban	Scalable	Available	Medium	Not Specified	High	Medium
Ref-32	Urban	Medium	Available	Medium	Not Specified	High	Medium
SCRP [33]	Urban	Scalable	Available	Medium	Medium	High	High
Ref-34	Urban	Scalable	Available	Medium	Moderate	High	High
GTLQR [35]	Urban	Scalable	Available	High	Moderate	Low	Low
Ref-36	Urban	Scalable	Available	High	Low	High	High

ISSUES AND CHALLENGES

1) Different DSRC standards are followed worldwide. USA adopts ASTM standard in which radio frequency is 5.9 GHz with 75 MHz bandwidth. European standard [CEN] uses 5.8 GHz frequency with 20 MHz bandwidth. Japan follows ARIB (Association of Radio Industries and Business) in which 5.8 GHz frequency with bandwidth of 80 MHz is identified for VANETs. The uplink and down link data transmission rates,

modulation schemes, transmission distance and channel separation are different for each standard. Hence there are interoperability and standard conformity issues. It is expected to develop a unified global standard in the near future in the light of IoT networks.

2) Several wired and wireless infrastructures such as WiFi, DSRC, WiMAX, 3G and LTE are available. Routing and vertical handover between different infrastructures are cumbersome tasks and need to be further addressed.

3) In [40], the authors bring a frame work of 5GenCIV for intelligent vehicle with self driving capability. Geographic routing with data analytic approach must be evolved to ensure safety, security, convenience and comfort driving.

4) In addition to QoS requirements, Quality of Experience from user perspective is to be ascertained.

5) Security, link stability, disconnected operations are the gray areas where there is a scope for future research.

6) Link stability with reference to signal strength, speed of vehicle and the duration of stable links along high way scenario is to be investigated.

7) In the context of infrastructure establishment, deployment of towers with sufficient resources, support to variable speeding vehicles, deployment of sensors, communication link setup, security, application specific communication are still need to be strengthened.

CONCLUSION

VANET is one of the fast emerging network standard in the recent times. In this paper, we have surveyed the routing protocols on specific aspect of VANET namely on topology and geographic based. Even though improvements were continuous as the performance of the VANET communication, the effective performances of services and application of VANET is yet to b explored. Important research issues which are open for further study are also presented. Still there are some open problems for future study.

In designing intelligent vehicles, cognition, intelligent control, computing, pattern recognition, video processing, video on demand [38] and sensing technology are the key areas which are to be addressed. In addition to that Quality Of Service (QoS)[39], Quality Of Experience (QOE), immersive experience features (Ubiquitous connectivity of vehicles, on demand location service, In motion Multimedia networking , Sharing of On board data, Human-vehicle connectivity) security attacks, threats, congestion control, directory service support, service discovery, service recovery, delay tolerant operations, collision and interference of radio channels, and performance of the protocols in real world application are to be evolved.

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