[Pagadala, 4(12): December 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.1133199 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

ROUTING PROTOCOLS IN VEHICULAR AD HOC NETWORKS: A SURVEY

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ABSTRACT

The networks that interconnect vehicles on road are called Vehicular Ad hoc Networks (VANETs). VANET is a unique type of network which comes under the shades of MANET, where the communication occurs between various vehicles moving on the paths. It is a different approach for intelligent transport system (ITS). The main target of research in VANETs is the improvements of vehicle safety by means of inter vehicular communication (IVC). Here the nodes are dynamic in nature because of this finding and maintaining route and routing process is very difficult. The performance of communication is depended on choosing the best path while communicating. The routing process is done by various routing protocols in Vehicular Adhoc Networks. The aim of this paper is to give a brief idea of VANET and focusing on categorization of routing protocols for improving the smartness of Intelligent Transport System.

Keywords: *Intelligent Transport System, IVC, Routing Process, Vehicular Ad hoc Networks.*

I. INTRODUCTION

The research work has started from the past few years on the area of Mobile Ad-hoc Networks also called as MANETS. It allows the mobile nodes to communicate in one to one and one to many without any predefined infrastructure. The protocols which are required to support MANETS are more complex when compared to other non-mobile networks because the nature of the mobility and there is no predefined infrastructure or topology for MANETS. New technologies are used to provide more and more facilities including safety applications. Among them VANETS is one. Here Vehicles are simulated as mobile nodes. VANET is a self organizing network and it is a subclass of MANETS for providing Intelligent Transport System. It comprises of the following features

- Dynamic Topology
- Mobility Patterns
- Variable Network Size
- Infinite Energy Supply
- Localization Functionality
- Interaction with Onboard Sensors
- No Power Constraints
- Frequent Network Disconnections
- Different communication environment

The various characteristics of VANET that makes it different from other type of networks are as follows:

- Communication Nodes are Vehicles.
- Speed of these vehicles is considerably fast, however relative speeds are slow
- Vehicles act as both receivers of data and as routers.
- VANET is not concerned much with power consumption, since vehicles are able to provide constant power.
- Vehicles form an extremely dynamic network and the network topology is constantly changing.
- High vehicle speeds and extremely dynamic network topology require fast real time transfer of data/packets.
- Network density of VANET is also highly dynamic.

- Motion of the vehicles is limited by the underlying road network and is somewhat predictable because it is governed by the physical road network.

Two vehicles are in direct communication range for an average time of 1 minute. The above mentioned characteristics of VANET play an important role in creating a vehicular ad hoc network, and these characteristics require for new protocols and new considerations. These considerations give rise in particular to the need of devising new routing protocols or altering existing protocols so that they can accommodate such uniqueness. Much work has been done regarding this and much still needs to be done. Many protocols have been tried and tested for VANET, some are totally new and some are revised versions of one's already being used in MANET's. This is still an open area for research; we plan to contribute to this research by analyzing the performance of existing routing protocols and suggesting improvements or possible enhancements to them.

Now a day's the research in area of VANETS has become very more why because which allows communication between vehicles to vehicles and vehicles to the internet via a sensing device installed which is installed in the vehicles on the network. But here MANET routing protocols are not suitable for the VANETS because of high speed of the vehicles and the data transmission to the neighboring vehicles and to the internet. The main need of VANET is to provide an efficient network where vehicles can communicate and share real time data. There are many difficulties facing VANETs systems design and implementation, including: security, privacy, routing, connectivity, and quality of services. Because of the high speed we will get high mobility and there may be a chance of getting frequent network disconnections, so routing in the VANETS is a big challenging task. This paper will mainly focus on the available routing protocols in vehicle to vehicle communication (V2V). The main goal for routing protocol is to provide optimal paths between network nodes via minimum overhead

II. APPLICATIONS OF VANETS

VANETs communication provides plentiful applications in present computing environment which are mainly classified into different classes such as

- Safety oriented applications
  - Emergency warning, stopped vehicle warning, lane changing warning, road conditions warning, etc.,
- Value added applications
  - Mobile commerce, entertainment, multimedia, streaming, etc.,
- Comfort applications
  - Traffic efficiency, weather information, nearest gas station, best restaurant etc.,

III. ARCHITECTURE OF VANET

When mobile nodes (Vehicles) and roadside units (infrastructure) combine with WAVE communication devices, form a highly dynamic Vehicular Ad Hoc Network (VANET), which is a sub kind of Mobile Ad Hoc Network (MANET). The feature of VANET mostly inherited from the technology of MANET in the sense of low bandwidth, self-management, self-organization, and shared radio transmission criteria remain same. But the key hindrance in operation of VANET comes from the high speed and uncertain mobility [in contrast to MANET] of the mobile nodes (vehicles) along the path. This suggested, although countless numbers of routing protocols have been developed in MANETs, many do not apply well to VANETs. VANETs represent a particularly challenging class of MANETs. So the design of efficient routing protocol demands up gradation of MANET architecture to accommodate the fast mobility of the VANET nodes in an efficient manner. This warranted various research challenges to design appropriate routing protocol.

Mainly two type of communication taken place in VANET, V2V (Vehicle to Vehicle) and V2I (Vehicle to Infrastructure), here infrastructure is mainly in form of Road Side Unit (RSU). This communication achieved from WAVE as a wireless medium. The main components are RSU (Road Side Unit), OBU (On Board Unit) and AU (Application Unit). Typically OBU is a peer device also known as user, mounted on nodes (vehicles) that use the services which provided by RSU. RSU host an application that provides services also known as provider. In addition of OBU a set of sensors also mounted on the vehicles for collection of various data and that data transmitted to other vehicle or RSU using WAVE.

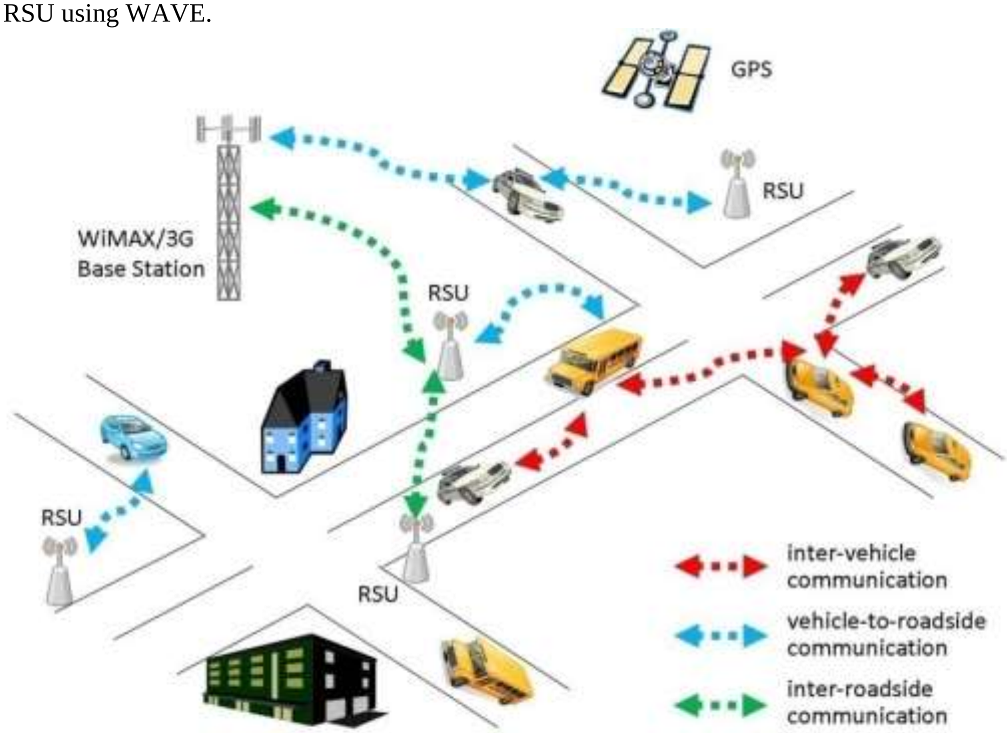

Fig:1 Architecture of VANETS

AU also mounted on nodes (vehicle) that use the application provided by provider (RSU) with the help of OBU, for example internet is the one kind of service provided by RSU and used by AU with the help of OBU.

The architectural categories of Vehicular ad hoc network are spread into three types such as

A. Pure Adhoc mode
B. Pure cellular/wlan mode
C. Hybrid networks.

Since the infrastructure of cellular towers and wireless access points are not necessarily widely deployed due to costs or geographic limitations.

[Pagadala, 4(12): December 2017] ISSN 2348 – 8034
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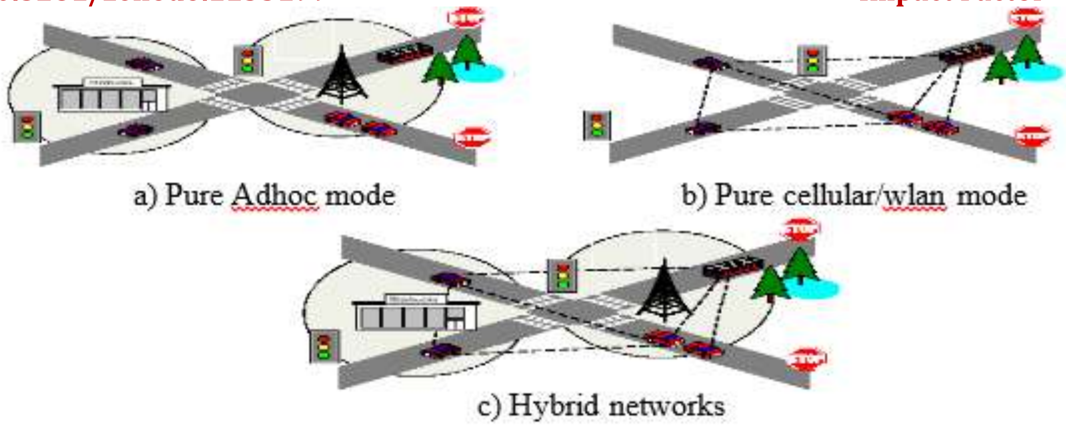

Fig: 2 Categories in VANETS

Information collected from Sensors on a vehicle can become valuable in notifying other vehicles about traffic condition and helping the police to solve the crime. The given figure shows infrastructure-less network architecture which is in the pure ad hoc category where nodes perform vehicle-to-vehicle communication with each other. When there are roadside communication units such as a cellular tower and an access point and vehicles are equipped with wireless networking devices, vehicles can take advantage of the infrastructure in communicating with each other. Various applications in areas of urban monitoring, safety, driving assistance, and entertainment have used infrastructure communicating units to access dynamic and rich information outside their network context and share this information in a peer-to-peer fashion through ad hoc.

The figure shows hybrid architecture of cellular/WLAN and ad hoc approaches provides richer contents and greater flexibility in content sharing. Since the nodes are mobile so data transmission is less reliable and sub optimal.

IV. COMMUNICATION MODES

A network of a huge number of mobile and high-speed vehicles through wireless communication connections has become electronically and technically feasible and been developed for extending traditional traffic controls to brand new traffic services. The different types of communication patterns we can observe here are as follows

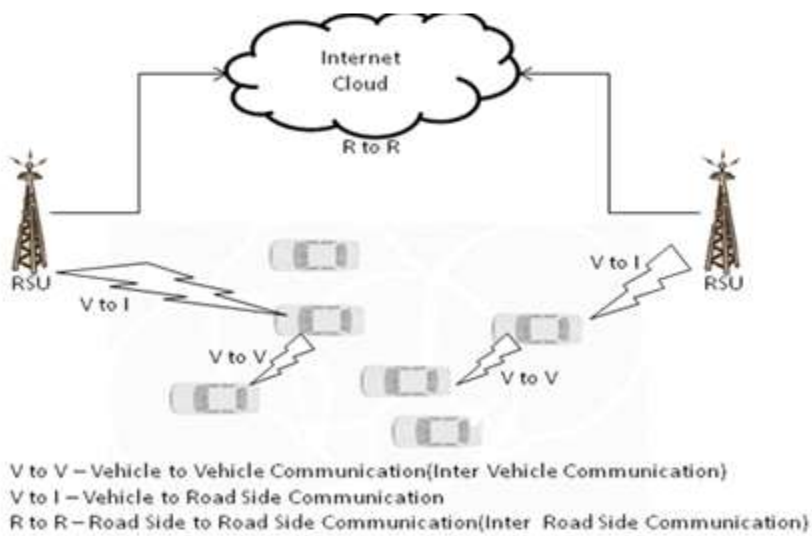

Fig:3 Types of Communication Modes in VANETS

ISSN 2348 – 8034
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Road Side Unit (RSU) RSU is equipped with device for short range communication using IEEE 802.11p radio protocol technology. It is generally situated on the road side and other dedicated location such as junction, parking spaces. It provided to enhance communication range and other routing strategies of VANET. According to C.C. Communication Consortium, the main functions and procedure associated with the RSU are:

1. Extending the communication range of the ad hoc network by re-distributing the information to other OBUs and by sending the information to other RSUs in order to forward it to other OBUs.
2. Running safety application such as a low bridge warning, accident warning or work zone, using infrastructure to vehicle communication (I2V) and acting as an information source.
3. Providing Internet connectivity to OBUs.

On Board Unit (OBU) According to C.C. Communication Consortium the main function of the OBU are reliable message transfer, data security, wireless radio access, ad hoc and position based routing, network congestion control. An OBU mounted on Vehicle consist of memory, resource command processor (RPC), a user interface, device for short range communication using IEEE 802.11p radio technology for non safety application IEEE 802.11a/b/g/n radio technology is used .

Application Unit (AU) The AU can be a dedicated device for safety application or a normal device such as personal digital assistant (PDA) for internet. According to C.C. communication consortium the distinction between the OBU and the AU is logical, The AU communicate with network solely via the OBU which takes responsibility for all mobility and networking functions.

Routing in VANET

Routing protocol is an important aspect in communication between networks. It is a set of rules that are framed for exchanging the information in a network from one node to another node as specified in the routing protocol. The main difference between the MANET and VANET routing is network topology, mobility patterns, demographics, density of vehicles at different timings, rapid changes in vehicles arriving and leaving the VANET.

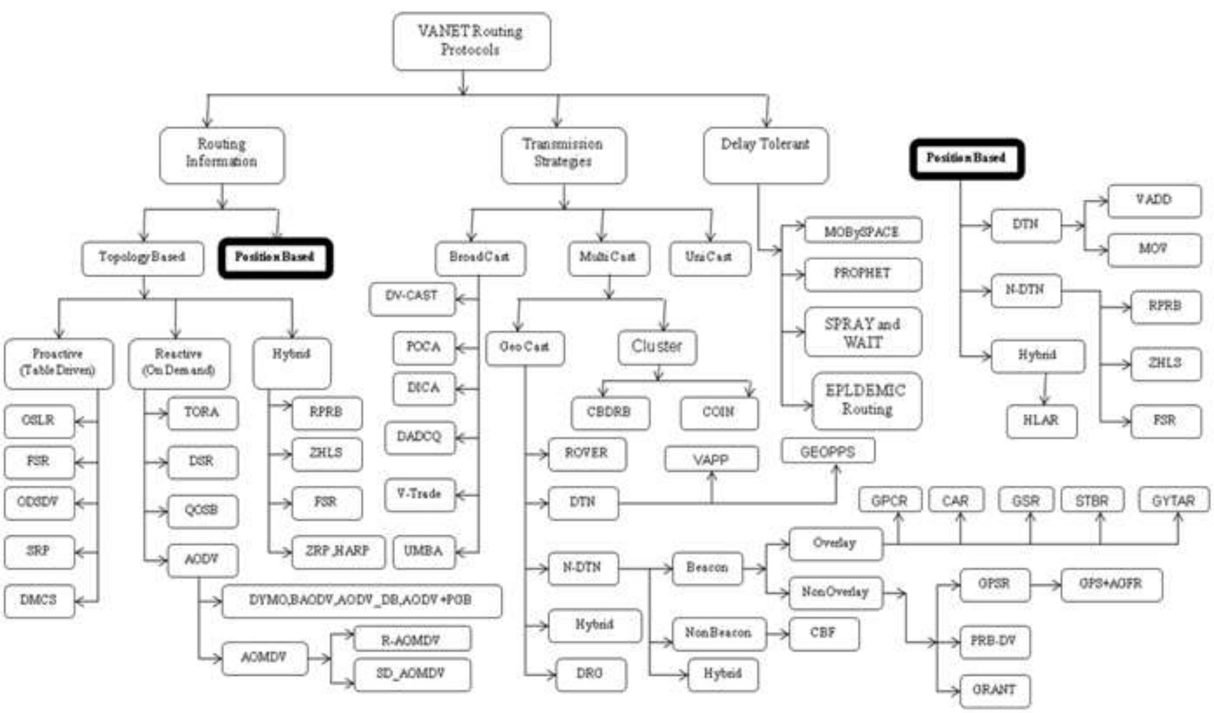

Fig: 4 Taxonomy of the literature on VANET routing protocols

VANET routing protocols have been developed to forward data packets to specified destinations using en-route relay vehicles. Vehicular environments present odd communication characteristics on roadways, such as heterogeneous traffic distribution ranging from massive to a sparse number of vehicles, along with the high mobility of vehicles. Routing in VANET can be classified under into many ways like based on Routing Information, based on transmission type, based on packets storing and forwarding and based on delay in the packets etc., This paper mainly focus on different types of available routing protocols and brief idea the about basic protocols.

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. The various types of proactive routing protocols are: FSR, DSDV, OLSR, CGSR, WRP, TBRPF.

FSR: Fisheye state routing FSR is Fisheye state routing, in FSR node maintains a topology table (TT) based upon the latest information received from neighboring and periodically exchange it with local neighbors. For large networks to reduce the size of message the FSR uses the different exchange period for different entries in routing tables. Routing table entries for a given destination are updated preferably with the neighbors having low frequency, as the distance to destination increases.

DSDV: Destination-Sequenced Distance-Vector Routing DSDV is a table-driven routing scheme for adhoc mobile networks based on the Bellman- Ford algorithm. It was developed by C.Perkins and P.Bhagwat in 1994. It eliminates route looping, increases convergence speed, and reduces control message overhead. In DSDV, each node maintains a next-hop table, which it exchanges with its neighbors.

OLSR: Optimized Link State Routing Protocol It is an optimization of a pure link state protocol for mobile adhoc networks. Each node in the network selects a set of neighbor nodes called as multipoint relays (MPR) which retransmits its packets. The neighbor nodes which are not in its MPR set can only read and process the packet. This procedure reduces the number of retransmissions in a broadcast procedure.

CGSR: Clusterhead Gateway Switch Routing The CGSR protocol differs from the previous protocol in the type of addressing and network organization scheme employed. Instead of a "flat" network, CGSR is a clustered multihop mobile wireless network with several heuristic routing schemes. It state that by having a cluster head controlling a group of adhoc nodes, a framework for code separation, channel access, routing and bandwidth allocation can be achieved.`

WRP: The Wireless Routing Protocol The WRP described in [12] is a table-based protocol with the goal of maintaining routing information among all nodes in the network. Each node in the network is responsible for maintaining four tables: (a) distance table, (b) routing table, (c) link-cost table, and (d) message retransmission list (MRL)table.

TBRPF: Topology Dissemination Based on Reverse-Path Forwarding It is a link-state routing protocol designed for ad-hoc networks. Every node constructs a source tree which contains paths to all reachable nodes by using topology table. Nodes are periodically updated with only the differences between the previous and current network state using HELLO messages. Therefore, routing messages are smaller, can therefore be sent more frequently to neighbors.

Reactive/Ad hoc based routing

Reactive routing opens the route only when it is necessary for a node to communicate with each other. 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,TORA, JARR.

AODV : Ad Hoc On Demand Distance Vector In AODV (Perkins, 1999) routing, upon receipt of a broadcast query (RREQ), nodes record the address of the node sending the query in their routing table. This procedure of recording its previous hop is called backward learning. Upon arriving at the destination, a reply packet (RREP) is then sent through the complete path obtained from backward learning to the source.

PGB : Preferred Group Broadcasting PGB (Naumov, 2006) is a broadcasting mechanism that aims to reduce broadcast overhead associated with AODV's route discovery and to provide route stability especially important in VANETs where fast moving vehicles are used as wireless hosts. Based on the received signal of the broadcast, receivers can determine whether they are in the preferred group and which one in the group to broadcast.

DSR : Dynamic Source Routing DSR (Johnson, 1996) uses source routing, that is, the source indicates in a data packet's the sequence of intermediate nodes on the routing path. In DSR, the query packet copies in its header the IDs of the intermediate nodes that it has traversed. The destination then retrieves the entire path from the query packet, and uses it to respond to the source.

TORA : Temporally Ordered Routing Algorithm TORA (Park, 2007) routing belongs to a family of link reversal routing algorithms where a directed acyclic graph (DAG) toward the destination is built based on the height of the tree rooted at the source. The directed acyclic graph directs the flow of packets and ensures reachability to all nodes. When a node has a packet to send, it broadcasts the packet. Its neighbor only broadcasts the packet if it is the sending node's downward link based on the DAG.

JARR: Junction-based Adaptive Reactive Routing The network topology of vehicular ad-hoc network (VANET) in a city environment consists of many possible paths and junctions that forms the routing paths. Shortest path routing is not viable because each path has to be populated with vehicles. A scalable multi-hop routing protocol that adapts well to the city environment even with rapidly changing network topologies and lots of disconnected and dense network conditions is sought after. A novel position based routing protocol i.e. JARR, which will address the shortcomings of the current protocols by estimating the density of paths to be used.

Hybrid Protocols

The hybrid protocols are introduced to reduce the control overhead of proactive routing protocols and decrease the initial route discovery delay in reactive routing protocols.

ZRP : Zone routing protocol In this the network is divided into overlapping zones. The zone is defined as a collection of nodes which are in a zone radius. The size of a zone is determined by a radius of length α where α is the number of hops to the perimeter of the zone. In ZRP, a proactive routing protocol (IARP) is used in intra-zone communication and an inner-zone reactive routing protocol (IARP) is used in intra-zone communication. Source sends data directly to the destination if both are in same routing zone otherwise IERP reactively initiates a route discovery.

HARP: Hybrid Ad Hoc Routing Protocol It divides entire network into non-overlapping zones. It aims to establish a stable route from a source to a destination to improve delay. It applies route discovery between zones to limit flooding in the network, and choose best route based on the stability criteria. In HARP routing is performed on two levels: intra-zone and inter-zone, depending on the position of destination. It uses proactive and reactive protocols in intrazone and inter-zone routing respectively. It is not applicable in high mobility adhoc networks.

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. Position based routing is broadly divided in two types: Position based greedy V2V protocols, Delay Tolerant Protocols.

[Pagadala, **4(12): December 2017]** **ISSN 2348 – 8034**
DOI- 10.5281/zenodo.1133199 **Impact Factor- 4.022**

GPSR : Greedy Perimeter Stateless Routing In Greedy Perimeter Stateless Routing (GPSR) (Karp, 2000),a node forwards a packet to an immediate neighbor which is geographically closer to the destination node. This mode of forwarding is termed greedy mode. When a packet reaches a local maximum, a recovery mode is used to forward a packet to a node that is closer to the destination than the node where the packet encountered the local maximum.

PRB-DV Position-Based Routing with Distance Vector Recovery PBR-DV uses AODV-style recovery as packets fall into a local maximum. The node at the local maximum would broadcast a request packet in which is the node's position and destination's location. Upon receiving a request packet, a node would first check if it is closer to the destination than the node at the local maximum. If it is not, it records the node from which it receives the request packet (similar to backward learning) and rebroadcasts the request; otherwise, it sends a reply to the node from which it receives the request.

GRANT : Greedy Routing with Abstract Neighbor Table GRANT (Schnaufer, 2008) uses the concept of extended greedy routing where every node knows its x hop neighborhood. This gives every node a far sighted vision of the best route to take to avoid local maximum.

GPCR : Greedy Perimeter Coordinator Routing GPCR is based upon the fact that city street form a natural planner graph. GPCR does not require external static street map for its operation. GPCR consists of two components: A Restricted Greedy forwarding procedure, A repair strategy for routing algorithm. A GPCR follows a destination based greedy forwarding strategy, it routes messages to nodes at intersection. Since GPCR does not use any external static street map so nodes at intersection are difficult to find.

GpsrJ+ removes the unnecessary stop at a junction while keeping the efficient planarity of topological maps. It uses two-hop neighbor beaconing to predict which road segment its neighboring junction node will take. If the prediction indicates that its neighboring junction will forward the packet onto a road with a different direction, it forwards to the junction node; otherwise, it bypasses the junction and forwards the packet to its furthest neighboring node.

CAR : Connectivity Aware Routing Protocols Following their work on Preferred Group Broadcast (PGB) to minimize broadcast from AODV route discovery and Advanced Greedy Forwarding (AGF) to account for node mobility, Naumov et al. (2007) presented Connectivity-Aware Routing (CAR) in VANETs. CAR protocols find a route to a destination; it has unique characteristics that it maintains the cache of successful route between various source and destination pairs.

GSR : Geographic Source Routing Earlier GSR was used in MANET. Then it was improved to use in VANET scenario by incorporating in to it greedy forwarding of messages toward the destination. If at any hop there are no nodes in the direction of destination then GPSR utilizes a recovery strategy known as perimeter mode.

A-STAR : Anchor-Based Street and Traffic Aware Routing A-STAR (Seet, 2004) is similar to GSR in that packets are routed through anchor points of the overlay. However, A-STAR is traffic aware: the traffic on the road determines whether the anchor points of the road will be considered in the shortest path. A-STAR routes based on two kinds of overlaid maps: a statically rated map and a dynamically rated map. A statistically rated map is a graph that displays bus routes that typically imply stable amount of traffic.

STBR : Street Topology Based Routing [29] STAR (Forderer, 2005) went further than A-STAR by computing the road connectivity at junction nodes. One of the nodes at a junction is selected as a master that is responsible for checking if links to the next junctions are up or down. Within the broadcast from every master, there is also link information to all neighboring links.

GyTAR : Greedy Traffic Aware Routing protocol GyTAR (Jerbi, 2007) is an overlaid approach similar to the approaches mentioned above in that packets are forwarded greedily toward the next junction which will then determine the best junction to forward next. GyTAR assumes that the number of cars is given per each road from roadside units and determines the connectivity of roads.

LOUVRE : Landmark Overlays for Urban Vehicular Routing Environments Lee et al. (2008) has summarized geographic greedy overlay routing into two camps. The first camp is geo-reactive overlay routing where the next overlaid node is determined based on their neighboring nodes' distance to the destination (STBR) or a combination of it and traffic density (GyTAR). The second camp is geo-proactive overlay routing where the sequence of overlaid nodes is determined a-priori (GSR and A-STAR). Landmark Overlays for Urban Vehicular Routing Environments (LOUVRE) belongs to the second camp.

DIR : Diagonal-Intersection-Based Routing Protocol DIR protocol constructs a series of diagonal intersections between the source and destination vehicle. The DIR protocol is based upon the geographic routing protocol in which source vehicle geographically forwards the data packets towards the first diagonal intersection, second diagonal intersection and so on until the last diagonal intersection and finally geographically reaches to designation vehicle.

ROMSGP : Receive on Most Stable Group-Path The ROMSGP algorithm is an integration of the receive on most stable path (ROMSP), with the grouping of nodes according to their velocity vectors, as previously demonstrated, with certain modifications to suit it to the VANET scenario. For example, the non-disjoint nature of ROMSP is not considered due to the strict mobility pattern of VANET networks.

AMAR : Adaptive movement aware routing protocol AMAR [Brahmi (2009)] is a Movement Aware Greedy Forwarding (MAGF) based on the greedy forwarding scheme to select nexthop node towards the destination. AMAR scheme makes use of additional information about vehicle movement to select an appropriate packet's next-hop that ensures the data delivery.

EBGR : Edge node based greedy routing protocol EBGR [Prasanth (2009)] is the position based routing protocol based on greedy forwarding strategy. EBGR protocol uses unicast for sending message from any node to any other node or broadcast for sending message from one node to all other nodes in highly dynamic networks. This method selects the edge node of the limited transmission range as a next hop node for sending message from source to destination.

B-MFR : Border-node based most forward within radius routing protocol Next-hop forwarding method like greedy forwarding scheme folinear network does not support well in highly mobile ad hoc
network such as vehicular ad hoc network. Therefore, other position based protocols such as MFR, GEDIR, Compass routing, etc. have been used for VANET to improve its performance for non-linear network in a high vehicular density environment.

ARBR : The Associativity-Based Routing ABR protocol defines a routing metric named as degree of association stability. That is free from loops, deadlock, and packet duplicates. Signal Stability-Based Adaptive Routing protocol (SSR) employs route selection criteria to choose the routes that have "stronger" connectivity. SSR can be divided into two cooperative protocols: the Dynamic Routing Protocol (DRP) and the Static Routing Protocol (SRP).

MORA : Movement-Based Routing Recent interest in car-to-car communications and networking has lead to the definition of the concept of VANET as an infrastructure-free ad-hoc networking solution in the automotive scenario. The requirement for providing reliable and efficient routing schemes in presence of relative movement motivates the proposal of MORA, a movement-based routing algorithm for VANETs.

VGPR: Vertex-Based predictive Greedy Routing It is a multi-hop vehicle-to-infrastructure routing protocol for urban environment. It estimates a sequence of valid junctions from a source node to fixed infrastructure and then, transmit message to the fixed infrastructure through the sequence of junctions. It uses position, velocity and direction of vehicles for calculating both sequence of valid junctions and greedy forwarding.

MIBR: Mobile Infrastructure Based VANET Routing It uses buses as a key element in route selection and data transfer process. While designing the protocol quality of transmission for each road segment and different transmission abilities of various vehicles are also considered. It measures the density of every road segment using bus line information. MIBR is a location based reactive routing protocol. Source node uses GPS system to get the destination information. Each bus contains two heterogeneous wireless interfaces and other vehicles have single interface.

DTSG Dynamic Time-Stable Geocast Routing: The main aim of this protocol is to work even with sparse density networks. It dynamically adjusts the protocol depending on network density and the vehicles speed for better performance. It defines two phases: pre-stable and stable period. Pre-stable phase helps the message to be disseminated within the region, and stable-period intermediate node uses store and forward method for a predefined time within the region.

TO-GO: Topology-assist Geo-Opportunistic Routing TO-GO is a geographic routing protocol which improves packet delivery in greedy & recovery forwarding that can bypass the junction area by using two hop beaconing. No hidden terminal occurs because all nodes can hear one another. From simulation result TO-GO, GPCR, GpsrJ+ have similar packet delivery ratio. Low S/N ratio is taken care of.

CBF: Contention-Based Forwarding CBF is a geographic routing protocol that does not make use of beacons. In CBF if there has a data packet to send, the sending node will broadcast the packet to all direct neighbors & these neighbors will find out among themselves the one that will forward the packet. Elimination of beacon message saves bandwidth.

VADD: Vehicle-Assisted Data Delivery VADD (Zhao et al., 2006) is a vehicular routing strategy aimed at improving routing in disconnected vehicular networks by the idea of carry-and-forward based on the use of predictable vehicle mobility. A vehicle makes a decision at a junction and selects the next forwarding path with the smallest packet delivery delay. A path is simply a branched road from an intersection.

GeOpps : Geographical Opportunistic Routing (2007) takes advantage of the suggested routes of vehicles navigation system to select vehicles that are likely to move closer to the final destination of a packet. It calculates the shortest distance from packet's destination to the nearest point (NP) of vehicles' path, and estimates the arrival of time of a packet to destination.

GeoDTN+Nav:(Cheng et al., 2008) is a hybrid of non-DTN and DTN approach that includes the greedy mode, the perimeter mode, and the DTN mode. It switches from non-DTN mode to DTN mode by estimating the connectivity of the network based on the number of hops a packet has travelled so far, neighbor's delivery quality, and neighbor's direction with respect to the destination.

Cluster Based Routing Protocols

Cluster based routing is preferred in clusters. A group of nodes identifies themselves to be a part of cluster and a node 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. The various Clusters based routing protocols are COIN, LORA-CBF, TIBCRPH, CBDRP.

CBDRP : Cluster-Based Directional Routing Protocol It divides the vehicles into clusters and vehicles which are moving in same direction form a cluster. The source sends the message to its cluster header and then it forwards the message to header which is in the same cluster with the destination. At last the destination header sends the message to the destination. The cluster header selection and maintenance is same like CBR but it considers velocity and direction of a vehicle.

TIBCRPH: Traffic Infrastructure Based Cluster Routing Protocol with Handoff Node's high mobility leads to frequent broken routes in VANET, using the idea of cluster can help to achieve efficient transmission of messages. The exiting traffic infrastructures to cluster the network effectively, which will assist the transmission of data packets. Due to the characteristics of radio-communication, the overlap between clusters will occur inevitably, in order to ensure the service quality of nodes' communications, it make use of the handoff idea of cellular networks and propose a new protocol which is special for VANET, the proposed scheme is dubbed Traffic Infrastructure Based Cluster Routing Protocol with Handoff.

LORA-CBF: Location Routing Algorithm with Cluster-Based Flooding In LORA_CBF, each node can become the cluster-head, gateway or cluster member. For each cluster, there is one cluster-head. The node which connects two clusters are called gateway. The cluster-head maintains information about its members and gateways. The packet forwarding is same the greedy routing. Only clusterhead and gateways can send out the location request (LREQ) packets when the location of the destination is not available as well as the phase of the Location Reply (LREP) messages. The proposed LORA-CBF shows highly heterogeneous performance results.

COIN: Clustering for Open IVC Network Cluster head selection in COIN is based on vehicular dynamics and driver intentions instead of ID or relative mobility as in conventional clustering methods. IVC also accommodates the oscillatory nature of inter-vehicle distances. Ideally, the relative mobility between a cluster head and a member node should be low, so they remain in radio contact for as long as possible.

HCB: Hierarchical Cluster Based Routing It is a novel based Hierarchical Cluster routing protocol designed for highly mobility adhoc networks. HCB is two-layer communication architecture. In layer-1 mostly nodes have single radio interface and they communicate with each other via multi-hop path. Among these nodes some also have another interface with long radio communication range called super nodes which exist both on layer-1and 2. Super nodes are able to communicate with each other via the base station in layer-2.

CBLR: Cluster Based Location Routing This algorithm assumes all vehicles can gather their positions via GPS. The algorithm divides the network into multiple clusters. Each cluster has a cluster-head and a group of members within the transmission range of the cluster-head. The cluster-head and members are formed as follow: A new vehicle transmits a Hello Message. If the vehicle gets a reply from the cluster-head vehicle, the new vehicle would become a member of the cluster. If not, the new vehicle becomes the clusterhead.

CBR: Cluster Based Routing Protocol Just as its name implies, it's a routing protocol which based on position and clusters. In this protocol, the geographic area is divided into some foursquare grids. Only if there is a vehicle in a grid will a vehicle be elected to the cluster header, and the data packet is routed by cluster header across some grids one by one.

Geo Cast Routing Protocols 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). The various Geo cast routing protocols are IVG, DG-CASTOR and DRG.

IVG : Inter-Vehicle Geocast IVG is proposed by Bachir et al. for disseminating safety messages to vehicles on highways. The protocol uses a timerbased mechanism for message forwarding and periodic broadcasts are used to overcome network fragmentation.

DG-CASTOR : Direction-based GeoCast Routing Protocol for query dissemination in VANET A novel geocast routing protocol is proposed, named DGCastoR protocol and especially tailored for Infotainment applications in VANETs. It aims to build a virtual community based on future locations prediction of the mobile nodes in the network. We call this community a Rendez-vous group where the nodes may meet in the near future. However, the query is only disseminated between the nodes belonging to the same Rendez-Vous group.

DRG : Distributed Robust Geocast routing protocol, is proposed by Joshi et al. The DRG protocol improves the reliability of message forwarding by defining the zone of forwarding (ZOF) which surrounds the region of interest. Vehicles in the ZOF region forward the message to other vehicles in the ROI.

ROVER: Robust Vehicular Routing It is a reliable geographical multicast protocol where only control packets are broadcasted in the network and the data packets are unicasted. The objective of the protocol is to send a message to all other vehicles within a specified Zone of Relevance (ZOR). The ZOR is defined as a rectangle specified by its corner coordinates. A message is defined by the triplet [A,M, Z] it indicates specified application, message and identity of a zone respectively. When a vehicle receives a message, it accepts the message if it is within the ZOR. It also defines a Zone of Forwarding (ZOF) which includes the source and the ZOR.

DTSG: Dynamic Time-Stable Geocast Routing The main aim of this protocol is to work even with sparse density networks. It dynamically adjusts the protocol depending on network density and the vehicles speed for better performance. It defines two phases: pre-stable and stable period. Pre-stable phase helps the message to be disseminated within the region, and stable-period intermediate node uses store and forward method for a predefined time within the region.

Broadcast Based Routing Protocols

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, V-TRADE,and DV-CAST.

BROADCOMM : It is based on hierarchal structure for highway network. In BRAODCOMM the highway is divided into virtual cells which move like vehicles. The nodes in the highway are organized into two level of hierarchy: the first Level includes all the nodes in a cell, the second level is represented by cell reflectors, which are few nodes located closed to geographical centre of cell. Cell reflected behaves for certain interval of time as cluster head and handles the emergency messages coming from same members of the cell or nearby neighbor.

UMB : Urban Multihop Broadcast Protocol UMB is designed to overcome the interference, packet collision and hidden node problems during message distribution in multi hop broadcast. In UMB the sender node tries to select the furthest node in the broadcast direction for forwarding and acknowledging the packet without any prior topology information. UMB protocol performs with much success at higher packet loads and vehicle traffic densities.

V-TRADE : Vector Based Tracing Detection It is a GPS based message broadcasting protocols. The basic idea is similar to unicast routing protocols Zone Routing Protocol (ZRP). V-TRADE classifies the neighbors into different forwarding groups depending upon position and movement information. For each group only a small subset of vehicles is selected to rebroadcast the message.

DV-CAST: Distributed vehicular broadcast protocol It uses local topology information by using the periodic hello messages for broadcasting the information. Each vehicle uses a flag variable to check whether the packet is redundant or not. This protocol divides the vehicles into three types depending on the local connectivity as well connected, sparsely connected, totally disconnected neighborhood.

EAEP: Edge-aware epidemic protocol It is reliable, bandwidth efficient information dissemination based highly dynamic VANET protocol. It reduces control packet overhead by eliminating exchange of additional hello packets for message transfer between different clusters of vehicles and eases cluster maintenance. Each vehicle piggybacks its own geographical position to broadcast messages to eliminate beacon messages. Upon receiving a new rebroadcast message, EAEP uses number of transmission from front nodes and back nodes in a given period of time to calculate the probability for making decision whether nodes will rebroadcast the message or not.

SRB: Secure Ring Broadcasting It is to minimize number of retransmission messages and to get more stable routes. It classifies nodes into three groups based on their receiving power as Inner Nodes (close to sending node), Outer Nodes (far away from sending node), Secure Ring Nodes (preferable distance from sending node). It restricts rebroadcasting to only secure ring nodes to minimize number of retransmissions.

PBSB: Parameter less broadcasting in static to highly mobile wireless ad Hoc It is an adaptive broadcasting protocol that does not require nodes to know about position and movement of their nodes and itself. It uses connected dominating sets (CDS) and neighbor elimination concepts to eliminate redundant broadcasting. It employs two-hop neighbor information obtained by periodic beacons to construct CDS. Each vehicle A maintains two lists of neighboring vehicles: R and NR, containing neighbors that already received and that which did not receive the packet.

V. CONCLUSION

Routing is an important component in vehicle-to-vehicle (V2V) and infrastructure-to-vehicle (I2V) communication. Here we discussed various routing protocols of VANET. Designing an efficient routing protocol for all VANET applications is very difficult. Hence a survey of different VANET protocols, comparing the various features is absolutely essential to come up with new proposals for VANET. The performance of VANET routing protocols depend on various parameters like mobility model, driving environment and many more. Thus this paper has come up with an exhaustive survey. From that the paper concludes the possible future research for routing protocols includes the integration of sensor networks with wired networks (i.e. Internet). Most of the applications in security and environmental monitoring require the data collected from the sensor nodes to be transmitted to a server so that further analysis can be done. Since the routing requirements of each environment are different, further research is necessary for handling these kinds of situations..

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[Pagadala, **4(12): December 2017]** **ISSN 2348 – 8034**
DOI- 10.5281/zenodo.1133199 **Impact Factor- 4.022**

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