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Analysis and comparative study of topology and position based routing protocols in VANET

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Abstract— VANET deals with the wireless network communication among the high mobility nodes such as vehicles which provides safe and comfort inter-vehicular communication system. VANET has become an important part of intelligent transportation system with a variety of applications such as cooperative driving, collision avoidance, internet access to vehicles on the move etc. VANET are the subclass of MANET that uses vehicles as the mobile nodes .These nodes itself act as both terminals and routers to route the message among the neighbouring vehicles. The characteristics of VANET that distinguishes it from MANET are high mobility and dynamic constraints .So choosing the routing protocol is a challenging task in VANET environment. Routing protocols in VANET must handle the issues such as frequent disconnected network, high dynamic topology and communication environment. In this paper the focus is made on different topology based and position based routing protocols and the recently introduced advanced routing protocols that are more efficient for VANET environment. The aim of my work is to analyze the features of these protocols in VANET. This paper surveys different topology based and position based routing protocols for VANET environment. Several performance metrics have taken in to consideration such as packet delivery ratio, scalability and delay to compare various protocols.

Keywords— VANET, topology based routing protocols, position based routing protocols, Intelligent Transport System, VANET routing protocols, vehicular networking, Ad-hoc network

INTRODUCTION

VANET are a form of mobile ad-hoc network that provides communication among neighboring vehicles and between vehicles and nearby fixed point. The road traffic in developed countries extensively causes the wastage of time and fuel. As a result of the development of Intelligent Transportation system, vehicles have become smart enough to adapt to the dynamic changes in road traffic. The traffic related problems such as road accidents, traffic jam .etc can be avoided by implementing the intelligent transport system (ITS) that uses VANET.It offers a promising technolgoy for traffic management, road safety and ease of information exchange between drivers and passengers.VANET routing protocols are categorized into five classes: topology based, position based, broadcast based, geo-cast based and cluster based routing protocols.

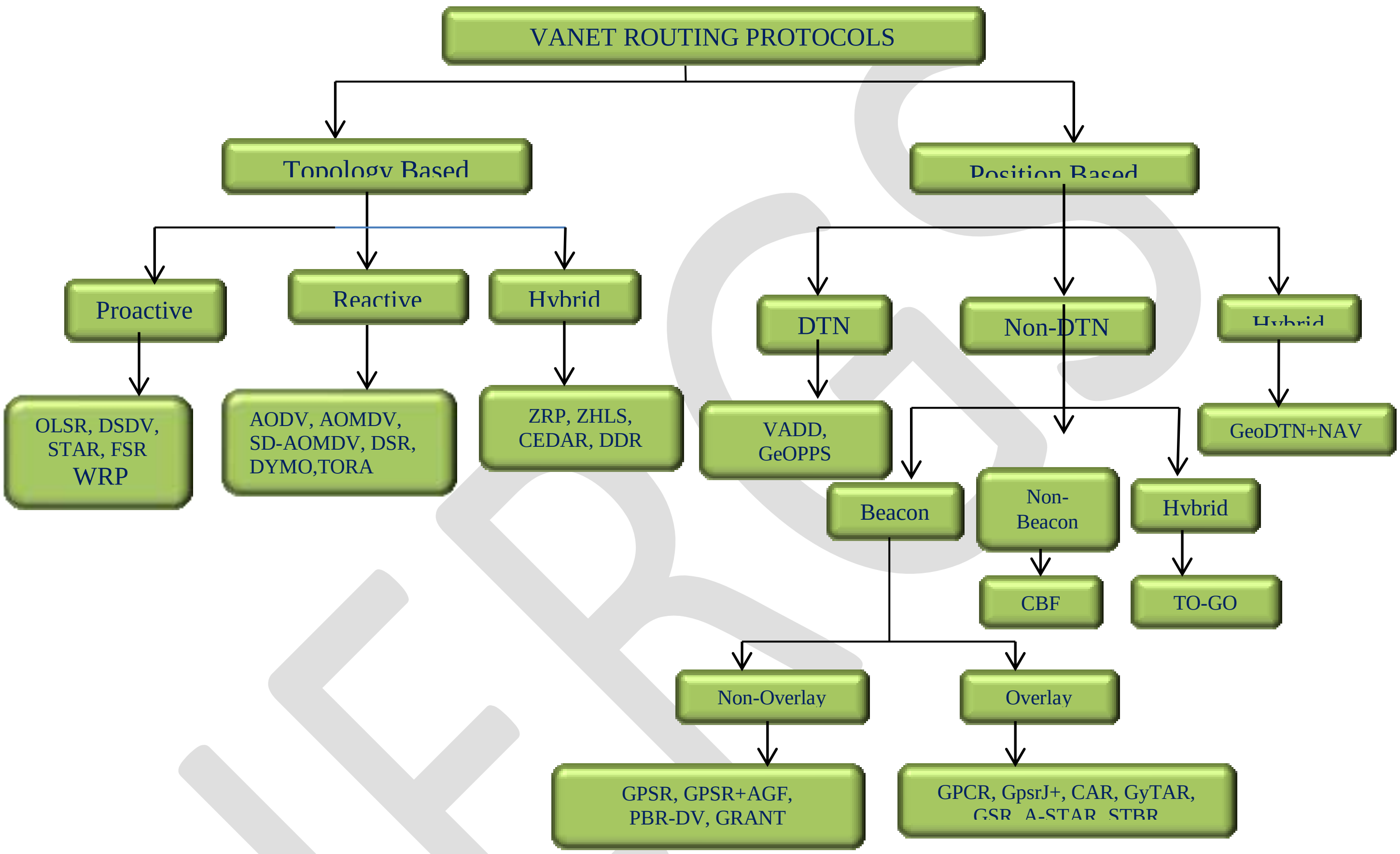
2. VANET ENVIRONMENT

VANET is a self organized network structure that does nto depends on any centralised server system for communication.VANET uses dedicated short range communication with 5.9 GHZ spectrum and 75 MHZ bandwidth with a range of 1000msuitable for VANET communication [1].In VANET as the vehicles move out of the range they are dropped out of service and new vehicles may join and participate in forwarding the messages.Vehicles uses computerized control mechanisms and sensors for communication within short range.VANET uses WiFi IEEE 802.11p ,Wireless Aceess Vehicular Environment(WAVE) and WiMAX IEEE 802.16.

3. ROUTING PROTOCOLS

Transmission of packets from one end to another through optimal and efficient path in VANET environment is achieved with the help of various routing protocols.Routing occurs at the networl layer of the OSI model.Routing in VANET involves no central entity to identify the optimum path among the nodes ,so implementing a routing mechanism is a challenging and crucial task. Several routing algorithms have been proposed by various researchers to adapt to the dynamic environment of VANET.The selection of routing protocol for VANET depends on the type of service needed. Routing protocols are classified based on different strategies but here the focus is made only on topology based and position based routing protocols.The need for a new hybrid protocol is also lighted upon to improve the efficiency of packet delivery mechanism in VANET.

Fig 1: Classification of VANET Routing Protocols



4. TOPOLOGY BASED ROUTING PROTOCOLS

Topology based routing protocols require the topology of all the nodes participating in the VANET for routing decision.These protocols discover and maintain the routes in a routing table before the transmission of data begins.These protocols are classsified as proactive,reactive and hybrid protocols.

A Proactive Routing protocols

These protocols are table driven routing protocols that stores the routing information of of every node participating in the network.The nodes keep on changing its position every second so it is necessary to updaye the information available in the routing table.The node send topological information among the each other and thereby update the routing table.There are two types of updates-periodic update and triggered update.In periodic update, the changes are communicated at the end of certain time period and thereby updating the routing table.The updations that are sent too frequently may congest the network. If the updates are sent too infrequently then the information might have been outdated since the vehicles are moving regularly.Bandwidth usage is high for periodic updates.In triggered updates the information is ecchanged only when there is a change in the network.There is no route discovery in proactive routing strategy because the infromation about the nodes are always available in the routing table.Each protocol that belong to this category may differ in the number of routing tables maintained and in the information exchange.It offers low latency for real time implementations[2]. Various types of proactive routing protocols are: Optimized Link state Routing Protocol (OLSR), Destination Sequenced Distance Vector Routing (DSDV), Source Tree Adaptive Routing (STAR) and Fish Eye State Routing (FSR).

Optimized Link State Routing Protocol (OLSR)

It is the enhanced version of the link state routing algorithm.It keeps the information about all possible routes to the network nodes usign topology control message.On topologocal changes each node sentd the updated infroamtion to some selective nodes which will retransmit the information to other nodes.It chooses optimal path for route set up and maintenance.Multi Point Relays are selected among one hop neighbours and they inturn cover two-hop neighbours.Two types ofmessages are communicated in this protocol.they are hello message and Topological control message.The hello messages are used to find the status of link and neighbours.Topological Control messages are used to send the broadcast infromation to the neighbours in the selected list[3].This protocol give better performance among the proactive routing protocols.By fine tuning the parameters specified by RFC 3626[7],this protocol can be made efficient for VANETenvironment[4].

Destination Sequenced Distance Vector Routing (DSDV)

DSDV uses the distance vector routing algorithm which uses the shortest path to find the route to the destination.The information stored in the routing table should be updated.Each node periodicaly broadcast the routing table infroamtion to its neighbours.It keeps only the optimal path to the destination rather than keeping multi path to the same destination.This protocol also guarantees loop free nodes, reduces count to infinity problem and also reduces control message overhead.This protocol is suitable only for smaller number of nodes[5].The regular updates of routing table require battery power consumption and bandwidth utilization and moreover flooding of messages causes network congestion.It is not suitable for highly dynamic networks.This protocol also maintains the routing information in routing table by periodic and triggered updates.

Source Tree Adaptive Routing (STAR)

This routing protocol is based upon link state protocol.This protocol maintains the topology of the entire network so it needs more memory requirements.It is suitable for larger networks.Each node creates a partial toplogy of the network based on the information aggregated from neighbouring nodes and the node has to maintain the source tree .This protocol works best for city scenarios.

Fish Eye State Routing (FSR)

The nodes in the network update the routing table besed on the information from neighbouring nodes i.e information of every node is collected from the neighbouring nodes.It combines the features of Link State and Global State routing.It exchanges only the partial routing infromation maong the neighbours thereby reducing the bandwidth [4].Link failure doesnot trigger any control message and hence the routing tables are not updated in such scenarios.Information form the farther end are broadcasted with lower frequency than that of nearer nodes.The growing network size causes increase in the routng tables and it fails to trace out the route when the destination moves out of scope.This protocol is not suitable for smaller networks.

Wireless Routing Protocol (WRP)

WRP is the enhanced version of distance vector routing protocol.It is similar to DSDV and also reduces the route loop and count to infinity problem.unlike DSDV it uses a set of table for keeping the up-to-date topological information. Nodes in the network periodically exchange routing tables information with its neighbors through update messages, or whenever there is a change in the link state table.It has faster convergence of messages and includes fewer updation of tables but it require larger memory and processing power among the nodes in the network just like STAR protocol.Like DSDV, it is also not suitable for highly dynamic wireless networks.

B. Reactive Routing Protocols

These protocols are known as on-demand routing protocol because the routing infromation is maintianed only when needed .Thus it reduces network overhead.whenever a source wants to send a message it floods the route request message to the network.Unlike proactive routing protocols it require route discovery mechanism since no information about the route is maintained before.This causes a little overhead at the beginning stage of message passing.when the request message reaches the destination it sends a route reply message back to source through unicast communication.These protocols are suitable for large scale networks and for frequent topology changes and higher mobility scenarios.Some of the reactive protocols include Ad-hoc on-demand distance vector(AODV),Dynamic Source Routing(DSR),Dynamic MANET On Demand(DYMO),Temporally Ordered Routing Algorithm(TORA)

Ad-hoc on-demand distance vector (AODV)

This is one of the best explored reactive routing protocol by the researchers.This protocol discover routes only on demand[6] i.e. it establishes a route only when any node needs to send a message to the desination.It starts with the route discovery process through broadcating the route request message (RREQ) to the network.The destination upon receiving the RREQ message unicast the Route Reply message (RREP)back to the source.It uses the destination sequence number for each route entry which helps in avoiding routing loops.This feature distinguishes it from all other reactive routing protocols.It offers low network ovehead by avoiding the flooding of messages periodically.in the network.It requries less memory size and the routing tables only contains the recent active nodes.Itkeeps the information of only the next hop rather than keeping the entire route based on the topology.AODV is flexible to highly dynamic and large-scale network.The problem with this protocol include a new route discovery upon route failure which cause additional delays apart from the intial delay in route discovery.This may cause decrease in the data transmission rate and also increase network overhead.Many protocols were proposed as the enhancement of AODV protocols and they are AOMDV,S-AOMDV,RAOMDV,SD-OMDV.

Adhoc On-demand Multipath Distance Vector Routing (AOMDV)

This protocol has the advantage that the information is already available with AODV and can maintain multiple loop free path with minimum overhead.It stoes additional infromation in the routing table such as next hop, last hop, hop count and expiration timeout.It is suitable for high mobility nodes [7].Several other protocols with additional features towards AOMDV was also proposed by many researchers such as S-AOMDV, R-AOMDV, SD-AOMDV.

SD-AOMDV

SDAOMDV is an improvised version of AOMDV protocol to suit the VANET characteristics. It adds the parameters such as speed and direction to hop count as new AOMDV routing metric to select next hop which helps in the route discovery phase. SD-AOMDV performs well in city and highway traffic scenarios.

Dynamic Source Routing (DSR)

In this protocol, the source floods the route requst to all the nodes within the range.This protocol mainly consists of two mechanism-route discovery and route maintenance.this protocol uses a unique id request in the route request packet The query packet copies the ID of all the intermediate nodes it traversed.This entire path from the query packet is used by the destination to respond back to the source.When no route is found, the destination will discover route back to reach source node.Due to the change in the topology, the source node may be unable to use the curent route to the destination .Route maintenance mechanism can be used at this scenario. To find another route to destination, route discovery is invoked again to transmit the message to the destiantion.However the route maintenance mechanism doenot repair a broken link this protocol provide multiple routes to the destination and also avoid loop formation.This protocol causes large end-to-end delay, connection set up delay and scalability problems [8].

Dynamic MANET on Demand (DYMO)

This protocol is an enhancement of AODV protocol and works on on multi hop wireless environment.It is a simple,highly combact protocol and is easy to implement.It can behave proactively and reactively.Itcombines the features of AODV and DSR ie it uses AODV structure but works on DSR mechanism.It involves two basic mechanism-route discovery and management.In route discovery RREQ packets are broadcasted to the network to locate the destiantion.it replis with RREP message which is unicasted to the source.A bidirectionbal link is established betwwen source and dstination.In case of node failure a route error packet RERR is sent to source node which ehlps in reinitiating the route discovery process.It stores only little routing information which reduces network ovehead and saves both bandwidth and power consumption[9].

Temporally Ordered Routing Algorithm (TORA)

It is one of the distributed routing protocols which uses multi hop routes.This protocol is based on the link reversal routing algorithm which uses directed acyclic graph to identify the flow of packets .The node broadcast the packets to the neighbouring nodes which will re- broadcast it only if it is the predecessor's downward link. This protocol includes creation of route, maintenance of route and erasure of route when the route is not valid.TORA's performance is better than DSR in highly dynamic ad-hoc environment [10].

C. Hybrid Routing Protocols

Hybrid protocols combine the features of both reactive and proactive routing protocols.It discards the disadvantages of both types of routing protocols.the control overhead in proactive routing protocols and also the delay in on-demand routing protocols are reduced.Hybird protocols divides the the network into many zones to achieve relaibility.It has higher scalabiluty than the reactive and proactive routing protocols.Only the appropritae nodes are use dto set up a route between source and destination.

Zone Routing Protocol (ZRP)

This is the first hybrid routing protocol.The protocol divides the network into overlapping zones.the nodes are called peripheral nodes towards the edge. The peripheral nodes perform the route discovery outside the zone and for this purpose a reactive approach is used.It uses the proactive routing scheme inside the zone and reactive routing scheme outside the zone [11].

Zone based hierarchical link state (ZHLS)

This protocol divides the network into non-overlapping zones .Every netowork has its ID and zone ID .Every node must be within the zone radius to communicate with each other so that they can share and aggregate the topology available to each node to cereate the entire topology.For intra zone communication a proactvie routing protocol is used and for inter-zone routing ,an inner zone reactive protocol is used.Source can send the data to the destination if both are in the same routing zone otherwise the protocol initiates a route discovery.

Core Extraction Distributed AdHoc Routing (CEDAR)

It is a protocol with integared QoS support.A reactiverouting protocol is used for core nodes.Fast moving and slow moving increasing waves are used for propogating link information.This porotocol includes three important phases-establishment of routing infrastructure,link states and their propagation and Qos route computation[12].

Distributed Dynamic routing algorithm Protocol (DDR)

It is a tree based routing protocol that does not require the root node support for data transfer.Periodic beaconing messages are used and exchanged among the neighbouring nodes. These trees form a forest with gateway nodes that performs the function of a link. Neighbor election, intra-tree clustering, inter-tree clustering, forest construction, zone naming and zone partitioning are the six phases in the protocol.It doesnot depend on zone map like ZLHS[12].

5. POSITION BASED ROUTING PROTOCOLS

Position based routing protocols are also known as Geographic routing protocol.In this type of protocol, the routing process is based on the positional information of the moving nodes.Rather than using the network address the source will send the message to the destination based on the geographical postion-i.e latitude and longitude of the moving vehicles.These protocol uses GPS to identify the geographical location nodes paticipating in the network.Each node knows its own and its neighbouring nodes geographical position . The information from GPS is used to identify the route.The source stores the geographical information of the destination in the packet header and this will help in forwarding the packets without identifying the topology.Route discovery and route maintenance are not required for these types of protocols and hence no routing table is maintained Position based routing protocols are classified into Delay Tolerant Network (DTN), Non Delay Tolerant Network (Non DTN) and hybrid.

B. Non-Delay Tolerant network protocols

Non-DTNrpotocols does not guarantee for disconnection issues .This protocol is suitalb efor highly dense network as it assumes that there will always be successfulcommunication .In this type of protocol,the nodes forward the packet to its immediate neighbour to the destination but it may fail when there is no node closest to destination other than the same node itself. These protocols are again classified into beacon, non-beacon and hybrid.

Beacon protocols

Beacon protocols transmit short hello message periodically. It indicates the position of a node.If a node fails to obtain a beacon from the neighbouring node within a certain period of time it assumes that theprevious neighbouring node is now out of range and it will be rmeoved fron the neighbouring table.Beacon protocols are again classified into overlay and non-overlay protocols.

Non-Overlay Protocols

The non-overlay network uses the existing network. It does not use any type of representative node or other network. All the protocols use the greedy forwarding technique. The greedy forwarding fails if the neighbour closer to destination is none other than the current node itself.In sucht cases different protocols propose different recovery strategy.

Greedy Perimeter Stateless Routing (GPSR)

GPSR[15] selects node closer to the destination using beacon.A node need to know only one hop neighbour information.It uses greedy frowarding algorithm for packet transmission.If it fails then perimeter frowarding mechanism is used to select a node for packet transmission.

GPSR+AGF

To avoid the stale information about the neighbouring nodes position in the sending node table a new approach called Advanced GreedyForwarding protocol [16] was proposed which overcome the disadvantages of GPSR.

PBR-DV

This protocol combines various approaches such as topology based reactive routing approach along with greedy position based stretegy and if the packet falls in local maximum, it uses the traditional AODV recovery mechanism.

A Delay Tolearant Netowork Protocols

DTN is a wireless network protocol that uses carry and forward technique to overcome the frequent disconnection of nodes in the network.It also works efficiently on networks with long unavoidable delays,limited bandwidth and power constaints.the source node if unable to contact other node may store the packets and forward it when the nodes becoems reachable .all the nodesin the network help each other in carrying the packetson the way to the destination.however packet transmission may take larger delays.some of these protocls are VADD,GeOpps

Table 1: Difference between topology based and position based routing protocols

Topology Based Routing Protocols	Position Based Routing Protocols
Based on route discovery scheme	Based on location service scheme
Need for route maintenance for all network	No need of route maintenance
Require large bandwidth if network topology changes	Does not require large bandwidth
Forwarding decision based on source node	Forwarding decision based on position of destination and next hop neighbour

Vehicle assisted Data Delivery (VADD)

VADD [13] can be used to enhance the routing in frequently disconnected networks.It is based onc arry and forward strategy.In VADD a vehicle can make a choice at an intersection and chooses the path of packet forwarding that has negligible delay.Three packet modes are available in VADD.they are Intersection, Straight and Destination.the optimum path can be identified by swapping the three modes.Amon the VADDprotocols H-VADD shows better performance.

Geographical opportunistic routing (GeOpps)

GeOpps [14] protocols use the vehicles navigation system to select the vehicle travelling closer to the packet destination. GeOpps calculates the distance between the destination and the nearest point of the vehicles path and estimates the arrival time of a packet at the destination.During the forwarding of packets if any node has minimum ariival time the packet will be forwarded to that node.

Greedy Routing with Abstract Neighbor Table (GRANT)

To avoid the local maximum, a new concept called Greedy Routing with Abstract Neighbor Table[17] was introduced.it is and extension of greedy routing algorithm.This table divides the planes into areas and include a representative neighbour for only one area.This concept works well for city scenarios especially with obstacles.

Overlay protocols

Overlay protocols include network that are connected through virtual or logical links, which are built on top of existing network.

Greedy Perimeter Coordinator Routing (GPCR*)*

GPCR [18] is a position-based overlay routing protocol that uses greedy algorithms to forward packet based on a pre-selected path .It has been designed to meet the challenges of city scenarios.NoGlobal Information System required for GPCR.

GpsrJ+

GpsrJ+[19] reduces the dependecny on junction node.It uses geographic maps to recover formlocal maximum.it uses two hop neighbour beacon infromation to calculate the routing path and for detecting junction.It visualize the roads which might be occupied by the junction node. Each node will send a beacon message about its coordinates and the road segments on which its neighbours ate located.

Connectivity- Aware Routing (CAR)

CAR [20] is wellsuited for city and highway scenarios.It uses AODV for path discovery and PGB for data dissemination.it also uses guard concept for path maintenance.It ensures the shortest connected path and no digital map is required for CAR.It has the highest packet delivery ration than GPSR and GPSR+AGF

Greedy Traffic Aware Routing protocol (GyTAR)

GyTAR [21] is an intersection based routing protocol which searches for junctions to find the routes through the city.it uses carry and forward technique.It utilises digital map and selects the connection based on traffic density and curvemetric distance to the destination.It uses the greedy routing mechanism to deliver the packet through road connected by two junctions.It reduces the end-to-end delay and control message overhead with very low packet loss.
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GSR (Geographic Source Routing)

GSR [18], ideal for city environment, uses greedy forwarding approach along pre-selected path using Djkshtra's shortest path algorithm. It combines the features of topological information and position based routing.The source identifies the position of all nodes between source and destination with the help of digital maps.GSR does not depend on traffic density to choos ethe optimum path form source to destination.The packet delivery ratio is superior than AODV and DSR protocols [20].It ignores the spars enetwork conditionand also experiences high network overhead due to the freuquent usage of HELLO messages.

Anchor-Based Street and Traffic Aware Routing (A-STAR)

A-STAR [22] is specially designed for city scenarios.It guarantees high connectivity in packet dekivery using traffic city bus infromation for an end-to-end connection.It uses local recovery strategy suitable for real time application.

Street Topology Based Routing (STBR)

STBR [23] works on three valid states; master, slave and forwarder.in this type of network one node is selected as master, others as slave and the intermediate nodes between junctions as forwarders. STBR is not suitable for both city and highway scenarios because it would try to send junction beacons along a highway.

Non-Beacon Protocols

These protocols do not make use of periodic beacons for sending data packets.

Contention Based Forwarding (CBF)

CBF [24] is a geographic routing protocol that doesn't make use of beacons for data transfer. To send a data packet, the sending node broadcast the packet to all its neighbors & these neighbors will decide among themselves the one that will forward the packet.It reduces the probability of packet collosion.It provides a lower packet forwarding delay.This protocol works better in highway scenarios.

Hybrid Non DTN protocols

TO-GO (Topology-assist Geo-Opportunistic Routing)

TO-GO [25] is a geographic routing protocol which improves packet delivery in greedy & recovery forwarding that can bypass the junction area by using two hop beaconing.All nodes can hear one anotherso there is no problerm of hidden terminal.End -to-End delay is higher than GPCR,GPSR,GPSRJ+

C. Hybrid position based routing

These protocols combine the scheme of more than one location based protocols.

GeoDTN+Nav

GeoDTN+Nav [26] is a combination of both DTN & Non-DTN routing which includes a greedy mode, a perimeter mode and a DTN mode. It can switch from Non-DTN to DTN mode. This approach proposes virtual navigation interface which provides necessary information regarding the mode of routing and the forwarder.

Table 2: Comparison of VANET routing protocols

Routing Protocols	Mobility Models	Propagation Models	Scalability	Delay	Delivery	PDR	Best Scenario
OLSR	Random Way Point	Nakagami	Good	More	Best Effort	Up to 97%	City
AODV	IDM on Manhattan grid	Probabilistic shadowing	Low	More	Best Effort	Up to 95 %	Highway
DSDV	Random Way Point	Radio Propagation	Medium	Less	Best Effort	Up to 92%	City
DSR	Reference Point Group	Path Loss	Low	More	Best Effort	91%	City
GPSR	MTS	Probabilistic shadowing	Medium	More	Guaranteed	Up to 80%	Highway
GRANT	Static trace from a uniform distribution	Road blocking	Medium	Less	Guaranteed	Up to 80%	City
GPCR	VanetMobisim	Road blocking	Good	Less	Best Effort	Up to 80%	City
GpsrJ+	VanetMobisim	Road blocking	Good	Less	Guaranteed	Up to 80%	City
CAR	MTS	Probabilistic shadowing	Good	Less	Best Effort	Up to 80%	Highway
GSR	Videlio, M-Grid mobility	Road blocking	Good	Less	Best Effort	Up to 80%	City
A-STAR	M-Grid mobility	Road blocking	Good	Less	Best Effort	Up to 80%	City
GyTAR	Proprietory	Free space	Good	Less	Guaranteed	Up to 80%	City
CBF	Random way point	Two-Ray ground	Good	More	Best Effort	Up to 80%	Highway
TO-GO	VanetMobsim	Road blocking	Good	More	Guaranteed	Up to 80%	Highway

6. CONCLUSION AND FUTURE WORK

In this paper, various types of geographic and position based routing protocols in VANET has been surveyed.By analyzing these routing protocols we have seen that the performance evaluation is required to verify the efficiency of a routing protocol with other routing protocols in city,highway and mixed scenarios.Some protocols have been found to be suitable for either city or highway scenarios but when it comes to real world application we need to consider the mixed scenarios and hence it can be concluded that although the position based routing protocols are more efiicient than topology based routing protocols,these protocols suffer from large end-to-end delay and low packet delivery ratio. Only the development of a new hybrid protocol will be a better solution to deal with all types of traffic scenarios and can out perform well when evaluated using all VANET environment metrics.In future the fous is on the development of a hybrid protocol that can outcome all the drawbacks of existing protocols and works well in mixed scenarios

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