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A Smart Automobile for Intelligent Traffic System using VANET Protocols

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Abstract*: The overall automobile industry in the world has encountered remarkable growth, vehicle increases traffic density which seems in increasing accidents. Thus the automobile Industries, researchers and government are shifted their focus in the direction of improving on-road safety instead of improving the condition of the roads. The top development in the wireless technologies emerged a diverse new sort of networks together with Vehicular Ad Hoc Network, VANET uses wireless network technology wherein driving gets safer by inter-vehicle communication. Using this technology, automobiles are not only envisioned to contact between each other, but also to get information from and transmit data to infrastructural units. In this, we have discussed about the traits and applications of VANET along with routing protocols. The routing protocols states how two communiqué individuals interchange information which covers the methods to generate path, to retain the route or improve from routing fiasco. In this we have explained two routing protocols i.e. Topology based routing protocol and Geographic (Position-based) routing protocol with its types, advantages and disadvantages as well as we have examined the performance of AODV and GPSR routing protocols using quality matrix.

Keywords: VANET, ITSs, GPS, AODV, TORA, NDTN, DTN, RREP, PDR, E2ED, SA, DA, SEQ_NO, Smart-Automobile.

I. INTRODUCTION

Vehicular ad-hoc network or vehicular network uses wireless network technology wherein driving gets safer by inter-vehicle communication. It permits vehicles to be in contact with each other and provide information about various traits like dangerous road, accident site and breakdown Automobiles are not only predicted to contact amid each other, but also to acquire knowledge from and convey data to infrastructural units.[19]

Previously drivers were using their voice, horns, gestures and observations of each other's path to tackle their activities. But due to extreme upsurge of vehicles made this quite difficult to tackle, so in the 19th century, traffic police took the responsibility to control and to manage the congestion (traffic) by means of hand signals and colored lights.

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Mechanization of road traffic indications and car signs were introduced widely in the 1930's and in the 1940's respectively. Later on variable message signs were introduced in 1960's to give processed data to the drivers. Now a days, the traffic information and traffic directions is exchanged by drivers, to each other.

Basically, VANET is a digital communication between vehicles. As vehicles are growing, the chances of accident has also aggrandized. So it is required to make our vehicles safer so that probability of accidents can be reduced. VANET enables vehicle-to-infrastructure (V2I), infrastructure-to-vehicle (I2V), and vehicle-to-vehicle (V2V) communications. VANET is that network in which communiqué has been done among RSUs to vehicles and vehicles to vehicles within the range of 100-300 m. For determining when to give alerts to driver, vehicles will need to depend on on the integrity of obtained data.

1.1 Basic Idea of Vanets

The usage of radio communication for vehicles to roadside and vehicle to vehicle communications for the purpose of:-

- Increasing traffic safety
- Increasing traffic efficiency (combat with traffic jams)
- Increasing environmental friendliness (reduce CO2 emission)

II. VANET VEHICLE CONFIGURATION

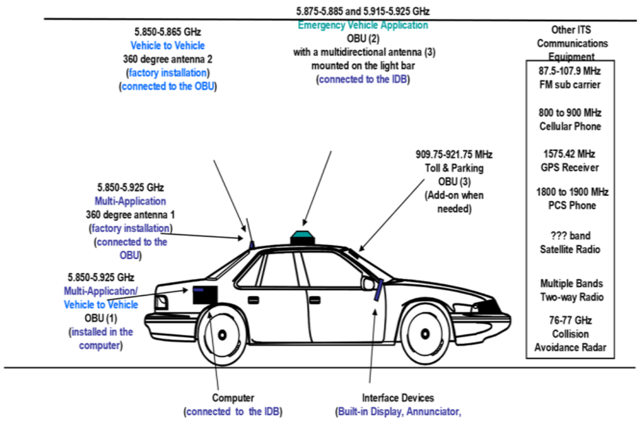

FIG 2.1: Vehicle Configuration [19]

The figure (2.1) given above shows typical configuration of a vehicle using VANET Technology. It consists of interface devices including in-built display and announcer to continuously update the driver regarding his surroundings. Vehicles are associated to the computer which is at rear end of the vehicle.

Also different antennas are installed in the vehicles each of which works in a separate frequency band. And thereby transmit and receive data from other vehicles and each antenna is for specific use. This figure also displays other ITS communications equipment (like GPS receiver, cellular phones etc.) with their frequency bands built in inside the vehicles. [19]

III. TERMINOLOGY IN VANET

A. Intelligent Transportation Systems (ITSs)

In ITSs, each vehicles do the role of router sender, and receiver to broadcast the info to the vehicular network, which then uses that information to ensure safety, free-flow of traffic. They need to be equipped which supports wireless ad hoc networks to be occurred for the occurrence of communication among roadside units and vehicles. They need to be attached with hardware that grants either GPS or a DGPS receiver information. So to permit communication, static RSUs need to be in position which are linked to the network. The distribution and number of Roadside units rely on the protocol which to be used. For illustration, few protocols requires RSUs to be disseminated entirely over the road network, few require RSUs at intersections points, whereas others requires RSUs at region borders. The communication of configurations in ITSs is depicted in fig 1, 2 and 3 respectively. Inter-vehicle, vehicle-to-roadside and routing-based communications are included which rely on correct and latest information nearby immediate environment. [17]

B. Inter-Vehicle Communication

Its configuration (Fig 3.1) employ multi-hop multicast or broadcast to redirect traffic regarding knowledge over multiple hops to the cluster of receivers.

FIG 3.1: Inter-vehicle communication[17]

There are two kinds of message forwarding in IVCs. First is naïve broadcasting in which vehicles communicate broadcast messages intermittently at frequent gaps. If the message originates from a vehicle behind it, the receiptant ignores the message. If the message transmits from an automobile in the front of it, the receiptant transmits its personal broadcast message to cars in the back of it which ensures that all vehicles will get all broadcast messages moving in the forward direction. The disadvantage of it is huge extent of broadcast messages are produced, therefore, increasing the threat of message collision which results in worse message delivery rates and augmented delivery times. Second is intelligent broadcasting which tackles the problems with an implicit acknowledgement inherent in naïve broadcasting by controlling the variety of messages broadcast for a given emergency event. Whenever the event-detecting vehicle gets the similar message from behind, it presumes that at the least one vehicle in the rear has accepted it and terminates broadcasting. The hypothesis is that the automobile in the rear will be answerable for moving the message along with the rest of the vehicles. If a vehicle accepts a message from multiple sources, it'll act on the primary or first message only. [17]

C. Vehicle-to-roadside Communication

The figure Fig 3.2 depicts a singly hop broadcast where the RSUs communicates a broadcast message to all furnished vehicles in the locality.

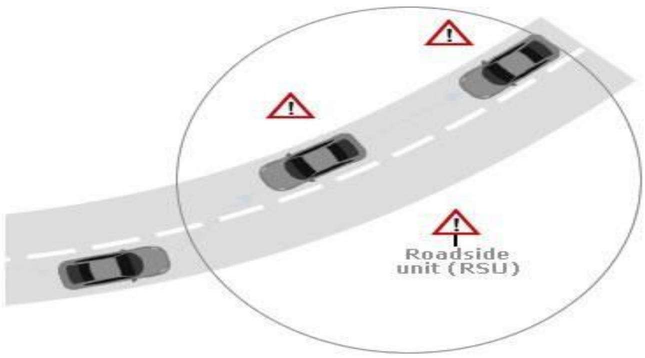

FIG 3.2: Vehicle-to-roadside Communication [17]

A high bandwidth link among automobiles and RSUs are provided by Vehicle-to-Roadside communication configuration. The RSUs might be located each kilometer or less to allow great data rates to be preserved in heavy congestion. For illustration, while broadcasting dynamic pace limits, the RSUs will evaluate the suitable pace limit conforming to its internal time table and traffic situations. The RSUs will sometimes broadcast a message comprising the pace limit and any geographical or directional limits will be compared with automobile data to evaluate, in case vehicles in the locality having a speed limit warning. Whenever an automobile breaches preferred pace limit, then a broadcast message will be conveyed to the automobile in the form of an audio or visual warning, demanding the driver to diminish his pace.

D. Routing-based Communication

It is a communication where a message is disseminated in a multi-hop manner till the vehicle carrying the wanted data is reached as shown in figure Fig 3.3.

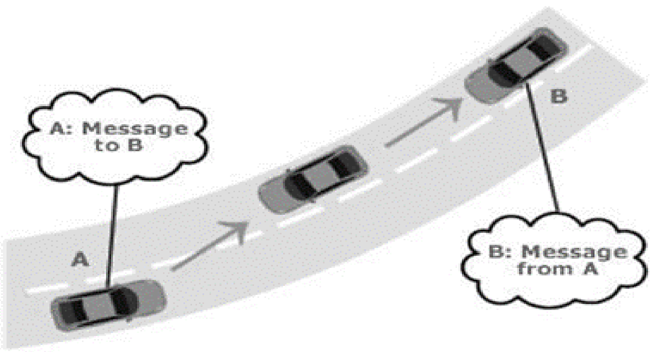

FIG 3.3: Routing-based communication [17]

When the vehicle accept question keeping the desired piece of information, the application at that vehicle promptly conveys a message comprising information toward that vehicle it acquired the request from, which further forward it so as to approach the query source. [17]

IV. TRAITS OF VANETS

A. High Dynamic Topology

The availability, choices of multiple path along-with the high speed of vehicles defines high dynamic topology.

B. Frequent Disconnected Network

High Dynamic Topology introduces frequency disconnected network since connection among two automobiles can be easily disappear while two vehicles are propagating information.

C. Mobility Models and Prediction

Mobility models forecast user's position. The estimation of vehicles position and their movements is very arduous. This trait of mobility modelling and prediction in VANET is based on availability of pre-defined roadmaps.

D. Interaction with Sensors

Sensors are the way of communications. Sensors can read information related to velocity of vehicles, direction and can liaise to data center. Thus sensors can be used in link formation and routing protocols.

E. Communication Environment

Mobility prototypes movement of users and user's location, pace changes over time. Mobility prototypes may have different traits relying on road architecture, highways. Therefore communication in this condition has to be taken in account.

F. Hard Delay Constraints

At the time of exigency, Delivery of messages on time is a very adverse problem. Therefore to manage such conditions is necessary.

G. Unlimited Battery Power and Storage

Nodes don't suffer from power and storage restriction in VANETs. [20]

V. APPLICATIONS OF VANETS

From simple exchange of vehicle status data to highly complex large-scale traffic management applications are based on vehicular communication. Safety oriented, convenience oriented and commercial oriented are the three most important classes of applications possible in VANET.

A. Active safety applications

The basic goal is to ensure driving harmless which means drivers are cautioned about a dangerous situation. Safety applications will control the adjoining and outer part of the road, approaching vehicles etc. They will interchange messages and work together to give assistance other vehicles. Thus, the automobile can try to evade an accident or react suitably if an accident can't be evaded anymore.

B. Convenience application

It is traffic management type. Its goal is to enhance traffic efficiency by lifting the degree of convenience for drivers. It results in traffic efficiency in a larger extent. This means that an accident cautionary is distributed in a greater extent to notify vehicles about the potential barrier so that drivers can have a dissimilar path.

C. Commercial applications

This application will provide the vehicle owner with the entertainment and other services like streaming video-audio web access. It provides many services like downloading music, expense for parking or road usage. Thus, driver gets both information and entertainment.

Another application of VANET is that it results in less pollution as there is lesser probability of a traffic congestion. Vanets are also planned to assist the work of public service. [19], [20]

Table-I: Overview of Application of VANETS [19]

	Situation/purpose	Application examples
I. Active safety	1. Dangerous road features	1. Curve speed warning, 2. low bridge warning, 3. warning about violated traffic lights or stop signals
	2. Abnormal traffic and road conditions	1. Vehicle-based road condition warning, 2. infrastructure-based road condition warning, 3. visibility enhancer, 4. work zone warning
	3. Danger of collision	1. Blind spot warning, 2. lane change warning, 3. intersection collision warning, 4. forward/rear collision warning, 5. emergency electronic brake lights, 6. rail collision warning, 7. warning about pedestrians crossing
	4. Crash imminent	1. Pre-crash sensing
	5. Incident occurred	1. Post-crash warning, 2. breakdown warning, 3. SOS service
II. Public service	1. Emergency response	1. Approaching emergency vehicle warning, 2. emergency vehicle signal preemption, 3. emergency vehicle at scene warning
	2. Support for authorities	1. Electronic license plate, 2. electronic drivers license, 3. vehicle safety inspection, 4. stolen vehicles tracking
III. Improved driving	1. Enhanced Driving	1. Highway merge assistant, 2. left turn assistant, 3. cooperative adaptive cruise control, 4. cooperative glare reduction, 5. in-vehicle signage, 6. adaptive drivetrain management
	2. Traffic Efficiency	1. Notification of crash or road surface conditions to a traffic operation center, 2. intelligent traffic flow control, 3. enhanced route guidance and navigation, 4. map download/update, 5. parking spot locator service
IV. Business/ entertainment	1. Vehicle Maintenance	1. Wireless diagnostics, 2. software update/flashing, 3. safety recall notice, 4. just-in-time repair notification
	2. Mobile Services	1. Internet service provisioning, 2. instant messaging, 3. point-of-interest notification
	3. Enterprise solutions	1. Fleet management, 2. rental car processing, 3. area access control, 4. hazardous material cargo tracking
	4. E-Payment	1. Toll collection, 2. parking payment, 3. gas payment

VI. OVERVIEW OF ROUTING PROTOCOLS

A routing protocol specifies how two communiqué units interchange info, it cover the process to generate path, decision to forward and action to sustain the path or improve from routing fiasco.

The routing protocols are as considered Topology based routing protocol and Geographic or Position-based Routing in vanet. These protocols are classified upon the area / application where they are utmost suitable. [15]

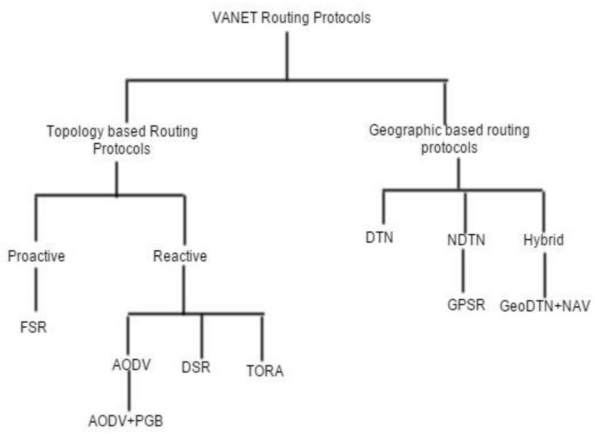

FIG 6.1: Various Routing Protocols [18]

6.1Topology-based Routing Protocols

These routing protocols employ link's info that presents in the network to dispatch packet forwarding. They can further be splited into proactive (table-driven) and reactive (on-demand) routing. [15]

6.1.1Proactive (table-driven):

This routing brings the different quality: the routing info like the consequent forwarding hop is preserved inside the background in-spite of communiqué appeal. Control packets are regularly broadcast and crowded amongst nodes to retain the tracks or the link states among any pair of nodes even if few of paths are never applicable. The table is created in a node so that every entry in the table shows the next hop node so as to approach a definite target. The pros of it is that no path discovery is required as route to the target is kept in the base and is always accessible on lookup. [15]

6.1.1.1 Fisheye State Routing:

It is a link state based protocol. The thought behind the LSR is that each node makes a topology map into a graph, reflecting which nodes are linked to which nodes. Each and every node calculates the next finest path from it to each likely destination in the network independently. The routing table will be formed which consist of collection of best paths. FSR has the capability to give route information immediately by maintaining a topology map at every node. Thus Updated information will be maintained from the neighbor node through a link state table. In each node, a full topology map is stored then employed. According to Klein rock and Stevens, FSR employs the "fisheye" technique where the technique was used to diminish the size of information needed to represent graphical data. [4]

Traits of FSR

- Maintaining a connectivity map at each node
- Decreases the control overhead by propagating topology information using fisheye technique

Pros of FSR

- FSR decreases considerably the consumed bandwidth as it interchanges partial routing update info with peers solely.
- Decrease routing overhead.
- Even if any link fails, altering in the routing table will not happen as it does not trigger check message for link fiasco.

Cons of FSR

- Nastiest presentation in small ad hoc networks.
- Fewer information of remote nodes.
- Rise in network size, processing overhead and the storage complexity of routing table.
- Scarce info for path discovery.

6.1.2Reactive (On Demand):

if it is essential for a node to interact with another node, reactive routing opens a path. It retains only the paths which are presently in application, thus lessening the load upon the network. Reactive routings generally have a path finding methods where query packets are crowded into the network seeking of a route. The phase terminates once a route is obtained. [15] The figure, graph, chart can be written as per given below schedule.

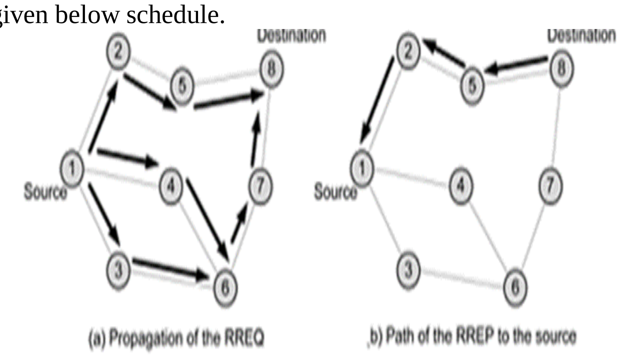

FIG 6.2: AODV route discovery

6.1.2.1 Ad Hoc on Demand Distance Vector:

It allows nodes to find routes rapidly for new targets and having the records of active nodes. It exits in both multicast and unicast routing. AODV is a reactive protocol i.e. it creates a path to a destination only when required. It confirms that the path is shortest and does not cover any loop. AODV uses pair (RREQ, RREP) to find out the route. The source node disseminate the RREQ i.e. Route Request message to its peers to find out the path to target. The RREQ message includes the DA and SA, lifespan of message, request ID as distinctive identification and SEQ_NO number of source and destination. [12]

Traits of AODV

- Nodes store solely the paths that are required
- Decreases memory requirements and unnecessary replications
- Rapid reply to link damage in active routes
- Evading Loops by applying destination sequence numbers.
- Accessible to great groups of nodes.

Pros of AODV

- An latest track to the destination due to use of destination sequence number
- Diminishes extra memory needs and the path replication.
- Reply to the link fiasco in the network.
- It can be relevant to great scale ad-hoc network.

Cons of AODV

- More time is desired to create a route for connection setup & initial communication

- Whenever intermediary nodes include old entries then it can take it to disapproval of the route. .

6.1.2.2 Preferred Group Broadcasting:

It is a dissemination process that goals to diminish broadcast overhead related with AODV's path finding and to give proposal path steadiness particularly vital in VANETs where swift mobile vehicles are used as wireless hosts. Receivers can confirm either they are in the PG or in the broadcast based group which received signal of the broadcast.

The only one node is permitted to broadcast and as the PGB is not only the one which forms the progress towards the target, path finding would possibly take longer than before. The other limitation is that broadcast can cease if the group is found to be empty.

Packet replication can take place as the two nodes in the selected group can broadcast simultaneously. The way to tackle with broadcast replication is to insert packet's predecessors into the packet. This forms the exactly same kind of overhead within the packet as DSR. [12]

Pros of AODV + PGB

- Decrease control message overhead
- Offers path availability in VANET environment
- Achieve the routes consistency
- For some nodes it is made possible by this algorithm to broadcast a route request date message to once again.

Cons of AODV + PGB

- Nearest node to destination is not found in spite of rebroadcasting the message. That's why delay in path finding process happens.
- If two nodes broadcast similar data packet simultaneously causes packet replication.

6.1.2.3 Dynamic Source Routing:

DSR employs source routing, that is, the supply shows in a data packet's the sequence of intermediary nodes on the routing path.

The IDs of the intermediary nodes are copied by, the query packet in DSR when visited in its header. The destination then fetches the complete route from the query packet, and uses it to reply to the supply. As a consequence, the supply can create a route to the destination. If we permit the destination to transmit multiple path replies, the supply node may accept and store multiple paths from the destination.

Another route can be used when some link in the present route gaps. In an interface with low mobility, this is beneficial over AODV since another route can be tried before DSR begins another flood for route discovery.

There are two major variations between AODV and DSR. The first is that in AODV data packets convey the target address, whereas, in DSR, data packets convey the full routing information.

This states that DSR has possibly more routing overheads than AODV. Moreover, as the network diameter rises, the amount of overhead in the data packet will endure rising.

The other difference is that in AODV, route reply packets convey the target address and the sequence number, whereas, in DSR, route reply packets dispatch the address of each node along the path. [12]

Pros of DSR

- To find route between nodes, it has small overload on the network. It employs caching which diminish load on the network for upcoming route discovery.
- No periodical update is needed in DSR.
- Routes are discovered only when they are needed
- Route caching diminish the cost of route discovery

Cons of DSR

- If there are numerous nodes in the network then the route information within the header will lead to byte overhead.
- Needless flooding burden the network.
- In high mobility pattern it performs poorer.
- Incapable to repair broken links locally.

6.1.2.4 Temporally Ordered Routing Algorithm:

It refers to the family of link withdrawal routing algorithms wherever a DAG (Direct Acyclic Graph) toward the target is built on the top of the tree rooted at the sender side. DAG drives to the drift of packets and analyses reachability of all nodes. A node broadcast the packet if the node has a packet to announce. Its neighbour without any division broadcasts the packet if the sending link of this node downwards links based on the DAG.

A node will create the DAG for producing a doubt packet. if any node has the downward link to the destination of a receiving a query packet, it will send the reply packet; on other hands, it will simply drop the packet. Based on receiving the reply packet, the node will enhance its height only in case the height from the reply packet provides the minimum of all the heights from reply packets and received till now. Then it will retransmit the reply packet.

The advantages of TORA are, Implementation of the algorithm provides a path to all the nodes in that network and it has reduced far-reaching control messages to a set of neighbouring nodes. Nevertheless, because this provides a path to all the nodes in the entire network, support of all these paths could be overpoweringly heavy, particularly in extremely dynamic VANETs. [12]

Advantages of TORA

- It generates DAG (Direct acyclic graph) when it required.
- Perform a good in a dense network.
- Diminish network overhead because all intermediate nodes don't require to rebroadcast the message.

Disadvantages of TORA

- This protocol is not scalable.
- This protocol has not used the main reason DSR & AODV perform very well than TORA.

Topology-based routing protocols are not too much suitable in case of VANETS since:

- Route discovery latency for these routing protocols is high.
- These protocols are not much scalable.
- The additional routes stored in routing tables occupy available bandwidth irrationally.
- AODV utilizes the extra bandwidth the main reason is periodic beaconing.

- Topology routing protocols gives an unsatisfactory performance in small networks.
- Topology routing protocols do not execute well for high mobility networks.

6.2 Geographic Routing Protocols

The Geographic based routing requires the class of routing algorithm. They share the property of using geographic positioning data to determine the next forwarding hops. The packet is transmitted without any knowledge of map to the one-hop to the neighbour, which are nearest to destination. Position-based routing is relevant since the global path from source-node to destination-node are not needed to generate and maintained. [15]

6.2.1 Delay Tolerant Network:

It uses carry & forward approach to overcome frequent disconnection of nodes in the network. In carry & forward approach when the node can't interact with other nodes it stores the packet & forwarding will be completed based on some metric of nodes neighbours.[8]

Traits of DTN

- rapid cut-off during communication
- large inevitable delays
- large/huge scalability
- limited bandwidth
- High power constraints and fault tolerance rates. [18]

6.2.2 Non Delay tolerant Network: It is a carrying and forwarding approach where transmission of data is tried from vehicles to static access points by conserving low level of channel utilization whereas satisfying user-defined delay. [8]

6.2.2.1 Greedy Perimeter Stateless Routing:

It takes a node which is nearest to the final destination by using a beacon. It operates by the greedy forwarding algorithm and if any case it fails then it operates perimeter forwarding for determining a node through which is packet will travel.

Advantages of GPSR

- The Sending packet decisions should be dynamic.
- To broadcast the packet a node requires to remember only one hop neighbour location.

Disadvantages of GPSR

- For the high mobility characteristics of the node, antiquated information of neighbours position are frequently contained in the sending node's neighbour table.
- Though the target node is portable to its information in the packet header of the intermediate node remains unchanged.

6.2.3 Hybrid Geographic Routing Protocol:

Geo DTN + Nav [4] is a combination of non-DTN and DTN strategy that encompasses the greedy method, the perimeter mode, and the DTN mode. It can be changed from Non-DTN to DTN mode. This strategy is suggested to virtual navigation interface (VNI) which provides necessary information for Geo DTN + Nav to evaluate its routing mode and forwarder.

Advantages of Geo DTN + Nav

- Geo DTN + Nav can be changed from Non-DTN to DTN mode. Geo DTN + Nav can be identified as a partition in the network.

Disadvantages of Geo DTN + Nav

- Latency rises & declines the PDR (packet delivery ratio) in the condition like a sparse network where GeoDTN+Nav strives to fallback to DTN mode again.

VII. RESULTS

In this section, AODV protocol and GPSR protocol is being analyzed. There are numerous quality metrics which need to be analyzed in order to calculate the performance of vanet protocols. Some of the quality metrics are as follows:

- **Packet Delivery Ratio:** PDR is the ratio of all packets received by the target to the packets sent by the sender. It is one of the vital metric which need to be analyzed.
- **End to End Delay:** E2ED is the ratio of time of transmission of packets from sender to receiver to number of received packets. It should be low to be effective protocol.
- **Efficiency:** It is the ratio of number of information sent and addition of quantity of routed packets along with information sent.

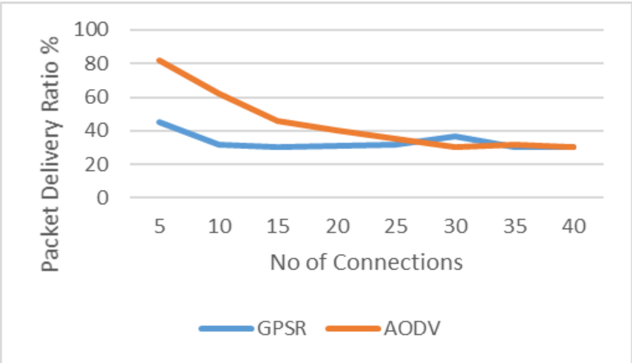

FIG 7.1: Analysis of PDR of AODV AND GPSR

In fig 7.1, it is being noted that topology based reactive protocol i.e. AODV is much better in terms of packet delivery ratio (PDR) as compared to position based protocol i.e. GPSR.

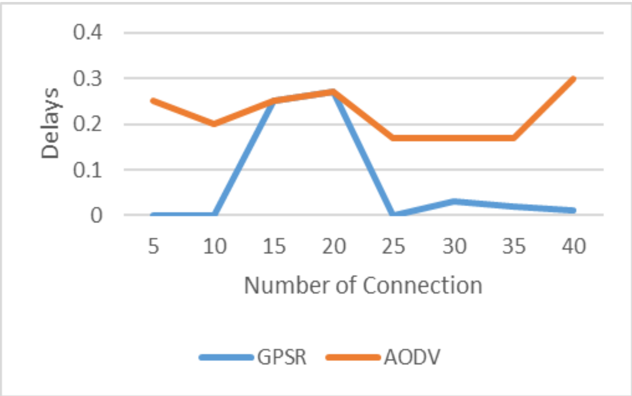

FIG 7.2: Analysis of E2ED of AODV AND GPSR

In fig 7.2, It is being noted that position based protocol i.e. GPSR is much better in terms of end to end delay (E2ED) as compared to topology based reactive protocol i.e. AODV.

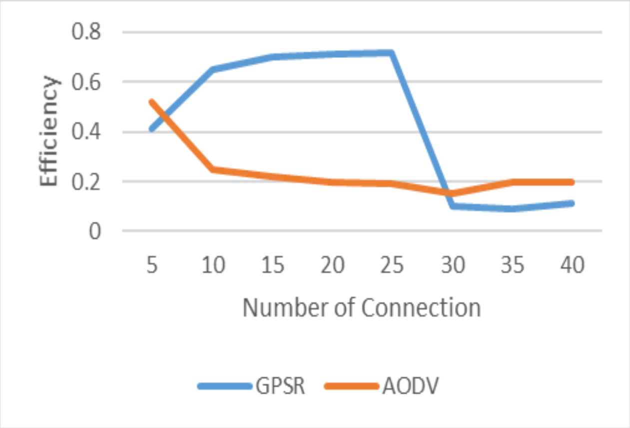

FIG 7.3: Analysis of Efficiency of AODV AND GPSR

In fig 7.3, It is being noted that position based protocol i.e. GPSR is better in terms of efficiency as compared to topology based reactive protocol i.e. AODV.

VIII. CONCLUSION

The combination of AODV and GPSR protocol can be very effective to create a new system as AODV is better in the terms of packet delivery ratio while GPSR is better in terms of end to end delay.

The purpose behind the proposed scheme is to create a Smart Automobile using VANET that covers of ITS.

In this table-II methodology, benefits, limitations are summarized.

Table-II: Summary of VANET routing protocols.

VANET Routing Protocols	Geographic Routing Protocols	Topology-Based Routing Protocols
Methodology	Position determining service Vehicle position is needed to forward data packets.	Packet forwarding is done based on link information stored in routing table. Use path having minimum distance.
Benefits/Strength	Beaconing. No requirement of route discovery and maintaining protocol. . Maintain high mobile environment.	Beaconless. Require route discovery to examine best possible shortest path among sender node and target node. Apt for unicast, multicast and broadcast routing.
Limitations	Position finding services Give least overhead. Deadlock may occur in location server.	Route discovery and delay constraint maintenance. Use more overhead. Failure in discovering complete path due to frequent network changes.
Remarks	Apt for large networks like Vanets. Study is in growth for controlling traffic and small networks.	Basically proposed for MANETs. Suitable for small networks.

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