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Research Article

Non-DTN Geographic Unicast Routing Protocol for VANET: State of the Art

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Abstract

The numbers of vehicles are increased on the roads exponentially in recent years, so the challenges on the roads are also increased like roads are full, safety problem, speed etc. One solution for these problem is to form a Vehicular Ad-Hoc Networks (VANET). VANETs are a special kind of Mobile Ad Hoc Network, (MANET), in which vehicles are the nodes and each vehicle have the transmission capabilities. There are different routing protocols are proposed. This paper describe different non-DTN geographical unicast routing protocols, categorize in to beacon, non-beacon and hybrid and compare with different parameter.

Keywords: *Vehicular Ad hoc Network, VANET, VANET routing, Non-DTN Geographic Routing*

1. Introduction

VANET is a special case of the MANET. So it is possible that we can use the routing protocols of MANET in VANET environment. When we use the popular MANET routing protocols in VANET environment the simulation results shows that, all the protocols have large packets overhead because the routs charge frequently due to high mobility. So we need the new routing protocols for VANET based on its characteristics and issues.

The Non-DTN Routing Protocols are also known as Mindelay protocols. The protocols always trying to minimize the packet delivery time from source to destination that's way most of the protocol trying to find the shortest path. Non-DTN protocols again classified in to beacon based, non-beacon based and hybrid routing protocols. Here is the Issues for non-DTN routing protocols:

- As the non-DTN routing always try to reduce the packet delivery time. To achieve this, the packets should have to pass through minimum intermediate node and this path should be shortest and optimal.
- To find the shortest path the nodes should have the knowledge of neighbors.
- If there is problem in delivery of packets then protocols should have recovery mechanism.

Greedy forwarding is the commonly used technique in Non-DTN routing protocols. In this approach packets are forwarded to a neighbor which is geographically closer to the destination node. This approach have problem where a packets reaches to a node which has no neighbors that is closer to destination. This is called local maxima. Every routing protocols have their own recovery strategy to deal with local maxima problem.

2. Classification

The Non-DTN protocols assume that roads are densely populated. It do not work well in sparse roads where the connectivity is irregular. Greedy forwarding is the commonly used technique, where the packet is forwarded to a neighbor which is geographically closer to the destination node.

Figure 1 will show the classification of different protocols under the Non-DTN Geographic Unicast routing.

Non-DTN protocols again classified in to beacon based, non-beacon based and hybrid routing protocols.

3. Beacon Based

The beacon based routing protocols use the "HELLO" beacon message to finds the neighbors. The nodes sends the beacons periodically to maintain the neighbor lists. It again classified into non-overlay and overlay.

3.1 Non-Overlay

The non-overlay network only use the existing network. It does not use any type of representative node or other network. All the protocols in non-overlay use the greedy forwarding. The greedy forwarding can

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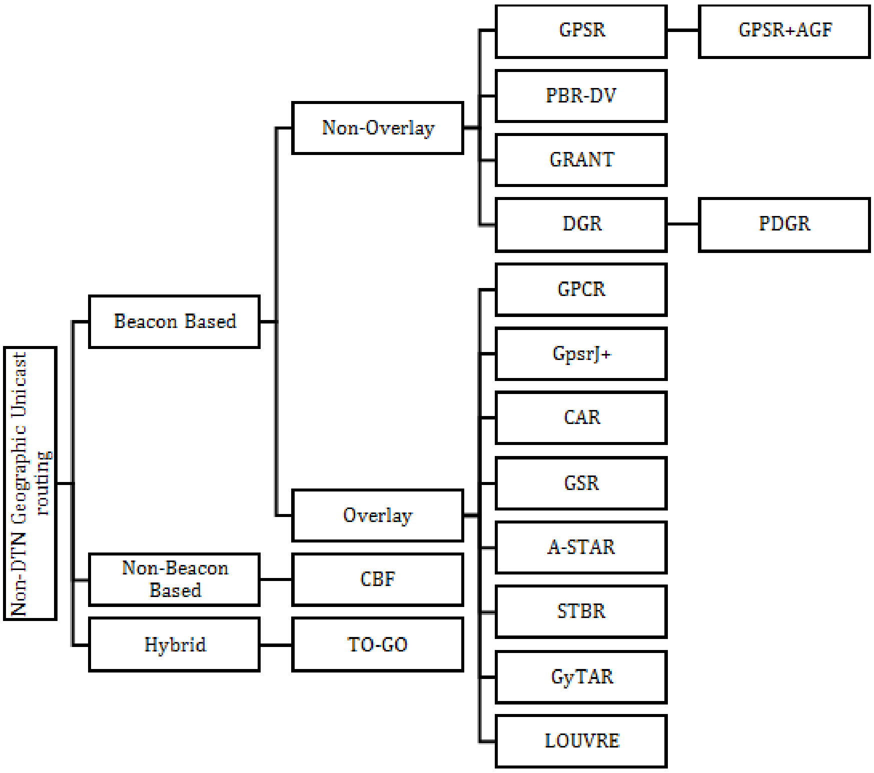

Fig. 1 Classification of Non-DTN Geographic Unicast routing

fail if no neighbor is closer to the destination other than the current node. In that case the different protocol propose different recovery strategy.

3.1.1 GPSR

Greedy Perimeter Stateless Routing (B. Karp *et al*, 2000) forward the packet to their nearest neighbor which is geographically closer to the destination. This forwarding is called as greedy mode. Whenever any local maxima encounter in packet forwarding the protocol goes to the recovery mode to resolve the problem. It is called as perimeter mode. It is based on Right-Hand Rule.

If we compare the packet delivery between GPSR and DSR in the highway scenario. The simulation shows, DSR performance start decreasing when the communication distance becomes larger. It is because DSR have to maintain the route from the sender and as the communication distance increases it becomes harder. GPSR have the 100% packet for any distance.

Advantage: In packet forwarding a node have to remember only one hop neighbor location. All the decisions of packet forwarding are made dynamically.

Disadvantage: In high mobility environment, the sending node's neighbor table have the outdated information of neighbor's position. The information of destination node is never updated in the packet header of intermediate node.

3.1.2 GPSR +AGF

Advanced Greedy Forwarding (AGF) is proposed by Naumov *et al*. in 2006. He observed two major problem which is encountered with GPSR in VANET are as follows. The first problem occur due to mobility, the node's neighbor table contains some outdated information of neighbor's position. The second problem is about the destination location within the packet which is never updated.

To overcome from both problems, a new greedy system will use is Advanced greedy forwarding. This combine the speed and direction of a node in the beacon packet and the total travel time, including the time to process the packet, upto the current forwarding node within the data packet.

Results shows at least three times of improvement in packet delivery ratio.

Advantage: The information of destination node is always updated in the packet header of intermediate node. All the information of unreachable nodes of neighbor table can be easily detected.

Disadvantage: It may not give desired optimal solution of shortest connected path.

3.1.3 Position based routing with distance vector (PRB-DV)

It uses AODV routing to recover from local maxima. When the packet reach to the local maxima it will broadcast a request packet. The request packet contains the node position and destination location.

There is no evaluation done comparing packet delivery and overhead in PRB-DV and GPSR thus performance is inconclusive.

Advantage: It proposes better packet delivery ratio & overhead.

Disadvantage: Excessive flooding is necessary for non-greedy approach.

3.1.4 Directional Greedy Routing (DGR)

Directional Greedy Routing (Gong, 2007) is also follow the greedy forwarding. It uses the combination of two forwarding strategies.

- Position First Forwarding: The position-first strategy tries to find the closet node towards destination as the next hop.
- Direction First Forwarding: It will select the nodes which are moving toward destination. Among those nodes, the one closet to the destination will be chosen as next hop. It takes both position and direction into consideration when choosing next hop.

DGR uses combination metrics of position-first and direction-first forwarding. The node with largest weighted score among current node itself and its neighbors will be chosen as next hop. If the current node has the largest score, it will carry the packet and forward it later.

The simulation results shows DGR have better results packet delivery ratio, end-to-end delay and routing overhead in comparison of GPSR.

Advantage: It considers both direction and speed in node selection.

Disadvantage: It may not give desired optimal solution of shortest connected path.

3.1.5 Predictive Directional Greedy Routing (PDGR)

Predictive Direction Greedy Routing (PDGR) extend DGR and predict the future neighbors. The PDGR calculate the weighted score for current node, its current neighbors and possible future neighbors. The packet carrier use 2-hop neighbors to get the knowledge of possible future neighbors. According to all these weighted scores, next hop is then decided.

So PDGR has two parts. One is to calculate weighted score for current neighbors, which is the same as DGR. The other is used for future neighbors in a short interval.

The simulation results shows that PDGR have better results packet delivery ratio, end-to-end delay and routing overhead in comparison of GPSR. PDGR also perform slightly better than DGR because of the use of prediction.

Advantage: It works better then DGR in some scenario like overtaking.

Disadvantage: It may not give desired optimal solution of shortest connected path.

GRANT (Greedy Routing with Abstract Neighbors Table)

It has the concept of extended greedy routing. In this every node knows its x hop neighborhood. Using this information every node can find better route and avoid local maximum. The matrix use in selection the next forwarding neighbor E is based on

- The node N
- X hop away from E and the Destination.
- The shortest path from N to E
- The cost per hop for multihop neighbors

The neighbors E which provide the smallest such matric will be selected at the next hop. It is very necessary to select the most promising neighbor as in beacon transmitting x-hop neighbors is too much overhead (Schnaufer, 2008),

GRANT divides the whole plane into small areas and have only one representative neighbor per area. When its receive a beacon a node that called as broadcasting node, compute the area along with its neighbors and distinguish them from different hope from current node.

Advantage: This extended greedy routing approach works better than as usual greedy approach when obstacles are present between the roads.

Disadvantage: The performance evaluation of GRANT is done on static traces. The overhead of beacon and possible inaccuracy in packet delivery are not measured.

3.2 Overlay

An overlay network built on top of another network which use set of representative nodes. The other network like city map, bus route etc. can be used, on which an overlay network will be built. In these maps the junction is the important place where decisions are made. The protocols here use this information many ways.

3.2.1 GPCR (Greedy Perimeter Coordinator Routing)

GPCR (Lochert *et al*, 2005) use the street map which is naturally forms a planar graph. So there is no need of planarization algorithms.

In this planar graph nodes would forward the pack*et al*ong to the road as far as they can go in both greedy or perimeter mode, but they have to stop at junction. Here all the decisions are made on the junctions and the packets are forward to junction to junction along to the roads.

As we know GPCR does not rely on a map or graph to find whether a node is located at a junction, but it use two heuristics to find whether a node is at a junction.

- The first heuristic is determined by the beacon messages. A node x is located at a junction if it has two neighbors y and z that are within the range of each other but they do not list each other as neighbors.
- The second heuristic is derived from a correlation coefficient that relates a node to its neighbors and

find out their linear relationship. A correlation coefficient close to 0 shows there is no linear relationship between the positions of the neighbors. This indicates the node is located at a junction.

Advantage: It does not require any global or external information like non-overlay protocols. It does not use any planar graph algorithm. It uses the underlying roads for representing the planar graph. It has no as usual a planarization problem like unidirectional links, planar sub-graphs & so on.

Disadvantage: It depend on junction nodes. The first heuristic fails on curve road. The second heuristic fails on a sparse road.

3.2.2 GpsrJ+

GpsrJ+ (Lee, 2007) minimize the packet forwarding node by removing the unnecessary stops at junctions without changing the efficient planarity of topological maps. It consider the two-hop neighbor beaconing to choose the next road segment at junction which is taken by its neighboring node. A node consider its two hope neighbor and predict the next forwarding node. If the next forwarding neighbor node is in different direction then the packet forward to the junction node. And if it is on the same direction then it bypass the junction and forward to its furthest neighboring node. When it reach to local maxima then it use the perimeter mode where GpsrJ+ uses the right-hand rule to find the best forwarding node. if the junction's next node is the best node in the same direction, then it is considered as the best forwarding node; otherwise, the best forwarding node is consider to be the junction's node.

GpsrJ+ increase packet delivery ratio and reduces the number of hops in the recovery mode by 200% compared to GPSR.

Advantage: The packet delivery ratio is better in GPSRJ+ as compare to GPCR. The number of hops in the recovery mode of GPSR is reduced by 200%. There no expensive planarization strategy is not required by GPSRJ+ to achieve above mention.

Disadvantage: This protocol can delay the delivery of packets so it is not appropriate for the delay sensitive applications. It did not apply on realistic city map that are not necessarily grids and realistic roads follow a more complex trajectory.

3.2.3 Connectivity-Aware Routing (CAR)

CAR (Naumov *et al*. 2007) does not use the digital map to point out junctions. It uses anchor points, which selected based on velocity vector this helps to find the curve road. It selects the anchor points for both junction and curve roads. It also provides the concept of guards (travelling and standing) to reduce the problem of sparse network. Standing Guards is a geographical area. And the guard status is maintained by the nodes with in the area and they called as grading node. Traveling guard contains the velocity vector along with guarded position and radius. And it calculate the new gaud position with help of velocity vector and the time between the two HELLO beacons. Traveling guards moves the information by the guard to travel with a certain speed along the road. The age counter of the traveling guard is decreased with every retransmission.

The simulation results show CAR's packet delivery ratio (PDR) higher than GPSR and GPSR+AGF. The reason that CAR's PDR is higher than GPSR+AGF is that CAR guarantees to find the shortest connected path whereas GPSR+AGF may suffer from sub-optimality of greedy mode in terms of finding such a path. CAR's path discovery overhead is checked by PGB. The overhead of storing guard is not in the data packets but in the beacons. According to their finding, a node on average only broadcasts 2-3 guards during the simulation. Thus, the beacon overhead is not overwhelming.

Advantage: It does not required digital map. It has no local maximum problem. CAR has higher packet delivery ratio than GPSR and GPSR+AGF, so it will have shortest connected path.

Disadvantage: This protocol select unnecessary nodes as an anchor. It cannot determine different sub-path when traffic environment changes.

3.2.4 Geographic Source Routing

GSR (Lochert *et al*., 2003) use the route map from the source to destination and finds a Dijkstra shortest path. This route map is converted in graph where the junction nodes are vertices and the routes are edges. When the route is found, it forwarding the delivery packets form junction to junction along to the road. But there may be possibility that the route have no connectivity (no vehicle). In that case it goes to recovery mode and follows the greedy forwarding.

The simulation results show GSR have better performance than AODV and DSR in packet delivery ratio. GSR forwards most of the packets in a densely populated network. GSR have no scalability problem as compared to AODV and DSR. However, GSR is not compared with other position-based routing protocols. Its performance in sparse networks is not verified.

Advantage: GSR has better packet delivery ratio as compare to position based protocols likes AODV & DSR. GSR is also scalable than AODV & DSR.

Disadvantage: The performance of GSR decrease in sparse network where there are not enough nodes for forwarding packets. GSR shows higher routing overhead than GyTAR because of using hello messages as control messages.

3.2.5 A-STAR

Anchor-Based Street and Traffic Aware Routing (Seet, 2004) is work same as GSR but it also use the anchor nodes. The GSR does not consider the traffic of the road but the A-STAR is traffic aware. It choose the anchor point from the traffic for shortest path. A-STAR use the two kind of overlaid maps for route discovery.

Statistically rated map- It is graph of city routes that use by buses etc. This map makes sure that route have stable traffic. So the shortest path use on this map will be well connected due to this heuristic knowledge.

Dynamically rated map- It is graph of city routes which is based on real time traffic on roads. The road-side deployment units which monitor the city traffic condition and broadcast this information to every vehicle. So the difference between the both maps are traffic condition.

The simulation result show A-STAR packet delivery ratio is lower than GSR and GPSR because A-STAR selects paths with higher connectivity.

Advantage: A-STAR work well in low traffic density to find an end-to-end connection. A-STAR uses a new path selection and local recovery strategy which is more suitable for city environment.

Disadvantage: Packet delivery ratio of A-STAR is lower than GSR & GPSR. The use of static information based on city bus routes cause connectivity problem on some portion of streets.

3.2.6 STBR

Street Topology Based Routing (Forderer, 2005) proposed new update to A-STAR where ever junction node will have the information about road connectivity. It does not calculate the Dijkstra shortest path as the other protocol do. A node at the junction will compute the link up to the next junction and it will find that link is up or down. This junction node is called as master node. So every junction will have a master node and they will have a table about the links to the next junctions. And they will broadcast there link information to other master links.

It calculates the geographic distance from packet's current position to the street where destination node currently present. And sent the packet to next node who has less geographic distance then the current position.

Advantage: It traverses least spanning multiple junctions for long distance unicast communication.

Disadvantage: STBR is not appropriate for mixed scenarios because it would try to send junction beacons along a highway. In STBR complexity increases because of some special cases like transferring the two-hop neighbor table to the new master when the old master leaves the junction.

3.2.7 GyTAR

Greedy Traffic Aware Routing protocol (Jerbi, 2007) also known as Improved Greedy Traffic Aware Routing Protocol is intersection-based geographic routing protocol which use new parameter traffic density to find robust routes. This protocol have two part.

Junction's selection: In this the protocol select the junctions through which the packets must go through. The selection of these junctions are done dynamically and one by one, it calculate a traffic density and the curve-metric distance (the distance measured when following the geometric shape of a road.) for next junctions when a vehicle wants to forward the packet. The source vehicle or an intermediate vehicle looks for the position of the neighboring junctions using the map.

Forwarding data between two junctions: Once we found the destination junction, the improved greedy strategy is used to forward packets towards the selected junctions. The current node marks all data packets with the location of next selected junction. When a packet is received by a node, it forward the packets to the node which is geographically closest to destination node. The selection of next node is done by current node based on the parameter (velocity, direction and the latest known position) recorded in neighbors table. If the packet reached to local maxima then it will follow the "carry and forward" strategy. The node carry the packet until it reached to next junction or any other new node comes to its range, As soon as it reached to next junction or any other new node it will forward the packet.

The simulation results show GyTAR have better packet delivery ratio than GSR. However, since it is not compared to any other overlaid routing protocol in this category, it is hard to gauge its relative performance.

Advantage: GyTAR works well if the network topology is unstable because of very high mobility. It has better throughput, delay and routing overhead than GSR.

Disadvantage: It assumes that the number of cars in the road will be given from roadside units. Gytar cannot avoid void areas in the network.

3.2.8 LOUVRE

The Landmark Overlays for Urban Vehicular Routing Environments (LOUVRE) is based on one factor that is vehicular density threshold. It observe all overlay link and calculate all vehicles on each overlay link, it does not matter what the geographical position of the vehicle on that overlay link. Then it decide a vehicular density threshold, all the overlay link which have lower vehicular density then the threshold value will not be consider.

It use peer-to-peer density, LOURVE first find out the road length and radio range and then determines the roads that do not have density over the threshold. The overlaid routes for packets are built on top of roads whose density is above the threshold. This forms the graph of overlaid routes. It is use the Dijkstra shortest path to find shortest path for forwarding the packets.

The simulation results shows LOUVRE performs better than GPCR and GPSR because LOUVRE have global knowledge of the density distribution on road segments and on local maxima, typical information that is not available to GPSR and GPCR. The hop count and delay are also significantly reduced as LOUVRE does rarely encounter local maxima and therefore mostly does not use a recovery mode.

Advantage: It estimates Peer-to-peer density so there will be no void area and backtracking. Packet delivery ratio is higher than GPCR & GPSR. Ensures an obstacle free geographic routing.

Disadvantage: When the packet delivery fails, its hop count increase in compare to GPCR. It have scalability problem.

4. Non-Beacon based

The protocols do not use the beacon message to maintain the neighbor lists. When the packets arrive then they find their neighbors.

4.1 CBF

Contention-Based Forwarding (CBF) (F¨ußler *et al*., 2004) does not use proactive transmission of beacon messages. It forward the packets in all direction towards their direct neighbors and the neighbors will decide whether it forward the packet or not. Distributed timer-based contention process is used by the forwarder which allows the best node to forwarding the packet by suppressing the other forwarder nodes.

Every CBF data packet contains the position of the node that has just forwarded the packet (called last-hop from the receiver's point of view), the ID and position of the final destination, and a packet ID. A node that receives such a packet and is not the final destination sets a timer to determine when to forward the packet.

CBF is compared with GPSR (perimeter mode not considered) and with beacons of different intervals using realistic movement patterns of vehicles on a highway. With beacon interval of 0.25 seconds (the lowest set in the experiment), the packet delivery ratio (PDR) of GPSR is low in comparison of CBF. As the beacon interval increases (up to 2 seconds), its PDR drops. The GPSR have more load on the wireless medium than CBF due to GPSR's constant beaconing overhead.

Advantage: As it does not use any beacon message which saves bandwidth. It reduces the probability of packet collision & inefficient routing. CBF protocol changes packet forwarding delay time according to the node mobility.

Disadvantage: It has low performance in city environment as compare to highways because in city environment local maximum occurs frequently.

5. Hybrid

The protocol use both approach beacon based and non-beacon based.

5.1 TO-GO

TOpology-assist Geo-Opportunistic Routing (TO-GO) (Lee *et al*., 2009) is a geographic routing protocol. It use the knowledge acquired via GpsrJ+'s 2-hop neighbor information and it select the best target forwarder from the forwarding set between the sender and the target node. It not use previous approaches where a forwarding region is defined between the current sender and the destination. The target node is next promising node other than the junction node which is normally choose by greedy or recovery mode.
The simulation result of TO-GO is divided in to two part. The first is error-free channel scenario, where TO-GO's performance is low in compare to GpsrJ+ but it is better than GPSR and GPCR. The second error-prone channel scenario, when the channel error increases, TO-GO have stable packet delivery rate while GpsrJ+'s decreases.

Advantage: All nodes can hear each another so no hidden terminal will be present. Consideration of low signal–to-noise ratio (S/N ratio).

Disadvantage: It has higher End-to-End latency as compare to GPCR, GPSR, GpsrJ+.

6. Comparison

Non-DTN protocols are broadly classified as Beacon, non-beacon and Hybrid protocols. Here different comparison is done based on different parameters.

6.1 Comparison of non-overlay beacon protocols

Here is the comparison of non-overlay beacon protocols based on protocol feature.

Table 2: Comparison of non-overlay beacon routing protocols

Routing Protocols	Forwarding strategy	Recovery Strategies	Predictive	Node Awareness
GPSR	Greedy	Flooding	No	1 hop
GPSR+AGF	Greedy	Flooding	No	1 hop
PRB-DV	Greedy	Flooding	No	1 hop
DGR	Greedy	Flooding	No	1 hop
PDGR	Greedy	Flooding	Yes	2 hop
GRANT	Greedy	Flooding	No	X hop

Table 3: Comparison of overlay beacon routing protocols

Routing Protocols	Forwarding strategy	Recovery Strategies	Predictive	Map-based	Traffic-aware	Anchored route
GPCR	Greedy	Flooding	No	Yes	No	Yes
GpsrJ+	Greedy	Store & Forward	Yes	No	No	No
CAR	Trajectory	Node Awareness	No	No	No	Yes
GSR	Greedy	Flooding	No	Yes	No	Yes
A-STAR	Greedy	Flooding	No	Yes	Yes	Yes
STBR	Greedy	Flooding	No	No	Yes	
GyTAR	Greedy	Store & Forward	Yes	Yes	Yes	No
LOUVRE	Greedy	Flooding	Yes	Yes	Yes	No

Table 1: General comparison of routing protocols

Routing Protocols	Mobility Models	Propagation Models	CPO	Scalability	Delay	Delivery	PDR	Best Scenario
GPSR	MTS	Probabilistic shadowing	Not Specified	Not specified	More	Guaranteed	Up to 80%	Highway
GPSR +AGF	MTS	Probabilistic shadowing	Not Specified	Not specified	More	Guaranteed	Up to 80%	City
PRB-DV	Not specified	Not specified	Not specified	Not specified	More	Guaranteed	Up to 80%	Not Specified
DGR	Not specified	Not specified	Not specified	Not specified	More	Guaranteed	Up to 80%	City
PDGR	Not specified	Not specified	Not specified	Not specified	More	Guaranteed	Up to 80%	City
GRANT	Static trace from a uniform distribution	Road blocking	Not specified	Not specified	Less	Guaranteed	Up to 80%	City
GPCR	VanetMobsim	Road blocking	Low	Good	Less	Best Effort	Up to 80%	City
GpsrJ+	VanetMobsim	Road blocking	Low	Good	Less	Guaranteed	Up to 80%	City
CAR	MTS	Probabilistic shadowing	Low	Good	Less	Best Effort	Up to 80%	Highway
GSR	Videlio, M-Grid mobility	Road blocking	Low	Good	Less	Best Effort	Up to 80%	City
A-STAR	M-Grid mobility	Road blocking	Low	Good	Less	Best Effort	Up to 80%	City
STBR	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	City
GyTAR	Proprietory	Free space	Low	Good	Less	Guaranteed	Up to 80%	City
LOUVRE	VanetMobsim	Road blocking	High	Low	More	Best Effort	Up to 80%	City
CBF	Random way point	Two-Ray ground	High	Good	More	Best Effort	Up to 80%	Highway
TO-GO	VanetMobsim	Road blocking	High	Good	More	Guaranteed	Up to 80%	Highway

6.2 Comparison of overlay beacon protocols

Here is the comparison of overlay beacon protocols based on protocol feature.

See table 3

6.3 Comparison of Beacon, non-beacon and Hybrid protocols

See table 4

Conclusion

VANET network is very dynamic in nature so it's very difficult to design a routing protocol which work in all vehicular environment and address all the problems. The popularity of GPS or other location devices increases the demand of location based services. So the geographic (position) based routing protocols are very popular to fill these demand. The position based protocols also popular because it have no overhead for establishing and maintaining routes as topology based protocols do. The position based protocols are mostly based on greedy forwarding and trajectory based forwarding. There are many protocols has been introduced. Most of them designed to address special conditions on the roads like curve road, sparse road, highway, city, junctions etc. The performance of the protocols is depend on many parameter like traffic mobility and driving conditions.

The major problem with these protocols is performance evaluation. There is no one standard benchmark to validate their performance and most the protocol take the GPSR as the benchmark and compare with that. The simulation results show that protocols using different mobility models. The mobility models are close to real traffic. There is lack of real traffic model because the limitation and accessibility of roadside units because of that we cannot get the real traffic information. The simulation results show that the protocols also use different propagation models. Most of them use simple road blocking model because the lack of understanding with the sophisticated analytical models.

There is need of benchmark tool to evaluate these protocols. It is required to reduce the end-to-end delay and increase the packet delivery ratio. Because in safety application high packet delivery and minimum delay are required. There is still need to work more on security of routing protocols because VANET environment is different form the communication networks.

8. Future Scope

The VANET is the combination for vehicles and RSU units. And the most important application is to help in traffic and road security. So the routing protocols should be quick and reliable. As we have described three important feature that a VANET routing protocol should have. SO the future protocol should incorporate these three properties.

We also have to improve the performance evaluation process of the protocols. There is need to set the benchmark for the mobility models. So we can compare the routing protocols on one mobility model.

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