© 2014 IJEDR | Volume 2, Issue 4 | ISSN: 2321-9939

A Survey of Routing Scheme for Vehicles in Intermittently Connected Network

Saloni Shah
PG Student
Computer Engineering,
L. J. Institute of Engineering & Technology, Ahmedabad, India

Abstract **- Delay-tolerant networks (DTNs) have the potential to interconnect devices in regions that current networking technology cannot reach. Delay Tolerant Networks are utilized in various operational environments, including those subject to disruption and disconnection and those with high-delay, such as Vehicular ad-hoc Networks (VANET). Vehicular networks can be seen as an example of hybrid delay tolerant network where a mixture of info stations and vehicles can be used to geographically route the information messages to the right location. VDTN'S routing protocols fall into two major categories of topology-based and geographic routing. In this paper, we provide a survey of geographic routing protocols for vehicular delay tolerant networks, and discuss the pros and cons of these routing protocols, and define some open issues and possible directions of future research related to using geographic routing protocols for vehicular delay tolerant networks.**

Index Terms **- Vehicular Delay Tolerant Network, Geographic Routing, Navigation Interface, VANET, VDTN**

I. INTRODUCTION

Delay/Disruption Tolerant Networking (DTN) is a new communication paradigm that can span across multiple networks and cope with harsh conditions not envisioned in the Internet model. The idea is that an end-to-end connection may never be present. To make communication possible, intermediate nodes take custody of the data being transferred and forward it as the opportunity arises. Both links and nodes may be inherently unreliable and disconnections may be long-lived.

Providing access to the Internet or other network services to remote regions with low population density is quite complicated, since vendors/companies may not be willing to invest in a communications infrastructure in these locations. A possible solution to this problem is using Vehicular Ad-hoc Networks (VANET) with Delay Tolerant Networks (DTN) architecture in order to provide Internet access and other services to these regions. This is quite a challenging task because it is really difficult to predict when vehicular nodes will be in contact with each other and how long it will remain connected. Roads are saturated, safety distance and reasonable speeds are hardly respected, and drivers often lack enough attention. Without a clear signal of improvement in the near future, leading car manufacturers decided to jointly work with national government agencies to develop solutions aimed at helping drivers on the roads by anticipating hazardous events or avoiding bad traffic areas.

A typical VANET node structure is shown in a Fig1, Global Positioning System (GPS) for tracking its own location, devices for neighbor's position and nearby obstacles on road side (radars), a set of sensors which report crashes and other statistics (engine condition, tire condition, brake statistics, weather conditions etc.), a pre-stored digital map and onboard computing device, which is responsible for all on board calculations.

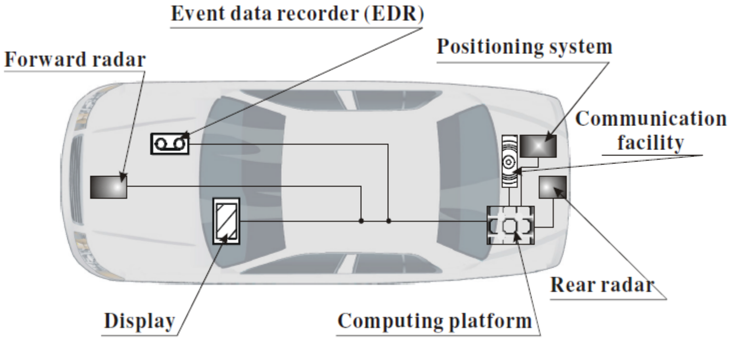

Figure.1 The structural components of VANET node

Vehicular Ad Hoc Networks (VANET), a particular instance of Mobile Ad Hoc Networks (MANET), are a particular kind of networks, where vehicles or transportation infrastructures equipped with transmission capabilities are interconnected to form a network. The topology created by vehicles is usually very dynamic and significantly non-uniformly distributed. In order to transfer information on that kind of networks, standards MANET routing algorithms are not appropriate. [1]

As shown in Fig 2, there are two categories of routing protocols: topology-based and geographic routing. Geographic routing uses neighboring location information to perform packet forwarding. Since link information changes in a regular basis, topology-based routing suffers from routing route breaks. Topology-based routing uses the information about links that exist in the network to perform packet forwarding. [3]

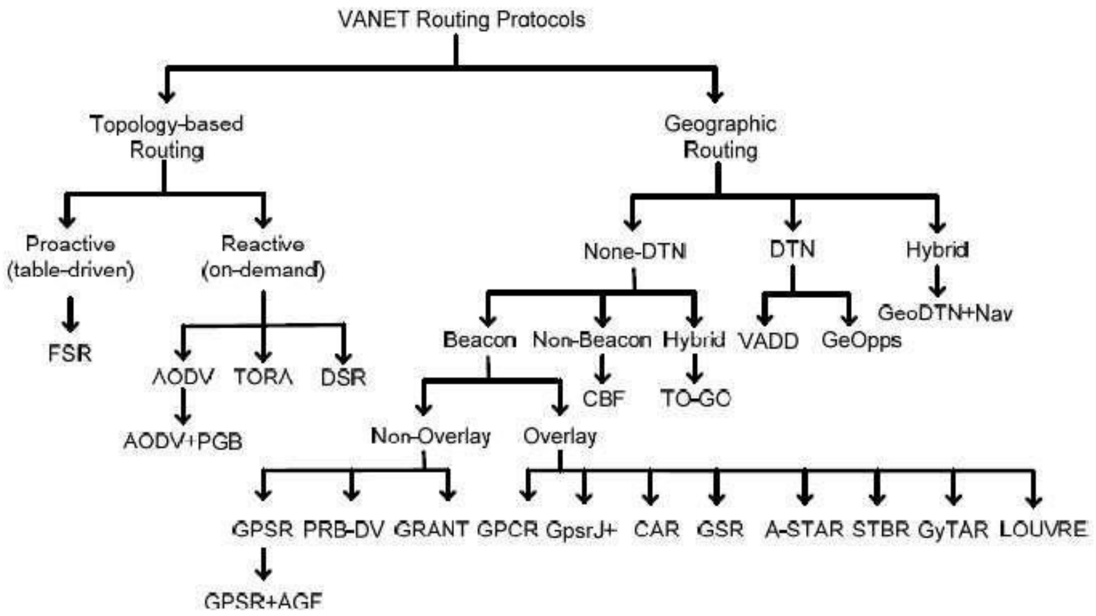

Figure. 2 Taxonomy of Various Routing Protocols in VANET [3]

Although geographic routing is a promising method in VANET, it also has limitations. Due to the non-uniform topology distribution, a node may not be able to find a neighbor closer to the destination than itself; a situation called a “local maximum” occurs. Several routing protocols are used to solve this problem. [1]

Greedy Perimeter Stateless Routing (GPSR) consists of two methods for forwarding packets: greedy forwarding and perimeter forwarding. In GPSR, 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. GPSR recovers from a local maximum using perimeter mode based on the right-hand rule. If the graph is not planar, that is, there are cross edges in the graph, routing loops may occur. GPSR provided two distributed algorithms that produce Relative Neighborhood Graph (RNG) (Toussaint, 1980) and Gabriel Graph (GG) (Gabriel, 1969) which are known to be planar. [5] The local maximum and link breakage can be recovered in perimeter mode forwarding, but packet loss and delay time may occur because the number of hops increases in perimeter mode forwarding. These characteristics of greedy forwarding decrease VANET reliability. [4]

Because nodes are highly mobile in VANETs, node planarization can become a cumbersome, inaccurate, and continuous process. Greedy Perimeter Coordinator Routing (GPCR), Lochert et al. (2005) have observed that urban street map naturally forms a planar graph such that node planarization can be completely eliminated. GPCR not only eliminates the inaccuracy of node planarization, but also improves routing performance as packets travel shorter hops in the perimeter mode. Each road segment is an edge of a planar graph while nodes at junctions are vertices. Routing decisions are made only at junctions; between junctions, packets are simply forwarded to next junction. The limitation of GPCR is that it assumes that the junction nodes always exist. But in reality, it is not always true. When junction nodes are missing, packets will be forwarded across junctions, causing possible routing loops. [1]

GeOpps takes advantage of the vehicles’ navigation system suggested routes 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 vehicles’ path, and estimates the arrival of time of a packet to destination. During the travel of vehicles, if there is another vehicle that has a shorter estimated arrival time, the packet will be forwarded to that vehicle. The process repeats until the packet reaches destination. MoVe uses the motion vector of a node to take forwarding decisions. The motion vector represents a node’s current moving direction. MoVe chooses the neighbor which has the shortest distance to destination. The shortest distance to destination is calculated as the distance from destination to the extending line of the motion vector. A variant is MoVe-Lookahead [6], which uses the next waypoint, i.e. points where vehicles change their directions, instead motion vectors to calculate the shortest distance.

All of these routing algorithms lack an integrated protocol to combine both the efficient position-based routing for connected partitions and delay tolerant forwarding for routing between partitions.

GeoDTN+Nav that includes the greedy mode, the perimeter mode, and the DTN mode. In order to know when to use one of these modes, a network partition detection method is proposed to evaluate for each packet the correct forwarding method to use in order to guarantee a better packet delivery even in sparse or partitioned networks. In GeoDTN+Nav, geographic routing is employed for efficient and fast routing within network partitions, while DTN “data mules” are used to ensure correct delivery between partitions yet at the cost of an increased delay.[3]

Table 1 Packet delivery concept [1]

Packet delivery	Connected/dense network	Sparse network
Geo routing	Fast	No delivery (dropped)
DTN routing	Slow	Slow
GeoDTN+Nav	Fast	Slow

II. GEOGRAPHIC ROUTING PROTOCOLS

I. Greedy Perimeter Stateless Routing

GPSR uses the positions of routers and a packet’s destination to make packet forwarding decisions. GPSR makes greedy forwarding decisions using only information about a router’s immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recovers by routing around the perimeter of the region. [5]

The two dominant factors in the scaling of a routing algorithm are:

- The rate of change of the topology.
- The number of routers in the routing domain.

The algorithm consists of two methods for forwarding packets: greedy forwarding, which is used wherever possible, and perimeter forwarding, which is used in the regions greedy forwarding cannot be.

In GPSR, 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. The packet resumes forwarding in greedy mode when it reaches a node whose distance to the destination is closer than the node at the local maximum to the destination. [3]

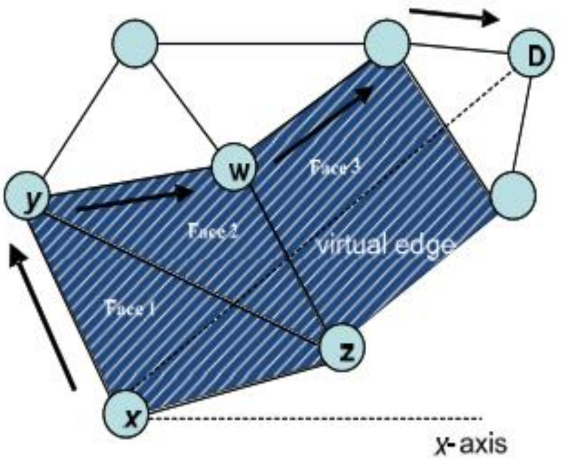

Figure. 3 Right hand rule in GPSR’s perimeter mode; packet performs face routing to route along Face 1, Face 2, and Face 3 toward destination D. [3]

GPSR recovers from a local maximum using perimeter mode based on the right-hand rule shown in Fig 3. The rule states that when a node x first enters into the recovery mode, its next forwarding hop y is the node that is sequentially counterclockwise to the virtual edge formed by x and destination D. Afterwards, the next hop z is sequentially counterclockwise to the edge formed by y and its previous node x shown in Fig 3. While walking the face, however, if the edge yz formed by the current node and the next hop crosses the virtual edge xD and results in a point that is closer than the previous intersecting point x, perimeter mode will perform a face change in that the next hop w is chosen sequentially counterclockwise to the edge yz where the closer intersecting point was found. Such routing is called face routing because the packet traverses many faces formed by nodes in the network until it reaches a node closer to the destination than where the packet entered in the perimeter mode and where the face routing started. [3]

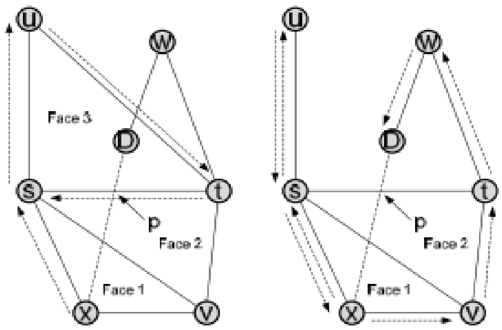

Figure. 4 On the left, packet will loop around face 3; on the right, packet will eventually route to D through u, s, x, v, t, and w. [3]

Note that if the graph is not planar, that is, there are cross edges in the graph, routing loops may occur. Consider Fig 4, *x* tries to reach *D* in perimeter mode. The packet will eventually loop around face 3 with no intersecting point closer than *p*. Had the cross edge *ut* been removed, the packet would travel the exterior face *u*, *s*, *x*, *v*, *t*, and *w* to reach *D*. Given that perimeter mode must operate on planar graphs to avoid routing loops, GPSR provided two distributed algorithms that produce Relative Neighborhood Graph (RNG) (Toussaint, 1980) and Gabriel Graph (GG) (Gabriel, 1969) which are known to be planar. Both RNG and GG algorithms yield a connected planar graph so long as the connectivity between two nodes obeys the unit graph assumption: for any two vertices, they must be connected by an edge if the distance between them is less than or equal to some threshold distance *d* and must not be connected by an edge if the distance between them is greater than *d*. However, the unit graph assumption is not true in VANETs due to channel fading (obstacles and mobility). As a result, planar graphs are usually hard to achieve in VANETs. [3]

Pros

-To forward the packet a node needs to remember only one hop neighbor location.

-Forwarding packet decisions are made dynamically.

Cons

-For high mobility characteristics of node, stale information of neighbors' position are often contained in the sending nodes' neighbor table.

-Though the destination node is moving its information in the packet header of intermediate node is never updated.

II. Greedy Forwarding Coordinate Routing

Two methods are proposed in GPSR to construct planar graph: Relative Neighborhood Graph (RNG) and Gabriel Graph (GG). However, it is impossible to construct a planar graph in VANET, because the network topology is always changing. Each time when nodes move, a new planar graph has to be constructed. Greedy Perimeter Coordinator Routing (GPCR) [6] solves the planarization problem by exploiting the urban street map that naturally forms a planar graph. Each road segment forms the edge in network topology, and the junctions of roads form the vertices. In GPCR's greedy mode, a node forwards packets until it reaches a node at a junction. The junction node forwards packets by choosing one neighbor which has the shortest distance to destination. In the perimeter mode, junction nodes forward packets to the next hop by applying right-hand rule. Non-junction nodes forward packets until it reaches a junction node.

Fig 5 shows an example of GPCR forwarding where node *A* would forward packets to node *B* at a junction even though node *A*'s radio range covers node *C*. [6]

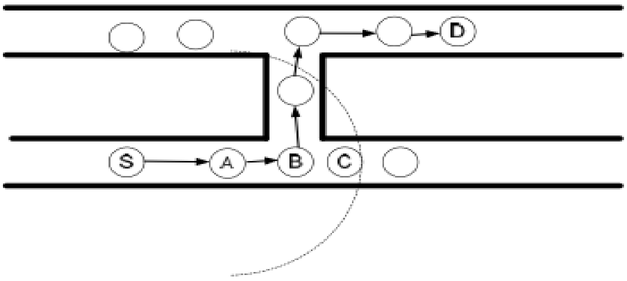

Figure. 5 GPCR routing along junctions. [6]

GPCR not only eliminates the inaccuracy of node planarization, but also improves routing performance as packets travel shorter hops in the perimeter mode. Furthermore, the improved routing decision keeps packets from being routed to the wrong direction that often leads to higher delay. GPCR does not rely on a map to determine whether a node is located at a junction, but rather provides two heuristics to determine whether a node is a junction. The first heuristic uses beacon messages and determines 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 do not list each other as neighbors. The second heuristic is derived from a correlation coefficient that relates a node to its neighbors. 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. Their evaluation, based on a dedicated vehicular traffic simulator, has shown that packet delivery rate does increase over GPSR. [6]

Pros

- Does not require any global or external information.

-For representing the planar graph it uses the underlying roads though it is based on the GPSR.

-It has no as usual a planarization problem like unidirectional links, planar sub-graphs & so on.

Cons

- Depends on junction nodes.

-There has a problem in the Junction detection approach in which first approach fails on curve road & second approach fails on a sparse road.

III. GeOpps

GeOpps [7] is a delay tolerant routing algorithm that exploits the availability of information from a navigation system (NS). Such navigation system includes a GPS device, maps, and the function to calculate a suggested route from current position to a requested destination. In GeOpps, each vehicle equipped with a navigation system communicates with one another and obtains information to perform efficient and accurate route computation. A NS is assumed to have the ability to calculate the route to a given destination and to estimate the required time to a given destination. When a vehicle wants to deliver a data packet, it broadcasts the destination of it. The one-hop neighbors of the packet holder will calculate the “Nearest Point” (NP). Since every vehicle using NS has a suggested path, the NP is the location that is the location on the path which is geographically closest to the destination. For example, in Fig 6, paths a, b and c are the different suggested paths of three vehicles. Their NPs to the destination D is marked as NP$_a$, NP_b and *NP*. The weakness of the approach is that the scheme assumes all vehicles have a navigation system and the navigation system provides the same transmission format and content. The assumption is not true in reality. As a natural *c* Consequence of the design, GeOpps does not utilize heterogeneous information from devices other than the navigation system and misses opportunities of finding a better forwarder.

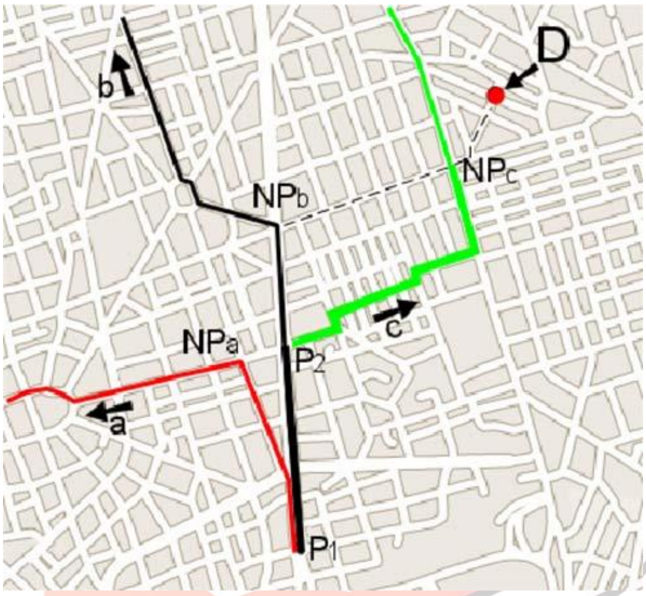

Figure. 6 GeOpps Neighbor Selection, where their routes are evaluated with respect to the potential “Nearest Point” (NPx) to the destination D [7]

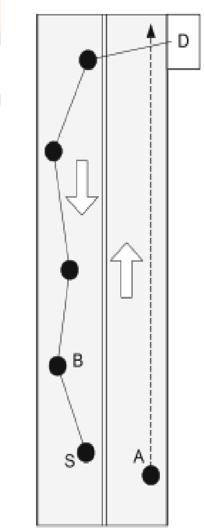

Figure. 7 GeOpps Problem, where node A is chosen as DTN mule whereas a geo-routing would have used the connected graph and selected node B for a faster progress [7]

Furthermore, since it is a DTN routing protocol and packets tend to be held by nodes whose NP is closer to the destination than another node whose NP is further yet it is on the connected path to the destination, thus, nodes generally experience higher delay in GeOpps than in GeoDTN+Nav. For example, Fig 7 shows a two-lane road segment with traffic in opposite directions. A sender node *S* is sending packets to a curb-side destination *D*. Among *S*’s neighbors *A* and *B*, *A* has the closest NP to the destination *D*. Thus, in GeOpps, the packet would be delegated to *A*. Since no other nodes have closer NP to the destination, the packets would remain stored at A and only delivered to the destination when *A* meets *D*. On the contrary, in GeoDTN+Nav, the packet would be first forwarded using geographic routing and successfully delivered at *D* since there is a connected path from *S* to *D*. Given that radio propagation is much faster than vehicle movement, we can expect that GeoDTN+Nav has lower latency in other similar scenarios.

Pros

-By comparing with the Location-Based Greedy routing and MoVe routing algorithm GeOpps has high delivery ratio.
-To find a vehicle which is driving towards near the destination GeOpps need few encounters.
- The delivery ratio of GeOpps rely on the mobility patterns & the road topology but not dependent on high density of vehicles.

Cons

-Privacy is an issue because navigation information is disclosed to the network.

Virtual Navigation Interface (VNI) design

We have already discussed different categories of vehicles in the previous section. In order to provide a consistent and generalized view of different vehicles in our routing decision, we assume VNI is installed on every vehicle. VNI is a lightweight wrapper interface that interacts with underlying vehicular components. It provides two kinds of primitive information:

1. Route_info: Route_info represents the vehicle's route information. Note that route information may either consist of detailed path, destination, or the direction of vehicles, depending on the types underlying data sources.

Table 2 Categories of vehicular route pattern [1]

Categories	**Examples**
Deterministic (fixed) route	Metro bus, metro train, campus shuttle
Deterministic (fixed) destination	Taxi, van pool
Probabilistic (expected) route/destination	Navigation system guided vehicles
Unknown	Non-random movement

As in Fig 8, VNI might be able to retrieve detailed path information from a navigation system while it may only retrieve vehicle's direction from an Event Data Recorder (EDR). In addition, VNI can also retrieve preconfigured route information.

2. Confidence: Confidence indicates the probability that the vehicle's movement would abide by the given route information. More specifically, confidence with 0% means that the vehicle move completely in random while confidence with 100% means that the vehicle move strictly based on its route information. This confidence information can be configured or derived from vehicles' movement history.

We installed VNI on every vehicle:

- VNI on buses would broadcast two-tuple information (*Path*, 100%) because buses move deterministically along its preconfigured route.
- VNI on taxis would broadcast (*Dest*, 100%) because taxis move deterministically toward its destination.
- VNI on vehicles with navigation systems would broadcast (*Path*/*Dest*, *P*%) depending on what information the VNI can obtain from the underlying navigation system.
- VNI on vehicles without navigation systems might broadcast (?, 0%) because VNI cannot obtain enough route information, or it might broadcast (*Dir*, *P*%), if VNI is able to estimate vehicles' moving direction. Based on the unified information provided by VNI, every vehicle now can collect navigation information from its neighbors and make routing decision accordingly. Note that this generic information advertised by VNI is independent from our GeoDTN+Nav protocol. It can also be used by other routing protocols serving different purposes. However, in this paper, we focus on using information provided by VNI to choose a neighbor which can potentially carry packets across disconnected networks.

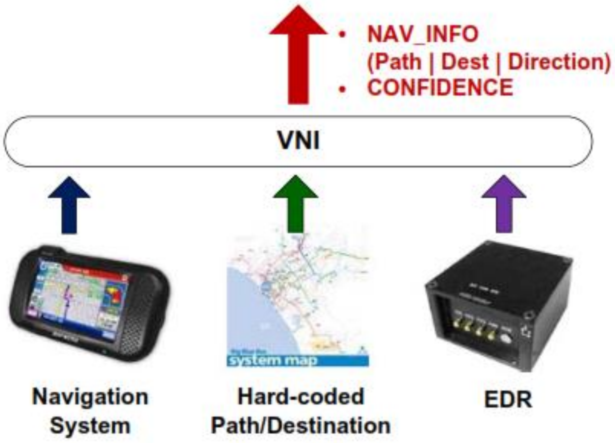

Figure. 8 Virtual navigation interface [1]

IV. *GeoDTN+Nav algorithm*

Traditionally, geo-routing routes packets in two modes: the first mode is the greedy mode, and the second mode is the perimeter mode. In greedy mode, a packet is forwarded to destination greedily by choosing a neighbor which has a bigger progress to destination among all the neighbors. However, due to obstacles the packet can arrive at a local maximum where there is no neighbor closer to the destination than itself. In this case, the perimeter mode is applied to extract packets from local maxima and to eventually return to the greedy mode. After a planarization process, packets are forwarded around the obstacle towards destination. In this way, the packet delivery is guaranteed as long as the network is connected. However, the assumption that the network is connected may not always be true. Due to the mobile characteristics of VANET, it is common that the network is disconnected or partitioned, particularly in sparse networks. The greedy and perimeter modes are not sufficient in VANET. Therefore, we introduce the third mode: DTN (Delay Tolerate Network) mode, which can deliver packets even if the network is disconnected or partitioned by taking advantage of the mobility of vehicles in VANET. Unlike the common belief that mobility harms routing in VANET, we specifically count on it in this work to improve routing. In short, packets are forwarded first forwarded in the greedy mode, and then by the perimeter mode when a packet hits a local maximum. If the perimeter mode also fails, it finally switches to the DTN mode and relies on mobility to deliver packets. Fig 9 illustrates the transition diagram between these three modes.

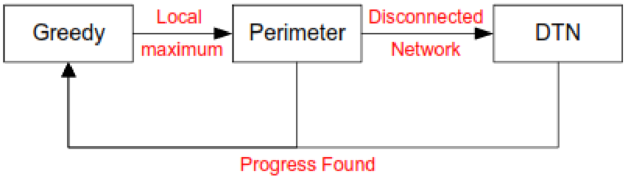

Figure. 9 Switch between greedy, perimeter, and DTN mode [1]

Two questions arise in this scheme: Exactly when should we switch to DTN mode, and when to switch back to the greedy mode. For the former, we will use cost function and a threshold related to a network partition detection and to the quality of nodes mobility pattern between partitions. For the latter, similar to the recovery mode, we will return to the greedy mode when relay with better progress than the one that triggered the DTN mode is found.

Restricted greedy forwarding

In GeoDTN+Nav, the default greedy forwarding strategy is the same as the restrictive greedy forwarding in GPCR, where packets are always forwarded between junction nodes as junctions are the only places where node can make significant routing decisions. This remains true even if a current forwarding node can greedily forward packets beyond a junction. At junctions, greedy decision is made to determine which road direction should be taken that can bring the maximum progress towards the destination. If a local maximum is reached, the recovery mode, called the perimeter forwarding, is used.

Perimeter forwarding

In GeoDTN+Nav, the default recovery mode is the same as VCLCR's. The goal of VCLCR in perimeter forwarding is to detect and remove cross links created by the lack of junction nodes to improve packet delivery. For GeoDTN+Nav, in order to support delay tolerant forwarding, we piggyback the following extra fields in data packets as shown in Fig 10:

1. DTN_Flag: the DTN_flag indicates whether or not this packet can be forwarded by delay tolerant mode. Applications that do not require on-time delivery can enable this flag to improve packet deliver probability.

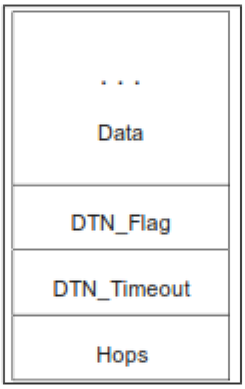

Figure. 10 Packet format [1]

2. DTN_Timeout: Applications specify packets' tolerated delay. Based on this information, nodes buffer and carry DTN packets can flush packets that are already expired or decide which packet to delete based on buffer management policy.
3. Hop_Count: The field records the number of hops that a packet has been forwarded in the perimeter mode. GeoDTN+Nav uses this information to determine if the network is disconnected. This field can be replaced or augmented if future work adopts other means to measure network connectivity.

The basic idea behind GeoDTN+Nav is that in the perimeter forwarding mode, nodes keep suspecting whether the network is disconnected based on how many hops the packet has traveled in the perimeter mode. Every node also monitors its neighbors' navigation information. Based on the connectivity and navigation information, a *switch score* is calculated for each neighbor. A packet would be switched to DTN mode only when the switch score is beyond a certain predefined threshold and the DTN_flag is set. For all neighbors, if no switch score is beyond the threshold, the packet would be forwarded based on conventional perimeter forwarding and increment the hops by one.

DTN forwarding

With DTN forwarding, the first question to address is when we should switch to DTN mode. Two factors need to be considered: network disconnections and delivery quality of nodes storing a packet. Determining network disconnectivity is not an easy task; in fact, there is no way to know whether the network is connected or not unless we have the complete information of network topology. Moreover, even if we have the complete network topology information, any decision is only valid at the time of the evaluation because the topology is changing all the time. Thus, what we can do is to take a good guess. We propose to base this decision on the hop count, as an increasing hop count in the perimeter mode could mean the network is partitioned. The delivery quality of nodes carrying a packet is the second criterion to determine whether we should use DTN forwarding or not. If there is a good neighbor that has a mobility pattern that will bring the packet closer to destination, we rely on it to deliver the packet. By a good neighbor, we mean a neighbor which has a path, destination, or direction towards the destination with high confidence. For example, a bus may have paths in NVI because its route is well-known, and may have high confidence because it seldom changes such route. A taxi may not transmit its path but its destination because it only knows the destination where customers want to go, and the confidence associated to that destination is low as real traffic condition may alter it. Network disconnectivity and the delivery quality only are not enough to define a good neighbor. We also have to consider the neighbor' moving direction. For example, a bus may have good delivery quality because it has a fixed route closer to destination but it is moving away from it, which makes it a less favored relay to carry a packet.

V. Geospray

The GeoSpray[10] routing protocol assumes that VDTN network nodes are aware of their location (geographical position) that is provided by a positioning device like a GPS navigation system. This system includes a GPS device, a map, and it is able to calculate the route, distance, and time between two map points. It also assumes that the location of terminal nodes (traffic sinks) is previously known, and that mobile nodes know their speed, and current route. It is important to notice that data bundles replicated or forwarded following the routing decisions of GeoSpray represent aggregates of datagrams that are destined for the same terminal node (traffic sink).

GeoSpray is inspired in the general guidelines of GeOpps geographic forwarding routing protocol described in the previous section. It uses geographic position information and other mobility parameters, together with bundle destination addresses, making sure that bundles are forwarded towards the destination. However, contrary to GeOpps that maintains at most one copy of a bundle in the network, GeoSpray combines selected replication and forwarding with explicit delivery acknowledgment.

The GeoSpray routing protocol employs the concept of ‘‘spray phase’’ from binary Spray and Wait, where a small/fixed number of bundle copies are distributed to distinct nodes in the network. However, instead of doing blind replication (as proposed in Spray and Wait), GeoSpray guarantees that bundle copies are only spread to network nodes that go closer (and/or arrive sooner) to the bundle's destination. Furthermore, instead of waiting until one of these network nodes meets the destination and delivers its bundle copy (as proposed in the Spray and Wait ‘‘wait phase’’), GeoSpray allows each node to forward its bundle copy further to another node that can take the data closer to the destination (or sooner in time).

GeoSpray provides robustness by allowing a limited number of copies of the same bundle to be routed independently. The protocol controls flooding by setting an upper bound on the number of copies created per bundle, while minimizes the transmission overload and resource consumption. Furthermore, GeoSpray uses the concept of active receipts presented in to explicitly clear delivered bundles. Network nodes send receipts to inform all the nodes they meet about bundles that have already been delivered. These bundles, which are buffered at intermediate nodes, are removed and storage capacity for upcoming bundles is improved. This is a very important feature because network nodes have limited storage capabilities. Moreover, it also helps to stop replicating/forwarding already delivered bundles thus also saving bandwidth resources.

III. COMPARISION OF GEOGRAPHIC ROUTING PROTOCOL

Table 3 Comparison of Geographic Routing Protocols

Routing Protocols	Type Of Routing	Delivery Ratio	Latency(sec)	Environment Applicable
GPSR	Non DTN	Low	High	Urban
GPCR	Non DTN	Low	High	Urban
Geopps	DTN	Low	High	Urban
GeoDTN+Nav	Hybrid	High	High	Urban
Geospray	Hybrid	High	High	Urban

IV. ACKNOWLEDGEMENT

I express my deepest gratitude to Prof. Krunal Panchal, LJIET and Prof. Kamal Sharma, Indus University for their guidance and contribution in the paper. I would also like to thank Mr. Priyank Kothari, Specialist, Homeland Security & Anti-Terrorism for his invaluable support and time.

V. CONCLUSION

This paper provides a survey of routing protocols in vehicular delay tolerant networks. The routing protocols fall into two major categories of topology-based and position-based routing. The paper discusses the advantages and disadvantages of these routing protocols. The comparison of various different geographic routing protocols is provided. This survey paper also shows how under various different sets of conditions packet reaches destination.

REFERENCES

[1] P. Cheng, K. Lee, M. Gerla and J. Härri, 'GeoDTN+Nav: Geographic DTN Routing with Navigator Prediction for Urban Vehicular Environments', Mobile Networks and Applications, vol. 15, no. 1, pp. 61-82, 2009.

[2] M. Khan, I. Wahid and G. Mehmood, 'A Global Mobility Management Scheme for Reducing Overall Handover Latency in IP Based VANET', http://airccse.org, 2012. [Online]. Available: http://airccse.org/journal/ijasuc/papers/3112ijasuc02.pdf. [Accessed: 08- Dec- 2014].

[3] K. Lee, U. Lee and M. Gerla, Survey of Routing Protocols in Vehicular Ad Hoc Networks, 1st ed. UCLA, USA: IGI-GLOBAL, 2014.

[4] V. Soares, F. Farahmand and J. Rodrigues, 'A layered architecture for Vehicular Delay-Tolerant Networks', 2009 IEEE Symposium on Computers and Communications, 2009.

[5] Karp B, Kung HT (2000) GPSR: greedy perimeter stateless routing for wireless networks. In: Mobile computing and networking, pp 243–254

[6] Lochert C, Mauve M, Füssler H, Hartenstein H (2005) Geographic routing in city scenarios. SIGMOBILE Mob ComputCommun Rev 9(1):69–72

[7] Leontiadis I, Mascolo C (2007) GeOpps: geographical opportunistic routing for vehicular networks. In: World of wireless, mobile and multimedia networks, 2007. WoWMoM 2007. IEEE international symposium on a, 18–21 June 2007, pp 1–6

[8] V. Soares, F. Farahmand and J. Rodrigues, 'A layered architecture for Vehicular Delay-Tolerant Networks', 2009 IEEE Symposium on Computers and Communications, 2009.

[9] T. Shmaspur, S. Yousefi and J. Bagherzadeh, 'PERFORMANCE IMPROVEMENT OF VEHICULAR DELAY TOLERANT NETWORKS USING PUBLIC TRANSPORTATION SYSTEMS', International Journal of Mobile Network Communications & Telematics (IJMNCT), vol. 3, no. 6, 2013.

[10] V.N.G.J. Soares et al., GeoSpray: A geographic routing protocol for vehicular delay-tolerant networks, Informat. Fusion (2011), doi:10.1016/j.inffus.2011.11.003