# DTN Routing Protocols for VANETs: Issues and Approaches

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**Abstract**

Delay Tolerant Networks (DTNs) are a class of networks that enable communication where connectivity issues like sparse connectivity, intermittent connectivity, high latency, long delay, high error rates, asymmetric data rate, and even no end-to-end connectivity exist. The DTN architecture model has been applied for vehicular Networks called Vehicular Delay Tolerant Networks (VDTN). In these networks vehicles use a message relaying service by their mobility in the network and collect messages from source nodes. In this paper, we will review the routing protocol in delay tolerant networks and compare the routing protocols that have been proposed specially for Vehicular Delay Tolerant Networks.

Keywords: *Delay tolerant networks; Vehicular Delay tolerant networks; Routing protocols.*

## 1. Introduction

Wireless networks have enabled a wide range of devices to be connected over vast distances. For example, today it is possible to connect from a cell phone to millions of powerful servers around the world [1]. Despite successfulness of these networks, they still cannot reach everywhere, and for some applications their cost is preventing. The main reason for these limitations is that current networking technology relies on a set of fundamental assumptions that are not true in all environments. The first and most important assumption is that an end-to-end connection exists from the source to the destination, possibly via multiple intermediaries [1]. These assumptions are not always true due to mobility, or unreliable networks. For example, when a wireless device is out of range of the network, it can use none of the application that requires network communication.

Delay-tolerant networks (DTN) try to extend the reach of networks. It promises to enable communication between challenged networks, which includes space networks, mobile ad-hoc networks, and low-cost networks. The core idea is that these networks can be connected if protocols are designed to accommodate disconnection.

Vehicular Delay-Tolerant Networks have the potential to interconnect Vehicles in regions that current networking technology cannot reach. The main core is that an end-to-end connection may never be reached. To make end-to-end communication possible, relay nodes take the advantage of mobility for the data being transferred and forward it as the opportunity arises.

The DTN architecture implements a store-and forward paradigm by overlaying a protocol layer, called bundle layer that it is meant to provide internetworking on heterogeneous networks operating on different transmission media [2]. At the edge of each remote area network, a border system has an application layer gateway to terminate applications and produce data bundles. The DTN architecture concept was also extended to transit networks, called Vehicular DTN (VDTN). In these networks vehicles (e.g., cars, buses, and boats) are exploited to offer a message relaying service by moving around the network and collecting messages from source nodes. A number of projects have been based on this general concept. For example, the Message Ferry project to develop a data delivery system in disconnected areas [3, 4]. Another example is the DakNet project proposed to provide low-cost connectivity to the Internet to rural villages in India [5]. Vehicular Networks have also been used for traffic condition notifications, accident warnings, automatic tolling, free parking spots information, advertisements, and for example to gather data collected by vehicles like road pavement defects [6-7]. The rest of this paper is organized as follows. Section 2 reviews the routing protocols in Delay Tolerant Networks. Then, in

Section 3, we have an overview on routing protocols proposed for Vehicular Ad Hoc Networks. Section 4 provides a comparative study of DTN routing protocols VANETs. Finally, in Section 5, we draw some conclusions.

## 2. Routing Protocols in DTN.

First, we present two routing protocols, Epidemic Routing and Spray and Wait, which do not need any information about the network state. Then we review two other protocols named, Prophet, Mobyspace .In these routing protocols, nodes can memorize contact history and use it to make more informed forwarding decisions.

### 2.1 Epidemic Routing

Epidemic Routing protocol is for message delivery in a mostly disconnected network with mobile nodes. The protocol is basically a flooding mechanism especially for mobile wireless networks. It relies on exchanges of messages between nodes whenever they get in contact with each other to deliver the messages to their destinations. Each node have a buffer containing messages that have been generated at the current node as well as messages that has been generated by other nodes and relayed to this node.

When two nodes initiate a contact, they exchange their summary vectors in the anti-entropy session. Comparing message IDs, each node decides what messages it has not already received that it needs to pull from other nodes.

The second phase of a contact includes nodes exchanging messages. Each message has a time-to-live (TTL) field that limits the number of contacts they can pass through. Messages with TTL = 1 are forwarded only to the destination. In epidemic routing the messages are flooded in the whole network to reach just one destination. This creates contentions for buffer space and transmission time [8].

### 2.2 Spray and Wait.

Spyropoulos et al. present Spray and Wait, a zero-knowledge routing protocol introduced to reduce the wasteful flooding of redundant messages in a DTN [9]. Spray and wait like epidemic routing, forwards copy of messages to other nodes met randomly during connection in a mobile network. Spray and Wait disseminates a number of copies of the packet to other nodes in the network, and then waits until one of these copies meets the destination [9]. Spray and Wait includes two phases. In the first phase, the source node generates $L$ copies of the message it holds, and then spreads these copies to other nodes for delivery to the destination node. The spreading process works as follows: When an active node holding $n > 1$ copies meets another node, it hands off to it $F(n)$ copies and keeps for itself the remaining $n-F(n)$ copies and so forth until a copy of the message reaches the destination. $F$ is the function that defines the spreading process [10].

The main difference from epidemic routing is that Spray and Wait limits the total number of disseminated copies of the same message to a constant number $L$ *[11].*

### 2.3 PROPHET.

In [12] propose PROPHET (Probabilistic Routing Protocol using History of Encounters and Transitivity), a single copy history-based routing algorithm for DTNs. Each node in PROPHET estimates a delivery predictability vector containing an entry for each other node. A probabilistic metric called *delivery predictability* estimates the probability that node *A* will be able to deliver a message to node *B*. The delivery predictability vectors are maintained at each node *A* for every possible destination *B*. Predictability vectors will be used to decide on packet forwarding. When two nodes contact each other, node if the delivery predictability for the destination of the message is higher at the other node, a message is forwarded to the other. In addition to the predictability vector, a summary vector of stored packets will be also exchanged upon contact.

The information in the summary vector is used to decide on which messages to request from the other node. The entry update process happens whenever each contact and works as follows. Nodes that are often within mutual ranges have high delivery predictability for each other, and as they increase their corresponding delivery predictability entries. Nodes that rarely connect are less likely to be good forwarders of messages to each other, therefore they will reduce their corresponding delivery predictability entries [13].

### 2.4 MobySpace.

In [14] introduce a virtual location routing scheme which makes use of the frequency of visit of nodes to a discrete set of locations in the network area in order to decide on packet forwarding. Authors, define a virtual Euclidean space named MobySpace. In MobySpace, two nodes with a small distance between them are more likely to have a contact than two nodes that are further apart. Therefore the forwarding algorithm makes decision to forward a message during a contact to a node that has a shorter distance to the message destination. Messages take paths through the MobySpace to bring become to near to the destination. Different distance functions have been proposed to measure node's mobility.

The MobyPoint of a node is not related to its physical GPS coordinate. The acquisition of the visit frequencies of the nodes to the location set is obtained by computing the respective fraction of time of being in a given location [10].

## 3. Delay-Tolerant Routing in VANETs.

Although most of the existing work on vehicle networks is limited to 1-hop or short range multihop communication, vehicular delay-tolerant networks are useful to other scenarios. For example, without Internet connection, a moving vehicle may want to query a data center ten miles away through a VANET. The widely deployed wireless LANs or infostations [11, 15, 16] can also be considered.

Vehicle delay-tolerant networks have many applications, such as delivering advertisements and announcements regarding sale information or remaining stocks at a department store. Information such as the available parking spaces in a parking lot, the meeting schedule at a conference room, and the estimated bus arrival time at a bus stop can also be delivered by vehicle delay-tolerant networks.

For the limited transmission range, only clients around the access point can directly receive the data. However, this data may be beneficial to people in moving vehicles far away, as people driving may want to query several department stores to decide where to go. A driver may query the traffic cameras or parking lot information to make a better travel plan. A passenger on a bus may query several bus stops to choose the best stop for bus transfer. All these queries may be issued miles away from the broadcast site. With a vehicular delay-tolerant network, the requester can send the query to the broadcast site and get a reply from it. In these applications, the users can tolerate up to a minute of delay as long as the reply eventually returns. In this section we will review the delay tolerant protocols specially proposed for Vehicular Networks.

### 3.1. VADD- Vehicle- Assisted Data Delivery

Zhao and Cao [17] proposed several vehicle-assisted data delivery (VADD) protocols. All of them share the idea of storing and forwarding data packets.
That is, nodes can decide to keep the message until a more promising neighbor appears on their coverage range, but trying always to forward them as soon as possible. Additionally, decisions about which streets must be followed by the packet are made using vehicle and road information such as current speed, distance to the next junction, and maximum speed allowed. These routing decisions are dynamically taken at junctions because the authors state that pre-computed optimal paths used by other protocols might rapidly lose their optimality due to the unpredictable nature of VANETs.

In VADD the main goal is to select the path with the smallest packet delivery delay. The behavior of the protocol depends on the location of the node holding the message. Two cases are considered: when nodes routing the message are located in the middle of a road and when they are located in a junction. The first case (also called routing in straight way) presents less alternatives: forwarding the packet toward the next junction or to the previous one. However, the second case (also called routing in intersections) is much more complicated because at junctions, the routing decision must consider the different roads, so that the number of options is higher.

### 3.2 GeOpps- Geographical Opportunistic Routing

GeOpps for vehicular networks [18] is a trajectory-based protocol that uses both the opportunistic nature of vehicular mobility patterns and the geographic information provided by navigation systems. This protocol assumes each vehicle is assumed to know its complete trajectory.

GeOpps applies a delay-tolerant mechanism, therefore a vehicle store data packets until a suitable next hop for them is found later on. To choose the next hop, each node computes the closest point in their trajectory in direction of the destination of the packet.

GeOpps is a protocol for delay-tolerant data, but the performance depends heavily on accurate the trajectory information. Therefore if the driver does not follow the route suggested by the GPS, the routing decision taken might be erroneous [19].

### 3.3 GeoDTN+Nav- Geographic DTN Routing with Navigator.

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, they 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, this protocol specifically count on it to improve the routing [20].

## 4. Comparison of Geographic Routing Protocols in VANETs.

Table1 indicates comparison study of routing protocol in vehicular delay tolerant networks. All of these protocols in table1 are position-based, using knowledge of vehicles' positions and velocities to route messages. In this table, the term traffic-aware use of traffic information for choosing a suitable route based on some information about the routes in the streets. All these protocols depend on digital map to determine positions of vehicle. In this table, recovery means using strategy to recover local optimum or repair broken routes. All protocols in table 1 use greedy forwarding by choosing farthest neibours and in sparse network. They use store-carry forward mechanism .They buffer the packet until they find a chance to forward it to other vehicle.

## 5. Conclusions

In this paper, we have reviewed Delay tolerant routing protocols and then the routing protocols specially proposed for Vehicular Ad hoc Networks. Finally, we give a comparative study of DTN protocols for Vehicular Ad hoc Networks in terms of map required, traffic data required and traffic aware and recovery.

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TABLE 1- QUALITATIVE COMPARISON OF VDTN ROUTING PROTOCOLS

| characteristics / Routing Protocols | Delay/tolerant | Traffic aware | Map required | Recovery | Greedy required | Buffering(carry-and-forward) |
|---|---|---|---|---|---|---|
| VADD | √ | √ | √ | | √ | √ |
| GeOpps | √ | | √ | | √ | √ |
| GeoDTN+Nav | √ | √ | √ | √ | √ | √ |

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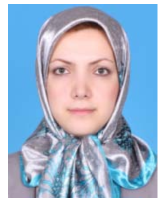

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