Non DTN Geographic Routing Protocols for Vehicular Ad Hoc Networks

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Abstract

Vehicular Ad Hoc Networks are highly mobile wireless ad hoc networks. Routing of data in VANETs is a challenging task due to rapidly changing topology and high speed mobility of vehicles. Geographic routing protocols are becoming popular due to advancement and availability of GPS devices. In this paper, we review the existing non DTN Geographic Routing Protocols for VANETs and also provide a qualitative comparison of them.

Keywords: *Vehicular Ad Hoc Networks, Mobility, Geographic Routing, DTN.*

1. Introduction

Vehicular Ad hoc Networks (VANET), a new technology to build a wireless network between vehicles (V2V) and vehicles to infrastructure(V2I).VANETs are based on short-range wireless communication (e.g., IEEE 802.11) between vehicles[1]. The Federal Communication Commission (FCC) has allocated 75 MHz in 5.9 GHz band for Dedicated Short Range Communication (DSRC). DSRC was conceived to provide architecture for vehicles in Vehicular Network to communicate with each other and with infrastructure. In DSRC, subsequently specialized as Wireless Access in Vehicular Environment (WAVE), GPS-enabled vehicles that are equipped on-board units can communicate with each other. Each vehicle's wireless network range may be limited to a few hundred meters, so providing end-to-end communication across a larger distance requires message to hop through several nodes.

Routing refers to move a data packet from source to destination and if required the assignment of a path to the destination. In multi-hop regime routing means to forward packets that contain information through other vehicles [14]. This information refers to alerts about events that already happened, like local danger warnings and traffic flow information. If no vehicle is within the communication range a packet is stored and forwarded as soon as a new vehicle comes into reach.

Routing is one of the key research issues in vehicular networks as long as it supports most emerging applications. Recent research showed that existing routing solutions for mobile ad hoc networks (MANETs) are not able to meet the unique requirements of vehicular networks. Thus, a lot of effort has been devoted during the last years to design VANET-specific routing protocols being able to exploit additional information available in VANET nodes [7](e.g., trajectories of nodes, city maps, traffic densities, constrained mobility, etc.).

Geographic routing is a technique to deliver a message to a node in a network over multiple hops by means of position information. Routing decisions are not based on network addresses and routing tables; instead, messages are routed towards a destination location. With knowledge of the neighbors' location, each node can select the next hop neighbor that is closer to the destination, and thus advance towards the destination in each step.

The rest of the paper is organized as follows. An overview of geographic routing protocols for VANET is presented in section II. A comparison of Non DTN Routing Protocols in VANET will present in section III and a brief overview of security in VANET and Non DTN geographic routing protocols present in section IV and V respectively. Finally this paper is concluded in sectionVI.

2. Overview of protocols

A routing protocol governs the way that two communication entities exchange information; it includes the procedure in establishing a route, decision in forwarding, and action in maintaining the route or recovering from routing failure. This section describes recent *unicast* routing protocols proposed in the literature where a single data packet is transported to the destination node without any duplication due to the overhead concern. Some of these routing protocols have been introduced in MANETs but have been used for comparison purposes or adapted to suit VANETs' unique characteristics. Because of the plethora of MANET routing protocols and surveys written on them, we will only restrict our attention to MANET routing protocols used in the VANET context. Table-1 illustrates geographic routing protocols in Vehicular Ad Hoc Networks.

In geographic (position-based) routing, the forwarding decision by a node is primarily made based on the position of a packet's destination and the position of the node's one-hop neighbors. The position of the destination is stored in the header of the packet by the source. The position of the node's one-hop neighbors is obtained by the beacons sent periodically with random jitter (to prevent collision). Nodes that are within a node's radio range will become neighbors of the node. Geographic routing assumes each node knows its location, and the sending node knows the receiving node's location by the increasing popularity of Global Position System (GPS) unit from an onboard Navigation System and the recent research on location services [2], respectively. Since geographic routing protocols do not exchange link state information and do not maintain established routes like proactive and reactive topology-based routings do, they are more robust and promising to the highly dynamic environments like VANETs. In other words, route is determined based on the geographic location of neighboring nodes as the packet is forwarded. There is no need of link state exchange nor route setup.

The fundamental principle in the greedy approach is that a node forwards its packet to its neighbor that is closest to the destination. The forwarding strategy can fail if no neighbor is closer to the destination than the node itself. In this case, we say that the packet has reached the *local maximum* at the node since it has made the *maximum* local progress at the current node. The routing protocols in this category have their own recovery strategy to deal with such a failure.

3. Non-DTN Routing Protocols in VANET

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3.1 GSR-Geographic Source Routing

Using the location of the destination, the map of the city and the location of the source node, GSR computes a sequence of junctions the packet has to traverse to reach the destination. The protocol aims to calculate the shortest route between origin and destination applying Dijkstra's algorithm over the street map. The calculated path is a list of junctions that the packet should go through [3, 13].

From here, it applies greedy forwarding, where the greedy destination is the position of the next junction of the list. That is, a node forwards the packet to one that is the closest to next junction. Once a junction of the path is reached, the greedy destination is changed to the next junction and greedy forwarding is applied again.

The protocol works in this way until that packet eventually reaches the destination node.

3.2 A-STAR-Anchor-based Street-and Traffic-Aware Routing

This routing follows the approach of anchor-based routing with street awareness. This is having consciousness of the physical environment around the vehicles; the protocol can take wiser routing decisions [4]. On the other hand, the use of anchor-based routing is not novel either. It consists of including within the packet header the list of junctions (anchors) that the packet must traverse. This approach has been employed in the GSR protocol. In fact, A-STAR relies on GSR to perform the routing task.

However, one novelty provided by A-STAR is the inclusion of traffic density information to weigh the streets of the scenario. This contribution modifies the behavior when computing the route of junctions that a packet must go through. In this way, every streets' weights are defined as a function of their traffic density, and the Dijkstra's algorithm is employed to compute the shortest route between source and destination. With this improvement, data packets are expected to be routed through those streets with more vehicles and, therefore, higher connectivity among nodes.

3.3 CAR- Connectivity-Aware Routing

The protocol is aimed at solving the problem of determining connected paths between source and destination nodes. VANETs' nodes present a high degree of mobility, and nodes cannot know the position of the rest of the vehicles due to several well-known scalability problems [5, 13]. This lack of information makes it impossible to determine, a priori, which streets have enough vehicles to allow messages to be routed through them.

CAR's algorithm is designed to deal with these problems, and to do that it is divided into three stages: (i) finding the location of the destination as well as a connected path to reach it from the source node, (ii) using that path to relay messages, and (iii) maintaining the connectivity of the path in spite of the changes in the topology due to the mobility of vehicles.

In the first stage, the source node broadcasts a route request message. The idea behind this initial broadcast is the following. The reception of, at least, one of these route request messages at the destination means that, at least one connected path exists. The destination node answers the route request message with a response message including its current location so that the first problem is solved. But the source node also needs to know the path to reach the destination.

3.4 GPCR- Greedy Perimeter Coordinator Routing

Because nodes are highly mobile in VANETs, node planarization can become a cumbersome, inaccurate, and continuous process. GPCR have observed that urban street map naturally forms a planar graph such that node planarization can be completely eliminated. In this new representation of the planar graph using the underlying roads, nodes would forward as far as they can along roads in both greedy and perimeter mode and stop at junctions where decision about which next road segment to turn into can be determined[6,7].

3.5 GPSR- Greedy Perimeter Stateless Routings

Using this routing is an algorithm that consists of two methods for forwarding packets: *greedy forwarding*, which is used wherever possible, and *perimeter forwarding*, which is used in the regions where greedy forwarding cannot be.

The greedy forwarding algorithm [8] uses packets that carry the locations of their destinations. The packets are stamped by the source node. This way, the packets are always forwarded to the neighbor that is geographically closest to the destination.

The drawbacks of pure greedy forwarding [9]:

• The position accuracy drops if the nodes move (mobility). It is possible that a location server node changes its position and before update process is performed some nodes remain without location server. This may lead to packet loss. Also, due to outdated neighbor table entries excessive re-sending of data may occur.

• Additional network load due to the beacons

• Missing of recovery from failure due to the link-layer broadcast of the beacons.

This leads to failure in transmission, because nodes being close to each other are not recognized as such.

The recovery strategy of the GPSR called *Perimeter Mode* [3,8] is used in order to avoid the lost packets that may occur in pure greedy technique when there is no neighbor available that is closer to the destination than the current forwarding hop. The perimeter mode of GPSR consists of two elements. First, a distributed planarization algorithm that locally transfers the connectivity graph into a planar graph by the removal of “redundant” edges. Second, an online routing algorithm for planar graphs that forwards a packet along the faces of the planar graph towards the destination node.

3.6 CBF-Contention Based Forwarding

Contention-Based Forwarding (CBF) [10] is a mechanism for position-based unicast forwarding, without the use of neighborhood knowledge. Instead, all suitable neighbors of the forwarding node participate in the next hop selection process and the forwarding decision is based on the actual position of the nodes at the time a packet is forwarded. This algorithm eliminates the drawbacks of pure greedy solution.

In position based routing [9] the principle is that the forwarding of the packet, from one hop to another, is done based on the local geographical position of the nodes. Being based on local position information of each node, it is not necessary to create and maintain a global route. Therefore, the algorithm is generally highly scalable and robust against network mobility.

The CBF mechanism [10] uses a contention-based algorithm to determine the next node forwarder and to keep silent the other nodes. Normally, CBF supports unicast routing, but can be used in VANET’s with information dissemination, so that the packet would be disseminated in several directions at the same time. Its main advantages are:

• All relevant nodes are involved in the decision making, i.e.: decision is based on the current position of all neighboring nodes.

• Low overhead, high scalability and high adaptability to the network mobility due to the missing of neighborhood table or knowledge as well as beacons.

3.7 RDGR-Reliable Directional Greedy Routing

RDGR is a reliable position based greedy routing approach which uses the position, speed, direction of motion and link stability of their neighbours to select the most appropriate next forwarding node [11]. It obtains position, speed and direction of its neighbouring nodes from GPS. If neighbour with most forward progress towards destination node has high speed, in comparison with source node or intermediate packet forwarder node, then packet loss probability is increased. In order to improve DGR protocol and increase its reliability, the proposed strategy introduces some new metrics to avoid loss of packets. The packet sender or forwarder node, selects neighbour nodes which have forward progress towards destination node using velocity vector, and checks link stability of those nodes. Finally, it selects one of them which has more link stability and sends packet to it. It uses combination metrics of distance, velocity, direction and link stability to decide about to which neighbour the given packet should be forwarded.

Unlike DGR this approach not only uses the one hop neighbor's position, speed and direction of motion information, it also considers all neighbours position, speed, and direction of motion information and link stability. This routing approach incorporates potential score based strategy, which reduces link breaks, enhances reliability of the route and improves packet delivery ratio.

3.8 LOUVRE-Landmark Overlays For Urban

Lee introduces a routing solution called "Landmark Overlays for Urban Vehicular Routing Environments" (LOUVRE), an approach that efficiently builds a landmark overlay network on top of an urban topology. Also define urban junctions as overlay nodes and create an overlay link if and only if the traffic density of the underlying network guarantees the multi-hop vehicular routing between the two overlay nodes. LOUVRE [7, 12] contains a distributed traffic density estimation scheme which is used to evaluate the existence of an overlay link. Then, efficient routing is performed on the overlay network, guaranteeing a correct delivery of each packet.

4. Security in Vehicular ad hoc network

As in any major public network, VANETs, when deployed without considering the security requirements, lend themselves vulnerable to a host of attacks. The danger involved in possible road accidents and loss of life further impress upon the need for fail-proof security for VANETs. For example, safety-related applications need a high level of security, as a single vehicle sending out false warnings can disrupt the traffic of a whole highway.
A number of research efforts are on in the field of VANET security.

The IEEE Standard 1609.2 specifies security services for the *Wireless Access in Vehicular Environments* (WAVEs) networking stack and for applications that are intended to run over that stack [15, 16]. Services include encryption using another party's public key and non anonymous authentication. The safety-critical nature of many *Dedicated Short-Range Communicatio*ns/WAVE applications makes it vital that services be specified that can be used to protect messages from attacks such as eavesdropping, spoofing, alteration, and replay. It also takes into account the owner's privacy rights. This means the security services must be designed to respect this right and not leak personal, identifying, or linkable information to unauthorized parties.

5. Comparison of Non DTN geographic Routing protocols in VANETs

In table 1 we give a comparison of the existing Geographic Routing protocols in vehicular ad hoc networks. We classified geographic routing protocols based on greedy forwarding. Some protocols are aimed at providing vehicle-to-vehicle services, while others focus on vehicle-to-roadside communication. In the set of characteristics criteria, we categorize based on the various strategies used by each protocol. All of the protocols are position-based, using knowledge of vehicles' positions and velocities to route messages. These protocols also utilize the greedy forwarding strategy for sending messages to the farthest neighbor in the intended direction. We also observe several predictive approaches, where some speculation is made about characteristics of the nodes involved in a route. Some algorithms make predictions on the current locations of nodes based on the last known position, and velocity of the node. Other algorithms use this same information to make predictions about the stability or estimated lifetime of a route. To provide higher rates of delivery in sparse networks, a buffering (carry-and-forward) strategy is often used. In this strategy, a node may hold a packet in a local buffer until a forwarding opportunity is available, instead of simply dropping the packet. We use a similar term, traffic-aware, to refer to a protocol's ability to utilize traffic information to select an efficient route which includes those protocols that make probabilistic assumptions about traffic density by using static knowledge such as bus routes and lane information.
The criterion route-repair or recovery refers to protocols which either uses a strategy to recover from a greedy local optimum in a position-based route or have a mechanism for repairing broken routes. And moving destination is different scenarios and when vehicles can move fast

6. Conclusions

In this paper, we have presented a review of non DTN Geographic Routing Protocol for Vehicular Ad Hoc Networks then we summarized the protocols and categorized them in terms of map required, transport route required, moving destination.

All these protocols utilize the absolute or relative locations of each node to greedily route message toward a next anchor or a destination vehicle.

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TABLE 1: QUALITATIVE COMPARISON OF VANET ROUTING PROTOCOLS

characteristics / Routing Protocols	Position-based/geographic	Vehicle to Vehicle	Buffering(Carry-and-forward)	Greedy forwarding	Map-required	Transport routes required	Moving destination
GSR	√	√		√	√		
A-STAR	√	√		√	√	√	
CAR	√	√	√	√			
GPCR	√	√		√			
GPSR	√	√		√			
CBF	√	√		√	√		
RDGR	√	√	√	√	√		√
LOUVRE	√	√		√	√		

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