An Efficient Routing Scheme for VANETs

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Abstract- In the near future vehicular networks (VANETs) based on wireless technology will be part of our daily lives. VANETs enable vehicles that are not necessarily within the same to communicate with each other. They also allow vehicles to connect to Roadside Units (RSUs), which are connected to the Internet, forming a backbone mesh that offers the capability of communicating with each other and with roaming vehicles. This paper, proposes a routing scheme for VANETs that makes use of Distributed Hierarchical Location Service (DHLS). This scheme exploits the RSU network and Hierarchical Location Service to efficiently route packets between far away vehicles in the VANET. The DHLS is called to get the destination position when the target node position is not known. We evaluate our system using ns2 simulation, and the results demonstrate the feasibility and efficiency of our proposed scheme in terms of query delay, packet delivery ratio, and generated traffic.

Keywords- **VANETs; Location-based Services; Geographic Routing; RSU.**

1. Introduction

VANETs (Vehicular Ad-hoc Networks) are a special case of MANETs (Mobile Ad-hoc Networks). Their major feature is the high mobility of nodes. A VANET is formed by vehicles that are equipped with wireless communication devices, positioning systems, and digital maps. In VANETs, a packet can be relayed from a vehicle to the next toward its destination through direct forwarding or through carry-and-forwarding mechanism. VANETs allow vehicles to connect to roadside units (RSUs), which are connected to the Internet and may also be interconnected with each other via a high capacity mesh network. Most of the previous research on routing in VANETs is limited to vehicles within few hops away [2], such as communicating with nearby vehicles to avoid collisions. However, in some applications it is important for a vehicle to send data to a far destination, thus necessitating a multi-hop routing protocol. A large number of unicast routing protocols have been proposed for MANETs. However, they cannot be efficiently used in VANETs because of the latter unique features. Hence, several researchers have developed unicast routing protocols for VANETs [2-6]. Some of these protocols use a position-based, greedy approach that uses data about the geographic coordinates of vehicles to create an efficient route[3-5]. Another set of protocols which aim to route packets in Sparse VANETs are called delay-tolerant algorithms. In such cases, carry-and-forward approaches are used [2], [6]. Each of the above mentioned routing protocols has its own conditions to provide good performance. Position-based protocols assume dense conditions in which a vehicle will always find a neighbor to forward the packet to. In contrast, delay-tolerant algorithms might not perform well in dense conditions. Hence, an approach is required which works well in both dense and sparse conditions. ROAMER routing protocol utilizes the RSU backbone network to efficiently route packets to distant locations in VANETs [1]. ROAMER relays heavily on fixed infrastructure and hence it is not cost effective. Hence, an approach is required which works well in both dense and sparse conditions as well as cost effective.

One salient characteristic of vehicular networks is that the high mobility of vehicles increases the frequency of their position changes and hence, making difficult to maintain up-to-date information without generating a traffic overhead. Thus a location service adapted to the special features of vehicular environments should ensure a good tradeoff between the overhead it generates in the network and the freshness of the information it provides. In this approach the Location Service is required to catch the destination position. The combination of this service with routing is quite natural in order to guarantee interesting performances. Several experimentations were carried out over NS-2 network simulator. These experimentations demonstrate that the Distributed Hierarchical Location Service (DHLS) enhanced the network performance.

2. Literature Review

Many algorithms were proposed to utilize the properties of VANETs for routing packets. These are usually classified according to how they communicate (i.e., broadcast, geocast, multicast, or unicast). In this section, we focus on routing protocols that deliver unicast services in VANETs. Position-based routing protocols use knowledge of vehicles' positions and velocities to route messages. The geographic source routing (GSR) algorithm [3] is an example in which a source creates the shortest path to the destination based on the roads layout and packets are forwarded using greedy geographical forwarding along this path. The Greedy Perimeter Coordinator Routing (GPCR) algorithm [4] improves upon GSR by eliminating the requirement of an external static street map for its operation.

The Connectivity-Aware Routing (CAR) protocol [5] maintains a cache of successful routes between various source and destinations. The Location-Aided Routing (LAR) protocol [8] uses location information of the mobile node to reduce the routing overhead. Another way of using location information for routing is proposed in [9] under the name DREAM. To keep its routing table updated, each node periodically broadcasts a control packet containing its own coordinates. VADD [6] is a routing protocols which utilize the predictable mobility in a VANET for data delivery. They abstract each road as a link whose delay is the time consumed to deliver a packet through it by multi-hop communication and carrying. The Static-Node Assisted Adaptive Routing Protocol (SADV) [2] focuses on data delivery in VANETs with low vehicle densities by depending on static nodes that are placed at intersections to assist in delivering packets. Finally, ROMER [1], exploits the network of RSUs that can commune at high speeds to route packets to far locations. ROAMER works well in both dense and sparse cases. These operations are similar to proposed scheme except that it makes use of location service to get the location of destination.

The protocols described above offer certain advantages in particular scenarios, but face degraded performance in other situations. To our knowledge, none of the proposed protocols in the literature proved to deliver messages to very far locations efficiently and conveniently. LSB-ROAMER exploits the network of RSUs that can commune at high speeds to route packets to far locations with the aid of Distributed Hierarchical Location Service (DHLS). The evaluation results of LSB-ROAMER showed a better suitability to VANETs as compared to ROAMER [1].

3. System Model

When exploring the problem of routing packets in VANETs, it is very important to distinguish between two different cases. The first case occurs when the destination is in the order of hundreds of meters far from the source. Hence, the sender and the receiver are few hops apart. The second case occurs when the destination is far from the source. Our basic objective is to efficiently route packets to distant locations.

- When a vehicle S needs to send a packet P to a faraway vehicle D, several problems need to be solved:
- Since D is moving, it is hard to specify its location at the time it receives P.
- When the network is sparse, P might be carried for long times by intermediate vehicle.
- In many cases, P might be carried by a vehicle which Moves away from D without meeting any vehicles to forward P to.
- When the destination is far, it is very hard to maintain a constant route for sending multiple packets especially when the network is sparse.

3.1 Location Service

This paper proposes a new hierarchical location service, DHLS for VANETs, based on the traffic density. This approach assumes that each vehicle knows its own geographic position thanks to the use of the Global Positioning System (GPS). Furthermore, It considers that vehicles are equipped with digital maps to acquire more awareness about the road topology and the paths along which they are traveling. The geographic area representing a given city is partitioned in a hierarchy of squares as shown in Figure 1 below. The highest level square, level-3, covers the entire area. It is further divided into four lower level-2 regions which are subsequently divided down to the level-1 regions. Using this partitioning strategy, This approach proposes to establish a hierarchy of distributed location servers with one location server level-3 (L3) at the top for the whole area and location servers level-1 (L1) at the bottom to manage locally the small regions defined for the level-1. As shown in below Fig. 1, the location server L1 stores up-to-date geographic coordinates of the nodes belonging to the low

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level area. Whereas, the location server L2 keeps the information about all the nodes belonging to the areas it has to manage and L3 keeps the global information about the location servers at the lower levels.

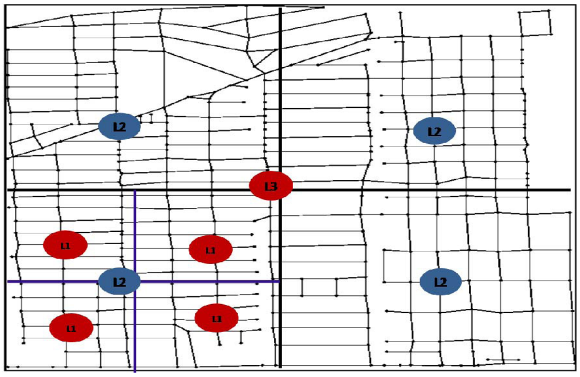

Fig 1: Location Server Hierarchy

3.2 Global View

In this approach we assume that RSUs are deployed at various hot spots. We also assume that each participant in the VANET is equipped with a positioning system (e.g., GPS), has access to a digital map of its locality, and equipped with navigation system that maps GPS positions. We require a Hierarchical Location Service to get the position information of far away vehicles.

In VANETs, in order to preserve their privacy, vehicles employ pseudonyms instead of their actual IDs. Also, each vehicle periodically changes its pseudonym. Each vehicle in this approach periodically sends Hello packets to its neighbors. Also, each vehicle maintains a list *L* of the pseudonyms, positions, speeds, distance, and timestamps of vehicles in its vicinity. Similarly, each Location server (RSU/any vehicle) receives periodic beacons from all vehicles within its vicinity.

3.3 Communication from a Vehicle to Location Server

When a vehicle wants to send a packet to a Location Server, it first examines whether the Location Sever is within its transmission range. If this is the case, the vehicle sends the packet directly though the wireless channel. Else, the vehicle depends on other vehicles to carry its packet until a vehicle carrying the packet becomes within the range of the Location server.

Communication model for Client with Server

1. Vehicle S creates location request packet of destination D
2. Location server's request packet contains information such as location, ID, speed, and so on
3. S identifies the path for communication based on it.

3.4 Communication from Location Server to Vehicle

Consider a Location server S that needs to send a packet P to a vehicle D. First, S identifies its location server for the location, speed, and direction of D. Since location server knows the location, speed, and direction of D, it can estimate D's current position. Suppose that S knows that D was at position $d1$ (i.e., distance between Sand D was $d1$), moving with speed $v1$ and the timestamp in the last beacon from D was $t1$. If the current time is tc, S estimates the distance that D traveled in (tc-$t1$) as:

$dt = (v1 \times (tc - t1)) \pm ds$, where ds is the error factor.

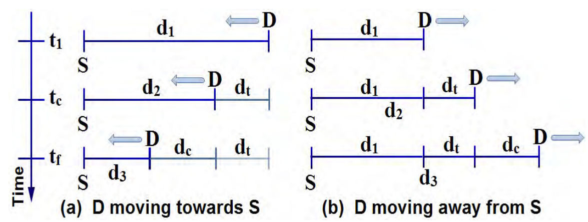

Fig 2: Estimating the distance of a vehicle D from an Location Server

Now, since D was at position $d1$, S estimates that D should be at time tc at a position $d2$ equal to $d1+dt$, *if* D is moving away from S and to $d1-dt$, *if* D is moving towards S as illustrated in the above Fig 2.

At Location Server:

1. Receives Location request from S
2. Locates information in its knowledge
3. If not available,
   Requests its super Location Server
   Obtains information
4. If available,
   Shares with requested client

3.5 Communication among Location Servers

We describe in this paragraph how a source node discovers the location of a distant node through the hierarchy of location servers. When a source node S needs to communicate with a node D out of its transmission range, it initiates a location query to get its position. A query packet contains the source's identifier, its position and the searched destination's identifier. First, the query is sent towards the Location Server at the low level to

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which the source node belongs. If the destination node belongs to the same low-level, its location information will be available on the location cache of a server at level-1. Any vehicle present within the cell which receives the request and has the location information in its cache sends back a reply to the requesting node. Otherwise, the request is forwarded successfully to the corresponding cell on the upper level until the identifier of the target node is found. When the requested information about D is found in the location server database, this latter handles the request and sends a reply packet in a greedy forwarding fashion. An example of this process is illustrated in below Fig 3.

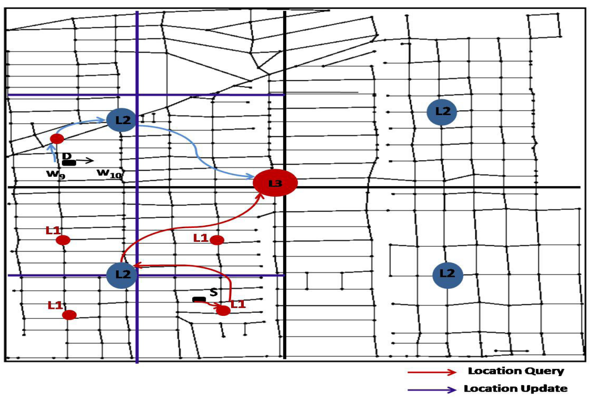

Fig 3. Location updates and queries and in DHLS

A vehicle S wants to discover the location information of a target vehicle D. S sends a query to its corresponding location server at level-1 region which is located at the waypoint w1. Any vehicle closer to that waypoint, when receiving the query, it searches for D's location information in its database. However, since the node D is situated in a different level-2 region, the request is forwarded to the next upper level and then to the highest level. Once the location server at level-3 situated receives the query packet, it looks for D's identifier and figures out that D is located at the lowest-level region and its moving between waypoints w9 and w10. A reply packet containing the geographic location of the destination, its speed is sent back to the source node.

Once the source node S receives the reply, it estimates the current position of the D and caches the location information for a period equal to the approximate time taken by the destination node to cross the next waypoint. The algorithm guarantees that in the worst case if the requested information is not available in an intermediate level, the location-query is forwarded to the location server at the highest level.

3.6 Routing from Source to Destination

A vehicle S wants to send a packet to another vehicle D, it first checks if the vehicle D is within its vicinity, if yes it will forward the packet directly to the destination vehicle D. if vehicle D is not within the vicinity of S, then S gets the location information of D and forwards the packet to D with the help of other vehicles moving in the direction of D if there is dense traffic and D is not faraway apart. If D is far away apart and traffic is spare then packet is forwarded to D with help of RSU backbone network.

4. Performance Evaluation

This section presents the simulations that were performed to evaluate the performance of proposed scheme and compared with existing scheme ROAMER. The system is implemented using the ns2 software.

End to End Delay

The below Fig 4 demonstrates the delay involved in communications using proposed scheme and ROAMER. The proposed scheme depicts comparatively low delay due to the usage of location server and hence reduced time in locating the destination vehicle.

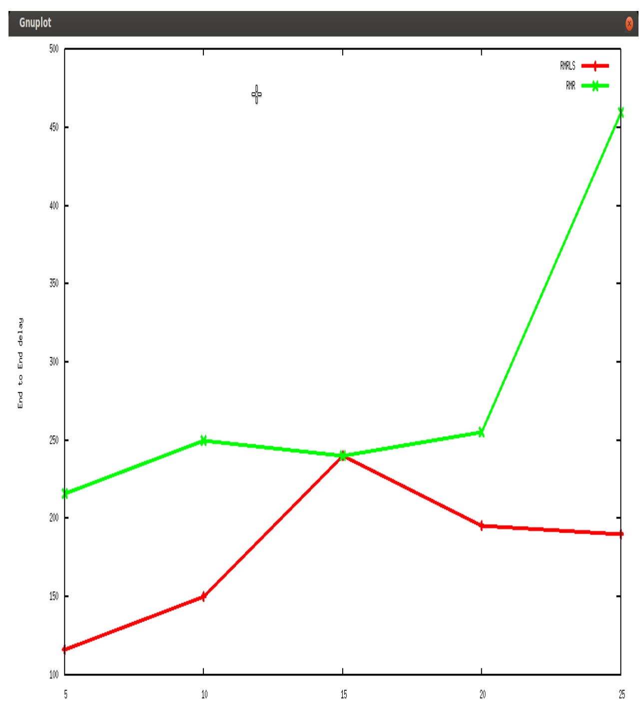

Fig 4: End to End delay Comparision

Number of control packets sent

The number control packets used for locating the vehicle in proposed scheme and ROAMER is as shown in below Fig 5. In proposed scheme the control packet overhead in locating the vehicles is reduced as compared to ROAMER.

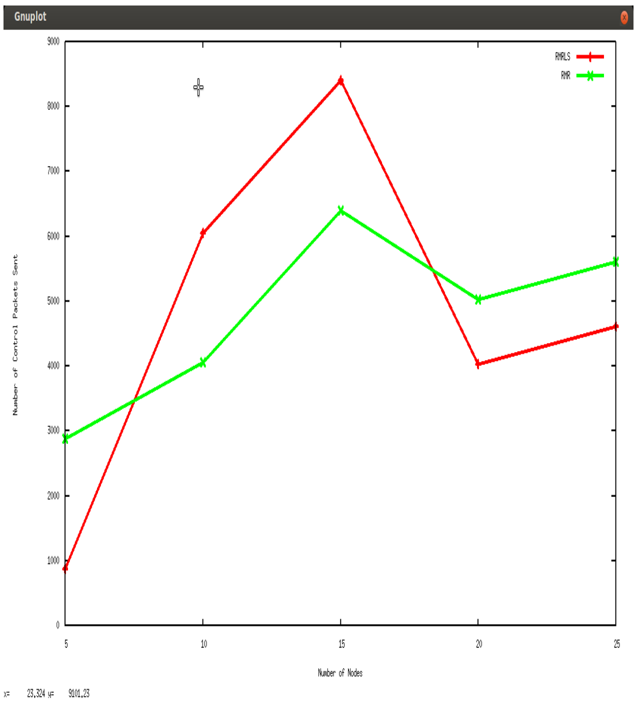

Fig 5: Control Packet generation

5. Conclusion

This paper presented a routing scheme for VANETs, which is part of a complete system being designed to provide car drivers and passengers pervasive access to needed data while on the road. The evaluation of the proposed scheme confirmed its effectiveness as compared to a recent routing protocol for VANETs. Future work focuses on devising secure mechanisms for registering users to the system of RSUs and designating them as proxies to Internet SPs that provide data to users and also to improve the efficiency of routing.

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