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The Involvement of RSUs in VANETs: Survey and Perspectives

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ABSTRACT:
VANETs (Vehicular Ad hoc NETworks) are the most active domain of research in recent years. They are aimed at offering safety and non-safety applications. All type of vehicles and infrastructure are the component elements of such networks. Their important characteristics are the special mobility pattern and very dynamic topology. This leads to particular features for this type of network. Frequently, communication path is disconnected between source and destination nodes, which represent a challenge to provide routing protocols with low communication delay and low overhead. Two types of communications are present in VANET: Vehicle-To-Vehicle communication (V2V) which uses only vehicles in the process of data propagation from source to destination. And Vehicle-To-Infrastructure communication (V2I) where the infrastructures are solicited to transfer data. Several routing protocols are proposed in the literature especially in the case of V2V communication. In this paper, we mainly survey routing protocols V2I in VANETs. This study allows us to have an idea of the area of operation of RSUs in VANETs.

KEYWORDS: *Ad-Hoc Networks, Vehicular Ad Hoc Networks, Routing Protocols, V2V communications, V2I communications, Roadside units and On Board units.*

I. INTRODUCTION

In 1998 the Intelligent Transportation Society of America adopted a definition of Intelligent Transportation Systems (ITS) [1]. It reads: People using technology in transportation to save lives, time and money. To improve safety and travel times on the transportation system, ITS exploits all the new technologies in term of electronics, telecommunications and information technology. Examples of systems concerned by ITS: traffic management, public transportation management, emergency management, traveler information, advance vehicle control and safety, commercial vehicle operations, electronic payment and railroad grade crossing safety. Several projects and activities are born to develop this technology in Europe, Japan and the USA, like carTalk [3], PreVENT [3], PRE-DRIVE [3], ASV (1, 2, 3 and 4), VSC-2, etc. VANET (Vehicular Ad hoc NETwork) consists of all types of vehicles (car, buses, etc.), referred as On Board Units (OBUs) and infrastructures installed on roads referred as Road Side units (RSUs). VANETs are dedicated to offer multiple applications; we can separate them into two main categories, safety [1] [2] and non-safety applications [3]. The first category is the main goal of VANETs, which aims to improve safety in the road by dissemination of critical alerts to vehicles. In this category, we can find accident prevention applications, collision alert, merge assistance, etc. In the second category, we find all other applications like real-time traffic congestion, high-speed tolling, mobile infotainment, online games between passengers in the road, etc. In order to implement all these applications, it is necessary to overcome the challenges related to the unique characteristics of VANETs networks. We present here the main challenges:

- **Mobility and environment conditions**
  The high speed and mobility of vehicles represent a challenge to most optimization algorithms aimed to predefine routes to forward packets.
- **Inherent characteristics of the radio channel:**
  The presence of objects in the road can degrade the quality of the received signal. In addition, the problem of the fading effects, which due to the mobility and the surrounding objects.
- **Security and privacy:**
  The users of this technology want to make sure that they can trust the source of information. Also, the privacy requirements of senders must be respected.
- **Lack of an on-line centralized management and coordination entity:**

The problem here is the efficient use of the available bandwidth of the wireless channel. In VANET, there is no entity able to synchronize and manage the transmission events of the different nodes which lead to a large number of packet collisions so a less efficient usage of the channel.

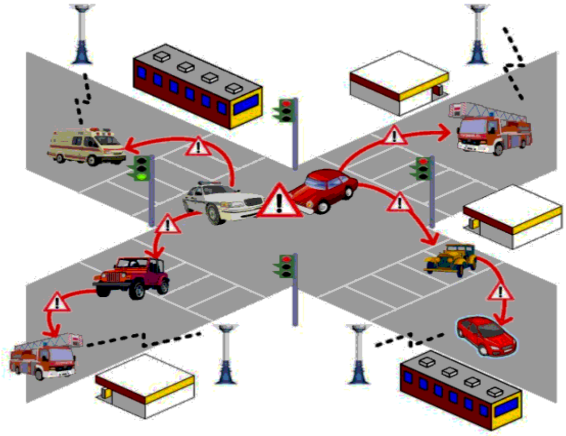

Figure 1: Different communication architectures in vehicular ad hoc networks

Figure 1 shows a structure example of vehicular networks illustrating the different communications architectures. In this figure we can distinguish two categories of communications: V2V communication represented by red continuous line, where the dotted line represents the V2I communication:

- **Vehicle-To-Vehicle communication (V2V) [1]:** The communication in this category is done through vehicles amongst themselves. Security applications are usually involved in V2V communication like warning of non-compliance with the safety distance, alert in case of accident, warning of the obstacles on the road and collaborative driving.

- **Vehicle-To-Infrastructure communication (V2I) [1] [4]:** Infrastructure is implicated in this case, in order to provide services like Internet access, information services and information on weather or traffic.

Routing protocols consist to establish routes for forwarding packets. So, for exchanging information different entities are defined. Routing protocol would be effective and ensure a good flow of packets with low delay, low overhead and good use of resources. Many routing techniques are developed to overcome the VANETs networks characteristics which are at the same time challenges. We find the following methods: *Unicast* routing which is the forwarding packet from a source to a target node in the network. *Multicast* routing delivery packet from a single source to several receivers (group of receivers called multicast group) by multi-hop communication. *Geocast* routing the packet is delivered to a specific geographic region. Vehicles of the target area should receive and forward packet. *Broadcast* routing is the process to forward packet from a source to all nodes in the network. Table 1 shows some routing protocols belonging to the previous categories.

Table 1: Some routing protocols of Vehicular ad hoc networks

Vehicular Ad hoc NETworks		
Unicast	Multicast/Geocast	Broadcast
GPCR VADD CAR DIR Reliable routing GVGRID	DRG IVG DG-CASTOR Mobicast routing	DV-CAST Broadcast Methods for V2V communications On the broadcast Storm Problem

Different routing protocols are proposed for VANETs specifically protocols based on V2V communication. In this paper, we focus only on routing protocols V2I communication in order to identify the involvement of RSUs in the routing process in VANETs. The rest of paper is organized as follows: Section 2 is an overview of routing protocols using V2I communication. Section 3 gives some possible future perspectives and challenges for the exploitation of RSUs. And finally, we present our conclusion in the section 4.

II. OVERVIEW OF PROTOCOLS V2I

In this section, we describe some routing protocols using the V2I communication.

2.1 Reliable Routing for Roadside to Vehicle Communications in Rural Areas

Authors in [5] propose a novel routing protocol applicable in rural roadways. This approach is based on the Access Points (APs) to maintain connections of vehicles to Internet. This protocol is proposed to address the issue of the terrain factor characteristics. This factor can be illustrated by the geographical characteristic (curve roadway and mountain) causes in the rural highway occasionally loses the line of sight between the nodes in VANET. Because of the lack of or sometimes the total absence of the fixed communication infrastructures in this area, the main solution in this case is the Multi-hop inter vehicle communication connecting to AP. Two reliable routing strategies are proposed for Roadside to Vehicle communication (R2V), prediction algorithm and routing algorithms. The first one, use the information about the current locations and velocities of nodes to predict the lifetime in terms of time units, all of this information can be piggybacked in the packets sent to APs. To establish a connection to the Internet, vehicle initiates a route discovery if it does not have a cached route. The discovery consists on flooding process by sending Route REQuest (RREQ) packets. When the request arrives to the AP, this last one selects a route for the source by sending a Route REPly (RREP). The AP can change the current path based on a tradeoff between lifetime of the path and its length. A long lifetime means a large numbers short links with long predicted lifetimes which leads to a high overhead and end up with long end-to-end. Also, the first selection of the path may have a shortest lifetime because the prediction may not be very accurate. Select a path with a minimum of hop-count leads to a quick break of links. So, the current path is changed if its predicted lifetime drops below a threshold or if the AP finds another path with the same lifetime but with smaller length. This method helps to prevent breakage of the path.

2.2 Infrastructure-Assisted Geo-Routing for Cooperative Vehicular Networks

The authors of this paper [6] propose to use the RSU for multi-hop communications to benefit of the increase of the range and reliability of communications due to the higher antenna height. The paper uses the topology-aware GSR routing protocol. Initially, with this approach, we have a road map topology where nodes are connected and the intersections are anchor points. Following the metric employed by the considered topology-aware routing protocol, the weights of the graph are calculated. They consider that the RSUs are directly connected through a network backbone. The principal of their proposition is based on the modification of the graph representation. So for the integration of the RSU in the new graph, they consider that the RSUs can be merged into a unique graph node, which is the backbone network. In the new graph "graph network", all the RSUs are represented as a unique graph node. This new representation of the infrastructure nodes will play a role in the calculation of the shortest path while vehicles perceive all RSUs as a graph node. In the final, when a RSU receives a packet, this last will be transferred to the next RSU. The new RSU will forward the packet to the node. On the other side, this technique doesn't ensure to find the short path from source to destination using a graph network that includes all the RSUs as a graph node.

2.3 A Static-Node Assisted Adaptive Routing Protocol in Vehicular Networks (SADV)

In this paper [7] a static nodes are used at road intersections to help relay data. This static nodes have a digital street map, based on which the trajectory is calculated for the packet forwarding. The path is obtained due to a graph of the street map, where we have the set of the static nodes and the set of the directed roads. The weight of each road is allocated according to the delay between adjacent static nodes. SADV is composed by three modules. SNAR (Static Node Assisted Routing): handles to store and forward data through optimal path until the disposal of vehicles to forward the packet to the next hop static node. LDU (Link Delay Update): measures the delay between intersections. To realize this, a single field is inserted in the packet head. At reception of the packet by the next static node, it will be easy to determinate the delay of the link used. This information will be encapsulate into the delay update message, a broadcast it to the others nodes by static node only. MPPD (Multi Path Data Dissemination): when the packet arrives at an intersection this last one send it to his adjacent static nodes which represent the best and the second best paths. With this technique, they increase the chance of hitting a better or even the real optimal path.

2.4An efficient routing protocol for connecting vehicular networks to the Internet

In paper [8] is destined to offer Internet connection to vehicles through a hybrid gateway discovery process to overcome the problem of high velocity of vehicles and the overhead. The communication can be established directly between vehicle and gateway if the vehicle is in the transmission range of the gateway, or in the other case through a multi-hop path. Authors assume that vehicles are equipped by a GPS in the goal to obtain their location. Speed, direction and location information will be used to predict the future location of neighbors of a vehicle. They assume also that the scenario is realized on highway. Each gateway broadcast advertisement message using Geocast capabilities in a specific area. The message contains, position, speed and direction of the sender, addresses of the relay nodes, time of the expiration of the route, zone of broadcast message and the location of the gateway, which represent the center of the circle. From the information about the distance separates gateways and the density of traffic; a zone of broadcast (circle or rectangle) is defined for each gateway. This zone delimits the process of broadcasting. When vehicles receive the broadcast message, just the vehicles located in the broadcast zone or the difference between their direction angle and the direction of the sender is less than $\pi/4$, and offers the longest lifetime, will be a relay and broadcast the message after the expiration of the timer. This mechanism reduces the problems related to the flooding of the network. The current path can be replaced with a new one if this last has the same lifetime and minimum of hops. This method insures the selection of the more stables path. Finally, a new path is found before the expiration of the lifetime of the current path due to the information collected by the advertisement messages of gateways and the method of selection of the relays.

2.5 Vertex-Based Multihop Vehicle-to Infrastructure Routing for Vehicular Ad Hoc Networks

Article [9] shows a method which permit to find a path from a vehicle to the nearest AP. Each vehicle has a digital map; this map is used by the vehicle to calculate the shortest path to the nearest AP. The path is a prediction of a sequence of intersections between source and destination (AP); this list is inserted in the packet header. Once the road found, the data transmission starts. In the road, vehicles exchange beacon messages among them, with this messages a forwarding vehicle can obtain a list of their possible future neighbors and calculate the weighted score for packet carrier of their current and future neighbors. The weight is calculated based on the position, direction and the distance between nodes and destination (Infrastructure). The neighbor with the highest weight is selected to carrier packet between intersections. In other hand, RSUs are utilized to provide short-time certificates updating for vehicles as they can be connected to the trust authority. This certificate is used to protect the privacy and security of information of users. Authors in [10] propose an algorithm for an optimal deployment of RSUs to allow the OBUs to get a new certificate before the expiration of the last one.

III. CHALLENGES AND PERSPECTIVES

As mentioned above, VANETs are constituted of mobile nodes (OBUs) and infrastructure (RSUs). However, the exploitation of RSUs is limited to date to providing Internet access and the short time certificate. This use is restricted due to additional processing time at the RSUs, and the cost of their installation which is expensive. Therefore, some future perspectives should include the following elements:

- Introduction of RSUs in the routing process (not just for Internet access), considering them as anchors and taking advantage of their transmission coverage and their known fixed positions.
- Improvement of the dissemination of emergency messages by collecting the information through the connection to the other RSUs and mainly to the authority center.
- RSU have the potential for load balancing traffic to avoid network congestion.
- The study of optimal location methods of the RSUs in cities is very important to solve the problem of the installation cost of RSUs.

IV. CONCLUSION

VANET is expected to play a powerful role in the improvement of safety in roads and offers more applications for the passengers during their travel in vehicle. In this paper, we presented a survey about routing protocols using V2I communications. The most works are oriented to the use of the RSU in order to provide the Internet access. RSU have the potential to provide an opportunity to improve routing in vehicular networks owing to higher antenna height which increases the range and the reliability of the V2I communications. These characteristics can be used to establish robust path for forwarding packets and they can play a role for load balancing traffic to avoid network congestion, mainly in the case of emergency messages. The use of RSU proves to be very important and deserves to be developed in order to exploit their potential in the routing process.

REFERENCES

[1] http://www.its.dot.gov/
[2] http://www.itscanada.ca/it/index.html.
[3] http://www.vanet.info/
[4] http://www.vehicle-infrastructure.org/
[5] S. Wan, J. Tang, and R.S. Wolff. Reliable Routing for Roadside to Vehicle Communications in Rural Areas. Proceedings of International Conference on Communications, pp. 3017 - 3021, Beijing, May 19-23, 2008.
[6] D. Borsetti and J. Gozalvez, "Infrastructure-Assisted Geo-Routing for Cooperative Vehicular Networks", IEEE Vehicular Networking Conference , pp. 255 - 262 Jersey City, NJ, December 13-15, 2010.
[7] Y. Ding, C. Wang and L. Xiao. A Static-Node Assisted Adaptive Routing Protocol in Vehicular Networks. IEEE Transactions on Vehicular Technology - IEEE TRANS VEH TECHNOL (Volume: 59, Issue: 5), 2010, pp. 2445 - 2455.
[8] A. Benslimane, S. Barghi and C. Assi. An efficient routing protocol for connecting vehicular networks to the Internet. Pervasive and Mobile Computing, pp. 98-113,February, 2011.
[9] R. K. Shrestha, S. Moh, I. Chung and D. Choi. Vertex-Based Multihop Vehicle-to-Infrastructure Routing for Vehicular Ad Hoc Networks. 43rd Hawaii International Conference on Systems Science, Koloa, Kauai, HI, USA, pp. 1-7, 5-8 January 2010..
[10] Y .Sun, R. Lu, X. Lin, J. Su and X. Shen. Wolff. Roadside Units Deployment for Efficient Short-time Certificate Updating in VANETs. Proceedings of International Conference on Communications, pp. 1-5, Cape Town, May 23-27, 2010.