Routing in VANETs: propose of a generic algorithm

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***Abstract*—Routing in VANET(Vehicular Ad-hoc Networks) is a developing area due the specific characteristics of these networks. One of the challenges is to provide information transport even that the channel is rapidly modified by the network's mobility. Mobility is a notable issue that has to be faced by the logical part in the network. The network layer needs to guarantee the stability of routing without relying on the mechanisms of traffic information from the physical layer. Routing protocols have different features for communication between different hosts/vehicles considering the constantly changing topology. In this paper, we propose a generic routing algorithm that encompasses several features of VANETs to explore features not covered in other existing approaches. This algorithm is an improvement dynamic source routing that can handle the large scale situations, decreasing the link breakage probability and forwarding the information with a better greedy method.**

I. Introduction

Traffic accidents have become one of the biggest problems faced by people because of their daily displacements, or not. It's known to all the numerous damages that the lack of traffic safety has brought to our society. This fact puts many lifes at risk, both of which drives their vehicles by public streets, as the pedestrians that circulate by them.

The basics objectives of a work turned back for raise traffic security condition are: a) reduce the totally number of accidents, dead and injured; b) reduce the risk in the streets; c) reduce the accidents consequences. For each one of these objectives, all can have a appropriate measure set and distinctiveness. Against this situation and to this set of objectives, the technology can be a strong ally. The technology also can be utilized for the traffic security help, and consequently the accidents reduction and prevention.

Targeting an idea of traffic security raise, the incentive is on the academic research to develop new technologies associated to the Vehicular Networks [1]. The Vehicular Ad-hoc Networks(VANETS) are communications systems composed by vehicles. The principal difference of these networks from the others communications networks is that the elements that composes the network are some kind of vehicle like cars, motorcycles, trucks, bus, etc, instead computers or other conventional devices. These devices are equipped with wireless interfaces and network infrastructure that can count with distributed equipments trough the streets and highways.

Vehicular Networks have gained a lot of space in research and also have attracted industries and market attention [1][2][3]. This fact occurs by offering a variety of applications that take into account, for example, driver assistance, tourist information diffusion, location of gas station, automatic toll collection, etc. VANETS can have applications on the entertainment branch too which it can be, for example, a music sharing system between vehicles. It also have applications back to traffic safety(focus of this work) where can develop solutions to spread accidents information, occurrences in transit, streets and highways adverse conditions, reduce of congestion, among others objectives. Besides, exist a possibility on a real time monitoring that has been target in the security industry, becoming a good solution for kidnapping situations.

In this paper we propose a generic routing algorithm that encompasses several features of VANETs, taking into account the deficiencies in existing approaches. Intend to develop a routing protocol that: (1) Being dynamic from the origin. That will be a reactive algorithm, routing on demand. (2) Present a good behavior in small/large scale situations. It will have a successful performance in small streets to big avenues. (3) Recognize the network topology even it is in rapidly exchange of nodes, and made it without wasting information. (4) Provide a bigger connection time between cars to a higher transmission of packets. The protocol must have mechanisms of link breakage. It is interesting that the proposed protocol present the same performance found in protocols that have been already made.

The paper is organized as follows. The section 2 presents the related works with algorithms that are developed to face the features of VANET networks. The sections 3 introduce some aspects of the Vehicular Ad-Hoc networks. The current situation of routing in VANETs is show in the section 4. The introduction about a generic algorithm in these networks is presented in the section 5. The section 6 shows the proposed generic algorithm. And the paper is concluded with the current work in the section 7.

II. Related Work

In TOPO (Two Phase Routing Protocol) is a algorithm proposed in [21] and have two phases: Access (routing on streets in the neighborhoods) and Overlay (routing on avenues where have a intense vehicles traffic). The algorithm uses the GPS (Global Position System) to localize the egress nodes. After TOPO combines the to phases to do the routing. The simulations was on NS2 (Network Simulator) [4] running on a TIGER map of orlando city. The paper shown that

the algorithm have a better performance to than the others algorithms from VANETs.

The vehicular networks have a low connection due the nodes high mobility. Also the vehicular environment has too many obstacles an reflexion affecting the signals and increasing the loss probability. So the MURU (Multi-Hop Routing for Urban VANET) algorithm proposed in [5] has the objective to decrease the disconnection between vehicles. To provide this services the algorithm calculates the EDD (Expected disconnection degree). The EDD predicts the link breakage on all the hops of the routing path. The algorithm is based on the AODV algorithm and was simulated in NS2 showing that the MURU has much better performance in terms of packet delivery ratio, data packet delay and algorithm overhead.

CAR(Connectivity-Aware Routing) [6] do not depend of a localization service. To find destination and path to it, CAR uses Preferred Group Broadcast(PGB) [7] algorithm which optimize broadcast specifically for VANET. The simulations shown a better performance than the GPSR(Greedy Perimeter Stateless Routing) [8] in many aspects, however, there are two points to be improved: the algorithm adds some unnecessary nodes incrementing the hops to the destination and the intermediary nodes can causes link breakage with the processing environment characteristics.

III. Vehicular Ad-Hoc Networks

The automotive vehicles gather considerable technologic advances ordering an improvement in the interaction between drivers and vehicle. The use of sensors, actuators and electronic devices allow, for example, the detection of others vehicles that are getting close. This fact allow a better sense of the environment that the driver are inserted. This evolution has improved so that a new trend that goes beyond the communication limits between driver and vehicle, and enables the iteration between different vehicles through a communication network [3].

This communication environment between vehicles is called vehicular network. The main objective of these systems is to enable the mobile devices communications that operate in a environment formed by users in transit. It provides the conditions required for user applications with different requirements are met satisfactorily. Examples of these applications include the cooperative traffic monitoring, the help of intersections without signaling or the colisions prevention. The idea is that these applications also allow the internet access anywhere and anytime [9].

These networks can be formed between the vehicles and a fixed infrastructure on the shores of streets and roads. The vehicular networks differ basically from others wireless networks because of the elements type that composes the network, that are composed by cars, trucks, bus, etc. (this vehicles have wireless interfaces), and by fixed devices on the surroundings of routes.

A. VANETs architecture

The vehicular networks architecture defines the organization, disposition and nodes communication form that composes the network. Actually, exists three principal architectures: pure Ad-Hoc(Vehicular Ad-Hoc Network - VANET), infra-structured or hybrid [10]. There is one architecture developed by IEEE (Institute of Electric and Electronic Engineers) called WAVE (Wireless Access in the Vehicular Environment).

The communication or information exchange realized only between vehicles is called pure Ad-Hoc. When the vehicles can communicate themselves with fixed units, on the streets or roads, it has the infra-structured environment. In the case that have communications between vehicles and with fixed units, the architecture is considered hybrid.

In the vehicular networks, the Ad-Hoc mode is known by V2V (Vehicle-to-Vehicle) and the infra-structured mode have as a synonymous the term V2I (Vehicle-to-Vehicle). Currently, some researchers refer to the vehicular networks like VANETs, even when exits the infrastructure. The standardization of vehicular networks communication architecture most utilized is the WAVE architecture, defined by a standard still in development called IEEE 802.11p WAVE [11] [12].

IV. Routing in Vanet

The challenge of determine rotes for information transport in the vehicular networks is a complex job due the high nodes mobility in the network and instability of wireless links. The routing protocols found for the communication between node are classified as : topological, geographical, opportunists and of information dissemination.

The protocols based in topology found the best path between any other pair source-destination of the network. Typically, the best path is that offers the lowest cost according to the utilized metrics. These protocols can be proactive, reactive and hybrid. The utilization of these protocols for vehicular networks can be not great enough, because they can result in a control overload due the high mobility of nodes in the network.

To reduce the control messages amount is used a mechanism of diffusion called PGB (Preferred Group Broadcasting), this was proposed in [7]. The position based routing (or geographical) is capable to provide more scalability in high mobility environments. In this approach, it‘s not necessary to keep information about the routes of each node in the network. This kind of situation is very common in the vehicular networks, so most of the routing algorithms are geographical, having some expansion like in [13]. This type of routing assumes that the present elements in the network have some location system like GPS, as Galileo [14].In these routing protocols the source send packets to the destination through multiple hops, being necessary for it, that the node knows its neighbors and its location [13].

Also exists the opportunists routing protocols, that considers scenarios with occurrence of services interruption and frequently node disconnection, similar to the problems faced by DTNs(Delay Tolerant Networks), fault tolerant networks [15]. Some approaches of this protocol can be found in [16][17]. The dissemination protocols, that spreads the information to the several applications of vehicular networks [18]. But also providing services with the possible link breakage [19].

The routing protocols offers different features to the communication between the vehicles hosts. The challenge of its applications is to find the most appropriate link for the existing situations that the node moves itself in high speeds. Considering these features, these networks must be robust and scalable, since they must operate in scenarios with few or some thousands os nodes.

So, the studies are realized in order to provide a greater diversity of features to these protocols. Exist algorithms that: carry large scales in the network on situations with high vehicles density for to improve the routing and have more objective [21]; that have support to the intense vehicle mobility, that adapts quickly to the new topologies and enables a greater connection without a possible link breakage [19], that have a adptation system to the constantly position exchange of nodes in the network [23]; passivity [24] and dynamic [22][20] for that don't have a intense network overhead. This fact is the packets sent by proactive algorithms, that have to update its possible paths database for the packets routing, in other words, the routing algorithm in VANETs has to forward packets in a demand orders.

V. Principals of a Generic Algorithm

Routing in vehicular networks or VANETs(Vehicular Ad-Hoc Networks) is important due the nodes high mobility and constantly topologies changes. Classic algorithms of MANETs (Mobile Ad-hoc Networks) fail to meet this characteristics [23]. Routing algorithms are proposed to attend this needs, trying to achieve the same MANETs algorithms features with VANETs characteristics. This algorithms are divided in two types: reactive and proactive. Reactive algorithms determines rotes on-demand, they don't depend of any algorithm external resource being dynamic. They are different from proactive algorithms, that needs the constantly routing table upgrade which will be consulted for known routes selection.

There are routing protocols based on reactive algorithms of the mobile ad-hoc networks. They must attend to the packets routing without the need of a prior knowledge of the networks topology.

Based on the currently proposed algorithms, note that each one of them have peculiar and individual characteristics, solutions given for the different needs of vehicular networks. This solutions are proposed by different algorithms, in other words, it's necessary a choice of some algorithms according to the problem found in the current topology. Arises the need of a more complete algorithm, that can handle with good performance in the needs of vehicular networks.

The objective of this work is define a routing algorithm that can gather the vehicular networks characteristics, taking into account the deficiencies in the existing approaches. It's also interesting that the proposed algorithm presents a similar performance to the algorithms already developed. The proposed one must attend to the vehicular networks needs and enable a packet routing on belonging conditions to scenarios of these networks.

Intends to develop an algorithm that:

- Be dynamic from the origin. The algorithm will be reactive, determining routes on-demand. [22].
- Presents a good behavior in small scale situation, like in the streets where they have a lower vehicles traffic; and in large scale, where the vehicles traffic is bigger like found in the avenues [21].
- Recognizes the networks topology even with the constantly change of nodes position, and do the routing without a lot of discarded packets [23].
- Provides a greater time connectivity between vehicle, for the packets routing can be done. And also presents mechanisms for link breakage situations between vehicles [19].

VI. The proposed algorithm

The main objective of this paper is propose a generic algorithm that can do the packets routing with high performance. The characteristics of VANETs prevent good behavior in routing with the algorithms of the MANETs (Mobile Ad-Hoc Networks). The high mobility and channel conditions are features that can be verified constantly for the information exchange. Apart from the possibility of treating in a better way the large scale routing. The proposed algorithm face this features for more throughput and less loss probability.

Many algorithms were develop treating specific aspects of VANETs. To integrate them in one a architecture was created to enable a new trend of routing protocols in VANETs. This new trend has to encompass a majority of VANETs features in a modularized way. The proposed architecture is shown in the Figure 1. Four steps composes the architecture and are explained later. The fact of being modularized is great because the integrated algorithms can be developed separately.

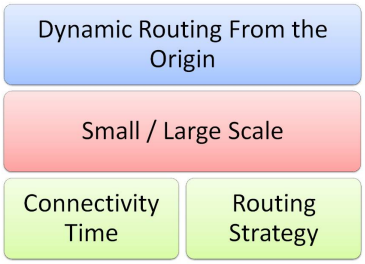

Fig. 1. Architecture of the proposed generic algorithm

The Figure 2 shows the selected algorithms to integrate a new generic algorithm. They have a good performance yet are focused in different features of the VANET network. They are explained in the next subsections.

A. The Dynamic Routing Step

To provide a dynamic routing from the origin the select algorithms are the DSR (Dynamic Source Routing) and MURU. The DSR send broadcasts requests for find the destination path. The nodes that receive the requests do the same process until the egress node responds. So the path is build a response

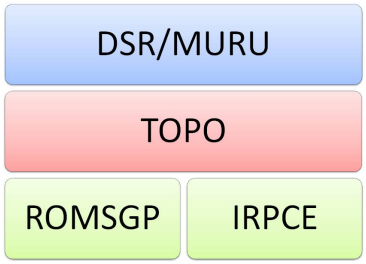

Fig. 2. Used algorithms in the architecture

to requests with the location of the destination up to the source node. When the source node receives the response with the path it starts to send information to the destination through the discovered path. But the DSR doesn't calculate the strength of the link on the path, and the connection may drop because of link breakage and a new path request process is made. To eliminate this problem the MURU algorithm calculate the strength of the link with the called EDD (Expected Disconnection Degree). The source can choice the shortest path with more link connection reliability.

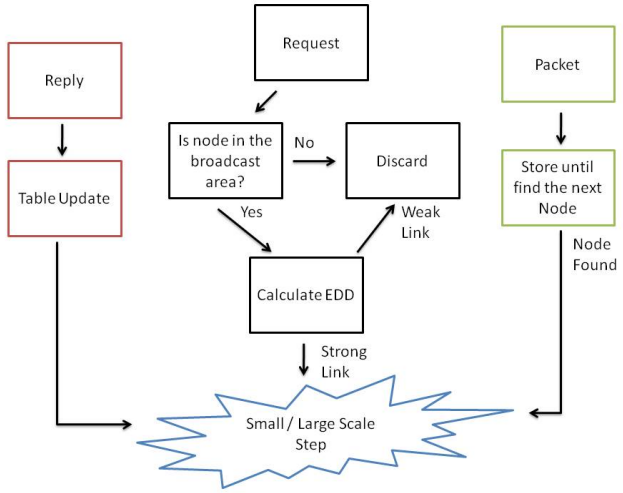

Fig. 3. The Dynamic Routing Step

Following the DSR the proposed algorithm has three phases : Request, Reply and Packet. When a node receives a request message it verifies if the node that sent the message is yet in the broadcast area to route the information. Reply is a phase to respond nodes with the destination path before update the routing table. And routing packets is possible when the next node of the path is know. If the next node is not available is necessary store the packet in a buffer until the next node is found. The process of the step is show in the Figure 3.

B. The Small—Large Scale situation

Sometimes the information needs to traffic through the city. But when the node starts the request messages to find the destination path the process may create a bigger overhead and increase the path request time. Also when a path node is not available all the process will be started again. To lead this problems the TOPO algorithm was developed. The algorithm can handle with good performance the small or large scale environment.

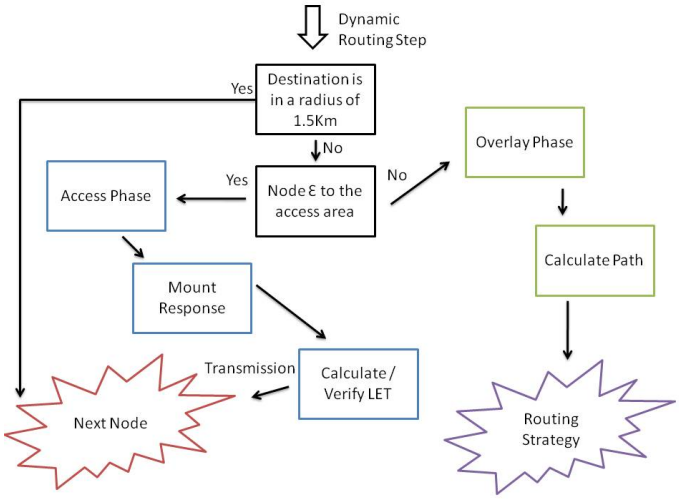

Fig. 4. The Small—Large Scale situation and The Connectivity Time Steps

TOPO utilizes two routing phases: Access and Overlay. It calculates the path based on the distance between source and destination. The GPS system is used to know the destination location and select one of the phases to do the routing. In the large scale situation the routing protocol utilizes the greedy method to route the packets between access areas. In this work the greedy method is utilized with a improved for route packets with a lower overhead.

The Figure 4 shows the process of the Small—Large Scale situation step. If the destination is in the broadcast area the proposed algorithm will route the information to the next node of the path till arrives the destination. An algorithm, like TOPO, will select one of the two routing phases to the packets routing.

C. The Connectivity Time Step

The LET parameter verifies the probability of link breakage with the help of a GPS. It calculates the distance between the vehicles and through the car's direction the ROMSGP algorithm proposed in [19] can say if the link will be broken during the transmission. This metric enables the possibility of find another path if the link is not good enough to send information increasing the end-to-end delay but decreasing the loss probability.

D. The Routing Strategy Step

To forward packets in the overlay phase, the selected algorithm is the IRPCE, proposed in [23]. The greedy method in the TOPO algorithm presents a large overhead in the network to route information between access areas. To provide a lower

end-to-end delay and decrease the overhead to forward packets in large scale situation the IRPCE protocol shows a method to move information in a better way.

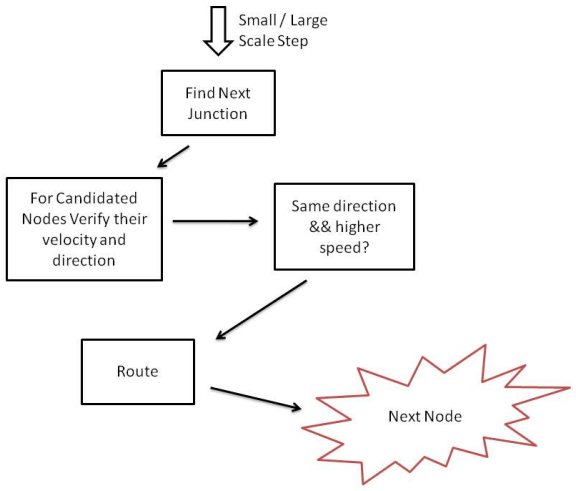

Fig. 5. The Routing Strategy Step

The figure 5 shows how the IRPCE method for forward packets in large scale situations is integrated on the proposed algorithm in this paper. The algorithm will find junctions till the destination node and route packets by nodes with same directions and higher speed. These information about the nodes is obtained in the packets and utilizes it to provide a better way for forward information in a greedy method.

VII. Conclusion

In this paper was shown a propose of a generic algorithm to face the VANETs features. The algorithm is subdivided in for steps. The steps are integrated in a modularized way to the selected algorithms being upgrade separately. The algorithm provides a dynamic source node with checking the strength of the path link, also it provides different treatments for small or large scale situations. For large situations the proposed algorithm utilizes a improved greedy method for forward packets by nodes with same direction and higher speed. To decrease the link breakage the algorithm calculates a metric called LET, this metric shows the reliability of the link between two nodes.

The proposed algorithm is on implementation in the NS2 simulator. Other algorithms shown in this paper are implemented too. This algorithm will be evaluated with the classic MANETs algorithm and the VANETs algorithms integrated in this one. The results must be the same of the other VANETs algorithm providing more reliability and performance.

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