EVALUATION OF ROUTING METHODOLOGIES OVER REAL VANETS SCENARIOS

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ABSTRACT

VANETs are becoming the biggest potential for communication among cars. The industry and academia have turned on the researchers to this subject. Routing protocol is the main issue in these networks. The need for routing protocol that achieves the performance, required in the vehicular environment, have gained a lot of proposals, focusing in many routing methodologies with no study in which is the best for VANETs. To face this problem an evaluation of such methodologies are presented in this paper. Real scenarios were chosen to try to show the best routing methodology for VANETs. In this paper the topological methodologies evaluated are: reactive, pro-active and architecture. The real scenarios are the urban and road environment of the Malaga city. The third scenario is the Manhattan Mobility Model. All scenarios have 30 nodes and the velocity of cars are between five and 30 m/s First an effect analysis of all evaluated protocols is made with the ANOVA statistical test. The differences of performance are checked with a graphical analysis. The results show that the architecture methodology is the most indicated for the design of new VANET routing protocols.

KEYWORDS

Routing, performance, VANETs, methodologies, ANOVA, Manhattan.

1. INTRODUCTION

VANETs (Vehicular Ad-Hoc Networks) are access networks composed by vehicles (cars, motorcycles, trucks, etc.) and optionally, by any communication infrastructure over the roads. The vehicles can communicate in two modes, according to the components present in the network: vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) [Alves 2009]. VANETs communication standard was finished in June 2010, and is regulated by IEEE 802.11p WAVE (Wireless Access in the Vehicular Environment) [IEEE 2007]. The standard is compatible with the DSRC (Dedicated Short Range Communications). DSRC supports high transmission data rate (6-54 Mbps) on the radius of 1000 meters.

Industry and academia researchers gave a lot of attention to VANETs in last few years [Hertenstein 2008]. The varieties of applications involving these specific networks are huge and that is the motivation for studying it. Drive assistance, tourist information propagation, location of gas station and automated toll collection are some examples of VANETs applications. VANETs can also be applied to entertainment like a system for video sharing among vehicles; and applications for the transit security, preventing accidents and congestion. Besides, exists the possibility of real time vehicles monitoring on the security industry, becoming a solution for kidnapping situations.

But all this potential for the future stumbles on the routing problem. Due the high velocity and mobility of vehicles packets routing through topology based approach is the major challenge. Many protocols have been proposed based in the specific characteristics of VANETs. Even exists many proposed protocols it is still hard to chose one and apply it to VANETs, and there is no draft or standard regarding routing. That is because these proposed protocols failed in the performance evaluation process. A big problem is the assumption of the performance of existing protocol for Ad-Hoc networks is the same for VANETs. This assumption is not true because VANETs differs a lot of Ad-Hoc networks, regarding the number of nodes, nodes speed, mobility, energy constraints, etc. Other big problem is the synthetic analysis, where the performance evaluation is conducted over fictitious scenarios, in other words, invalid for making decisions to real networks. So, before developing a good routing protocol for VANETs a good analysis of how ad-hoc routing protocols behaves on the VANETs environments must be done to understand which routing techniques are more effective in this new communication environment. To contribute with solving the performance evaluation problem of VANETs the objective of this paper is to evaluate the topological routing methodologies over real scenarios. The main objective in this paper is to indicate which routing methodology is the best for VANET and explain why.

The research questions to be answered are: RQ1: The routing methodologies have same performance? RQ2: Which is the best routing methodology for real VANETs scenarios? For every question we have a hypothesis formulation. The null hypotheses are the ones we want to refute. The results obtained by the simulation model will show the statistical and importance significance for refute or accept the null hypotheses. The hypotheses for RQ1 are: H1-0 : The methodologies have no statically significance difference. H1-A : The methodologies have statically significance difference. The hypotheses for RQ2 are: H2-0 : Based on the results for ad-hoc networks in [Mittal 2009], the reactive methodology is not the best for real VANETs scenarios. H2-A : The reactive methodology is the best for real VANETs scenarios.

The simulation model is designed based on three scenarios. The scenario A is a real trace of the Malaga city, in Spain, on an urban perimeter. The scenario B considers Malaga city in a road perimeter, and scenario C uses the Manhattan mobility model with 30 nodes. In the scenario C the variations of maximum cars speed will be analyzed too. The main objective of this paper is to evaluate the best performance routing methodology for VANETs The metrics used in comparison among routing protocols are: : Packet Delivery Ratio, Application Throughput, Delay and Dropped packets. All the simulation were held on the NS2 (Network Simulator). The results show a match between the routing protocols AODV and GVDSR, which cannot be observed for the DSDV protocol.

The paper is summary as follows: the Section 2 introduces the routing in VANETs with the description of each routing methodology evaluated; after the simulation model is presented in Section 3; the results and discussion are found in the section 4 and the paper in concluded in Section 5.

2. ROUTING METHODOLOGIES

2.1 Pro-active Methodology

Pro-active protocols are characterized by the transmission of neighborhood and link states routing information from all nodes of a network to each other, for a given time. With this methodology the routing table always needs to be updated and transmitted. The constant transmission of routing tables creates higher overhead and delay compared to other methodologies. But, the information about link state is useful for creating alternative routes when needed. The DSDV [Perkins 1994] protocol is an example of routing protocol which implements a proactive mechanism based on the classical Bellman-Ford routing, with the elimination of loops in the routes. Some of the important characteristics of DSDV are: routing table entries must have sequenced numbers of routes and the announcement is made in the necessary events. DSDV requires periodic updates in the routing tables, which may affect your performance, since there is a large power consumption in battery of the nodes and also has a low transmission rate even if the network is idle.

2.2 Reactive Methodology

The reactive routing determines routes on demand. Main idea in on-demand routing is to find and maintain routes only to the necessary nodes when they are requested. The main advantage is the possibility to discover routes against the cost with the undesired routes. Also, there is no need of send messages to neighborhoods with routing tables, so the overhead tends to be lower in this approach. The disadvantages are delay in the route discovers phase and when routes need to be repaired. AODV [Perkins 1999] is the major example of reactive routing protocol proposed for Ad-Hoc network. An important feature of AODV is the route states maintenance based on a time for each destination, related to the use of each node, making a route expires if not used recently. A backup list of previous nodes is also maintained for each entry, showing the set of neighbors who use this entry to forward packets. Every detected broken link (no transmission via a channel), caused by any change in topology, will be notified via an error message broadcast, informing the other nodes that the hop is unavailable.

2.4 Architecture Methodology

The architecture methodology aims to aggregate the main characteristics of VANETs and their various routing protocols bringing them together into a single protocol. The advantage is the hypotheses is that the differentiated mechanisms are united in one single protocol will increase performance. The most important disadvantage is the event to have conflicting techniques. The GVDSR protocol was proposed in [Barros 2010b], presenting an integration of several routing protocols in one unified solution for VANETs. The GVDSR is an extension of the DSR protocol, this protocol is the basis of the routing protocol. GVDSR remains the phase of route discovery and structure of packages of the DSR. The other protocols are responsible for: alternating phases of high densities of vehicles and high speed and low density of vehicles and low speed (The large | small component, used in the TOPO protocol [Wang 2007]); broken link checking (The connectivity time component, used in the ROMSGP protocol [Taleb 2007]) and using an algorithm that contains a heuristic based on vehicle dynamics for tactical packet forwarding (The routing tactics component, used in the IRPCE protocol [Ali 2009]).

3. SIMULATION MODEL

3.1 Simulation Design

The simulation of each methodology of routing in VANETs is important to understand the behavior of them and their advantages and drawbacks. This process will help the researchers to identify the need of routing in different VANETs scenarios. The pro-active, reactive, and architecture methodologies are analyzed. The DSDV, AODV, GPSR and GVDSR protocols are simulated. These protocols represent each methodology respectively.

To evaluate the routing methodologies and their routing protocols we used three different scenarios. The first twos are areas of the Malaga city. One area corresponds to an urban perimeter. The other correspond the road perimeter. The third scenario uses the Manhattan mobility model to control vehicles mobility. This model is extensive used in simulation for VANETS. This consists of vertical streets and horizontal streets and their intersections. In this model, it is assumed which node are uniformly distributed and there are only four directions in every street (verticals: north and south; horizontals: east and west). As in real life, a node when reaching an intersection can turn left, right or move straight. Each node has 50% chance of stay in the same direction or 25% chance of turning to the east/north or 25% chance of turning to the west/south. The Manhattan mobility model is useful in modeling movement in urban areas. Each protocol on each level of each factor was replicated 10 times. Totalizing 70 replication of each protocol in all scenarios, we had a 280 total replication.

3.2 Instrumentation

For all experiments we used the NS2 (Network Simulator version 2.33). This simulator is largely used in the academia, this fact is a advantage for comparing results between papers. The modulated design of NS2 help developers for implementing new protocols. We chose this simulator because the large usage, tutorials and the ease network configuration. For the statistical and graphical analysis we used the R project software . To obtained statistical significance with confidence interval or statistical tests this is the recommended software to use.

Table 1. Simulation parameters for all scenarios

Metric	Value
Number of Nodes	30
Velocity	5 – 30 m/s
Number of Communicating Nodes	20
Simulation Area	1000x1000m
Transceivers	IEEE 802.11 standard
Propagation Model	Two Ray Model
Antennas	Omnidiretionals
Routing Protocols	AODV/DSDV/GVDSR
Queue	Priority
Traffic Protocol	UDP
Application Protocol	CBR
Packet Rate	4 packets / s
Simulation Time	200s

3.3 Scenarios

In scenario A, was utilized the urban perimeter traffic model of the Malaga City (Andaluzia, Spain,) illustrated by Fig 1. Cars can vary their velocity in the range of 5 to 30 m/s, appropriate range for the mobility standards in vehicular scenarios. The number of nodes/vehicles in this scenario is 30 being that 20 are communicating nodes. Others information for the scenario A are presented in the Table 1. The scenario B presents the same basic characteristics of the scenario A. But in the scenario B, the perimeter of the Malaga city is on a road zone. Others information for the scenario B are presented in the Table 1. The scenario C is a simple analysis with the Manhattan mobility model. Speed is the objective of the analysis. In the Manhattan mobility model with 30 nodes the cars speed will varies in the vector {20,30,40,50,60}. This analysis will help us to observe the robustness of the routing protocols.

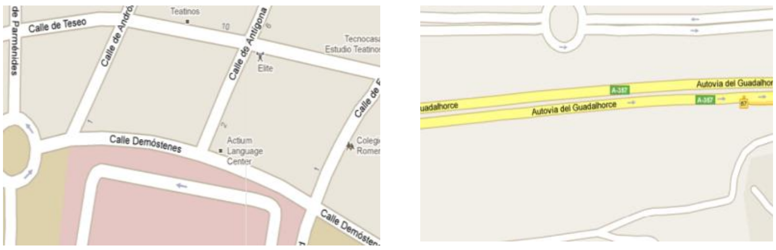

Figure 1. (Right) The Urban Environment and (Left) the road environment of the Malaga city.

3.4 Metrics

To compare the performance of the routing protocol we used four metric: Packet Delivery Ratio, Application Throughput, Delay and Dropped Packets. Packet Delivery Ratio (PDR) is the percentage of the total received packets under the total of the send packets. This metric shows the completeness and correctness of routing protocols. These mechanisms are important because the VANETs scenarios are characterized by high level of loss. Application Throughput (AT) is the data rate per second delivered to the destination application. This metric show how the routing protocol uses the maximum available bandwidth in the network. The high mobility and velocity helps to decrease this rate, but the routing protocol must adjust itself for a higher throughput. Delay (DE) is calculated as the difference between the time of arrival of the packet and the time of sending the packet. These metric shows the average time a packet takes to reach its destination. Dropped Packets (DP) is the number of the dropped packets for an eventual occasion. All these metrics were chosen because they are largely used in many works of the academia. They are important to measure many behaviors of the protocols in different scenarios. When the routing protocol achieves the highest PDR and AT and achieves the lowest DE and DP is the chosen one for VANETs.

4. RESULTS AND DISCUSSION

Table 2 shows the p-value with the Oneway ANOVA statistic test. The confidence is 95%. So with a p-value greater than 0.05 the null hypothesis is accepted for that metric. Otherwise, the alternative hypothesis is accepted. The entire statistical test above is about the hypotheses 1. In all scenarios the only metric which accepts the null hypothesis is the delay for scenario B. But we can say with 95% confidence that the performance of routing protocol varies from one protocol to another. This refutes the null hypothesis 1 (H1-0).

Table 2. P-value for each metric in all scenarios.

Metric	P-value(Scenario A)	P-value (Scenario B)	P-value (Scenario C)
Delay	**< 2.2e-16**	**= 0.3711**	**< 2.2e-16**
Throughput	**< 2.2e-16**	**= 0.01175**	**< 2.2e-16**
Packet Delivery Ratio	**< 2.2e-16**	**< 2.2e-16**	**< 2.2e-16**
Dropped Packets	**< 2.2e-16**	**= 1.562e-08**	**< 2.2e-16**

According to the evaluated topologies is possible to identify different behaviors of the evaluated algorithms. For the scenario A, which represents the city of Malaga in an urban perimeter, we can find a balance between the algorithms evaluated with respect to throughput and delivery rate. This shows that due to the reduced number of vehicles as well as the low level of mobility found in urban environments, there were no differences in the representative results. Graphs can be found in Figure 2. Now regarding the delay and the amount of discarded packets, Figure 2, we can see that according to the routing technique used representative differences. For the delay, the techniques that are based on routing tables instead of creating a list of hops had better results. With respect to dropping packets, AODV showed the best results, since the level of node mobility is relatively low. But when they happen the AODV route update mechanism was more efficient than DSDV and GVDSR.

In the scenario B, which considers the topology of the city of Malaga in a highway environment, we find a completely different behavior from that observed initially. In the four metrics evaluated, all protocols led to similar results, as shown in Figure 3. We can see a degradation of the network performance, reducing the throughput and delivery rate also the considerable increase in the number of packets discarded. In the delay, the technique that presents a list of hops performed better, since only a small number of packets delivered generally through direct communication among vehicles. These changes occur due to large differences in the pattern of mobility, speed and dispersion of vehicles. Road environments have a degree of mobility much higher than urban environment. Also vehicles with higher speed and more distant from other vehicles are affected too, which undermines the quality of communication.

Last scenario used the Manhattan topology with a fixed number of nodes. This scenario illustrates an urban environment with a high amount of ways, and consequently a greater dispersion of vehicles than in urban route from Malaga, completely different results were found. Graphics are displayed in Figure 4. As already mentioned, the greater dispersion of the nodes caused a drop in the levels of throughput and packet delivery rate than in urban routes from Malaga. In addition, the DSDV protocol, representing a proactive approach, which initially showed results similar to other protocols evaluated had a significant decrease in performance. As the topology becomes more conducive to breaking of communication links, and because it is an algorithm pro-active, we spent more time without notice to expect the restoration of communication.

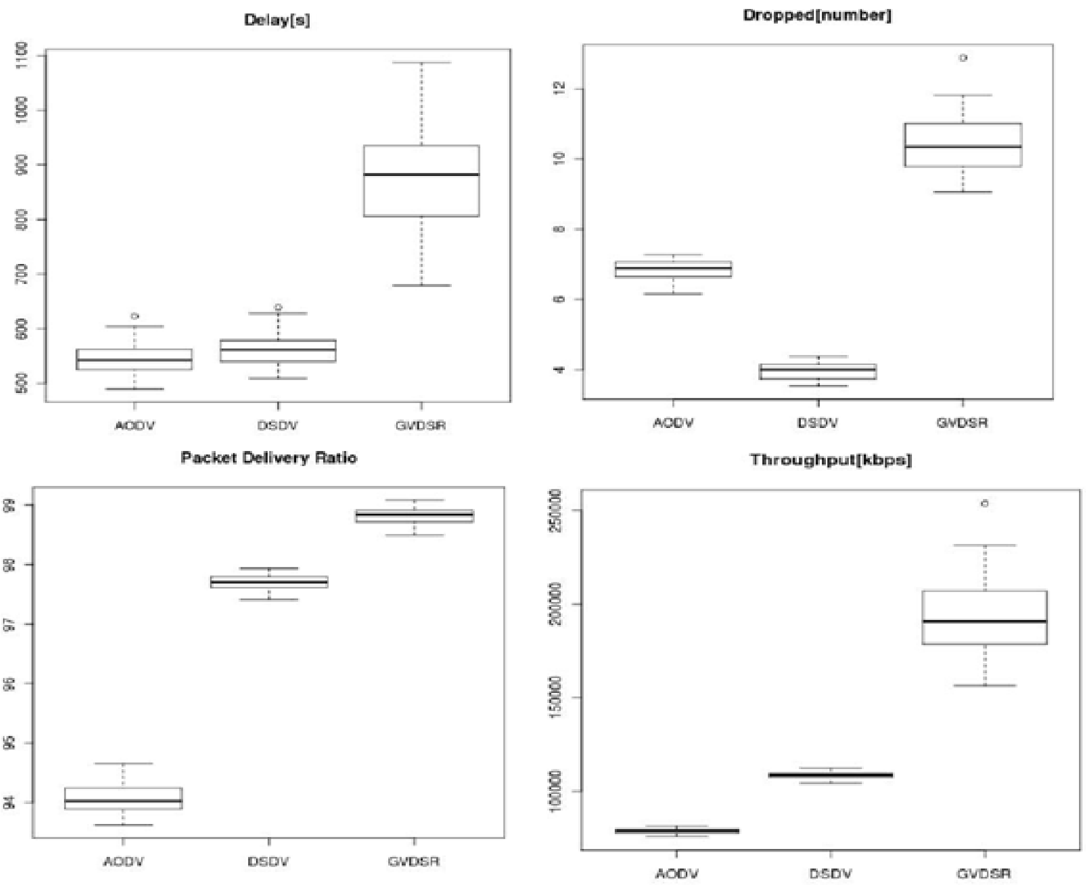

Figure 2. All results for scenario A.

The delay showed that techniques which control their routes through routing tables instead of lists of hops can be traced to more quickly locate the nodes in the environment and therefore deliver the package more quickly. Finally, regarding the dropped of packages, the DSDV again showed poorer results than other algorithms, which was expected since it had already presented a lower packet delivery rate than the others. It may be noted from the graph that the methodology for routing architecture performed better, but one cannot draw final conclusions because the methodology and presents results approximate reactive. From the graphical analysis we can refute the hypothesis H2-0. The reactive methodology is not the best for VANET since exists an assimilation of the AODV and GVDSR protocols. This fact guide us to more simulation analysis for guarantee the contribution of the architecture methodology for VANETs.

5. CONCLUSION

This paper presents the performance evaluation of three different routing methodologies for vehicular networks: proactive routing, reactive routing and routing architecture. Three scenarios were chosen with differing patterns of mobility and dispersion of vehicles. The first scenario is an urban area of the city of Malaga. The second scenario is a road perimeter of the city of Malaga. The Manhattan mobility model with a fixed number of nodes, as in previous scenarios, is presented as the third scenario. In all scenarios, the type of application was used CBR (Constant Bit Rate) over UDP, with a rate of 4 packets/second. Also for all scenarios, the speeds of the cars were chosen between 5 and 30 m/s. The simulations were done in Network Simulator 2, where they were each scenario was run 50 times to ensure statistical inferences.

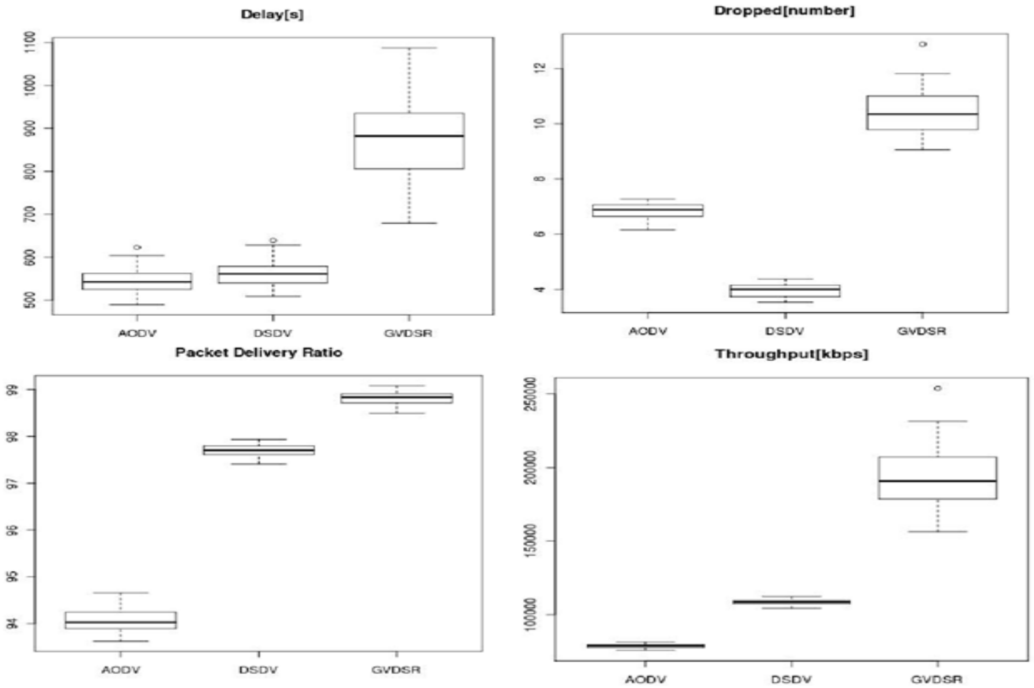

Figure 3. All results for scenario B.

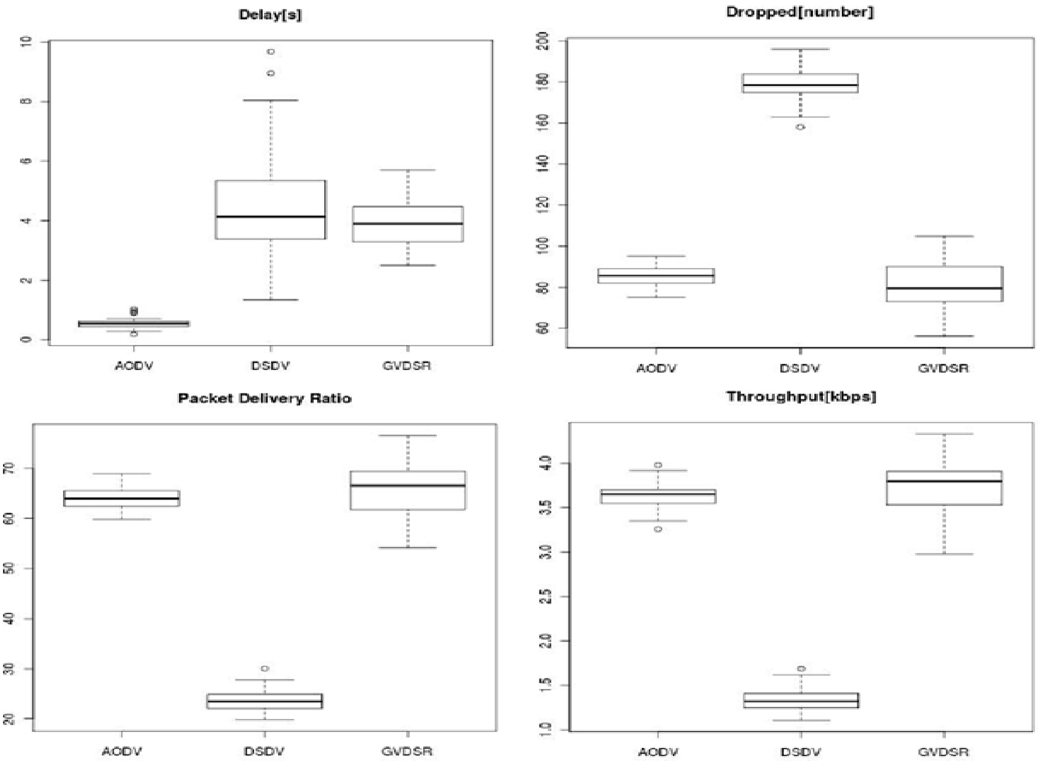

Figure 4. All results for scenario C.

The three scenarios used may note that there is a match between the routing protocols AODV and GVDSR. We note that the main difference between these two protocols is the delay, but which in fact may be impacting on these networks is the jitter that was not measured in the experiments. In order to a just conclusion of the methodologies and reactive routing by a routing architecture, and as the basis for the protocol is DSR the GVDSR in which all the features of DSR are preserved only by adding new technologies. It is noted in the literature, but in particular[Mittal 2009] a significant difference between protocols DSR and AODV, in which the architecture has raised the performance of DSR in the form of GVDSR to match in some metrics such as AODV. The author suggests a change in the basis of the routing architecture for vehicular networks, developing and evaluating a new protocol's performance.

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