A new Advanced Greedy perimeter stateless routing for Vehicular Ad Hoc Networks

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Abstract. In VANET, Vehicles can be seen as probes that locally detect traffic status. Various applications that target transport efficiency could make use of the vast information collected by the vehicles; however, this collection of information needs to be transported over larger distances. For this purpose, various protocols were proposed in the literature and are surveyed in this paper. The information dissemination 'lifecycle' is structured in four phases: obtaining information, transport of information, summarization of measurements, and aggregation of information. In this paper, we will focus on the first and second phases to insure the transport of information. And we improve the behavior of GPSR protocol in term of delay and throughput to deal with the limited capacity of the vehicular wireless network.

Keywords: VANET, routing protocol, simulation, delay, throughput, delivery ratio.

1 Introduction:
One of the fastest-growing domains of interest in VANET is safety, where communications are exchanged in order to improve the driver's responsiveness and safety in case of road incidents. To improve road safety or allow Internet access for passengers, many research works are interested in Ad Hoc wireless networks due to their low cost when there is a need to communicate in the absence of infrastructure, road safety systems have been emerged to ensure exchange inter-vehicle and fixed vehicle infrastructure information in a wireless network.

2 Related work:
2.1. Vehicle communication:
Vehicular communications and networks are expected to be used for a number of purposes such as for enabling mobile users to transfer data and information from other networks such as the Internet and for implementing services such as Intersection Decision Systems (IDS), Automated Highway Systems (ARS), and Advanced Vehicle Safety Systems (AVS) [1].

In the V2V communication, Messages need to be routed from the source to one or several destinations, so in the next paragraph we describe the routing technique to present our contribution.

2.2. Routing techniques
We are interested to the Vehicle to vehicle communication. One way to propagate information between vehicles very fast is to use flooding. In a naive implementation every node that receives this information will simply rebroadcast it. To avoid infinite packet duplication, each node will broadcast a given packet at most once. In addition a time to live (TTL) counter may be used to limit the area where the packet is
distributed. This naive approach will transmit a large amount of redundant packets, potentially leading to severe congestion. This is known as the 'broadcast storm problem'[2]. Many approaches have been proposed to deal with this problem.

Ad hoc unicast routing schemes can be divided on two categories: First category is topology base, this use a proactive or reactive approach to create routes [3]. Second category is based on the position [4], it use not routing tables to store route. Instead, they use position information about neighboring and destination to identify the next node forwarding to destination.

The routing protocols can also be defined as flat routing or hierarchical routing. In the first one, each node has the same responsibility in the routing process. But this technique suffers from scalability issues but still is the most popular ad hoc routing techniques. The second technique is only assigned to a certain number of nodes that provide required routing information to the rest of the nodes.

Paper [5] analyzed the performance of OLSR protocol treated in paper [6] and AODV protocol [7] in a vehicular network. They used CAVENET simulator to generate the vehicles movement and NS3 as network simulator to test the performance of routing protocols. As a results we notice that OLSR is better than AODV for high values of transmission rates.

The authors of [8] analyzed AODV, AOMDV, DSDV and DSR using NS2 simulator for different vehicle’s velocity. We note that DSR is better in case of the throughput and the end to end delay. Whereas in case of PDR (Packet Delivery Ratio) and packet loss, AOMDV and AODV are better.

As for the work[9], the authors analyzed the performance of routing VANET protocols GPSR and AODV [10] using NS2 simulator with VanetMobiSim, under Packet Delivery Ratio (PDR) and average End-to-End Delay (E2ED) as comparison metrics. The GPSR performs better than AODV in case of E2ED.

Recently, some routing protocols for VANETs have been improved, and especially for GPSR protocol. In the following, we discuss this protocol.

2.3. GPSR protocol:
The GPSR “Greedy Perimeter Stateless Routing” algorithm is based on two methods to forward packets [11]: greedy forwarding, which is used wherever possible, and perimeter forwarding used in the regions where greedy forwarding is unused.

2.3.1. Greedy forwarding method:
The greedy approach is often used by routing protocols especially VANET geographic protocols for selecting the next neighbor [12].
In the operation of GPSR every node maintains the knowledge of its one hop neighbors. Each node participating in routing process selects the next-hop closest to the destination (figure 2). This procedure is called greedy forwarding. In GPSR, the locations of neighbors are obtained by exchanging periodic HELLO messages among nodes. When node receives a HELLO message from its neighbors, it sets the HELLO timer (Ht) for each of its neighbors for the next reception of the HELLO message. If it does not receive HELLO message from a neighbor before the HELLO timer expires, it assumes that the neighbor has gone out of range.

The objective of GF is to choose the next node according to its distance from the destination "u" represents the source "d" represents the destination; “v” is a candidate node.

![Figure 2: Greedy forwarding algorithm](image.png)

To reach the destination “u” will chose “v” as a farthest node in the direction of destination to send information in a shortest delay.

The greedy forwarding algorithm can fail when there is no node in every 120° angular sector

### 2.3.2. Perimeter forwarding method.

When the Greedy Forwarding algorithm fails, the Perimeter Forwarding algorithm will be used. Apply the right-hand rule to traverse the edges of the void and find a path using the topology’s perimeter as shown the figure 3.

![Figure 3: the right-hand rule.](image.png)

The combination of the two algorithms of Greedy and Perimeter Forward allows creating the GPSR protocol which will use the algorithm (s) necessary to find the best path in a given topology.

![Figure 4 : The necessary algorithm for GPSR](image.png)
The Greedy Forwarding mechanism appears promising for VANET networks so we decided to optimize this mechanism and we call it Greedy Forwarding Advanced (GFA).

### 3 Amelioration of greedy forwarding method

The process of communication is composed of the following steps:

- Election of the vehicle which is near to the candidate junction to send the message
- Electing the vehicle closest to the center of the cell

Enrichment of the aggregation package elected by the vehicle, by adding information about: traffic density, the position of the center, the identifier of the cell i, and send the packet to the vehicle closest to the cell i+1. So, it can quickly reach the range of the vehicle so as to arrive faster to elected vehicle in the cell i-1 (repeat the procedure until getting the vehicle to a cell I which is the source junction)

The procedure is composed of following step:

- Take into consideration the distance between the vehicle, the next cell, the speed of candidate nodes and the geographical position of these nodes
- The notion of score will also be assigned to the node according to time: \( tp = \frac{(xp-xi)}{vi} + ti \) (1) The node will be selected is the node with the minimal score (figure 5)

With:

- \( tp \): time needed to reach the limited scope of the vehicle
- \( S \)
- \( ti \): Vhi moment the vehicle and the position \( xi \)
- \( Xi \): Vhi position of the car at time \( t \)
- \( Xp \): scope of the vehicle \( S \)
- \( Vi \): Car speed Vhi

To send data between two junctions, we consider:
- The direction of the next vehicle
- The speed of this vehicle.

The proposed GF algorithm is as follows:

- The node \( Ni \) receives the packet,
- If a node or group of nodes are within the reach of node \( Ni \),
- Then select the node that has the smallest \( tp \) score,
• Otherwise, save the package to find a node in its scope and select the one with the lowest score
• Repeat these steps until to reach D (destination).

Each vehicle maintains a neighbor table where all information mentioned above is registered.

In the following, we will compare between the classic greedy forwarding algorithm and our amelioration
AGF “Ameliorated Greedy Forwarding” described above.

4 Simulation in NS3
4.1 Simulation of GFA
Firstly we compare between GF (Greedy Forwarding) method and our proposition which we call GFA
(Greedy Forwarding Advanced)

The simulation model is a small section of road (600m in length)

Table 1. GFA simulation parameters

| Parameter                  | Value                  |
|----------------------------|------------------------|
| Topologie                  | 600*9                  |
| Simulation time            | 200s                   |
| Capacity of the medium     | 2Mb/s                  |
| Radio propagation model    | Two ray ground         |
| The communication range    | 250M                   |
| Machine                    | System 64 bits, 4 GO   |
|                            | RAM                    |
According to the simulation, our algorithm has a lower end to end time. GFA has a better performance compared to GF approach especially in the case where the distance between the candidate nodes is small and the speed of the further node is low compared to other candidate’s nodes.

According to the results and in order to improve the operation of the GPSR protocol, we introduce the GFA instead of classic Greedy Forwarding method, and we compare between classic GPSR and our proposition AGPSR “Advanced Greedy Perimeter Stateless Routing”.

4.2. Simulation of AGPSR

AGPSR is simulated using NS3 [13] as a network simulator, while the urban traffic mobility is simulated using SUMO [14].

SUMO is an open source, highly portable, microscopic and continuous road traffic simulation package designed to handle large road networks.

We simulate the traffic in Mohammedia city, it is a municipality of Morocco located near Casablanca which is the biggest and crowded city in morocco.

This grid is used to model a common road network for an urban scenario formed by streets and crossroads. To make the simulation more realistic, we use SUMO to generate the movement of vehicles that is restricted by the road network as shown in figure 8.
In Figure 8, we use a real-world urban map extracted from the Open StreetMap.

The map of Mohammedia city is extracted from online database Open Street Map (OSM), the map is imported to SUMO tool by converting map file into .net.xml file by using NETCONVERT utility of SUMO.

The conditions of the simulation are as below:

| Table 2: AGPSR simulation parameters |
|-------------------------------------|
| Simulation parameter               | Value                          |
| Transmission range                 | 250 m                          |
| Data channel rate                  | 6 Mbps                         |
| Traffic type                       | Constant bit rate (CBR)        |
|                                    |                                |
| CBR data size                      | 512 bytes                      |
| CBR generating rate                | 2 packets/s                    |
| Moving velocity                    | 30–50 km/h                     |
| Simulation time                    | 200 s                          |
| Mac layer                          | IEEE 802.11p                   |
| Machine                            | System 64 bits, 4GO RAM        |

In order to evaluate the performance of our proposed method compared to investigate performance factors (the packet delivery ratio, average end-to-end delay).
Packet delivery ratio represents the ratio of packets that are successfully received. Average end-to-end delay represents the average delay of packets that are successfully delivered from source vehicles to destination vehicles. Each simulation instance is simulated 10 times and then we take the average of the resulting values.

In the graph of Figure 9, the packet delivery ratio of the two protocols decreases as the vehicle speed increases. We can also observe that packet delivery ratio is better for AGPSR than GPSR protocol and inversely proportional to the speed. This is explained by the fact that AGF gives better performance that GF as shown in figure 6, and AGF help the node to select the right relay to reach the destination before expiration of TTL.

Analyzing the results of Fig. 10, we can conclude that AGPSR presents the lowest E2E delay. However, the delay of AGPSR and GPSR decrease when the node density increases, caused by the use of the
greedy algorithm. Since the time, taken to route packets efficiently to the final destination, is reduced by using AGF.

Overall, the results confirm that the relay selection mechanism using GFA as metric for routing in VANETs with heterogeneous communication range leads to a better selection of next-hop nodes for increasing the packet delivery ratio and decreasing the average end-to-end delay.

5 Conclusion and further work
The GPSR protocol is one of the best routing VANET protocols in case of end to end delay and Packet delivery ration. The article evaluates and compares our proposition called AGPSR and GPSR protocol used for VANETs, using SUMO and NS-3 simulators, to determine the benefits and challenges of each protocol. From this work, performance of AGPSR could be considered as the best one for this scenario in terms of E2E delay and PDR. Indeed, AGPSR and GPSR are based on the location of the destination which is carried in the packet, so the retransmitting nodes don’t need the location information again, so it reduce the overhead.

The field of routing protocols in VANET is an important research topic; many related open issues and problems still need to be resolved. As a future work, we will consider more metrics that affect network performance, such as the size of the map and the model of propagation.

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