GyTAR: improved Greedy Traffic Aware Routing Protocol for Vehicular Ad Hoc Networks in City Environments

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1. Introduction

The fundamental component for the success of VANET (Vehicular Ad hoc NETworks) applications is routing since it must efficiently handle rapid topology changes and fragmented network conditions. Current MANET (Mobile Ad hoc NETworks) routing protocols fail to fully address these specific needs especially in a city environment (nodes distribution, constrained but high mobility patterns, signal transmissions blocked by obstacles, etc.).

To address the specific needs of VANET, some routing protocols have been recently proposed. Among them, GSR [1] (Geographic Source Routing) and A-STAR [2] are the most important ones. These protocols suffer however from many several limitations. Indeed, improved protocols are often based on a simple greedy forwarding concept (closest vehicle to the destination) and do not takes into account neither the vehicle direction nor its velocity. Also, the real time traffic road conditions criterion is not considered in the routing or forwarding decision. Moreover, key characteristics of vehicle to vehicle communications context such as: multi-lanes and multi direction roads, spatiotemporal traffic road variations, were not implied in the previous studies.

In this work, we present a novel geographical routing protocol for vehicular networks in urban environment called GyTAR: improved Greedy Traffic Aware Routing protocol. Based on a localization system like the GPS (Global Positioning System), GyTAR aims to efficiently relay data in the network considering the real time road traffic variation and urban environment characteristics. It also takes into account information about vehicles speeds and directions since we consider real city configuration with multi lanes and double direction roads. GyTAR aims to efficiently use the network resources (wireless bandwidth) by limiting the control message overhead, and to route data packets from sources to destinations in the vehicular network with a reduced end-to-end delay and low packet loss.

2. GyTAR - improved Greedy Traffic Aware Routing Protocol

GyTAR is a new intersection-based geographical routing protocol capable to find robust routes within city environments. It consists of two modules:

2.1 Junctions selection:

In GyTAR, junctions[1] through which a packet must pass to reach its destination are chosen dynamically and one by one in order to take into account the real time vehicular traffic variation. When selecting the next destination junction, a node (the sending vehicle or an intermediate vehicle in a junction) looks for the position of the neighboring junctions using the map. A score is given to each junction considering the traffic density Tj and the curvemetric[2] distance Dj to the destination. The best destination junction j is then the junction with the highest score:.

$S(j) = \alpha \times f(Tj) + \beta \times g(Dj)$,

where α and β are weighting factors.

Figure 1 shows an example of how the next junction is selected on a street. Once vehicle *A* receives a packet, it computes the score of each neighboring junction. Considering its curvemetric distance to the destination and the traffic density, junction (2) will have the highest score. Then, it will be chosen as the next anchor.

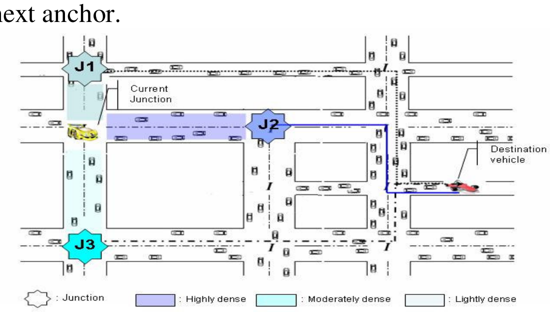

Figure 1. Selecting junctions in GyTAR.

[1] A junction is a place where two or more roads join or meet.
[2] This term describes the distance measured when following the geometric shape of a road.

2.2 Forwarding data between two junctions

Once the destination junction is determined, the improved greedy strategy is used to forward packets towards the selected junctions. For that, all data packets are marked by the location of this junction. Each vehicle maintains a neighbor table in which position, velocity and direction of each neighbor vehicle are recorded. This table is updated through hello messages exchanged periodically by all vehicles. Thus, when a packet is received, the forwarding vehicle computes the new predicted position of each neighbor using the recorded information (velocity, direction and the latest known position), and then selects the next hop neighbor (i.e. the closest to the destination junction).

Recovery strategy:

Despite the improved greedy routing strategy, the risk remains that a packet gets stuck in a local optimum[3] (the forwarding vehicle might be the closest to the next junction). Hence, a recovery strategy is required. The repair strategy of GyTAR is based on the idea of "carry and forward": the forwarding vehicle of the packet in a recovery mode will carry the packet until the next junction or until another vehicle, closer to the destination junction, enters/reaches its transmission range.

3. Simulation Results

To evaluate the performance of our proposed approach, we used the Qualnet simulator. We implemented two versions of our proposed protocol: B-GyTAR (Basic GyTAR without local recovery), and GyTAR with the recovery strategy. They are compared to two well-known ad-hoc routing protocols: DSR (Dynamic Source Routing) [3], and LAR (location Aided Routing) [1]. All the key parameters of our simulation are summarized in the following table:

Parameter	Setting
Traffic model	15 CBR connections
Data packet size	128 bytes
Packet sending rate	0.2 second
Number of vehicles	300
Transmission range	~266 m
Map size	2500x2000 m2
Number of intersections	16
Number of roads	26
Vehicle velocity (City)	30-50 ± 5 Km/h
MAC protocol	IEEE 802.11 DCF
Simulation time	200s

Table 1 : Simulation Setup

In Figure 2, we measured the packet delivery ratio versus the nodes number. In general, GyTAR achieves the highest packet delivery ratio for the different nodes number. This is mainly because GyTAR does not need to keep track of an end-to-end route when relaying data packets from source to destination; the path is determined progressively following road traffic density and urban environment characteristics.

[3] Situation where there is no neighbor of the forwarding node s, which is closer to destination than s itself.

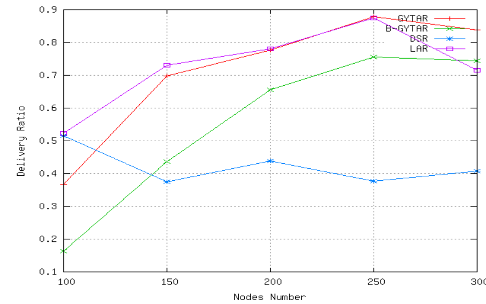

Figure 2. Delivery ratio vs. nodes number

In Figure 3, we evaluate the overhead of the four protocols as function of data sending rate. B-GyTAR and GyTAR show good results. This is expected since in GyTAR, we have only the hello messages as control messages and we have already seen that the fraction of data packets that are successfully delivered to their destination vehicles is high. While in LAR and DSR, we have three types of control messages (Route Request, Route Reply, and Route Error). Furthermore, these control messages are generated each time a route is lost which is very common in VANETs increasing the control overhead.

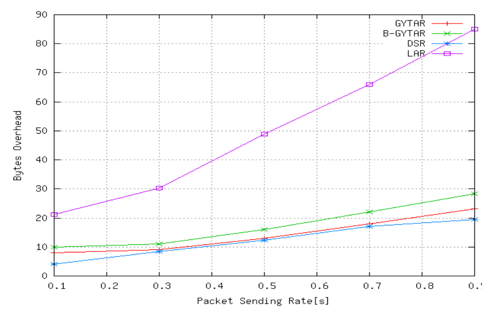

Figure 3. Control overhead vs. Packet sending rate

4. Conclusion and Future Work

In this work, we have presented an improved greedy routing protocol (GyTAR) which uses real time traffic density information and movement prediction (following direction and speed) to route data in vehicular ad hoc networks.

As for future works, we are currently studying approaches for real time inference of road densities.

5. References

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