Smart Broadcast of Warning Messages in Vehicular Ad Hoc Networks*

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Abstract

Broadcasting of safety messages is one of the fundamental services in vehicular ad hoc networks (VANETs). These services typically require to deliver the information to all vehicles traveling over a geographical area, with high reliability and low delay. In this document, we study the performance of a forwarding scheme and a channel access mechanism for improving the efficiency of message broadcasting in VANETs. The proposed channel access scheme is based on a spatial differentiation approach: vehicles that are about to rebroadcast the message access the channel with different priorities, depending on their distance from the last vehicle that retransmitted the message. We study the performance of the proposed solution by simulation and present some preliminary results.

I. Introduction

Transportation safety is one of the most important applications of vehicular networks. Vehicles can communicate information on traffic and road conditions with each other, as well as with fixed network nodes. The dissemination of emergency messages to all vehicles is a crucial problem in traffic scenarios such as for instance in case of accident the dissemination of safety messages may prevent secondary accidents and play a crucial role in the rescue of people It is therefore important to ensure a reliable broadcasting of warning and alarm messages, with low delivery delay.

Broadcast solutions in the context of VANETs are studied in [1], [2], [3], [4]. In [3], an IEEE 802.11-based scheme is proposed to address the broadcast storm and the hidden terminal problems in urban areas. The use of IEEE 802.11e EDCA scheme for priority access is investigated in [2], where the authors study through simulation the broadcast reception rate in presence of different channel propagation models. The performance of the optimum broadcast algorithm defined over the node minimum connected dominating set is studied in [4], in the case of a unidimensional ad hoc network.

In this work we rely on the solutions proposed in [6] and in [7], and compare the two schemes under a simple network scenario. Some preliminary results have been derived by using OPNET.

II. System Description and Assumptions

We focus on a unidimensional inter-vehicular network, where vehicles travel over a single-lane road. Vehicles are randomly distributed with spatial density ρ, and the minimum inter-vehicle distance is set to 5 m.

All vehicles have a common coverage radius, R, and are equipped with a GPS. Thus, upon a message reception, a vehicle is able to detect whether the sender is located ahead or behind, as well as its own distance from the sender.

*This work was supported partially through the NoE NEWCOM Project and partially by Politecnico di Torino, Universit`a di Padova, and Universit`a di Torino.

III. Message Broadcasting

In this section we propose a channel access mechanism and a forwarding scheme that aim at reducing the latency and the overhead of message broadcasting.

At the MAC layer, we consider an access scheme based on the CSMA/CA mechanism (e.g., based on the IEEE 802.11 standard). The key idea is to assign different access priorities to the vehicles that are currently in charge of forwarding the message, so that the advancement corresponding to a message hop is maximized.

Let v be the last vehicle that (re)broadcasted the message. We define different forwarding zones within the coverage range of v, and assign to the vehicles belonging to each zone a different value of contention window, CW. The larger the distance from the sender v, the smaller the contention window.

We consider the two following methods to assign the contention window values:

- **Smart Broadcast A**: vehicles belonging to different zones are assigned disjoint contention windows. As an example, given three zones, the corresponding contention windows can be selected as: $[0, 7]$,$[8, 15]$,$[16, 31]$.
- **Smart Broadcast B**: the contention windows assignment reflects the 802.11e proposal [5]. I.e., in the case of three zones, we have: $[0, 7]$,$[0, 15]$,$[0, 31]$.

Furthermore, we consider that a vehicle aborts its rebroadcast attempt if it hears the same message being rebroadcasted by a vehicle ahead. Doing so, the broadcast overhead is reduced.

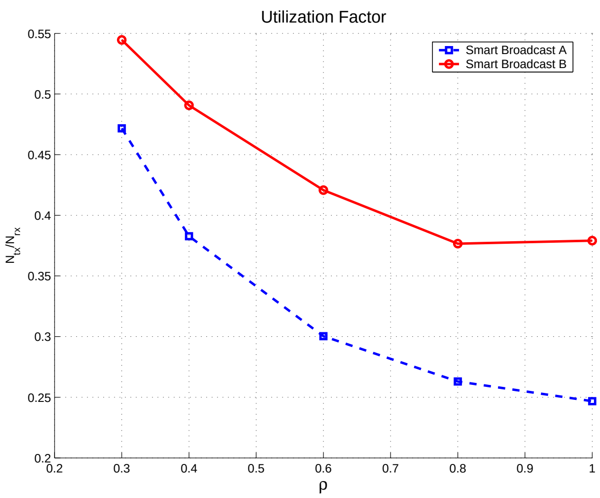

Fig. 1. Channel utilization as a function of the vehicle density, ρ

IV. Simulation Results

We implemented the message forwarding and the two schemes, *Smart Broadcast A* and *Smart Broadcast B*, as described in Section III, in OPNET.

We considered three possible zones and set the associated contention windows as $\{[0, 7]$,$[8, 15]$,$[16, 31]\}$ in the case of the Smart Broadcast A, and as $\{[0, 7]$,$[0, 15]$,$[0, 31]\}$ for the Smart Broadcast B. The road length is set to 3.5 km, and the nodes communication range R is equal to 45 m. The packet size is 32 bytes and the packet physical and MAC headers are as defined by the IEEE 802.11 standard; the transmission data rate is equal to 1 Mbps.

Several instances of network topology have been simulated through OPNET, and plots have been obtained by averaging over the results derived from the different simulation instances.

Figure 1 shows the channel utilization, defined as the ratio of the number of retransmitting nodes to the number of nodes that successfully receive the broadcast message. Results are presented as functions of the vehicle density ρ, and give an insight on the efficiency of the proposed schemes with respect to flooding, where the number of retransmitting nodes is equal to the number of receiving nodes (i.e., the flooding utilization factor is always equal to 1). The plot shows that the Smart Broadcast A outperforms the Smart Broadcast B, since using disjoint contention windows ensures that the furthest vehicles with respect to the previous sender have the highest priority in accessing the channel. It follows that less transmissions are necessary to broadcast the message along the road. The effect is more remarkable for high values of vehicle densities, since disjoint contention windows also reduce collisions.

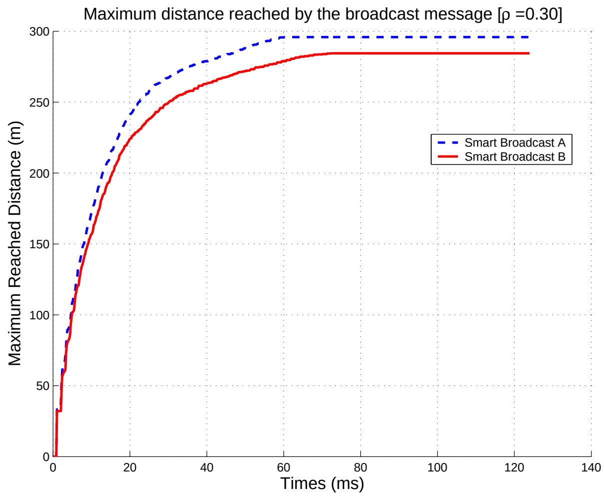

Fig. 2. Maximum reached distance as a function of time, for ρ=0.3

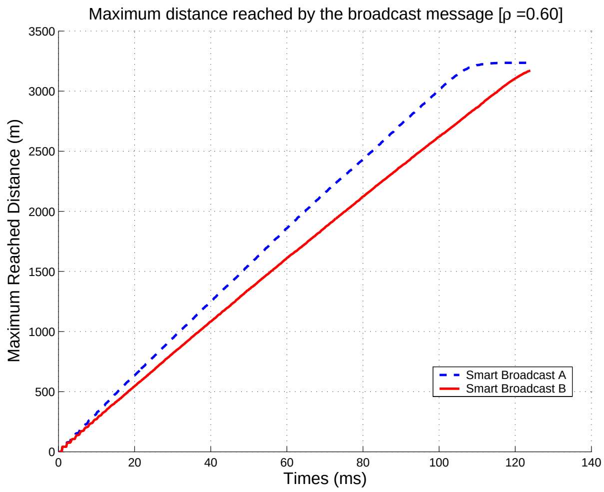

Fig. 3. Maximum reached distance as a function of time, for ρ=0.6

Figures 2–4 present the maximum distance reached by the broadcast message as a function of time for different values of vehicle density (namely, ρ =0.3, 0.6 and 1.0). The performance between the Smart Broadcast A and the Smart Broadcast B varies depending on the value of ρ. For low vehicle densities, the difference in performance is negligible as shown in Figure 2. We highlight that more extensive simulations are actually needed for low values of ρ to better understand the two schemes behavior. For larger ρ's, instead, disjoint contention windows provide a smaller collision probability, resulting in a smaller broadcast latency.

V. Conclusions and Future Work

In this paper we addressed the problem of message broadcasting in VANETs. We compared the performance of two schemes, previously proposed in [6], [7], and presented some preliminary results. A more thorough performance evaluation will be subject of future research. In particular, we intend to assess the performance of the two schemes when larger transmission ranges and high values of vehicles densities are considered, while the number of zones are kept constant, as well as for low vehicle densities. Also, a comparison with other broadcasting schemes proposed in the literature would be of great interest.

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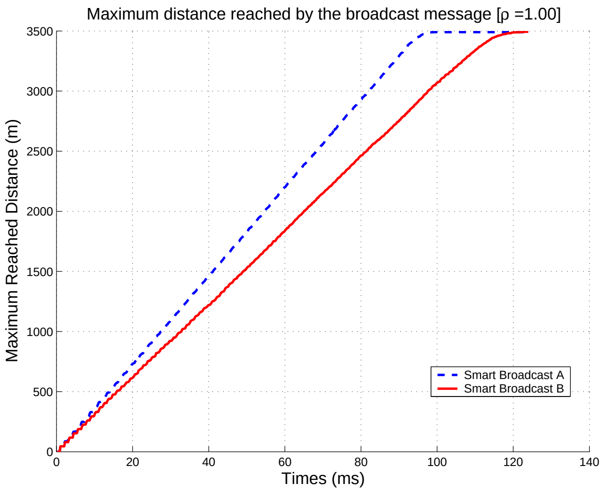

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