Automatic IP Address Configuration in VANETs

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***Abstract*— Cars' high mobility and density impede the direct utilization of traditional networking techniques and protocols in vehicular networks. In this context, automatic IP address configuration is a challenging and yet unexplored issue. We propose a novel scheme that exploits the topology of Vehicular Ad-hoc Networks (VANETs) and an enhanced Dynamic Host Configuration Protocol (DHCP) service with dynamically elected leaders to provide reliable and fast address configuration.**

Keywords: VANETs, address configuration.

I. Introduction

In the field of inter-vehicular communication (IVC) a plethora of appealing services emerges that involves vehicles located in proximity of each other (i.e., navigation safety, online games, data/file sharing). These vehicles can be connected in an ad-hoc fashion thus creating Vehicular Ad-hoc Networks (VANETs). Even in this context, effective communication is possible only if each node can be identified through a unique and automatically assigned address.

Existing VANET literature bypasses the issue of node configuration by assuming that nodes are configured *a priori*. However, this issue cannot be skipped so easily since neither address autoconfiguration protocols for traditional fixed networks nor solutions proposed for classic ad-hoc networks can be directly applied to VANETs [2][4][1]. Indeed, VANETs have unique characteristics that require a specific analysis of the problem [3]: very high mobility, theoretically infinite extension, absence of a centralized control, and intermittent connectivity through the sparse infrastructure.

In this paper we propose a novel automatic IP address configuration protocol named *Vehicular Address Configuration* (VAC), which is specifically designed for this scenario. In particular, VAC exploits the topology of a VANET and a distributed Dynamic Host Configuration Protocol (DHCP) run by dynamically elected Leader-vehicles to quickly provide unique identifiers and reduce the frequency of IP address re-configurations due to mobility.

II. System Model

DSRC/802.11p is a wireless communication technology that supports vehicles' communication within a maximum transmission range of $1000m$. Therefore, the width of streets and freeways becomes negligible with respect to the communication range. We can hence assume that the topology of the network is linear and reduce our case study to a group of nodes that move following a track with an internal mobility with respect to each other. Considering that vehicles on a freeway have speeds between $50-70mph$ ($22-31m/s$), the relative velocity among them is generally in the range $0-20mph$ ($0-9m/s$).

III. Vehicular Address Configuration Protocol

VAC represents the first protocol for IP address configuration in VANETs. It is a Leader-based protocol and is meant to provide unique identifiers to nodes in the VANET that are located within a given distance. VAC organizes Leaders in a connected chain so as to have every node in the communication range of at least one Leader. The hierarchical organization of the network allows limiting the signal overhead for the address management tasks. Only Leaders communicate each others and maintain updated information on configured addresses in the network.

Leaders act as servers of a distributed DHCP protocol and Normal nodes ask Leaders for a valid IP address whenever they need to be configured.

VAC guarantees unique IP addresses within a delimited area around each Leader, called *SCOPE*. To elaborate, the *SCOPE* of Leader A is the set of Leaders whose distance from A is less or equal to $scope$ hops. Considering the normal node Y that received the *IPy* address from A, *IPy* will be unique as long as Y moves within the *SCOPE* of A. If Y goes out of the *SCOPE* of A, in order to still ensure address uniqueness, Y has to ask for another address to the new Leader. Considering that the relative speed between nodes is low, changes in the address configuration due to having left the own Leader's $SCOPE$ are not frequent.

This represents an important contribution of our work since, in any case, these changes would be much more frequent if vehicles had to rely on fixed Internet Gateways (IGs) to obtain their IP addresses. To this aim, Figure 1 shows the time duration of an IP address from when it is assigned to a node to when the node needs to be re-configured. Three cases are compared: i) a car travelling at 60mph through the coverage area of a fixed IG , ii) a car travelling through the coverage area of a Leader with $scope = 0$, and iii) a car travelling through the coverage area of Leaders implementing VAC with $scope = 4$. As expected, case i) presents a constant outcome (30s), while cases ii) and iii) are able to ensure much higher stability to the address configuration.

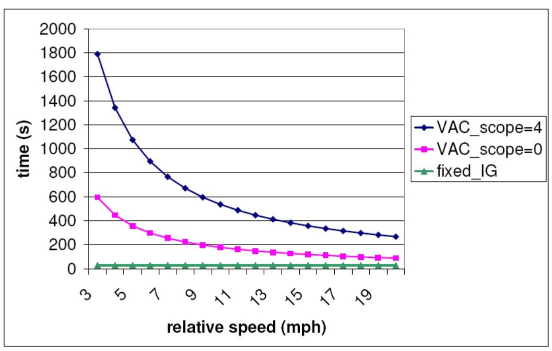

Fig. 1. Address validity time with 400m coverage range.

IV. Preliminary Results

VAC has been implemented in Qualnet version 3.7. Simulations were configured with 50 mobile nodes moving over a $15000m$x$20m$ terrain. Nodes joined the network with a certain $inter\_arrival$ time in the range $0.5 - 2s$, and moved along the Cartesian x-dimension with a random speed in the range $26 \pm (vel\_gap/2)\, m/s$, where vel_gap is the gap between the minimum and the maximum speed of nodes in the scenario.

The main goal of VAC is to perform a reliable address configuration service with low configuration time in order to efficiently support every kind of application. Indeed, during the address configuration procedure data cannot be delivered, it is hence important that the configuration time remains low. To this aim, Figure 2 shows that nodes are able to configure valid addresses in less than 70ms. This represents a very good result for it proves that VAC is suitable even for real-time applications. Finally, as emerges from Figure 2, the configuration time results independent from node mobility and node density.

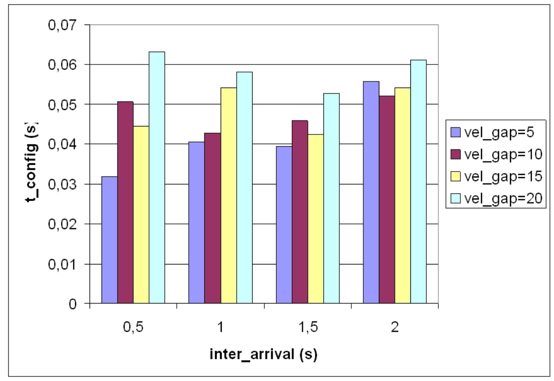

Fig. 2. VAC's configuration time with *scope* = 4.

V. Conclusion

In this paper we have discussed the IP address configuration in VANETs. The unique characteristics of vehicles preclude us from directly applying techniques developed for traditional ad-hoc networks. Consequently, we have developed VAC, an efficient protocol for the IP address configuration in VANETs that is characterized by low configuration time.

References

[1] M Fazio, M Villari, and A. Puliafito. IP Address Autoconfiguration in Ad Hoc Networks: Design, implementation and Measurements. *Computer Networks Journal, Elsevier Science Publisher*, 50:898–920, 2006.

[2] S. Nesargi and R. Prakash. MANETconf: Configuration of Hosts in a Mobile Ad Hoc Network. In *INFOCOM 2002*, New York, June 2002.

[3] A.K. Saha and D.B. Johnson. Modeling Mobility for Vehicular Ad Hoc Networks. In *poster at ACM VANET 2004*, October 2004.

[4] Y. Sun and E. M. Belding-Royer. A Study of Dynamic Addressing Techniques in Mobile Ad hoc Networks. In *Wireless Communications and Mobile Computing*, pages 315–329, April 2004.