Demo: Information Dissemination in Multi-technology Vehicular Networks

Idoia de la Iglesia*†, Pedro M. d'Orey*, Nitin Maslekar*, and Unai Hernandez†
* NEC Laboratories Europe, Kurfürsten-Anlage 36, 69115 Heidelberg, Germany
{idoia.delaiglesia, pedro.dorey, nitin.maslekar}@neclab.eu
†DeustoTech-Mobility, University of Deusto, Av. Universidades 24, 48007 Bilbao, Spain
{idoia.delaiglesia, unai.hernandez}@deusto.es

***Abstract*—Vehicular Networks enable a vast number of innovative applications, which rely on the efficient exchange of information between vehicles and infrastructure (V2V/V2I). However, efficient and reliable data dissemination is particularly challenging in the context of vehicular networks due to the underlying properties of these networks, limited network infrastructure availability and variable penetration rates. In this paper, we present and demonstrate an information dissemination system based on virtual infrastructure selection in combination with multiple communication technologies. The simulation-based demonstration shows the feasibility of the system to achieve maximum message penetration with reduced overhead.**

I. INTRODUCTION

Vehicular Networks enable a vast number of innovative applications, which rely on the exchange of information between nodes and can greatly benefit from information generated far away (e.g. to warn drivers of accidents and road works ahead). Efficient and reliable data dissemination is a challenging task, specially in the context of Vehicular Networks. Timely data dissemination in large scales is challenging due to a number of reasons, namely: i) the underlying properties of Vehicular Ad Hoc Networks (VANETs) (e.g. network partitioning), ii) the limited static infrastructure availability (e.g. VANET Vehicle to Infrastructure (V2I) infrastructure) iii) non-optimal single technology info dissemination (e.g. 802.11p may have lower latency, while cellular networks might provide wider coverage), and iv) the variable penetration rates for the several communication technologies.

To address the above mentioned challenges, we propose in [1] a novel system and mechanism for information dissemination in multi-technology vehicular networks. In this paper, we propose a method for selecting virtual infrastructure, i.e. mobile (either stationary or moving) infrastructure nodes, in combination with multiple communication technologies for efficiently and reliably increasing the penetration of information in a geographic region. On the one hand, selecting appropriate vehicles as virtual infrastructure can alleviate the requirements for fixed infrastructure. On the other hand, by combining multiple communication technologies, their advantages in terms of characteristics and performance can improve the system overall performance while still considering variable penetration rates. To optimize the election of vehicles as virtual infrastructure an optimal dissimilarity relation is defined among vehicles under constraints, such as vehicle mobility, network load, application requirements.

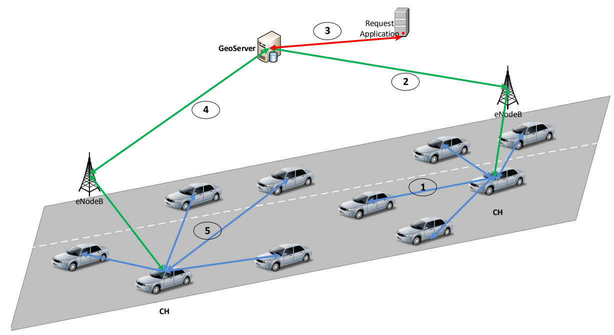

Fig. 1. Multi-technology information dissemination system:(1) Periodic broadcast of CAMs allows collecting information on the dynamic neighborhood relation. (2) Communication to geoserver of aggregated neighbor tables; (3) Data dissemination request and virtual infrastructure selection at geoserver; (4) Information dissemination execution and (5) Local data dissemination by virtual infrastructure.

II. MULTI-TECHNOLOGY INFORMATION DISSEMINATION

The multi-technology information dissemination system relies on the collection of neighborhood information of vehicles to determine the best data dissemination strategy at a centralized location. The system selects virtual infrastructure nodes (vehicles) in a multi-technology vehicular environment. The selection of vehicles to act as virtual infrastructure is based on application requirements, the characteristics of vehicular environment, network load, among other constraints. The proposed greedy approach ensures minimal computational to maximize the election efficiency.

Figure 1 outlines the general architecture of the proposed system and the related three main execution phases, which are presented in more detail in the following:

1) Data Collection: Vehicles broadcast periodically broadcast single-hop Cooperative Awareness Messages (CAMs) that contains vehicle information. By receiving CAMs, vehicles become aware neighbor stations as well as their positions, movement, basic attributes and basic sensor information. This enables the construction of neighbor tables at each vehicle. As decision making is done at a central location, these aggregated neighbor tables are transmitted to the Geoserver to serve as basis for the virtual infrastructure election procedures.

2) Virtual Infrastructure Selection: The information collected allows the geoserver to have a bird-eye view of static and dynamic network characteristics. The geoserver may also receive additional information from other data sources (e.g. coverage information from network operators). Whenever, the geoserver receives the request from a service provider, the virtual infrastructure selection process starts. Based on input requirements and the collected data, the Geoserver analyzes all potential vehicle stations that can act as virtual infrastructure and iteratively selects the nodes that maximize the message penetration in a given geographic area. Nodes are selected from the set of available nodes based on the *dissimilarity index*. The dissimilarity relation is an index where the less similar areas a vehicle covers, the larger are the relation index values. In the selection process, the Geoserver considers static and dynamic constraints, namely service requirements, network constraints and vehicular network constraints prior to making the selection decision. Depending on request requirements (e.g. in terms of delay), the algorithm can adaptively select through two dimensions: i) number of nodes and ii) number of hops.

3) Data Dissemination Strategy Execution: The decisions made at the geoserver are propagated to selected vehicles that perform local action execution. The selected vehicles can also instruct other nodes to further propagate the information among the peers. The generic method also considers the adaptation of the geoserver instructions at vehicles if the local conditions have evolved.

III. DEMONSTRATION SETUP

The main objective of the demonstration is to show the feasibility and performance of the proposed information dissemination algorithm. To achieve this goal, we assess the performance of the algorithm under varying conditions using an integrated simulation platform. The integrated simulation platform Vehicular Networks Simulation (VNS) [2] by Fernandes et al. was extended and adapted for this demonstration.

VNS[1] provides a complete and transparent integration between a microscopic traffic simulator (DIVERT 2.0) and several network simulators (e.g. NS-3). This platform follows a modular architecture which allows the independent development of network and traffic simulators. DIVERT is a efficient and scalable microscopic traffic simulator allowing realistic mobility replication and the simulation of thousands of nodes. NS-3 [3] is an open source and validated discrete-event network simulator widely used by the research community. The latest version of this network simulator (NS-3.19) provides a complete set of models for assessing heterogeneous vehicular networks, including models for Long Term Evolution (LTE) communication networks and short-range vehicular communication networks (i.e. 802.11 p). The Network Integration Module (NIM) enables the bidirectional interaction between both simulators, which allows vehicles on the traffic simulator to be accessible from the network simulator and vice-versa.

Figure 2 depicts an overview of the demonstration simulation platform. Regarding the network simulator, we have integrated our extended version of NS-3 simulator into VNS, namely replicating the Geoserver and vehicle functionality. Vehicles are responsible for providing the Cooperative Awareness Service and for providing neighbor information to the geoserver. On the other hand, the geoserver collects

[1]http://www.dcc.fc.up.pt/~rjf/vns/

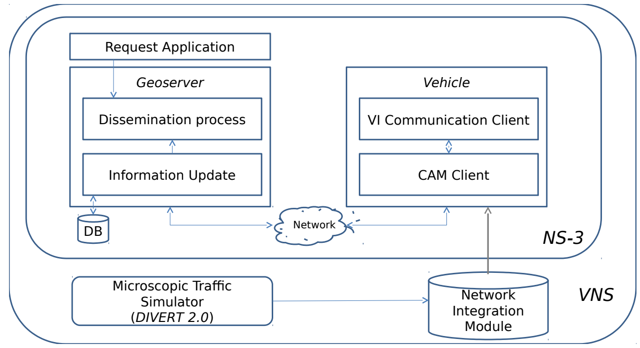

Fig. 2. Demo simulation platform: The architecture and algorithm is implemented in the NS-3 discrete network simulator, which mimics the behavior and the interaction between Vehicles and the Geoserver. The realistic mobility of vehicles is generated by DIVERT 2.0. The Network Integration Module (NIM) enables the bidirectional interaction between network and traffic simulators.

information and determines the best strategy to disseminate information into a geographical area. The NS-3 simulation extensions are elaborated in [1]. The graphical user interface of the VNS simulator has been also tailored and extended for the demonstrations. The demonstration setup comprises of a Personal Computer (PC) and a monitor.

For the demonstration, we consider a simple Manhattan scenario with no propagation obstacles (e.g. buildings, foliage). Vehicles broadcast single-hop CAMs with a frequency of 1 Hz, which allows vehicles to be aware of their evolving neighborhood. During the simulation the network connectivity graph between vehicles is displayed. The aggregated neighbor tables are transmitted to the Geoserver to serve as basis for the virtual infrastructure election procedures. The user interacts with the demonstrator by generating a dissemination request (button in the simulator graphical interface). For simplicity reasons, we consider the entire scenario as the target dissemination area. Following a new dissemination request, the platform invokes the information dissemination algorithm, which results in the selection and informing of the vehicles elected to become virtual infrastructure. The demonstrator will highlight the vehicles selected as virtual infrastructure and their connectivity graph, showing, as a result, the dissemination strategy for each dissemination message request. Moreover, selected simulation and algorithm performance parameters are shown in the user interface, including the number of vehicles in the network, the number of vehicles that have received the dissemination message, among others.

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[2] R. Fernandes, F. Vieira, and M. Ferreira, "VNS: An Integrated Framework for Vehicular Networks Simulation," in *Vehicular Networking Conference (VNC), 2012 IEEE*, Nov 2012, pp. 195–202.

[3] "Network Simulator 3 (NS-3), 'http://www.nsnam.org/,' accessed: 2014-09-30.