Real Deployment of the V2X-Based Data Probe Application and its Integration with a Commercial Traffic Platform

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***Abstract*—In Vehicle to vehicle and vehicle to infrastructure communication the vehicles are expected to transmit continuously and frequently information that include their velocity and location coordinates. Such real-time geographical information, if collected properly, can be used for inferring the current status of the traffic on the roads. In this contribution, the authors elaborate on how this information can be used to enable an accurate source of data for traffic management platforms. The contribution includes a real implementation of the solution using a standard-compliant V2X platform, as well as its integration with a commercial traffic platform.**

Keywords-V2X; V2V; V2I; C2X; DSRC; VANET; probe; traffic; ITS.

I. INTRODUCTION

Vehicle to vehicle and to infrastructure communication (V2X) is an emerging technology that is expected to bring on our vehicles' dashboards many new interesting applications and services [1]. Certainly, road-safety applications are the key driver for such an emerging technology, but there are also many infotainment and traffic efficiency applications that will be enabled on top of such a technology.

Indeed, when V2X will be deployed, many new applications and improvements of existing applications become possible. Traffic information is a good example of existing applications that will be improved considerably thanks to V2X.

In V2X related standards [2], Data Probe is listed as one of the first applications that will be enabled by V2X. In such an application, selected vehicles participate by sharing their probe data with a designated Road Side Unit (RSU) deployed on the road. In this contribution we present our implementation of the Data Probe application along with its integration with a commercial traffic platform.

The rest of this paper is organized as follows: Section II presents the related works. Section III presents the implemented solution. Section IV presents the test-bed and field tests. Finally, Section V concludes the contribution.

II. RELATED WORK

A. Tradditional Traffic Data Calculation

Different techniques have been used in the field of Intelligent Transport Systems (ITS) to calculate close-to-real-time traffic information [3]. Such techniques rely mainly on collected data about road users that come from sensors installed either at fixed locations on the road, in road user's vehicles, or in road users' mobile devices [6]. These collected probe data is used to calculate the traffic information and enable different ITS services and applications. One of the simplest solutions to calculate the traffic information from probe data consists of comparing the reported road user's speed to the normal speed of the road segment on which the user is currently driving.

B. V2X-based Data Probe

Data Probe is one of the applications listed in the V2X-related standards [2], and it consists of using V2X capabilities to collect accurate and real-time data about the vehicles on the road. As described in [2][4], to enable the data probe application, the On-Board Units (OBUs), while driving on the road, report their current and past probe data (location, speed, heading, etc.) to a nearby RSU. After receiving the probe data from passing vehicles, the RSU can transmit it to the backend. Once the data reaches the backend, it is stored and processed to produce real-time and historical traffic information.

As per the related standards [2], the transmission of the probe data by the passing vehicles can happen in three ways: (1) periodically: transmitted every defined period of time, (2) reactively: transmitted as a response to a request received from the RSU, and (3) while moving: transmitted only when the vehicles is moving.

Only some vehicles participate in running the data probe application [2], which leads to some gaps due to the lack of information about other vehicles on the road. In [5], the authors propose to have the selected vehicles reporting not only theirs, but also their neighbors' probe data to the RSU through multi-hop communications.

III. USING BSM AND CAM TO ENRICH V2X-BASED DATA PROBE APPLICATION

In our solution we propose to use the Basic Safety Message (BSM) [2] or the Cooperative Awareness Message (CAM) [7] to collect the probe data of the passing vehicles. The BSM and CAM contain the location, speed, heading and other useful information, and they are transmitted periodically by each vehicle to inform other vehicles about its presence. Therefore, by using the information in the BSM and CAM received from neighboring vehicles, a selected vehicle can construct the probe data of all those neighboring vehicles. That selected vehicle can now include its

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neighbors' probe data when transmitting its own probe data to the RSU.

Our implementation is similar to the solution proposed in [5] with two main differences: (1) the reporting vehicles act in a reactive and not in a proactive mode, and they are assumed to be pre-equipped (e.g. belonging to a partner fleet), and (2) the transmission of the probe data is made through one and not multi hop.

By letting the vehicles that participate in the data probe application send theirs and their neighbors' probe data, the RSU can get a broader visibility about a larger number of vehicles in the traffic around its location.

Figure 1 illustrates the proposed solution through an example where A is a participating vehicle running the data probe application. The vehicle A constantly collects the probe data of other vehicles around it through their BSMs or CAMs. When entering the RSU's communication range, the vehicle A transmits to that RSU the collected probe data, which contain its own and its neighboring vehicles' probe data. The driving direction of the reported vehicles (heading field in CAM and BSM) is used in the backend to map each vehicle's probe data on the right road segment.

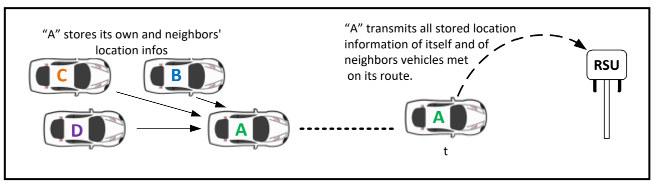

Figure 1. Example of a vehicle reporting the prob data of its own and of other vehicles in its communication range.

IV. IMPLEMENTATION AND FIELD EXPIRMENTS

To validate our contribution we have implemented and deployed it on a real V2X platform that is being piloted in Doha, Qatar. Our experimentations included three vehicles, each equipped with one OBU, and one RSU installed on the side of the road at a selected intersection. Both the OBUs and the RSU communicate over 5.9 GHz band in compliance to the European V2X standards [7]. In our implemented solution, a selected vehicle is equipped with a data probe application that keeps storing the probe data of its own and of any vehicle met on the road thanks to the received CAMs.

To validate our implementation from an end-to-end perspective, we interfaced it with our commercial traffic platform Masarak™ [8]. On Masarak, we can see both real-time and historical traffic information that is calculated based on the collected V2X probe data. Figure 2 illustrates snapshots of the obtained traffic information as shown by Masarak™ [8] on a map using road segment coloring codes (Red: heavily congested traffic, Orange: slow-moving traffic and Green: clear traffic).

In this initial experimentation work we did not pay attention to measuring the impact of the data probe application on the overall network overhead. This is something we plan to do along with other measurements in the future, and present the findings in an extended version of this contribution. But, we believe that the impact on the network overhead is relatively small, as only pre-selected vehicles are enabled with the data probe application. It is also important to mention that as per the standards [7], the traffic efficiency applications are assumed to use a different radio channel than the one allocated for safety applications.

Figure 2. Traffic states information as shown on Masarak™ based on V2X probe data messages.

V. CONCLUSIONS AND FUTURE WORK

This contribution presents initial findings from our experience with the implementation of V2X-based Data Probe application and its integration with a commercial traffic platform. In our contribution, we proposed an enhancement to the conventional solution as described in the related standards, by letting a participating vehicle report not only its own probe data but also those of its non-participating neighboring vehicles through single-hop transmissions.

Further experiments and results of the implemented data probe application will be presented in a future longer paper.

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REFERENCES

[1] J. Harding, et. all., (2014, August) "Vehicle-to-vehicle communications: Readiness of V2V technology for application." (Report No. DOT HS 812 014). Washington, DC: National Highway Traffic Safety Administration.

[2] Dedicated Short Range Communications (DSRC) Message Set Dictionary, J2735_201603, 2016-03-30, issued by V2X Core Technical Committee, SAE International.

[3] L. Montero, et al., "Impact on Network Performance of Probe Vehicle Data Usage: An Experimental Design for Simulation Assessment," Journal of Advanced Transportation, vol. 2018, Article ID 3736417, 12 pages, 2018.

[4] M. B. Brahim and H. Menouar, "V2X-based traffic flow calculation with support of unique identifier randomization," 2016 2nd IEEE International Conference on Computer and Communications (ICCC), Chengdu, 2016, pp. 1226-1232.

[5] L. Yang, J. Xu, G. Wu, J. Guo, "Road probing: RSU assisted data collection in vehicular networks." 2009 5th International Conference on Wireless Communications, Networking and Mobile Computing. IEEE, 2009.

[6] M. R. Islam, N. Ibn Shahid, D. T. Karim, A. Al Mamun, M. K. Rhaman, "An efficient algorithm for detecting traffic congestion and a framework for smart traffic control system," 18th International Conference on Advanced Communication Technology (ICACT), Pyeongchang, 2016, pp. 802-807.

[7] Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service, ETSI TS 102 637-2 V1.2.1 (2011-03).

[8] Masarak™ - http://www.masarak.com/ [retrieved: May, 2019]