Poster: An Experimental Vehicular On-Board Unit for the Execution of Anticipated Cooperative Collision Avoidance Services in Cross-Border Scenarios

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ABSTRACT

The ubiquitous Vehicle-to-Everything (V2X) connectivity enables successful deployments of emerging vehicular services around the world. However, geographical cross-border scenarios are challenging for vehicular services deployments over heterogeneous infrastructure and at the same time vehicles to maintain seamless service connectivity across borders. In this paper, we present the development and validation of an experimental vehicle On-Board Unit (OBU) for the execution of Anticipated Cooperative Collision Avoidance (ACCA) services in cross-border scenarios. The OBU flexibly supports the integration of different V2X protocols to communicate with heterogeneous cloud-based services offered by different Original Equipment Manufacturers (OEMs) within the ACCA service infrastructure.

CCS CONCEPTS

• **Networks → Mobile networks**.

KEYWORDS

5G, V2X, C-ITS, Mobile Edge Computing

ACM Reference Format:
Roshan Sedar[1], Francisco Vázquez-Gallego[1], Ramon Casellas[1], Ricard Vilalta[1], Raul Muñoz[1], Rodrigo Silva[2], Laurent Dizambourg[2], Antonio Fernández[2], Jesus Alonso-Zarate[1]. 2020. Poster: An Experimental Vehicular On-Board Unit for the Execution of Anticipated Cooperative Collision Avoidance Services in Cross-Border Scenarios. In *14th International Workshop on Wireless Network Testbeds, Experimental evaluation & Characterization (WiNTECH'20), September 21, 2020, London, United Kingdom.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3411276.3414693

WiNTECH'20, September 21, 2020, London, United Kingdom

ACM ISBN 978-1-4503-8082-9/20/09.
https://doi.org/10.1145/3411276.3414693

1 INTRODUCTION

Modern vehicles are equipped with an OBU for V2X communication, which enables vehicles to exchange locally sensed data with the other external entities over wireless connectivity. Such vehicles are capable of sharing information in the form of Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Vehicle-to-Network (V2N) communications. V2X connectivity extends the perception range beyond the limits of on-board sensors, thus supporting emerging vehicular services that will increase traffic efficiency and road safety.

Cellular V2X (C-V2X) [3] is gaining more attention worldwide through promising field trials of vehicular services [1, 2]. On-going 5G Cross-Border Control (5GCroCo) project is conducting trials of C-V2X based vehicular use cases deployed in cross-border scenarios. ACCA is one of the use cases deployed in 5GCroCo [4] which anticipates impending collisions ahead of time and informs approaching vehicles to avoid any dangerous incidents, e.g., stationary vehicle, an accident, or a traffic jam, among others. Concretely, each vehicle shares its status information and detected roadside hazardous events with the ACCA service deployed on the MEC infrastructure from which it creates a distributed dynamic map with all the collected information, and informs those vehicles that are required to, including relevant information within their geographical region of interest. The key challenge in the deployment of ACCA is to facilitate seamless interoperability among OBUs from different OEMs and car manufacturers, since they typically need to support different V2X protocols to communicate with backend services. As a result, the testing of ACCA functionalities and the interoperability of V2X communication interfaces can be a complex as well as an expensive task since this requires the use of several commercial OBUs from each OEM. Motivated

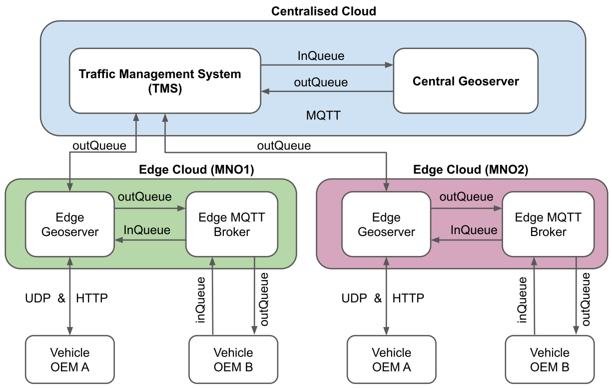

Figure 1: ACCA architecture.

by this need, we present in this paper an experimental OBU that supports two V2X protocols to realise communication with backend applications: the UDP/IP protocol, carrying ETSI C-ITS encoded messages; and the MQTT protocol on top of TCP/IP, with JSON encoded messages.

2 ACCA SERVICE

Fig. 1 shows the high level architecture of the ACCA service, illustrating the communication interfaces between vehicles and backend services. To achieve low-latency, the backend services are deployed at the edge configured on the MEC infrastructure. Two edge cloud instances are shown in Fig. 1, where each instance is operated by a different telecom operator (MNO1 and MNO2). Vehicles communicate with the backend using a specific V2X communication protocol: UDP/HTTP or MQTT. The Edge Geoserver processes incoming messages from both vehicles and the Edge MQTT broker, and aggregates the information. The Edge Geoservers exchange MQTT messages (in JSON) with the central cloud service. The central cloud service comprises of Traffic Management System (TMS), responsible for cross-border message exchange, and a Central Geoserver. Both TMS and Central Geoserver aggregate, filter and process incoming messages.

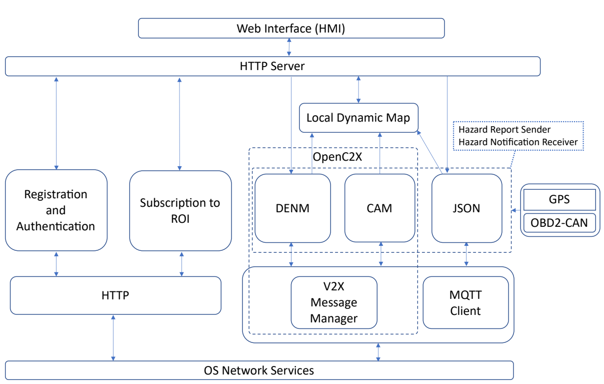

Figure 2: Software architecture of the OBU.

3 ON-BOARD UNIT IMPLEMENTATION

The OBU is composed of a laptop and several external hardware devices which are a 4G/5G cellular modem, a GPS/GNSS receiver, a Controller Area Network (CAN) bus to USB adapter, and a DC/DC converter. The 4G/5G cellular modem provides the external V2X connectivity. The modem is connected to the computer using a USB to mPCI adapter. The GPS receiver provides the real-time positioning of the vehicle and at the same time leverages the time component of the GPS signal to run a GPS-based time service using NTP protocol from which the OBU keeps its internal clock synchronised with the backend applications. The CAN bus to USB adapter bridges the connectivity with in-vehicle sensors and actuators network.

The OBU software leverages the OpenC2X [5] ETSI C-ITS stack. As shown in Fig. 2, it is composed of decoupled modules communicating internally using ZeroMQ sockets. In summary, we have extended OpenC2X to handle UDP/HTTP and MQTT/JSON communication within ACCA service. It includes modules for authentication with the backend and subscription to send/receive interested events in a geographical region, and connectivity to in-vehicle sensors and actuators network either through an OBD or a CAN interface.

4 CONCLUSIONS

We have implemented and validated an experimental OBU based on an open-source ETSI C-ITS protocol stack. It can be used as a driver-assistance system for ACCA and supports two V2X protocols to communicate with edge/cloud-hosted services provided by different vehicle OEMs and MNOs.

ACKNOWLEDGMENTS

This work is part of 5GCroCo project that has received funding from the European Union H2020 Research and Innovation Programme under grant agreement No. 825050. It has also been partially funded by SPOT5G (TEC2017-87456-P), AURORAS (RTI2018-099178-B-I00) and by Generalitat de Catalunya under Grant 2017 SGR 891.

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