Enhancing the Situational Awareness of Vehicular Use Cases with CAM message generation in V2X

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***Abstract*—Communication serves to exchange information and knowledge, playing a vital role in the functioning of modern-day societies. Similarly, for intelligent and fully Unmanned Automated Vehicles (UAVs), the ability to interact with their surroundings is crucial. This encompasses communication with other vehicles, Vulnerable Road Users (VRUs), and the infrastructure, collectively known as Vehicle-to-Everything (V2X) communication. Through V2X, UAVs can enhance their situational awareness by receiving information from other entities in the environment, in addition to their onboard sensors. However, there are significant challenges to be overcome before V2X can fully meet the requirements for applications like autonomous or remote driving. This paper focuses on the potential of 5G cellular technology and Vehicular Edge Computing (VEC) to address these challenges. Additionally, it introduces a novel Controller Area Network (CAN) to Cooperative Awareness Message (CAM) edge application that can be deployed on 5G networks, aiming to mitigate the lack of standardization in CCAM (Cooperative, Connected, and Automated Mobility) message generation. The proposed CAN to CAM edge application offers a solution to the existing challenges associated with CCAM message generation.**

***Index Terms*—5G and beyond, V2X, UAV, CCAM, VEC, CAN**

I. Introduction and Motivation

The rising popularity of Automated Vehicles (AVs) has led to advancements in computer vision and sensor technologies, improving their self-driving capabilities. However, perceiving the environment remains a challenge in terms of cost and reliability. To address this, Cooperative Intelligent Transport Systems (C-ITS) have emerged, enabling AVs to go beyond relying solely on their own information, which may be limited by malfunctions or Line of Sight (LoS) constraints. Vehicle-to-Everything (V2X) communication allows for the exchange of information among different road users, such as Vehicles, Infrastructure, and Pedestrians, fostering improved situational awareness and a shared perception of the environment.

The European Telecommunications Standards Institute (ETSI) standardizes the Cooperative Awareness Message (CAM) based on encoding and transmission but lacks a generalized way to generate these messages. In this paper, we propose the Controller Area Network (CAN) to CAM Edge Application (Fig. 1) that is designed to bridge the gap between the CAN bus of vehicles and the air interface. The overall system provides a way to read, filter and convert CAN messages into CAM messages (Fig.1). The system can be extended to support higher-level protocols like J1939 and On-Board Diagnostics 2 (OBD2) and is ready to be deployed on the Smart Highway[1] testbed.

II. Can to CAM Edge Application

The CAN to CAM Edge application is an application that can run anywhere on the edge of the 5G and beyond network. The application uses the DUST (Distributed Unified Streaming) core developed by IDLab [1]. This core allows applications to run using different communication technologies without needing to edit the application. By leveraging the DUST framework, we can test these communication technologies and reuse the application on newer communication infrastructure. We use DUST to publish our CCAM data to the vehiCulAr coMmunIcation maNagement framewOrk (CAMINO) [1]. The CAN to CAM generator, as the name suggests, generates CCAM messages as defined in ETSI EN 302 637-2 V1.4.1. Therefore, it takes as input the CAN messages, that are generated by different components in the car (Fig. 1).

[1]https://www.uantwerpen.be/en/research-groups/idlab/infrastructure/smart-highway/

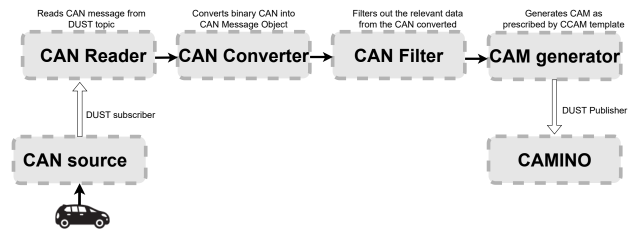

Fig. 1. CAN to CAM System overview

A. CAN based protocols

The CAN protocol, which defines a framework for sending messages, poses a challenge for creating the CAN to CAM Edge application due to its varying implementation across different car makes and types. There is a need for a more standardized approach to read the CAN bus data from vehicles. Heavy-duty vehicles, including trucks, buses, and construction vehicles, rely on the J1939 protocol for internal communication. J1939 provides a standardized framework specifically designed for these types of vehicles, offering a more uniform and consistent way to analyse the data present in J1939 messages. OBD2 is a standardized protocol used in modern vehicles for diagnostic purposes. OBD2 provides a uniform framework for accessing and retrieving diagnostic information from a vehicle's engine and other systems. OBD2 enables the diagnosis and monitoring of various vehicle parameters, including engine performance, emissions, and sensor data. By adhering to the OBD2 protocol, vehicles ensure compatibility and ease of access to diagnostic tools and software.

III. Results

The CAN to CAM Edge application can translate CAN messages into CAMs (Fig. 1). Thanks to the incorporation of DUST and CAMINO, the system can be deployed on the edge on a variety of networks. The main problem with creating a CAN to CAM converter is the different implementations of the CAN protocol by manufacturers. This creates a challenge

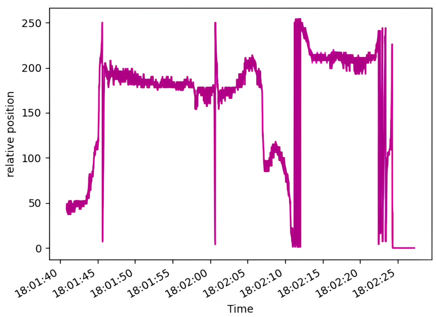

Fig. 2. Brake pedal position CAN

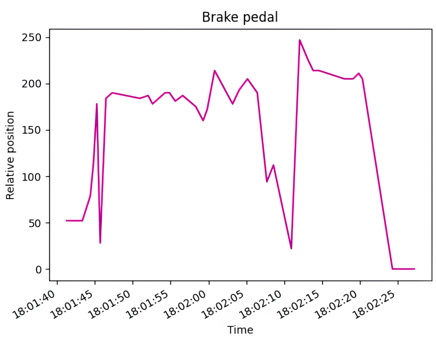

Fig. 3. Brake pedal position CAM

for CAM generation since this makes it difficult to extract information from these CAN message logs. The task of reverse engineering these CAN messages proves to be difficult as mentioned by De Hoog et al [2]. Our proposed system can extract the steering wheel and brake pedal data from the CAN logs. Fig 2 prescribes the brake pedal data in CAN. This data will be fed into the CAM generator (Fig. 1) which will send a CAM message every second (this frequency can be increased). This results in the CAM brake pedal data in Fig 3. The CAM is structured using the template provided by ETSI. This template does not provide a data field for a brake pedal or a brake light. Therefore, in the actual CAM, the brake pedal data is mapped to the vehicle speed field since these are somewhat (inversely) related.

IV. Discussion

ETSI standardizes CAMs for CCAM, focusing on encoding and transmission but lacking a generalized method for message generation. The CAN to CAM Edge application aims to bridge the gap between the CAN bus and the air interface. However, deeper insight into CAN data is necessary for the proposed application to be more beneficial in V2X scenarios

As a continuation of the current research, 3rd Generation Partnership Project (3GPP), continuously develops and releases new standards to meet the evolving needs of the industry. In the context of this study, the focus has primarily been on release 16 (2020)[2], which has reached a frozen state. However, it is important to acknowledge the significance of delving deeper into release 18, as it holds great potential for future V2X deployments. Exploring the advancements and features introduced in release 18 can provide valuable insights into the possibilities and challenges of V2X communication in the coming years. While a significant amount of research in V2X communication has centred around offloading and resource management, it is essential to consider the generation of V2X messages, which operate under stringent latency constraints. Generating these messages efficiently and effectively remains an area that requires attention and improvement. The current literature highlights the absence of a general approach or methodology for generating V2X messages, which, if addressed, could significantly propel research and development in this field. Therefore, it is imperative to prioritize the development of a comprehensive solution for CCAM message generation. One potential avenue for advancing V2X applications lies in the utilization of Vertical Application Enabler (VAE) in 3GPP release 18. This emerging technology shows promise in providing solutions for the development of V2X applications by offering specialized services to specific sectors or verticals. By leveraging the capabilities of VAE, researchers and practitioners can explore innovative approaches to overcome existing challenges, improve message generation, and enhance overall V2X communication systems.

As such, the potential of leveraging the Service Enabler Architecture Layer (SEAL) and Vertical Application Layer (VAL) frameworks in 3GPP to accelerate the adoption of 5G and beyond technology has high potential. The SEAL framework from 3GPP offers valuable resources for the efficient development of 5G applications, while the VAL layer introduces VAEs tailored to specific use case domains. Building upon this foundation, future research can extend the exploration of these frameworks to further enhance and refine vehicular communication and connectivity. Particularly, the V2X VAE emerges as a promising tool for advancing the development of vehicular applications within the 5G and beyond ecosystem. By harnessing the capabilities provided by the V2X VAE, novel approaches and optimizations can be pursued to address challenges in vehicular communication. A second part of future research should focus on the creation of standardized CAN-bus data transmission methods. While higher-level protocols like OBD2 and J1939 already provide the possibility of generalized CAN messages, there is a need for establishing a standardized approach to ensure seamless and interoperable data transmission across various vehicular systems. By developing a comprehensive standard for CAN-bus data transmission, researchers can facilitate efficient and reliable communication between different components and systems within vehicles, promoting compatibility and ease of integration in the context of 5G-enabled environments. This standardized approach would pave the way for enhanced data exchange and interoperability, fostering advancements in the field of vehicular technology.

[2]https://www.3gpp.org/specifications-technologies/releases/release-16

V. Acknowledgement

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