Orchestrating Safety: Unveiling the DEDICAT-6G Edge Computing Approach for Enhanced Pedestrian Safety

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***Abstract* — The DEDICAT-6G project strongly emphasises dynamic resource allocation, connectivity, flexibility, and trustworthiness to meet the demands of emerging human-centric services. Our solution for enhancing Vulnerable Road User safety addresses the imperative for heightened awareness in urban environments. This is achieved by harnessing the power of edge computing, communication protocols, and efficient resource management to mitigate accidents at intersections. Our architectural framework involves Road Side Units, On-Board Units, and Vulnerable Road Users, incorporating a Collision Detection Edge Application for real-time data analysis. A Monitoring System facilitates comprehensive performance evaluation. Promising early results from simulations, particularly in limited-sight scenarios at intersections, underscore the effectiveness of our approach.**

Keywords—Vulnerable Road Users, Edge Computing, Collision Detection, Pedestrian Safety, Network Orchestration, Monitoring.

I. Introduction

In the context of advancing 6G network requirements, the DEDICAT-6G project [1] stands as a significant endeavor, seeking to establish an intelligent connectivity platform. This platform integrates existing communication infrastructure with innovative edge intelligence distribution to facilitate energy-efficient real-time experiences [1]–[3]. Building on the foundations laid by 5G [5], DEDICAT-6G places emphasis on dynamic connection development, efficient resource utilization, and enhanced privacy preservation. focusing on security, privacy, and trust assurance in mobile edge services [3], [5].

DEDICAT-6G explores various use cases such as smart warehousing, public safety, and a smart highway as part of its proof of concept. The project leverages simulations and field evaluations to advance intelligent network load balancing and human-machine interactions [3]. In the realm of public safety and smart highways, our experiment focuses on improving the safety of Vulnerable Road Users (VRUs) at intersections with obstructed visibility. This is achieved by designing a Safety Mobile Application (SMA), shown in Fig. 2 prioritizing VRU safety. The SMA utilizes real-time location tracking, 5G, and C-V2X [6] communication technologies, along with collision prediction algorithms. The goal is to provide timely alerts to both VRUs and vehicle drivers, potentially preventing accidents and ensuring safer mobility.

II. Methodology

A. Architecture

Our solution is intricately designed with a three-layered architecture, each layer playing distinct roles and executing specific tasks. The initial layer, responsible for data collection, involves the Vehicle OBU and VRUs equipped with the SMA. Together, they contribute to real-time location tracking and seamless communication with the Smart Highway, facilitated by the C-V2X communication protocol between vehicles and RSUs and 5G between VRUs and Road Side Units (RSUs).

At the core of the system resides the second layer, responsible for data treatment, embodied as the Collission Prediction Edge Application (CPEA). This application critically analyzes Cooperative Awareness Messages (CAM) from vehicles and Global Positioning System (GPS) location data from VRUs.

The third layer, tasked with monitoring resources, comprises the Monitoring Infrastructure. Leveraging LXD containerization, this infrastructure ensures seamless management and monitoring across all nodes, including RSUs, OBUs, and the SMA infrastructure. The interconnected Grafana Dashboard serves as a centralized interface for stakeholders, offering dynamic performance data and status updates. This facilitates informed decision-making on resource allocation, optimization, and scalability. An overview of the experimental architecture is show in Fig. 1.

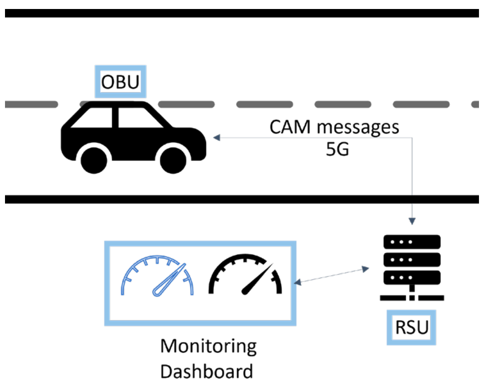
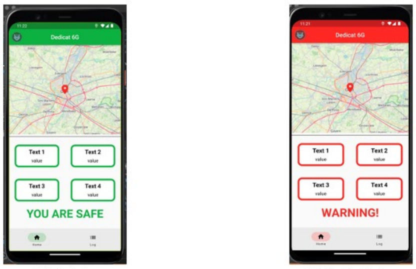


Figure 1 Experimental Architecture of the Smart Highway Use Case

B. Network Architecture

The network architecture boasts advanced components in both the RSU and OBU. The RSU has a powerful General Purpose Compute Unit (GPCU) featuring an Intel Xeon E5-2620 processor, 32 GB RAM, and a 1 TB SSD, ensuring robust processing capabilities. Furthermore, it incorporates Cohda MK5 RSU and Cohda MK6c EVK components, designed for IEEE 802.11p and C-V2X connectivity.



(a) Safe display (b) Warning display

Figure 2 VRU Mobile App Interface

The RSU incorporates the USRP N310 Software-Defined Radio (SDR) for high-speed data transfer and efficient communication. This SDR not only facilitates rapid data transfer but also supports multiple antennas and boasts a wide frequency range, contributing to the overall versatility of the communication system. The Septentrio AsteRX-m2 is another integral component of the RSU, ensuring high-precision Global Navigation Satellite System (GNSS) reception. This element enhances the accuracy and reliability of location-based information within the network.

C. Implementation

The experimental focus was on quantifying the RSU's energy consumption, with a particular emphasis on the edge node, amid varying communication ranges—specifically, at 30, 50, 70, and 80 meters. The experiment involved transmitting data packets from the OBU in the BMW to the RSU, simulating diverse distances to evaluate their impact on energy efficiency.

Regarding CPU load, at 30m, CPU load started at 7-8%, increased to 13.07% during CAM transmission, then decreased to 10.66%. At 50m, load began at 12.79%, peaked at 17.75% during transmission, then stabilized at 11.86%. At 70m, load started at 13.41%, peaked at 18.53% during transmission, and stabilized at 13.50% post-transmission. At 80m, load started at 13.45%, peaked at 20.02% during transmission, then stabilised at 13.11%.

This meticulously designed experiment provided a comprehensive understanding of the RSU's energy consumption patterns at the edge node across varying communication ranges. Integrating a robust power distribution unit, a sophisticated monitoring system and cutting-edge containerisation technologies facilitated precise measurements and insights into the RSU's performance in a dynamic 5G communication environment.

III. Conclusions

The presented paper encompasses a comprehensive exploration of an intelligent connectivity platform aimed at enhancing road safety through advanced communication technologies, edge computing, and real-time monitoring, shown in Fig. 3. The study involves the integration of OBUs in vehicles and RSUs strategically positioned in urban settings, establishing a robust 5G communication network.

The architectural design of the system is carefully structured into three layers, each playing a distinct role. The first layer focuses on data collection, involving OBUs, VRUs equipped with the SMA shown in Fig. 2, and RSUs.

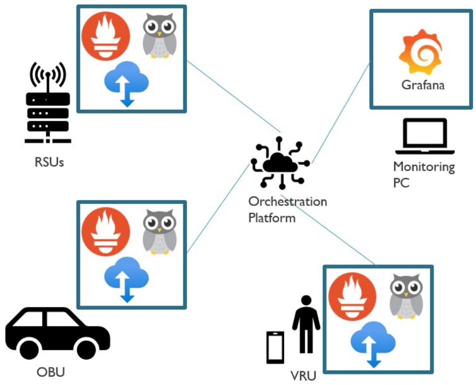


Figure 3 Monitoring Infrastructure

The experimentation phase, conducted at the University of Antwerp Campus Groenenborger, delves into the energy consumption and CPU load of RSUs at varying communication distances. Overall, the findings pave the way for future research and development, emphasizing the need for adaptive communication systems and user-friendly safety solutions in the evolving landscape of urban mobility.

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