Multi-domain MEC orchestration platform for enhanced Back Situation Awareness

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Demo Abstract: Multi-domain MEC orchestration platform for enhanced Back Situation Awareness

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***Abstract*—Network Function Virtualization (NFV) and Multi-Access Edge Computing (MEC) are among the key technology pillars of 5G systems and beyond for fostering and enhancing the performance of new and existing use cases. In the context of public safety, 5G offers great opportunities towards enhancing mission-critical services, by running network functions at the network edge to provide reliable and low-latency services. This demo introduces an on-demand Back Situation Awareness (BSA) application service, in a multi-domain scenario, enabling early notification for vehicles of an approaching Emergency Vehicle (EmV), indicating its Estimated Time of Arrival (ETA). The application provides the drivers ample time to create a safety corridor for the EmV to pass through unhindered in a safe manner thereby increasing the mission success. For this demo, we have developed an orchestrated MEC platform on which we have implemented the BSA service following modern cloud-native principles, based on Docker and Kubernetes.**

***Index Terms*—MEC, 5G, multi-domain back situation awareness, NFV orchestration, vehicular communications**

I. INTRODUCTION

The advent of NFV/MEC as key 5G technology enablers have paved the way towards introducing novel use cases and creating new business values that were not possible with the previous generations of communication technologies [1]. In this demo paper, we introduce the realization of a novel use case in the public safety domain by leveraging 5G technology of NFV/MEC to enhance situation awareness of vehicles during emergency event management.

Presently, when an emergency situation occurs, civilian vehicles become aware of the presence of an Emergency Vehicle (EmV) only when it is within the audible and visual range of the drivers (e.g., blaring sirens, flashing lights, etc.). As the awareness in this case happens in a close proximity, it might not provide sufficient time for the drivers to adjust their speed and maneuver to create a clear corridor in a calm and coordinated way enabling the EmV to proceed unhindered towards event location in a safe and timely manner [1].

In view of the above limitations, we present the demonstration of a system that enhances the Back Situation Awareness (BSA) of EmV in a multi-domain environment by providing early notification about the Estimated Time of Arrival (ETA) of an approaching EmV to the vehicles on the route path of the EmV that are beyond audio-visual range of the EmV by leveraging the 5G MEC systems and the development of a BSA application service.

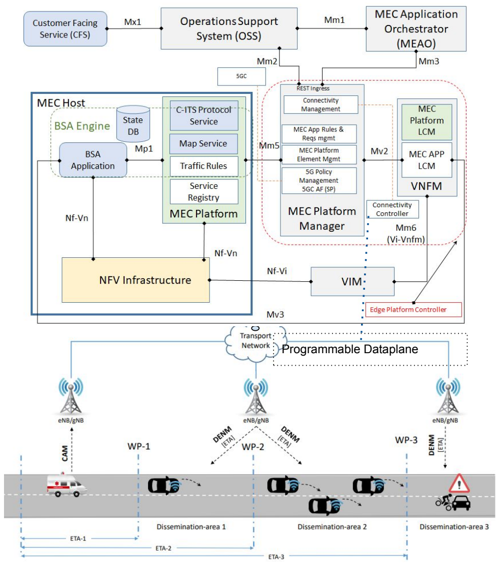

Fig. 1. BSA System and Deployment Architecture.

II. SYSTEM ARCHITECTURE

In Figure 1, we present the high level architecture of the orchestrated MEC platform, and the BSA application, with reference to the standardized ETSI MEC framework [2]. The orchestrated MEC platform comprises as key components an Edge Orchestration component, i.e., MEC Application Orchestrator (MEAO), and an Edge Platform Controller [3], which extends the open-source container orchestration platform Kubernetes[1] to perform MEC Platform Management as well as connectivity control based on an extension to the Container Networking Interface (CNI) of Kubernetes, supporting

[1]Kubernetes Project Portal: https://kubernetes.io/

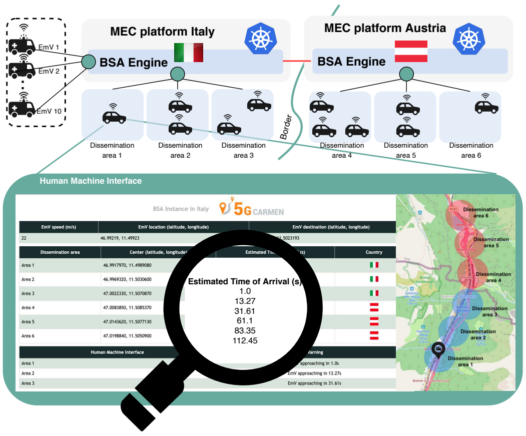

Fig. 2. Visualization of the demonstration environment.

Fast Data Input/Output (FDIO) operations on additional and customized data plane interfaces for Kubernetes PODs[2].

In the view of the BSA application, the additional interfaces are used for low-latency operations, i.e., i) to receive C-ITS Cooperative Awareness Messages (CAMs) that provide information on the speed, location, and route path of the EmV, and ii) to disseminate C-ITS Decentralized Environmental Notification Messages (DENMs), which contain ETA values for all vehicles in dissemination areas on the route of the EmV. The Edge Platform controller also enforces the life-cycle management operations of the BSA application.

The BSA Engine, shown in Fig. 1, comprises the key components that execute the logic of BSA, i.e., i) C-ITS Protocol Service[3], used for encoding and decoding C-ITS messages (i.e., CAMs and DENMs), ii) the Docker container-based BSA application to implement a self-correcting algorithm for ETA of the EmV, iii) the location service to emulate the EmV route path, and iv) the database application for maintaining important states of the EmV and to provide data for state migration to BSA application instances in other MEC platforms and domains (i.e., countries).

III. Demo

To demonstrate the operation of the orchestrated MEC application that we developed for the project 5G-CARMEN[4], we created the experimental setup in a testbed environment that is shown in Fig. 2. The setup consists of two MEC platforms and one BSA application instance (i.e., BSA Engine in Fig. 2) per each domain, i.e., country. The main idea of the scenario is the multi-domain deployment and operation of the BSA application, which is simultaneously serving one or multiple EmVs that travel from Italy to Austria in order to, as fast as possible, reach the destination with an emergency situation. In this scenario, the EmV from a specific location in Italy is selected and dispatched as the most suitable for an emergency situation in Austria, which happened close to the border between these two countries. The demo includes the following components:

- Multi-domain service deployment in which the MEC orchestration platform simultaneously instantiates two MEC application instances on top of the two MEC platforms (Fig. 2).
- External geolocation service that emulates locations for the EmV, based on the Google map for the route between the starting point of the EmV (Italy) to the destination (Austria). In case of a real vehicle, which is equipped with the on-board units, connects to the BSA application, our BSA will resolve the location of EmV from the periodic upstream CAMs that are sent from EmV.
- Customized setup of an FDIO link to the BSA service on the MEC to connect to a remote service instance as well as to the mobile network for dissemination of DENMs. Per this demo setup, connectivity between two BSA service instances enables periodic update of a remote instance in Austria, which does not receive the periodic CAMs from the EmV until it crosses the border, with information on the current location/speed of the EmV on the Italian side of the border to prepare ETA notifications for the Austrian dissemination area, which enables cars in that region to be aware of the approaching EmV and prepare for clearing the lane.
- Map dashboard that shows the route, six dissemination areas, and the EmV moving along this route.
- Human Machine Interface (HMI) dashboard inside a vehicle, which displays the current location of EmV, and the notification about the ETA.
- Key-Performance Indicator (KPI) dashboard with the i) application resource consumption statistics, ii) overall response time to the emergency event, iii) application execution time upon reception of CAMs from EmV, iv) state update delay between application instances, and v) ETA calculation accuracy.

IV. Acknowledgement

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[2]Kubernetes POD is the smallest deployable unit of computing that can be created and managed in Kubernetes.

[3]Vanetza: an open-source implementation of the ETSI C-ITS protocol suite: https://www.vanetza.org/

[4]H2020 5G-CARMEN: https://5gcarmen.eu/