



Fig. 2. Visualization of the demonstration environment.

perform MEC Platform Management as well as connectivity control based on an extension to the container networking interface of Kubernetes, supporting Fast Data Input/Output (FDIO) operations on additional and customized data plane interfaces for Kubernetes PODs².

In the view of the virtualized BSA application, additional interfaces are used for low-latency operations, i.e., i) to receive C-ITS Cooperative Awareness Messages (CAMs), sent via the 5G network, providing information on the EmV’s speed/location/route path, and ii) to disseminate C-ITS Decentralized Environmental Notification Messages (DENMs) that contain ETA values for all vehicles in dissemination areas on the route of the EmV, being further dispatched to cars via 5G.

The BSA Engine, shown in Fig. 1, comprises the key components that execute the logic of BSA, i.e., i) C-ITS Protocol Service³, 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.

III. DEMO

To demonstrate the operation of the orchestrated MEC application that we developed for the project 5G-CARMEN⁴, 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 scenario includes 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,

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

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

⁴H2020 5G-CARMEN: <https://5gcarmen.eu/>

reach the destination with an emergency situation. 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.
- In-vehicle dashboard, which displays the current location of EmV, and the notification about the ETA.
- Performance 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.

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