Development and Performance Evaluation of Network Function Virtualization Services in 5G Multi-Access Edge Computing

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1 Summary

5G technology aims at enriching the telecommunication network ecosystem by improving the existing mobile networks and by supporting the deployment and provision of services from several vertical industries. It is now commonly agreed that three technologies are crucial for the success of 5G, i.e., Network Function Virtualization (NFV), network slicing and Multi-access Edge Computing (MEC). Leveraging these technologies, the 5G-Transformer (5GT) project has developed an open and flexible 5G NFV/MEC-based transport and computing platform tailored to support the tight and heterogeneous requirements of a wide range of vertical services.

In order to assess the effectiveness and reliability of the 5GT architecture, five vertical domains have been selected to develop different use cases (UCs). In this thesis, we focus on the automotive UC, in particular on the design and implementation of a collision avoidance (CA) service (i.e., a road safety service) which provides support to vehicles approaching urban crossroads. The service is based on the periodic and anonymous exchange of messages between vehicles and a CA algorithm hosted in the cellular network infrastructure. By combining the information contained in these messages, the algorithm can detect possible dangerous situations in advance and send unicast warnings to the involved vehicles.

The core of our safety service is indeed the CA algorithm. We have designed a trajectory-based algorithm able to detect collisions between any

type of entity, i.e., not only between vehicles, but also between cars and vulnerable road users (e.g., pedestrians). Leveraging this algorithm, we have built a first testbed of a CA service on an *OpenAirInterface* architecture (an open-source software-based cellular network implementation) including MEC functionalities. The service is composed of two main VNFs running in a virtualized environment on the MEC platform: the Cooperative Information Manager (CIM) VNF and the CA VNF. The CIM is a database which decodes and stores the messages sent by vehicles, while the CA VNF runs the trajectory-based algorithm, by relying on the messages stored in the CIM, and generates the warning messages for the cars involved in potentially dangerous situations. We have then assessed the effectiveness and reliability of our CA service through a hardware-in-the-loop simulation technique. We have obtained excellent results, as all the simulated collisions were timely detected (i.e., the alert messages were received by the drivers *sufficiently* in time to react before the collision), with a low number of false positives (i.e., alerts referring to low or even no danger situations). We have hence shown how the latency and reliability required by delay sensitive safety applications can be addressed by the MEC paradigm and the cellular network.

Finally, once a reliable CA service was developed, we have assessed the performances of the 5GT architecture. In particular, we have tested the automated deployment of our CA application and two important management functions that are provided at the service runtime, i.e., arbitration and scaling. These two functionalities enable the fulfillment of the requirements during the whole lifecycle of services. The architecture developed in the 5GT project has proven to be suitable to meet the significantly different requirements of vertical services, offering a platform on which they can be easily deployed, guaranteeing, at the same time, their service level agreements.