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XXXIII Cycle

Study of Multi-Access Edge Computing Systems

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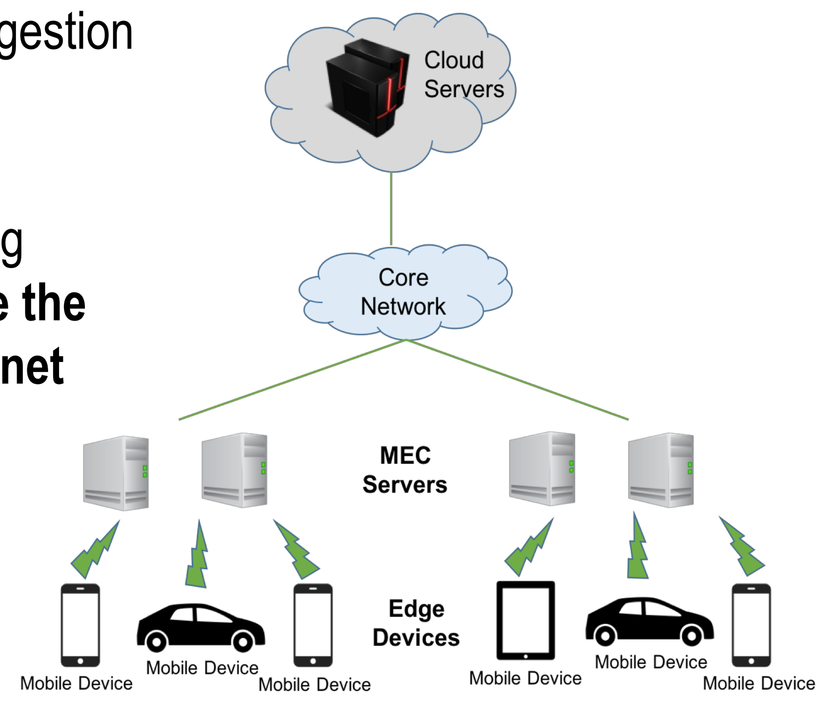
Research context and motivation

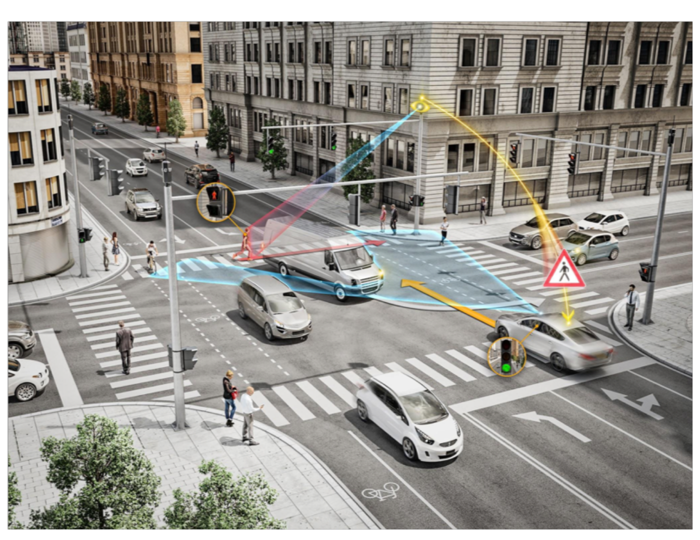
- **Multi-access Edge Computing** (MEC) is a network paradigm that **provides IT services and cloud computing capabilities, at the edge of the network**, within the Radio Access Network (RAN), so close to the final users. Such proximity to the end user translates into **ultra-low latency** and **high bandwidth**, while, at the same time, it alleviates traffic congestion in the network core.



- MEC technology is not only useful for offloading capabilities or storing data but also to **improve the different types of services available on the net or creating new ones**. Some examples:
  - Video stream analysis;
  - Augmented reality;
  - Computations offloading;
  - Road safety applications.
- MEC represents a key technology to enable the evolution to 5G, since it helps advance the transformation of the mobile broadband network into a programmable world and contributes to satisfy the demanding requirements of 5G in terms of expected throughout, latency, bandwidth and automation.

Addressed research questions/problems

- We want to show the impact of edge computing resources on a crucial vertical domain, namely the **automotive domain**. We focus on a relevant class of these services the **Extended Virtual Sensing** (**EVS**) class. Such services aim at enhancing the sensor measurements aboard vehicles with the data collected by the network infrastructure.



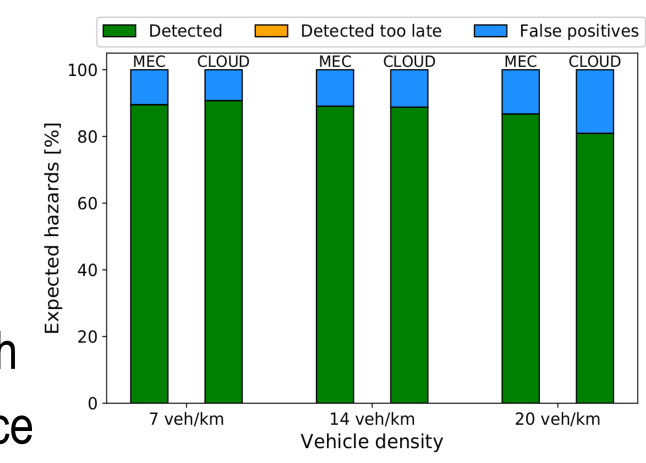
- In particular we want to evaluate the performance of a **V2I low-latency road-safety application** on a **MEC capable mobile network**. The **Open Air Interface** (**OAI**) project is exploited: it is an **open source project implementing a full LTE network**. The latest version includes **MEC functionalities**.
- **Which are the performance of a MEC-based EVS against a Cloud-based solution? Which benefit can the MEC paradigm bring?**

Submitted and published works

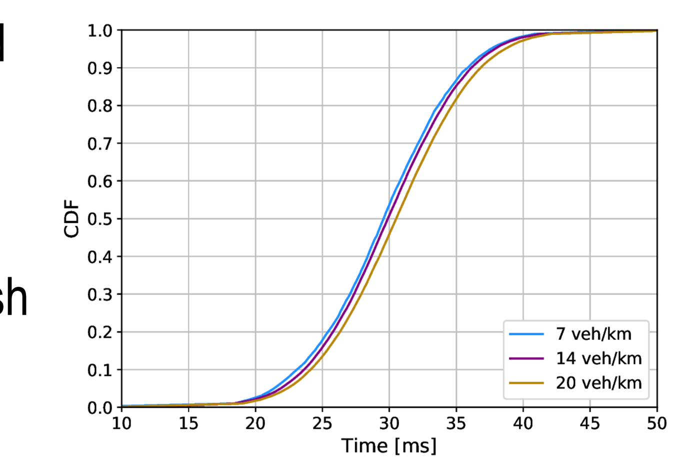
- Avino G., Malinverno M., Malandrino F., Casetti C. E., Chiasserini C. F., "Characterizing Docker Overhead in Mobile Edge Computing Scenarios", ACM SIGCOMM, Los Angeles (California), 2017
- Avino G., Malinverno M., Malandrino F., Casetti C. E., Chiasserini C. F., Nardini G., Scarpina S., "A Simulation-based Testbed for Vehicular Collision Detection", IEEE VNC, Turin (Italy), 2017
- Malinverno M., Avino G., Casetti C., Chiasserini C. F., Malandrino F., Scarpina S., "Performance Analysis of C-V2I-based Automotive Collision Avoidance", IEEE WoWMoM, Chania (Greece), 2018
- Avino G., Malinverno M., Casetti C., Chiasserini C. F., Rapelli M., Zennaro G., "Support of Safety Services through Vehicular Communications: The Intersection Collision Avoidance Use Case" Automotive, Milan (Italy), 2018
- Malandrino F., Chiasserini C. F., Avino G., Malinverno M., Kirkpatrick S., "From Megabits to CPU Ticks: Enriching a Demand Trace in the Age of MEC, IEEE TRANSACTIONS ON BIG DATA
- Avino G., Giordanino M., Pantelis F. A., Vitale C., Casetti, C., Chiasserini C. F., Gebru K., Ksentini A., Stojanovic A., "A MEC-based Extended Virtual Sensing for Automotive Services", 2019 AEIT, Turin (Italy), 2019
- Avino G., Bande P., Frangoudis P. A, Vitale C., Casetti C., Chiasserini C. F., Gebru K., Ksentini A., "A MEC-based Extended Virtual Sensing for Automotive Services", IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT
- Malinverno M., Avino G. , Casetti C., Chiasserini C. F., Malandrino F., Scarpina S., " MEC-based Collision Avoidance for Vehicles and Vulnerable Users", IEEE VEHICULAR TECHNOLOGY MAGAZINE, Submitted
- Baranda J., Avino G., Mangues-Bafalluy J., Vettori L., Martinez R., Chiasserini C. F., Casetti C., Bande P., Giordanino M. , Zanzola M., "Automated deployment and scaling of automotive safety services in 5G-Transformer", DEMO @ IEEE NFV-SDN, 12-14 November 2019
- Landi G., Giardina P., Capitani M., Kondepu K.; Valcarenghi L., Avino G., "Demo: network slices for virtual Content Delivery Networks in 5G infrastructures", ACM MOBIHOC 2019, Turin (Italy), 2019
- DEMO exhibition @ EuCNC Conference, Valencia 18-21 June 2019

Novel contributions

- We confirmed that the **MEC** will be a **key technological enabler in the development of sophisticated road safety applications.**
- For a full autonomous vehicle, we confirmed, in addition of information coming from on-board sensors, **the need of information provided by the mobile infrastructure**. Only in this way each vehicle is completely aware about what other vehicles in the surroundings are doing.
- We tested the reliability of our service, in terms of collisions correctly detected and false-positive alerts:
  - **100% of collisions detected in time** (i.e., the drivers has enough time to react)
  - The **false-positives** are **lower than 15%**; a high number may affect the drivers trust in the service

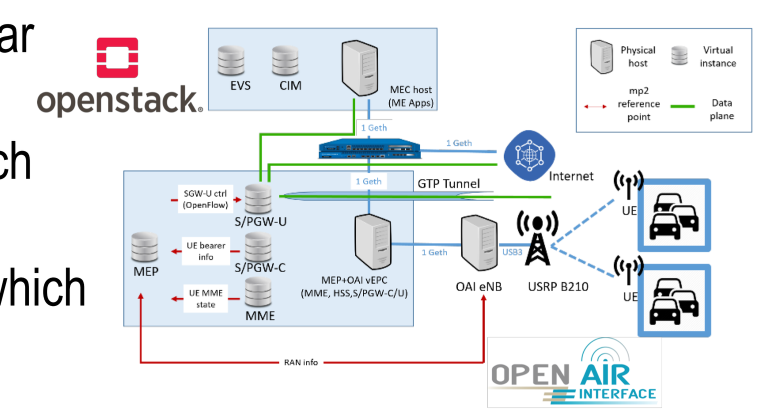


- We compared the **End-to-end delay** (i.e., time elapsed between the CAM transmission by a vehicle and the reception, by the same vehicle, of the alarm that such CAM has triggered) between a **MEC-based** and a **Cloud-based solution**. LIDAR sensors typically refresh their information every 60 ms and, for the information contained in the DENM to be coherent with on-board sensors, the maximum end-to-end latency should not exceed this value.

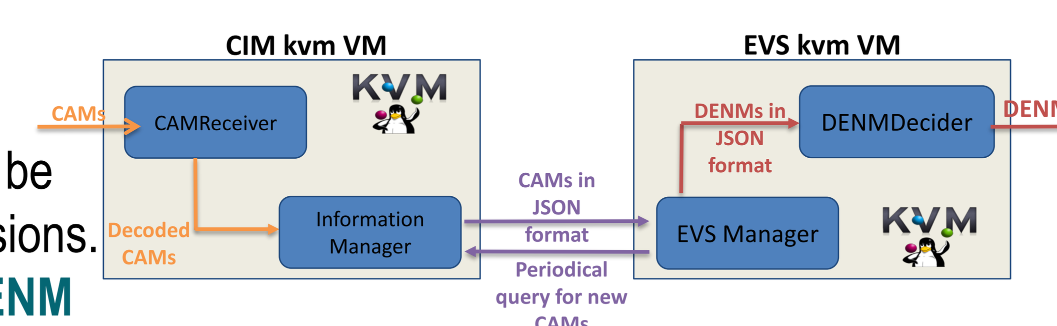


Adopted methodologies

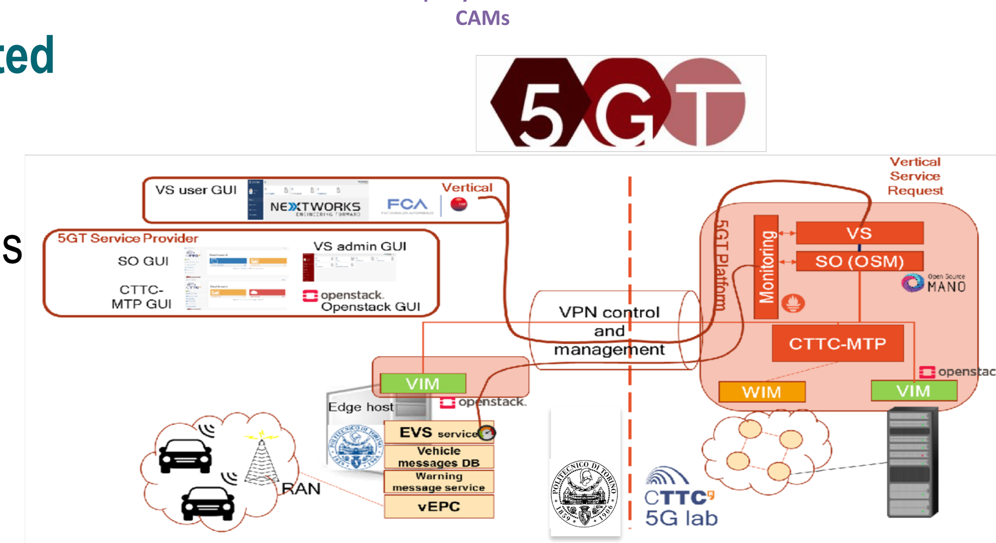
- For testing our MEC service, we exploit the popular **OAI project**, which allows to build your own LTE network. We virtualize and manage the VMs (which run the MEC services) using **OpenStack**.
- The core of the service is the EVS VM on top of which the **Collision Detection algorithm** runs.



- CAMs are received by the CAMReceiver and sent to the CIM database. **Every 5 ms EVS queries for new CAMs** which will be parsed to determine possible collisions. In case of collision, a couple of **DENM messages** is generated and **transmitted to the two involved vehicles**.



- This work is part of the European project **5G-Transformer**. 5GT proposes **an open and flexible 5G transport and computing platform** tailored to support diverse service requirements of various vertical industries.



Future work

- Test the road-safety service with real cars;
- Introduction of other types of services (e.g., video streaming service);
- Make possible, in this testbed, the coexistence of C-V2X (OAI) and 802.11p communication, in order to create and study a heterogeneous scenario;
- Introduction of Docker containers in the OAI testbed to reduce the system complexity.

List of attended classes

- 01PJHRV – Cloud computing per applicazioni e-science(16-10-2018, 4)
- 01QORRV – Writing Scientific Papers in English (21-03-2018, 3)
- 01RONKG – Python in the Lab (28-08-2019, 4)
- 01SHBRP – Examples of graph optimisation models in management science (didattica di eccellenza) (19-01-2018, 4)
- 01SHCRV – Unsupervised neural networks (didattica di eccellenza) (09-04-2018, 6)
- 01RRDIU – Semantic Web (23-01-2019, 4)
- 02LWHRV – Communication (06-06-2019, 1)
- 01SWPRV – Time management (07-01-2019, 1)