5G services in the vertical domains of connected cars and smart maritime

National and Kapodistrian University of Athens Campus

5G TESTBED

NKUA Network Technologies, Services and Applications (SCAN group activities)

Large scale experimental infrastructure:

- 5G Testbed
- IoT testbed
- SDN/NFV, SDR testbed
- UXV testbed

Application areas:

- Smart Cities,
- Industry 4.0,
- Smart multimodal transportation
- Smart Grids , etc.

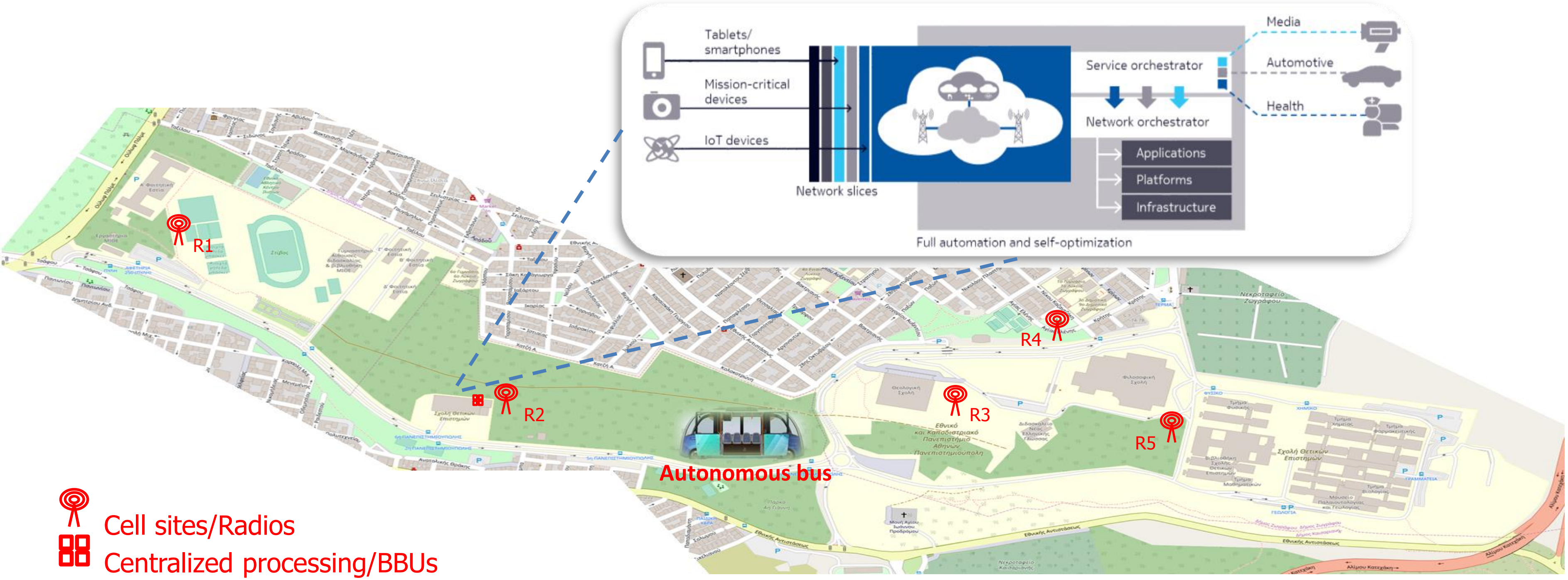
Capabilities:

- Smart networks, network slicing, multimode connectivity
- AI and big data analytics for wireless networks, network management
- Massive MIMO, 3D beamforming
- Multi-access edge computing, MEC
- Extreme mobile broadband (events, VR/AR, broadcasting)
- Machine to machine communication, IoT, energy management, wearables
- Critical machine communication (robotics, autonomous driving, emergency services)

NKUA Testbeds

- **5G Testbed (deployed by COSMOTE):**
  - Supported Technologies: GSM900, LTE800/1800/2600, 5G700/3500/mmwaves
  - Five (5) new Antennas + one (1) upgraded, Hight 12 – 20m. Local power support 1x40A or 3x16A
  - Additional 3-6 3500/mmwaves Small Cells in hotspot – indoor
  - Computer room for Network Management and baseband infrastructure in the Dept. Informatics and Telecommunications of NKUA.
  - Connectivity of radio and baseband infrastructure through fiber optics, type G.652d.
- **IoT Testbed:** IoT platform, more than 250 sensors (proximity, fire/smoke, temperature, humidity, light, etc.)
- **SDN/NFV, SDR testbed:** More than 3 controllers/Vswitches, 10 USRPs (OAI etc.), 40 access points
- **Autonomous Bus and UXV testbed:** 1 bus, variety of drones, octa/quad-copters, ground vehicles

Network Topology



SCAN-5G CROCO results

- A vehicle is moving and depending on the geographical environment, coverage gaps (e.g. tunnels, mountains, forests) can occur.
- Additionally, specific network conditions (base station load, number of moving UEs in the vicinity, etc.) further influence the allocated resources and the provided QoS
- Traffic prioritization will not solve the problem that QoS requirements by an application cannot be met, if radio resources are not available at all or their quality is too bad.
- Prediction enables in-advance information of the expected network quality for a given location and time to a specific subscriber of the network. It can include direct or indirect coverage information of the radio network and available network capacity.

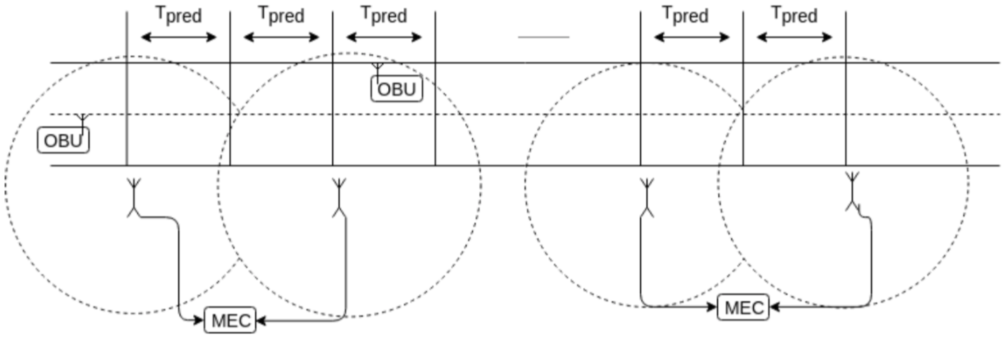
SCAN-5G CROCO main inputs

- In order to adequately address the specific QoS requirements, the mechanism needs to identify the different parts, which comprise the end-to-end communication path.
- Predictive QoS in time-critical scenarios needs to proactively process
  - diverse types of context information
  - spanning across all the network layers.
  - Access layer:
    QoS1 = f(RSSI, RSRP, RSRQ, CQI, SINR, client (GPS, velocity, heading), geolocation map)
  - Networking/transport/facilities layers:
    QoS2 = f(RSU-related network load, RSU-Queues load, Max clients limit per cell)
  - Network upper-layers' performance perspective:
    QoS3 = f(packet loss, delay, jitter, latency, throughput, bandwidth)
  - Application specific information
    QoS4 = f(cluster-based communication type, priorities, etc.)

- Geolocation Map: heatmap for areas with signal degradation (high traffic areas, environmental factors (such as obstacles, reflection surfaces, other signals)
- Delay is broken down into different categories:
  - Radio delay (OBU - RSU communication),
  - Communication delays between RSU and MEC / MEC and cloud
  - Computational delay at MEC/cloud
  - Communication delay between the Cloud and the Internet

Assumptions

- We assume all vehicles are equipped with geolocation information/Global Positioning System (GPS) and provide their velocity, direction and position information to the controller in pre-defined time intervals, according to scenario.
- Furthermore, we assume regular reporting, both from the OBU/UE side (RSRQ/RSRP, channel quality indicators, etc.), as well as from the RAN elements (load, number of connected clients per base station, etc.).

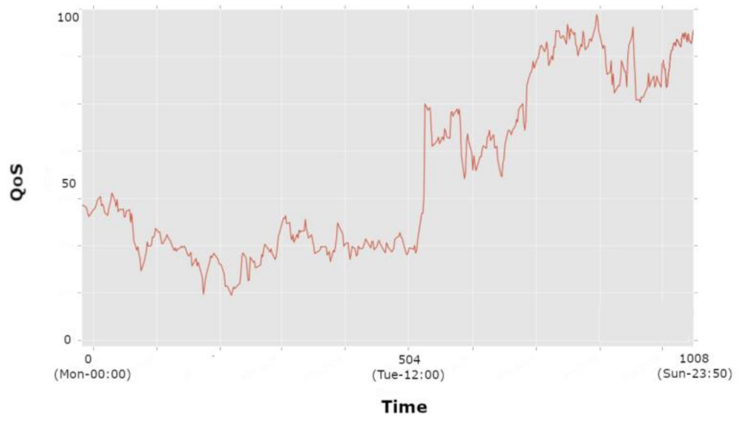


Fusion Machine Learning

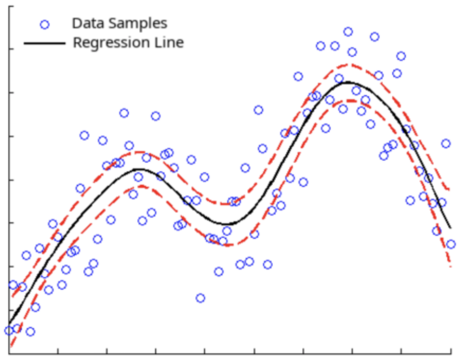
- The proposed mechanism is based on a Fusion Machine Learning scheme, which combines different data sources
- Depending on the specific V2X service requirements and available context information, the mechanism is able to adapt its configuration in a flexible manner:
    - different weights are assigned to the above QoS indicators to create tailored models (based on regression, LSTM, etc.)
- One of the primary steps is to partition the physical space into a grid, comprising of a large number of cells, towards clustering them, which demonstrate similar Regression Models in terms of specific QoS metrics (threshold-based)
- Initial cell dimensions are randomly initiated at very low dimensions and then based on the clustering steps are gradually converging towards larger geographical grid cells with correlated QoS behaviour

Clustered Grid

- The predicted values apply per cell cluster



- Confidence intervals are provided per cluster cell



Cell	Data Rate	Delay	Datetime
132	55.21 ± 2.5 Mbps	12 ± 2.3 ms	57
....	....	....	....
24	48.81 ± 2.3 Mbps	14 ± 2.7ms	282

- At the end, the mechanism predicts the cluster cell, in which a UE will be located and links it to the respective regression model

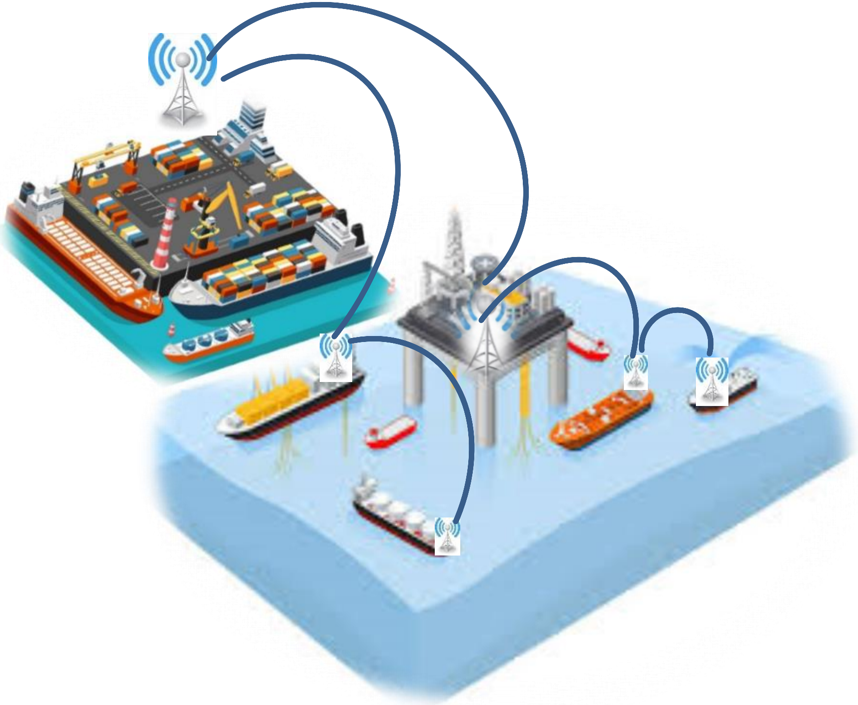
Augmenting regression models based on real-time information

- Besides the historical data-based prediction model, additional regression models for each cluster are created based on the available real-time information.
- For example:
- the number of UEs in each cluster in relation to the time (same weekly 10-minute time interval)
- the real-time load of the base stations
- the latest RSRQ/RSRP values from the UE reporting
- other real-time information
- The correlation between the QoS over time and the additional regression models is determined using Pearson Correlation.
- This is important due to the fact, that if the system knows the current traffic, our Algorithm considers it as an extra parameter in the decision making process.

Example:

1. The UE will be at Cluster 14 at 15:32 (Tuesday)
2. The main model of Cluster 14 returns the **initial prediction** for Tuesday 15:30 [e.g. expected UL data rate = x Kbps for N seconds, expected DL delay = y ms for M seconds, etc.]
3. The **additional regression model** of Cluster 14 returns the average UEs for Tuesday 15:30 which is [e.g. **#UEs = 100**]
4. The network reports in **real time** how many UEs, given their trajectory, will be at Cluster 14 at 15:30 [e.g. **#UEs = 300**]
5. The algorithm **updates the predicted values (to lower rates/higher expected delays**) taking into account the real-time information (how much lower QoS will be depends on the correlation between traffic and QoS)

Smart Maritime Concept approach



Real time port activity– Cargo, transportation, logistics in smart port + IoT

Marketplace Operations | Create Demand | Create Offer | Services | Interactive Port Map

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