

Distributed Machine Learning for Network Monitoring and Predictive QoS in Automotive Applications

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5G-IANA project

❖ 5G-IANA (<https://www.5g-iana.eu>) is an ICT-41 project running from June 2021 to November 2024 aiming at providing an open 5G experimentation platform, on top of which third-party experimenters (i.e., SMEs) in the Automotive vertical will have the opportunity to develop, deploy and test their services.

❖ 5G-IANA will develop a Distributed Artificial Intelligence / Machine Learning (AI/ML) (DML) framework, that will provide functionalities for simplified management and orchestration of collections of AI/ML service components and will allow ML-based applications to penetrate the Automotive world, due to its inherent privacy preserving nature.

KEYWORDS

5G, CCAM, Distributed Machine Learning, Federated Learning (FL), Predictive Quality of Service (QoS), Network monitoring.

Distributed Machine Learning in 5G-IANA

Objective:

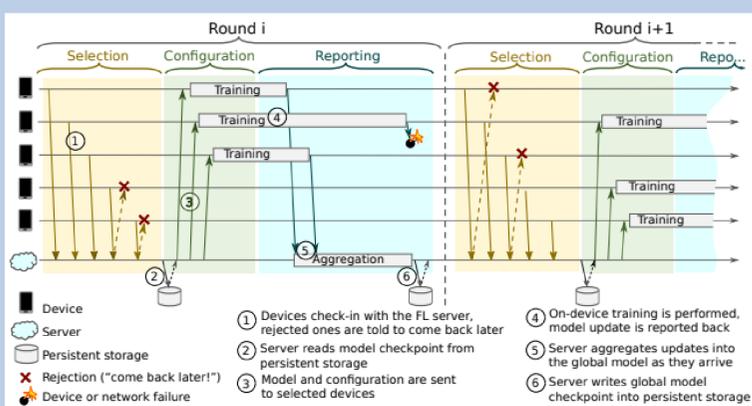
- ❖ Estimate QoS conditions and pro-actively adjust network and service configuration, in cases of expected QoS degradation.
- ❖ Deliver In-advance QoS Notifications (IQN) to applications, in the context of Predictive QoS.

Method:

- ❖ The estimation of upcoming QoS conditions heavily builds on the use of historical data.
- ❖ Training of a ML model with a large set of historical data, to later use it for inference based on the current conditions.
- ❖ In the context of Predictive QoS, data sources include the 5G mobile network, having the vehicle itself as the natural focal point of past QoS experience and contextual information.

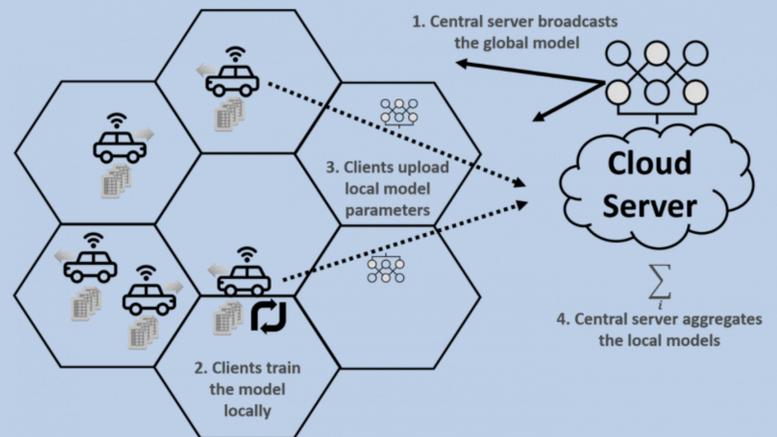
Why DML/FL:

1. Training data can be of high volume consuming non-negligible network resources for collection.
2. Subject to privacy concerns such as vehicle trajectory.
3. The dynamics of mobility call for a continuous learning process able to adapt to evolving and short-term conditions.



The advent of DML, including FL promises to address some of these challenges by realizing multi-node ML systems that bring the (un-)trained model to the data and hence (re-)train, collect and aggregate model instances in repetitive (a)synchronous steps.

The DML/FL framework in 5G-IANA:



1. A model aggregator in the central cloud server selects a subset of clients and dispatches the current global model;
2. The clients perform local model training;
3. The clients upload the local models back to the cloud server;
4. The central cloud server aggregates the local models.

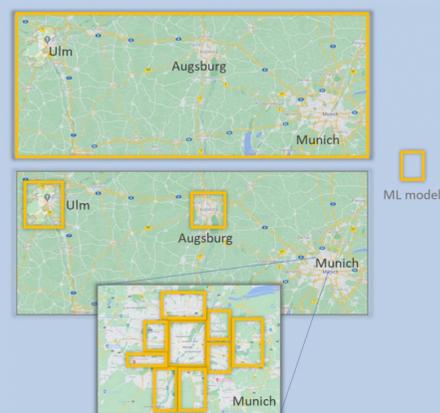
Challenges:

Realizing a DML/FL scheme requires the inclusion of vehicle On-Board Units (OBUs) and Road-Side Units (RSUs) within the broader operational scope of MANO processes:

- Integration of virtualization & programmability.
- Presence of intermittent connectivity/availability.
- Requirement for advanced DML/FL MANO primitives, reducing the complexity of processes such as client selection, overlay topology formation, and placement.

5G-IANA scope:

- ❖ Provide generic MANO primitives and NetApp VNF support for the realization of DML/FL services/applications.
- ❖ Network monitoring data produced in NOKIA 5G testbed in Ulm, Germany, which consists of 5 sites-with 3 radio cells each.
- ❖ The monitoring data will be used to feed a DML/FL-enabled Predictive QoS service, with the purpose of eventually delivering IQNs for consumption by other services.
- ❖ Selection of ML model / aggregation server corresponding to spatio-temporal QoS maps of the region of interest.



Conclusions:

- ❖ Within 5G-IANA, a DML framework will be developed that will enable ML-based applications to penetrate the Automotive world, allowing to participate in the learning process increasing the efficiency and the deployment areas of AI/ML services.
- ❖ As a result, a DML/FL-enabled predictive network monitoring (i.e., QoS) service will be deployed that will support 5G-based applications to make efficient use of their data and resources.

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