technische universität dortmund

Communication Networks Institute

(Bachelor Thesis /) Master Thesis

Federated Learning-Based Mobile Network KPI Prediction in Novel Public 5G Networks

In previous works, machine learning (ML) prediction models 5G non-standalone (NSA) mobile networks for pQoS (predictive quality of service) were evaluated [1]. These can be utilized in advance predict KPIs like uplink and downlink data rates. With this information, the feasibility of data rate-reliant applications like video streams for tele-operated driving can be derived. For battery-based devices, energy consumption can be reduced by transmitting data if the achievable data rate is sufficiently high.

However, the described mobile network system underlies drift and local characteristics. A model trained on rural data may fail to predict the QoS in urban environments. That is a challenge for the distribution of the ML models to the users. Additionally, the learning data set needs to be available at a powerful centralized entity, resulting in privacy issues [2].

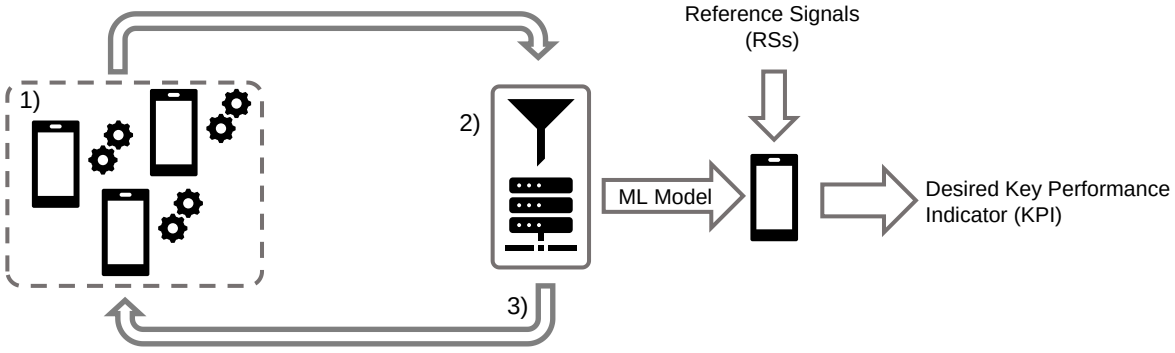

Figure 1: Methodology of federated learning for quality of service prediction

Federated Learning (FL) aims to overcome these issues by decentralizing the learning process. A local model is trained on every user equipment (UE) and is exchanged, e.g., via a central server. This server combines the local models into a global model, which shall outperform the local models. Then, the global model is redistributed to the UEs, which (partially) update their local model [2]. The goal of this FL process is to match or outperform the locally trained ML model and reduce the number of federated model exchange rounds to reduce the amount of exchanged data [3]. At the same time, the model exchange has to take place so that the user behavior cannot (or only with a high effort) be reconstructed from the exchanged local model.

To sum up, federated learning enables the deployment of mobile network quality prediction in a real environment at a large scale [4]. Several applications like tele-operated driving, smart city applications and everyday smartphone users would benefit.

Potential work steps of your master thesis:

- Familiarization with machine learning concepts and 5G NSA mobile networks
- KPI prediction with well-known machine learning concepts
- Implementation of suitable Federated Learning (FL) machine learning algorithms for mobile network KPI prediction
- Comparison with central machine learning performance and different variants of federated learning

Requirements

- Interest in mobile communications, 5G technology and modern machine learning methods
- Participation in MDK lecture (Grade: excellent/good) highly desirable; other CNI lectures are a plus
- Excellent English skills, Willingness to write thesis in English highly desirable
- Advanced Python and basic LaTeX/TikZ skills

Hendrik.schippers@tu-dortmund.de www.cni.tu-dortmund.de

References

[1] B. Sliwa, H. Schippers, and C. Wietfeld, “Machine Learning-Enabled Data Rate Prediction for 5G NSA Vehicle-to-Cloud Communications,” in 2021 IEEE 4th 5G World Forum (5GWF), Oct. 2021, pp. 299–304. doi: 10.1109/5GWF52925.2021.00059.

[2] J. Park et al., “Communication-Efficient and Distributed Learning Over Wireless Networks: Principles and Applications,” Proceedings of the IEEE, pp. 1–24, 2021, doi: 10.1109/JPROC.2021.3055679.

[3] F. P. C. Lin, C. G. Brinton, and N. Michelusi, “Federated learning with communication delay in edge networks,” in GLOBECOM 2020 - 2020 IEEE Global Communications Conference, 2020, pp. 1–6. doi: 10.1109/GLOBECOM42002.2020.9322592.

[4] K. Bonawitz et al., “Towards federated learning at scale: System design,” arXiv preprint arXiv:1902.01046, 2019. [2] Reference 2