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AI-assisted dimensioning methods for Network Slicing in Next Generation Mobile Networks

ABSTRACT

This doctoral dissertation explores the dimensioning of 5G mobile network technology, with a specific focus on incorporating the impacts of network slicing. The research carried out in the context of this dissertation contributes to the advancement of techniques for dimensioning 5G networks. It is believed that as the complexity of the 5G architecture rises, the manual tasks performed by technical experts will no longer suffice for input preparation, such as traffic modeling, making it essential to develop AI-based methods.

As a result of the research, a new methodology and framework was developed that considers the:

1. key performance indicators selection,
2. performance forecasting,
3. predictive modeling for regression of selected outputs (e.g. throughput and delay),
4. indirect estimation of link capacity,

which will be used in Nokia's network planning and dimensioning processes. The use of real network data to develop and verify the models and algorithms created adds to this innovation.

Forecasting throughput and delay is an important component of the framework that allows indirect dimensioning of 5G BTS capacity. As part of the research, the use of multivariate predictive models was performed to forecast slice level throughput and delay as a data-driven approach to dimension 5G capacity. After comprehensive comparison, the VARMAX model, a vector autoregressive moving average model with additional exogenous inputs, was selected as the best model to forecast throughput and delay. The results indicate that this model is equally effective for short- and long-term predictions with commendable accuracy. Additionally, incorporating configurational knowledge, such as the frequency band, into the model's training process enhances its accuracy. The evaluation of one-dimensional models for the forecasting of environmental variables was also performed as a supporting element for the multivariate model. For this problem a Lag-Llama model, which is a foundational time series model, was selected after a thorough evaluation. All validations and comparisons were made with normalized mean absolute error and mean absolute percentage error metrics.

In addition, this work presents an original technique, using system-level traffic data, to estimate the statistical multiplexing gain of aggregated 5G transport links. The algorithm enables the scalability of the simulation outcomes. This approach reduces the computational time from days to seconds, which is crucial for network planning recommendations, and ultimately improves the efficiency and flexibility of services provided to telecommunication operators. Two case studies have been presented, demonstrating the alignment of the estimations with

measured values from microwave links in mobile networks and highlighting their relevance to cloud BTS dimensioning.

Finally, a data-centric framework is introduced for forecasting and dimensioning, integrating the digital twin concept. This model can autonomously serve as a forecasting tool for (sliced) network dimensioning and traffic management, or it can act as a key component of a comprehensive digital twin. In addition, it illustrates the feasibility of how interconnected methods investigated in this work deliver the necessary output.

To verify the validity of the framework and evaluate its applicability and ability to maintain the physical context, experiments were performed on the actual data. The results show that the proposed framework can effectively elucidate and quantify these phenomena through data-driven simulations of sliced wireless networks.

Implementing the framework will reliably assist Nokia processes by automatically recommending capacity expansions or configuring parameters for slice planning based on the real data.