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Master's thesis

Data-driven resource management for self-organizing 5G Network Slicing

While traditional mobile communication networks until 4G mainly address end-consumer voice telephony and internet access, the fifth generation of mobile networks (5G) aims to be a multi-service network. This means that a wide variety of vertical industries with differing and partially contradicting requirements have to be supported. For this, the so-called Network Slicing emerged, which divides a single physical network into multiple virtual networks called Slices [1]. These Slices are tailored to the specific needs of a service or vertical industry, supporting a wide variety of Quality of Service (QoS) or Quality of Experience (QoE) parameters like, among other things, guaranteed data rates, latencies, and packet error rates.

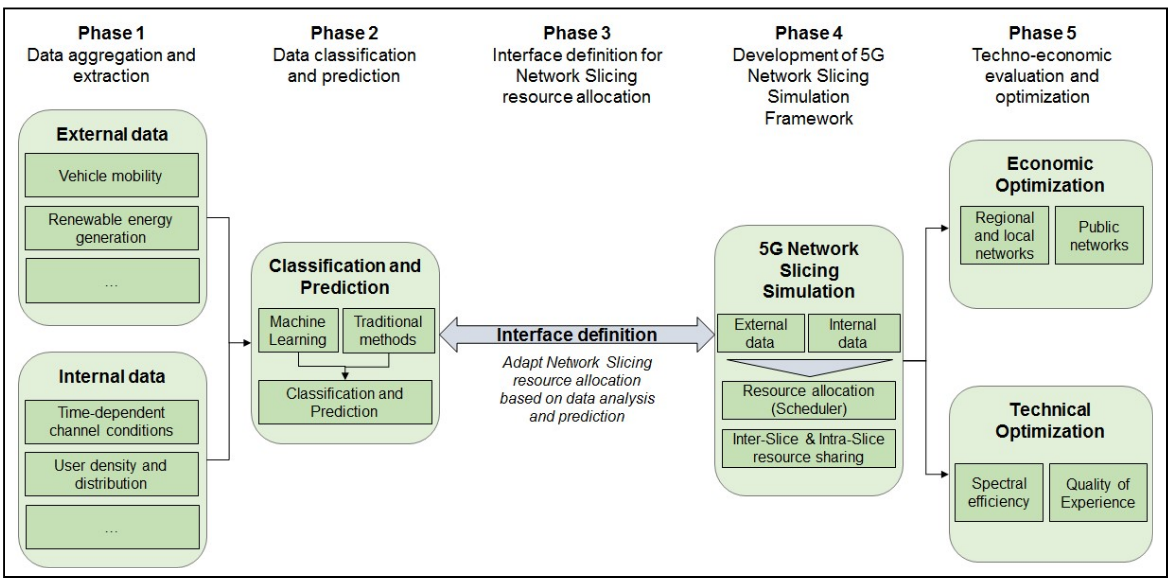

Figure 1: Possible work phases and architecture to support data-driven Network Slicing management.

The management of Network Slices imposes a set of new challenges:

Inter-Slice (between Slices) and Intra-Slice (Slice-internal) resource sharing is needed to ensure that all Network Slices are served according to their requirements while not wasting any free resources (spectral efficiency) [2]. Furthermore, constant Slice adaptation is required due to varying communication channel conditions and service requirements, so a static slice configuration will only work for a short period. For example, a slice with User Equipment (UEs) in bad channel conditions requires far more resources to achieve the same data rate as a slice with optimal channel conditions [3]. Additionally, channel conditions of a slice can change over time, e.g., moving vehicles in an autonomous vehicle slice.

Moreover, a sudden increase in demanded data rate can occur, e.g., in a renewable energy generation slice, where a peak in solar energy would require more control intervention by the grid operator as otherwise grid stability would be endangered.

As forementioned slices are highly critical and thus require very short reaction times, human-aided slice adaptation will not suffice. To solve this, self-organization of Network Slices is desirable [4]. This could be achieved by considering different data sources to proactively adapt slices prior to changing conditions. In this master's thesis, a **data-driven self-organization of Network Slicing** shall be developed and evaluated. Figure 1 depicts the elements and work phases of this thesis, which are summarized as follows:

- **Data aggregation and extraction:** Internal data, like varying channel conditions, and external data, e.g., vehicle or user mobility, have to be aggregated and extracted in order to establish a data basis for self-organization.

- **Data classification and prediction:** The aggregated data shall then be used to develop models using Machine Learning or traditional methods like regression. These models represent the foundation for prediction of future events and requirements regarding the communication network.

- **Development of 5G Network Slicing Simulation Framework:** In order to evaluate the effects of the data-driven approach, a simulation of 5G Network Slicing is required. For this, parameters and new approaches in 5G have to be identified and transferred into the simulation, e.g., greater transport block sizes, better modulation coding schemes, shorter transmission intervals and the combination of different numerologies in a single mobile cell [5].

- **Interface definition for Network Slicing resource allocation:** Proper interfaces between the Network Slicing Simulator and the prediction engine have then to be developed to be able to adapt slices based on the predictions.

- **Techno-economic evaluation and optimization:** All forementioned work can then be used to evaluate and optimize the developed approaches, both in **technical**, e.g., by analyzing the gain in spectral efficiency, and **economic** terms, e.g., by using the cost equation for private 5G networks defined by the German Federal Network Agency [6]. With this, a possible network sharing between different tenants can be analyzed to optimize the costs caused by private 5G networks, which is also encouraged by the Federal Network Agency. The private network approach can then be compared with the usage of Network Slicing in public networks.

Requirements:

- General understanding of mobile communication networks and protocols
- Desirable: General understanding of machine learning principles
- Desirable: Python programming

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