Optimization of multilayer networks with time-varying traffic aided by traffic prediction

Aleksandra Knapińska

Over the years, in light of the continuous increase in the amount of transmitted data, the persistent efforts to enhance the backbone communication networks have focused primarily on the development of new technologies. The proposed improvements in optical networking require, however, complex equipment upgrades. Thus, they are usually performed relatively rarely. However, the recent development in pattern recognition tools and the availability of massive amounts of data have turned the attention of the community to new approaches to network optimization. Models built using data-driven methods enable the provisioning of increasing amounts of bandwidth requirements within the existing infrastructure, steering the network based on the data analytics information. Therefore, in this Dissertation, we investigate algorithmic approaches to improve the network performance. We comprehensively research the notion of traffic forecasting in optical networks and its application in multilayer networks with time-varying traffic. We put a particular focus on thoughtful model design to achieve the desired network operation improvements and enable their practical implementation.

In this Dissertation, we address two research problems: *network traffic prediction* and *optimization of multilayer networks with time-varying traffic*. The formulated research thesis states that *it is possible to demonstrate advantages of using traffic prediction to enhance the optimization of multilayer networks with time-varying traffic against baselines*. The research conducted to prove the research thesis resulted in the following Dissertation contributions.

- Collection of network traffic data and creation of real and semi-synthetic datasets.

- Preparation of network traffic datasets for research purposes by feature engineering.

- Development of traffic prediction models for network optimization tasks based on data aggregation.

- Development of a long-term traffic network prediction method based on data stream mining techniques and its broad evaluation on real data.

- Development of an adaptive network traffic prediction method that minimizes the window of infeasible forecasting amid concept drifts around link failures and traffic restoration.

- Development of an optimization algorithm for multilayer networks with time-varying traffic aided by traffic prediction.

- Evaluation of the performance of multilayer networks with various traffic patterns and quantification of the benefits from using traffic prediction and grooming.

- Evaluation of the performance of multilayer networks with time-varying traffic under various generations of commercial devices.

- Evaluation of the impact of geographical constraints by quantification of the importance of network nodes depending on their frequency of appearance in shortest paths.

- Evaluation of the energy efficiency of multilayer networks with time-varying traffic depending on reallocation frequency.

- Assessment of the performance of dynamic network optimization with overprovisioning consideration.