Thesis Topic Description

The Chair of Communication Networks at the Technical University of Chemnitz, Germany, is currently conducting research on advanced methods for the design of Intelligent and Data-Driven Communication Networks. In line with this filed of research, we are currently offering a thesis topic on:

Modelling, Optimization and Performance Evaluation of High-Speed Networking Systems by Graph Neural Networks

Network modelling is a key enabler to achieve efficient network operation in next-generation, self-driving Software-Defined Networks (SDN). In this regard, the modelling of high-speed networks requires approaches that unveil the dependency of the network performance on the traffic load, the service classes, the routing method and the network capacity. Application scenarios of high-speed networks include core networks which are built as multi-layer systems that combine packet and circuit-switched networking technologies. In core networks, high-speed connectivity is accomplished by circuit-switched systems based on wavelength division multiplexed (WDM) and optical transport networks (OTN) which operate in the optical and the electrical domain, respectively. WDM networks supply high-speed bandwidth through circuits realized by lightpaths which are set up in the optical domain. OTN networks, on the other hand, are deployed over WDM systems so as to supply bandwidth through dedicated circuits provisioned as containers (or time-slots) in the electrical domain. WDM lightpaths and OTN containers supply the bandwidth that leverages the delivery of IP/MPLS packet-switched transport.

WDM and OTN networks behave as large-scale stochastic loss systems. Understanding the dynamic behaviour of these systems is essential for the dimensioning of low cost networks that provide optimum performance. Although the theory of stochastic networks provides the framework for the definition of analytical models for these systems, their applicability is limited since the huge cardinality of the network state-space precludes the calculation of key network key performance indicators (KPI). This thesis aims at investigating an alternative solution to this problem by applying Artificial Intelligence methods based on Graph Neural Networks (GNNs). These networks have the capability to learn and understand the complex relationships between topology, routing, and input traffic so as to produce accurate estimates of network KPIs such as service-class blocking probabilities and transmission delays. The goal is to assess the ability of GNNs to learn and model graph-structured information and to generalize over arbitrary topologies, routing schemes and traffic intensities.

The network models based on GNNs should be designed as Machine Learning (ML) instances embedded into simulation frameworks implemented in Python. Simulations should be set up to validate the models on selected use cases where the KPI predictions of the GNNs must be compared with known KPI data sets.

The successful applicant will acquire the following skills:

- Simulation and performance evaluation of communication networks.
- Machine Learning and Artificial Intelligence methods for the design of cognitive networks.
- Design of high-speed networks with resource contiguity and continuity constraints.

Thesis Guidelines:

- Thesis type: Monograph.
- Duration: Six (6) months.
- Supervisor: Dr.-Ing. Ronald Romero-Reyes (acting as project advisor)
- The thesis will be supervised remotely by the project advisor through weekly meetings that include tutorial sessions.
- Interested candidates should speak fluently at least one of the following languages: English, German or Spanish.

Required Skills for Application:

- Good programming skills.
- Basic knowledge on networking concepts.

Interested candidates should email their CVs and transcript of records to:

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