DESCRIPTION FOR THE GENERAL PUBLIC

Telecommunications networks are undergoing constant evolution, which is currently largely related to the deployment of fifth-generation (5G) mobile networks and, in the near future (by 2030), sixth-generation (6G) networks, which are already undergoing research and development. 5G and 6G networks will enable the realization of multiple communication services over a shared network infrastructure. Among these services are (a) Enhanced Mobile Broadband (eMBB), assuring the available transmission bandwidth of mobile devices up to 1-20 Gbps in 5G and 1 Tbps in 6G, (b) Ultra-Reliable Low-Latency Communications (URLLC), which is essential for e.g. in virtual and augmented reality applications or autonomous vehicles, and (c) massive Machine Type Communications (mMTC) that enable devices to communicate and realize the Internet of Things (IoT). To meet the expectations of 5G and 6G services, the mobile networks will rely on new radio access technologies, higher radio frequency bands, and network densification, i.e., the installation of additional antennas/access points to which users' mobile devices connect.

From the network user's point of view, the connection of his mobile device (such as a smartphone, tablet, or laptop) to the Internet first takes place via a wireless connection to an access point (antenna) of a radio access network (RAN). Through such a connection, traffic (e.g. multimedia streaming, messaging in instant messaging) generated by mobile applications (such as www, YouTube, WhatsApp, Netflix, etc.) is transmitted. This traffic is received at the access point and then transmitted via the so-called Xhaul transport network connecting RAN elements, such as access points and the intermediate computing "radio cloud" responsible for processing the radio signal to acquire the transmitted data, with the so-called core network, which is itself connected to the Internet. In this context, one of the challenges in 5G and 6G networks, particularly in the case of "dense" urban networks, is the construction of Xhaul networks capable of providing flexible support for a large number of radio access points, while enabling the transmission of large amounts of traffic at low cost. The solution that makes this possible is a multilayer network realizing the transmission of radio data in the form of packets transmitted in the well-known Ethernet technology via high-capacity fiber connections established in an optical network based on wavelength division multiplexing (WDM) technology. The project focuses principally on this type of multilayer Xhaul network.

The main challenge in multiservice Xhaul networks, supporting diverse 5G and future 6G services over the same (packet-optical) transport network infrastructure, is to provide processing resources (in the radio cloud) and transmission resources (in the transport network) according to the needs of individual 5G/6G services. These needs can vary significantly for given services and are related to, among other things, maximum latency, required bit rate, and service reliability/availability. The implementation of multiple services on the same network infrastructure, referred to as network slicing (NS), is a challenging task, as services compete for shared network resources while their quality of service (QoS) and reliability needs must be met. In addition, the network should be capable of reconfiguration and adapting to dynamic slice requests and traffic changes. In this regard, among the specific open research issues related to the operation of multiservice and multilayer Xhaul networks are the effective prediction of latency at the flow and service level, ensuring network reliability through protection mechanisms, considering the impact of signal distortion on transmission quality in optical fibers, optimizing dynamic Xhaul networks with variable traffic, and cross-layer optimization of the packet and optical layer. The main scientific objective of this project is to develop and evaluate models and methods that solve these issues in multi-service and multilayer Xhaul networks.

Dedicated optimization models and methods are needed to effectively design multiservice and multilayer Xhaul networks and to operate them in a coordinated manner that covers different network layers and domains (including transport network, radio network, and radio cloud). Optimization problems that relate to network design (e.g., network planning, resource placement) and those related to network operation (e.g., resource allocation, network re-optimization) can be formulated as mathematical models based on so-called mathematical programming methods, such as mixed integer programming (MIP), and then solved using computer tools. Since most of these problems are difficult (so-called NP-hard), dedicated heuristic and meta-heuristic algorithms are developed and applied to complex optimization problems, allowing solutions (not necessarily optimal) to be obtained in less time. Ultimately, machine learning (ML) methods are applied to the optimization of complex and dynamic communication networks. The project assumes the development of algorithms and models applicable for optimizing Xhaul networks based on these methods.