DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

The communication networking is undergoing immense changes which are governed by the development and integration of diverse network technologies and applications. The current trends result in an exponential increase of traffic on the level of 30% – 90% per year (depending on application and traffic type). However, this trends are not followed by an adequate growth of capacity of conventional dense WDM (DWDM) transmission systems (20% per year). The disparity between the foreseen increase in traffic demands and capacity growth in core networks, sometimes referred to as *optical networks capacity crunch*, leads to the need for new solutions ensuring very high bit-rate connectivity (up to 10 Tbit/s) and increase of optical fiber capacity up to 1 Pbit/s (in 2010, it was ~100 channels × 100 Gbit/s ≈ 10 Tbit/s) in the next few or several years. In this context – and according to the research agenda of the European Commission (EU) under the program "H2020 5G Infrastructure PPP" – optical networks are considered a key technology for building transport infrastructure for future Internet networks based on the fifth-generation (5G) wireless networks. Capacity requirements of such networks, up to 100× more than currently available in the core, necessitate new solutions, more scalable than the current ones. Spectral division multiplexing (SDM), combined with elastic optical networking (EON), is foreseen as breakthrough technology and the only long-term solution that could satisfy such requirements. For efficient design and operation of SDM elastic optical networks dedicated optimization models and methods are needed.

The main concern of the Project is modeling and optimization of SDM elastic optical networks. Modeling and optimization of communication networks is a well-established and important area of research. Mathematical programming methods, such us mixed-integer programming (MIP), are a basic tool in modeling and solving optimization problems. Optimization problems that arise in network design (e.g., network planning, resource placement) and operation/control (e.g., network re-optimization, resource allocation) can be formulated as MIP problems. Most of these problems are *NP*-hard, which means that there are no known algorithms that could deterministically solve them in polynomial time. To generate solutions, both exact algorithms, based on a branch-and-bound method, and heuristics are applied.

SDM introduces a new dimension in network optimization by enabling parallel transmission in optical fiber modes and cores, or in fiber bundles. Indeed, the application of spatial division multiplexing, along with wavelength division multiplexing technologies (which are also utilized in DWDM and EON networks), increases network capabilities, since optical carriers forming high-capacity "super-channels" are not carried just on adjacent frequencies in the frequency domain (*spectral elasticity*), but they can also be distributed over different modes, cores or fibers (*spatial elasticity*). This extends the set of decision variables in network optimization and leads to the routing, space, and spectrum allocation (RSSA) problem – a basic problem in planning and operating SDM elastic optical networks. The RSSA optimization problem is more complex than the routing and spectrum allocation (RSA) problem in EONs. Consequently, previous RSA solutions cannot be applied directly and new methods and algorithms have to be developed for solving RSSA. Optimizing the network beyond the basic RSSA scenario is yet more challenging. Here, additional problem constraints and variables resulting from consideration of network survivability, signal regeneration, traffic grooming, or multi-layer design, are involved and have to be taken into account in the optimization problem and its resolution methods.

In multi-core fiber and few-/multi-mode fiber transmission systems, the impact of crosstalk between adjacent fiber modes and cores on transmission quality needs to be investigated in order to develop models for its estimation in core networks, in which provisioning of quality of transmission (QoT) guarantees is particularly critical due to large transmission distances. Such models are indispensable in physical layer impairment (PLI)-aware network planning and operation; we will focus on developing them in the Project.

So far, most of the research efforts have targeted mainly physical-layer aspects related to the realization of SDM transmission, in particular, development of dedicated optical fibers, system components and transmission devices. At the same time, to the best of our knowledge, there are very few papers concerning modeling and optimization of such networks, including the development of adequate methods and algorithms for the RSSA problem, even though the potential scope of research is very extensive if we consider its similar context as in WDM and EON networks. Due to these reasons, among others, the studies undertaken in this Project have a pioneering character and will contribute to the development of scientific discipline (communication networking).

An important goal of the Project is to build a unique research methodology and increase the competencies of the Research Team in the emerging area of SDM elastic optical networks. It is a timely and still not deeply explored direction of research in the field of communication networks.