DESCRIPTION FOR THE GENERAL PUBLIC

Communication networking is undergoing profound transformation, which is driven to a large extent by the imminent deployment of the 5th generation wireless networks (5G). The importance of 5G networks will be enormous since they will span over main domains of people activity, having revolutionary impact on economic and social aspects of our life by enabling *4.0 Industry*, *Internet of Things* (IoT), *autonomous transport*, etc. 5G will bring ubiquitous access to new wireless services that are classified as: (a) enhanced Mobile Broadband (eMBB), with the increase in available transmission capacity of mobile devices (up to 1-20 Gb/s), (b) massive machine type communications (mMTC) for connected devices and IoT (over trillion devices in total and more than million per sq. km is foreseen), and (c) ultra-reliable and low latency communications (URLLC), which is necessary, e.g., in virtual and augmented reality applications as well as for autonomous vehicles. In order to enable such services, 5G networks require the implementation of new radio access technologies and concepts, utilization of higher radio frequency bands, and the dense installation of antennas / wireless access points (so-called *network densification*) with which users' mobile devices connect.

The connection of mobile devices (such as smartphones, tablets, laptops) to the Internet is done via the access points of radio networks. In particular, mobile applications (www, YouTube, Facebook, WhatsApp, etc.) that use Internet resources generate traffic (e.g., when sending email messages or streaming multimedia), which is transmitted via access points and transported in a radio access network (RAN) that connects the access points with the so-called backbone network, which itself is connected to the Internet. One of the main challenges of 5G networks deployment, in particular, in the case of "dense" urban networks, is the provision of networks carrying traffic in RANs. Such networks should make use of inexpensive transmission technologies and, at the same time, be flexible so as to ensure easy connection and maintenance of a large number of different types of radio access points.

Transport technologies used in current 4G / LTE networks are not capable of meeting the above requirements. Therefore, the manufacturers of telecommunications equipment (such as Nokia, Ciena, Fujitsu, ADVA, TransPacket) have been developing new solutions based on a well-known and low-cost Ethernet technology, in which data is sent in the form of frames / packets. Consequently, the transport solutions proposed for 5G assume implementation of packet-based transport networks (5G-PTN) in which packets are routed in the network by means of Ethernet switches. The 5G-PTNs enable convergent (simultaneous) transport of multiple types of data / traffic flows, including those generated as part of 5G wireless services, related to fixed broadband access or resulting from links between data centers, within a common, shared network infrastructure. In convergent 5G-PTNs, Ethernet switches can be connected using both fiber optic technologies (e.g., as part of a passive optical network – PON) and wireless technologies (milli- and micro-wave radio links).

The main challenge in 5G-PTNs is to ensure the appropriate level of service quality (QoS) for carried traffic flows. The need for such guarantees results both from high quality demands posed by the above discussed 5G services and from requirements of radio processing functions performed in RANs. The mentioned traffic flows are characterized by stringent and diverse requirements related to allowable *latency* (i.e., time needed to deliver data) and *jitter* (which expresses variation of packets latency). The nondeterministic nature of packet transmission in 5G-PTNs requires packet buffering in network switches in the case when that packets are redirected at the same time to the same output link. Packet buffering introduces unpredictable delays, thus affecting the QoS of traffic flows. Therefore, the traffic flows in 5G-PTNs require a proper handling that will take into account QoS requirements. This should be done through adequate allocation of transmission resources and proper routing in the network, aimed at avoiding congested links that introduce too large latencies, as well as by appropriate allocation of computational resources at selected network nodes which are needed both for radio processing functions and for realization of particular 5G services.

The above described problem leads to a series of difficult and open optimization problems that are present both in network planning and operation. In order to solve such problems, dedicated models and optimization algorithms are necessary. Therefore, the main goal of the Project is to develop appropriate analytical models that aim at estimating the QoS levels of individual traffic flows and developing effective algorithms that make use of these analytical models in optimization of the 5G-PTNs. Eventually, the developed methods will be used to assess the performance of the 5G-PTN network in comparison to other, alternative solutions.