Switching Fabrics for Modern Telecommunication Networks

Do you know the saying that a chain is only as strong as its weakest link? Have you ever thought that a connection in a telecommunication network might be in a way compared to a chain?

The fact that you can use your device (smartphone, tablet, laptop, or regular phone) to retrieve information "from the world" is mostly due to the telecommunication network, nowadays also called the information and communication network. But what is this network? When you use your smartphone, you cannot *see* any network. This is because today's user devices largely have wireless access to the network. They do not even require any wired connection implying that there must be something at the other end of the "cable". But does this mean no telecommunication network is necessary?

Have you ever used a smartphone, a computer, and a television set connected to the Internet, all at the same time? Or, have you been browsing the Web while people around you were doing the same or were talking on the phone? Have you wondered how it is that so much information is transmitted simultaneously, and you receive exactly what suits *your* preference, and not another person's near you, who is interested in completely different information?

The reason behind all this is the telecommunication network. What is it precisely? A telecommunication network is a countless number of devices that generally perform one of two basic functions. The first one is transferring (sending and receiving) of information via various media (various types of copper wires, optical fibers, air, etc.). This function is called transmission. However, for given information to be sent specifically to you, it must not only be transmitted, but also properly directed in the network. Directing information takes place in nodes, and this function is performed by switching devices. In the past, these devices were telephone switchboards, and currently they are routers and switches. Switching is also called commutation, so the devices performing this function are called commutators.

Thus, the path of information transmission in a telecommunication network may be likened to a chain. The chain is composed of links that are alternately connections (transmission systems) and nodes (commutation or switching systems). On the route from one network user (e.g., a caller) and another, this chain may include many links. The effectiveness and quality of a call is determined by the efficiency of telecommunication devices within the network.

In order to explain the fundamental task of our project, let us recall a comparison made by Professor Andrzej Jajszczyk (currently with the AGH University of Science and Technology in Kraków), winner of the 2008 Foundation for Polish Science prize (dubbed the Polish Nobel Prize), and pioneer of research on modern commutation at the Poznan University of Technology in the 1970s. Let us imagine a network of highways and junctions. The junctions are communication nodes in a highway network. A collision-free junction of two highways is relatively easy to design and build. A collision-free junction of three highways is much more complicated. Now, let us think of light pipes as highways, optical fibers as traffic lanes, and ICT network nodes as communication junctions. Cars in this illustration represent the transmitted information. It is our task to design such junctions (network nodes) that the information (cars) can pass through it in all possible directions, and do it fast, accident-free and without jamming. However, in this case there are tens and hundreds of such data highways (highways for information).

Today's transmission systems employ more and more advanced methods of signal processing and increasingly improved transmission media, such as multi-fiber and multicore light pipes. In addition, a signal in a single fiber may be transmitted simultaneously on many wavelengths. Physicists put a lot of effort into building optical transmitters and receivers allowing for the transmission of huge amounts of information through optical fibers. At the same time, they create newer and more efficient optical elements to facilitate switching optical signals between the fibers. However, the speed and lack of collisions and losses in switching the optical signals – and thus information – relies on correctly designed network nodes. Only well-designed network nodes can avoid becoming the weakest links in the whole connection chain between the users of telecommunication networks.

Therefore, **the fundamental goal** of our project is to propose new nodes for telecommunication networks, able to switch optical signals between a very high number of light pipes. These nodes should be capable of commuting signals of very different transmission speeds. This is because they need to rise to the challenges faced by the future telecommunication networks in which users will simultaneously use multiple different services, such as telephone calls (with modest requirements in transmission speed) and 4K television transmission at very high speeds.