Design, analysis and simulation for optical access and wide-area networks.

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Abstract

Due to the tremendous growth of traffic volume caused by both exponential increase of number of Internet users and continual emergence of new bandwidth demanding applications, high capacity networks are required in order to satisfactorily handle the extremely large amount of traffic. Hence, optical fiber communication is the key technology for the network infrastructure. This thesis addresses design, analysis and simulation of access and core networks targeting important research problems, which need to be tackled for the effective realization of next generation optical networks.

Among different fiber access architectures, passive optical network (PON) is considered as the most promising alternative for the last mile connection due to its relatively low cost and resource efficiency. The inherent bursty nature of the user generated traffic results in dynamically changing bandwidth demand on per subscriber basis. In addition, access networks are required to support differentiated quality of service and accommodate multiple service providers. To address these problems we proposed three novel scheduling algorithms to efficiently realize dynamic bandwidth allocation in PON, along with guaranteeing both the priority and fairness of the differentiated services among multiple users and/or service providers. Meanwhile, because of the increasing significance of reliable access to network services, an efficient fault management mechanism needs to be provided in PON. In addition, access networks are very cost sensitive and the cost of protection should be kept as low as possible. Therefore, we proposed three novel cost-effective protection architectures keeping in mind that reliability requirement in access networks should be satisfied at the minimal cost.

Regarding the optical core networks, replacing electronic routers with all-optical switching nodes can offer significant advantages in realizing high capacity networks. Because of the technological limitations for realizing all-optical nodes, the focus is put on the ingenious architecture design. Therefore, we contributed on novel switching node architectures for optical circuit and packet switching networks. Furthermore, we addressed different aspects of routing and wavelength assignment (RWA) problem, which is an important and hard task to be solved in wavelength routed networks. First, we proposed an approach based on the information summary protocol to reduce the large amount of control overhead needed for dissemination of the link state information in the case of adaptive routing. In addition, transparency in optical networks may cause vulnerability to physical layer attacks. To target this critical security related issue, we proposed an RWA solution to minimize the possible reachability of a jamming attack.

Finally, in order to evaluate our ideas we developed two tailor-made simulators based on discrete event driven system for the detailed studies of
PON and switched optical networks. Moreover, the proposed tabu search heuristic for our RWA solution was implemented in C++.

**Key Words**
fiber access networks, passive optical network, dynamic bandwidth allocation, reliability, switched optical networks, switching node, optical circuit switching, optical packet switching, routing and wavelength assignment, security