Abstract

Given the huge amount of bandwidth offered by the optical transmission medium, it is widely believed that IP over optical networks will be a major component of the next generation Internet.

In this dissertation, we address some important routing and resource allocation problems stated at different network layers. Starting from the optical layer, we first consider the dynamic routing and wavelength assignment problem in transparent optical networks. We argue that shortest path based routing techniques are not always suited for automatically switched optical networks, which require dynamic lightpath establishment for every new connection request. Especially in wide area networks, where physical impairments must be taken into account, there is the need of optimizing the lightpath set up process to improve the quality of transmission other than resource utilization and blocking probability of the network. Here, we show how significant improvements can be achieved by jointly considering the routing and wavelength assignment problem. Moreover, traditional shortest path search has been replaced with our algorithm based on a flow network representation. Two routing algorithms, based on a maximum flow and on a minimum cost flow computation, have been proposed to improve overall performance with a relatively low increase in complexity.

When considering the integrated IP over optical networks routing problem, we deal with the multilayer traffic engineering paradigm where lightpath establishment is a service provided from the optical to the IP layer. Due to the convergence of most services on the IP layer, optical networks need to provide transport for a variety of applications having different Quality of Service (QoS) requirements. This implies that the Differentiated Service (DiffServ) paradigm, which considers the QoS in pure IP networks, needs

to be extended to the new underlying infrastructure. Here we argue that service differentiation can be achieved by using a different routing policy for each Class of Service (CoS) in combination with a virtual topology differentiation mechanism. We propose and compare three service differentiation schemes and show that the best performance is achieved when the different CoS share a limited amount of resources.

To fully address the routing problem in IP over optical networks we also take into account the economic aspect arising in multi-domain routing operations which, after all, supports the growth of the telecommunication sector. Internet Service Providers (ISPs) have interest in offering efficient transport services resulting in a positive impact on their monetary return. When ISPs charge customers or other ISPs for using their transit link they can set the price in order to maximize their expected utility taking into account the load in the network and other ISPs' possible choices. The competition among ISPs generates a continuous action game where the ISP's action is the choice of the price of its transit links. Hence, we study the inter-domain routing problem from a game theoretic prospective and we analyze the possible outcomes in terms of efficiency and stability of the solution. We propose two reinforcement learning algorithms which may be used as a tool by ISPs to learn the optimal price and equilibrium solution. We discuss the theoretical aspects arising in the game and show the advantages of learning the links price using reinforcement learning.

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