Exact Algorithms for Overlaid BSHR Design

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Abstract

This paper addresses new network design problem arising from the deployment of optical transmission system linking Central Offices (COs) of a telecommunication operator. Recently, many telcos adopt a ring architecture in order to enhance the survivability of their own regional networks. On this ring architecture, so called Self-Hearing Ring (SHR), the inter-CO communication traffic is transmitted through the optical links that visit each CO in a circular fashion. Given a set of nodes (COs) in a region and traffic demand between nodes, telcos have to assign demands to SHRs subject to the ring capacity. On each SHR, it is necessary to install ADMs (Add-Drop Multiplexers) at every end-node incident to one of the assigned demand pairs. The capacity of a SHR is limited by the processing capability of the ADM on the SHR. Also, the routing schemes (uni-directional (USHR) or bi-directional (BSHR)) affect the maximum amount of traffic on a SHR. Due to the processing limitation of an ADM, it is inevitable to partition the entire set of demand pairs into several subsets, each of which constitutes an independent SHR.

In contrast to the previous researches on overlaid USHR design (for example, Sutter, Vanderbeck, and Wolsey (1998), etc.), we focus on overlaid BSHR design on the same ring topology network, which cover all the traffic demands between each node pair subject to the traffic loading constraints of the BSHR. However, the traffic loading constraint of BSHR is so different from that of USHR that new solution methods should be developed. To our knowledge, this paper is the first effort to deal with the overlaid BSHR design problem.

Considering the high cost of ADMs, this problem aims at finding out the minimum installation of ADMs that deal with all the demand pairs while satisfying capacity restriction of each SHR. Furthermore, the objective of this study is to develop not only a fast and effective heuristic but also an exact algorithm to solve the problem optimally. To achieve these goals, after identifying our problem as a kind of capacitated edge partitioning problems, we employ branch-and-price approach and develop a heuristic based on the concepts of limited column generation and dual ascent.