Models and Algorithms for IP Network Optimization

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Abstract: Most data networks nowadays employ shortest path routing protocols to manage the flow of data packets. With these protocols, all end-to-end traffic streams are routed along shortest paths with respect to some administrative routing weights. The simplicity of this policy offers many advantages in practice, but also introduces many difficulties when planning such networks. For example, it is not possible to modify end-to-end paths individually. The routing paths can be controlled only jointly and only indirectly by changing the routing weights of the network links. Finding a metric of weights that induces a set of globally efficient end-to-end routing paths is a major difficulty in planning such networks.

In this presentation, we address the minimum cost network design problem and the minimum congestion routing problem for unsplittable shortest path networks. The task in the minimum cost network design problem is to simultaneously optimize the network topology, the node and link hardware installation, and the routing such that the total hardware installation cost is minimized. In the minimum congestion routing problem, the goal is to find routing weight such that maximum link congestion is minimized for the induced traffic flows, while the network topology and hardware configuration remains fix.

We develop integer programming formulations for these problems and discuss several subproblems that arise when solving these formulations. We also show how the models can be extended to cope with additional network survivability requirements. Finally, we present computational results obtained with this approach for instances that arose in the planning of the German research networks G-WiN and X-WiN and other real-world networks.

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