An Exact Algorithm for IP Traffic Engineering

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Most IP networks nowadays use shortest path protocols such as OSPF or IS-IS to route the traffic. Given administrative routing weights for the links of the network, all data packets are sent along shortest paths with respect to these lengths from their source to their destination. The fact that all routing paths depend on the same weights leads to rather complicated and subtle interdependencies among the paths that comprise a valid routing and makes network planning extremely difficult. Finding routing weights that induce a set of globally efficient routing paths is a major challenge in planning such networks.

Additional difficulties arise if each communication demand must be sent unsplit on a single path - a requirement that is often imposed in practice to avoid package reordering and other undesired effects of multi-path routing. In this case, the routing weights must be chosen such that all shortest paths are uniquely determined.

In this talk, we consider the traffic engineering problem in such networks. Given a capacitated directed graph and a set of communication demands, the task is to find routing weights that define a unique shortest path for each demand and who's induced routing minimizes the maximum congestion over all links.

We present an integer programming algorithm for this problem, which has been applied very successfully in the planning of the German national research and education network. This algorithm decomposes the problem of finding an optimal routing into the problem of finding optimal end-to-end routing paths and the problem of finding routing weights that induce exactly these paths. We illustrate the basic decomposition approach and discuss the most important implementation aspects. Finally, we report computational results on various real-world and benchmark problems, which demonstrate the efficiency of our algorithm.