Abstract

In this dissertation, we investigate the optimization issues on four different topics related to fault-tolerant and QoS routing in networks. Research on fault-tolerant and QoS routing covers lots of topics from the real-world engineering problem to the computability and computation complexity analysis, here we will focus on the algorithm design and analysis aspect.

The first problem, which is known as the Delay-Constrained Shortest Disjoint s-t-Path Pair Problem, is to find two edge-disjoint paths in a graph G with minimum total cost from a source node s to a sink node t which satisfies a given delay bound. This problem is $\mathcal{NP}$-hard, so we focus on designing approximation algorithms for it. We tackle this problem by two different methods. The first method is based on existing work, which finds two edge-disjoint paths by using a Fully Polynomial-Time Approximation Scheme (FPTAS) algorithm for the well-known restricted shortest path problem as a building block to find a suitable flow and then it reduces the delay at the tradeoff of cost increase. By this method we propose an algorithm which achieves the current best bicriteria approximation factor. The second method uses Lagrangian Relaxation. Applying this method, we simply modify the weight of each edge and then do binary search in the solution space. Our second algorithm can compute a reasonable solution at a much quicker speed than all previous algorithms.

The second problem is on the minimum-cost single-source unsplittable flow. We first focus our efforts on two cases: either with arbitrary capacities or with very large capacities. For a graph G with arbitrary edge capacity, we present a new algorithm to compute a minimum-cost single-source unsplittable flow in polynomial-time. This algorithm has a performance guarantee same as the current best bound for this problem, while the time complexity is lower and the implementation is easier. After that we modify this algorithm to cope with the situation when the largest demand in G is far less than the minimum capacity in it. Our last algorithm in this area is for the minimum-cost single-source $k-$splittable flow problem, it achieves the best performance guarantee so far.

The third problem is on computing the Inner-node Weighted Minimum Spanning Trees. Here we present a general framework which can find a multi-logarithm approximation algorithm for this problem. Based on this framework, we further propose two polynomial-time approximation algorithms which can achieve a better performance guarantee than all existing results.

Finally we study the energy-efficient broadcasting issue in mobile ad hoc networks. We present a distributed and localized algorithm for saving energy during a broadcast session and show by simulation data that it is energy efficient and scalable.