Large Neighborhoods in Variable Neighborhood Search Approaches for Generalized Network Design Problems

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Many network design problems can be extended by substituting individual nodes with clusters of nodes and requiring that from each cluster exactly one (or at least one) node is used. Such extensions are called *generalized* versions of the original problems. For example in the generalized minimum spanning tree problem (GMSTP), a minimum cost tree connecting one node from each cluster is sought. We further consider the generalized traveling salesman problem (GTSP) and the generalized minimum edge-biconnected network design problem (GMEBCP). Even when the underlying network design problem is efficiently solvable, the generalized version is often NP-hard, as it is the case for GMSTP. Instances of such problems appear in practice for example when designing a larger network that connects several already existing, smaller networks.

Such problems can be approached from two opposite point-of-views: On one side, we might first consider the selection of the nodes to be used and then solve the original network design problem on this restricted set, yielding the edges of the solution. On the other side, we can first choose the global structure of the solution, i.e. fix the pairs of clusters that will be directly connected, and then determine the specific edges and nodes to be used. Unfortunately, direct implementations of both approaches only perform poorly, since in both cases, optimal decisions withing the two phases strongly depend on each other.

The two point-of-views, however, lead in a very natural way to two different types of large neighborhoods defined on dual representations. We use these neighborhoods in a general variable neighborhood search framework and explore them by means of exact algorithms and heuristic methods. Various experimental results indicate the benefits of this approach.