# Hybrid heuristic for Capacitated Network Design Problem

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## 1 Introduction

We study the topology and the dimensioning of the Capacitated Network Design Problem (CNDP) with modular capacity. The polyhedral structure study of the loading problem with modular capacity was introduced by Magnanti et al [1]. Magnanti and Mirchandani [2] considered the single commodity problem and introduced the cut-set inequality then study the multicommodity network loading problem with two cable types. They strengthened the multicommodity flow formulation with integer cable installation variables with cut-set, 3-partition and arc-residual-capacity inequalities.
The CNDP involve design decisions which are to activate links in the underlying network, and operational decisions which are to allocate facilities and to route traffic demands.

## 2 Proposed Solution

We develop an hybrid heuristic combining greedy and local search approaches. The Working Capacity Search ($WCS$) algorithm is the greedy constructive heuristic based on an iterative routing. It starts with an empty graph, applies specific rules to select the best path to routes iteratively commodities, defines the network topology and adjusts the necessary edge capacities at each iteration.
The local search heuristic is the Maximum Unused Capacity ($MUC$) algorithm starts from feasible solution provided by $WCS$ algorithm, it tacks for improvements to the initial solution by applying searching through the neighborhood, it stops when a specified criteria is satisfied.
The improvement will be achieved by exploring changes on the working paths (routes) basing on the maximum unused capacity value. Each iteration selects a neighbor to the current solution which permits a local increase in the total cost.
The main two keys of $MUC$ algorithm are the selection of the most promising link $(i, j)$ and the choose of demand(s) to move at each iteration. The neighborhood is constructed while considering three types of demand(s) moves : single demand move, multiple demand move and fractional demand move. It differs on the amount of flow moved from the original routes to the second ones. The neighborhood search combines both ; best improving and first improving strategies. The best improving while searching the link $(i, j)$ with the maximum currently unused capacity in the network (most promising link), first improving strategy is used when searching path to be moved on the link $(i, j)$. During our improvement process we maintain two kinds of $VisitedLists(VL)$; $VL.Arcs$ and $VL.Demands$ contain respectively links and demands previously contributed in the neighborhood search.

## 3 Experimental Result

We test our contribution on some problem instances (Polska, France, Germany50 and Pioro40) tacked from the Survivable Network Design Library (SNDlib1.0) [4]. Each instance is characterized by the number of nodes $|V|$, the number of potential links $|E|$, the number of traffic demands $|D|$ and value of the best dual bound.
Table 1 shows the solutions provided by $WCS$ and $MUC$ algorithms and theirs gaps comparing

to the best dual bounds ($DB$) of instances having $(U, U, M, A, I, A, N, N)$ as values, the reader is referred to [3] for more details on design parameters.
We examine the optimality gap, defined as the difference between the $WCS$ solution cost( or $MUC$ solution cost) and the value of dual bound (published in [4]).

**Table 1.** $WCS$ and $MUC$ solutions

| Problem Instance | $\|V\|$ | $\|E\|$ | $\|D\|$ | $DB$ | $WCS$ | $Gap$(%) | $MUC$ | $Gap$(%) |
|---|---|---|---|---|---|---|---|---|
| Poska | 12 | 18 | 66 | 23619 | 25661 | 08.64 | 25129 | 6.93 |
| France | 25 | 45 | 300 | 20200 | 23600 | 16.83 | 21400 | 5.94 |
| Germany50 | 50 | 88 | 662 | 645520 | 742670 | 15.04 | 687730 | 6.53 |
| Pioro40 | 40 | 89 | 780 | 414440 | 430109 | 03.78 | 425596 | 2.69 |

## Conclusion

We propose an hybrid heuristic for Capacitated Network Design Problem, which is extremely study as one of NP hard problems.
Our proposition contains two simple heuristics ; the initial one is $WCS$ algorithm generates an initial feasible solution followed by $MUC$ algorithm. We define three moves depend on unused capacities, links and demands. Our proposition produce a near solutions to the best dual bounds.

## References

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