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# ng-Memory Based Capacity Cuts

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## Abstract

We present new valid inequalities for the capacitated vehicle routing problem (CVRP), called the *ng*-capacity cuts (*ng*-CCs). These valid inequalities are stronger than the rounded capacity cuts, but still have the attractive property that they are robust when the *ng*-route relaxation is used in a branch-price-and-cut (BPC) algorithm. That is, including the duals of the *ng*-CCs in the pricing problem, a shortest path problem with resource constraints, does not require extra resources.

In this paper, we formalize the concept of *ng*-robustness and we present the first *ng*-robust valid inequalities, the *ng*-CCs. This framework can facilitate the search for new *ng*-robust counterparts of known valid inequalities. Furthermore, we introduce different separation techniques for separating the *ng*-CCs and compare these numerically. We show that the separation of these cuts is equivalent to separating rounded capacity cuts on a modified graph. We present results on including the robust *ng*-CCs in a BPC-framework for solving CVRP benchmark instances, compared to using rounded capacity cuts. We also investigate for which types of problems these new valid inequalities outperform the rounded capacity cuts.

**Keywords:** CVRP, Column Generation, Branch Price and Cut, Valid Inequalities, *ng* Route Relaxation

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