

# Dynamic NG-path Relaxation

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In [1] we introduced a new state-space relaxation, called *ng*-path relaxation, to compute lower bounds to routing problems, such as the Capacitated Vehicle Routing Problem (CVRP) and the VRP with Time Windows (VRPTW). This relaxation consists of partitioning the set of all possible paths ending at a generic vertex according to a mapping function that associates with each path a subset of the visited vertices that depends on the order in which such vertices are visited. The subset of vertices associated with each *ng*-path is used to impose partial elementarity. This relaxation proved to be particularly effective in computing lower bounds on the CVRP, the VRPTW and the Traveling Salesman Problem with Time Windows (TSPTW) [2].

In this talk, we propose a new dynamic method to improve the *ng*-path relaxation which consists of defining, iteratively, the mapping function of the *ng*-path relaxation using the results achieved at the previous iteration. This method is analogous to cutting plane methods, where the cuts violated by the *ng*-paths at a given iteration are incorporated in the new *ng*-path relaxation at the next iteration.

The new technique has been used to solve the Traveling Salesman Problem with Cumulative Costs (CTSP) and to produce new benchmark results for the TSPTW. The results obtained show the effectiveness of the proposed method.

**Key words** : traveling salesman problem, time dependent, time windows, state space relaxations, dynamic programming.

## References

- [1] Baldacci, R.; Mingozzi, A. & Roberti, R. New Route Relaxation and Pricing Strategies for the Vehicle Routing Problem. *Operations Research*, 2011 (forthcoming).
- [2] Baldacci, R.; Mingozzi, A. & Roberti, R. New State-Space Relaxations for Solving the Traveling Salesman Problem with Time Windows. *INFORMS Journal on Computing*, 2011 (forthcoming).