



Fabián Arturo Castilla Peñaranda

**Vehicle Routing Problems with Time Windows
and Exact Synchronization Constraints**

DISSERTAÇÃO DE MESTRADO

Dissertation presented to the Programa de Pós-Graduação em Informática of the Departamento de Informática, PUC-Rio as partial fulfillment of the requirements for the degree of Mestre em Informática

Advisor: Prof. Marcus Vinicius Soledade Poggi de Aragão

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Abstract

Castilla Peñaranda, Fabián Arturo; Aragão, Marcus Vinicius Soledade Poggi de (Advisor). **Vehicle Routing Problems with Time Windows and Exact Synchronization Constraints**. Rio de Janeiro, 2013. 68p. MSc Dissertation – Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

This dissertation addresses a generalization of the vehicle routing problem (VRP) that arises in real life applications in ports and mine operations. In this VRP variant, each customer may demand different types of vehicles to perform a task collaboratively. Vehicles are allowed to wait at the locations but they must start operating at the same time. The objective is to route the available vehicles while maximizing the (weighted) sum of served customers and minimizing the total distance traveled. The specific case where all customers must be served while minimizing the total distance traveled is the central problem here studied. This special case can be viewed as a straightforward generalization of, a well known and more specific routing problem, the VRP with time windows (VRPTW) where the capacity of the vehicles is sufficiently large. We support this narrower scope by stating that it allows a clear comparison of the problem hardness by its relation to the VRPTW. Sticking to the classification of synchronization in vehicle routing proposed by (DREXL, 2012) we named this problem as the Vehicle Routing Problem with Time Windows and Exact Operation Synchronization (VRPTWEOS). In this work, a formal definition for the VRPTWEOS is provided. Integer programming models for this problem are proposed and analyzed. Furthermore, we propose a solution method based on the Dantzig-Wolfe decomposition for which exact and approximated resolution algorithms are described. In order to test the performance of those algorithms, a group of benchmark instances for the VRPTWEOS was created on top of the Solomon benchmark for the VRPTW. The method used to create the benchmark instances is described in detail. Computational experiments over the mentioned set of instances showed that the proposed solution approach is a promising alternative for solving the VRPTWEOS.

Keywords

Vehicle Routing Problem; Time Windows; Synchronization Constraints; Integer Programming; Column Generation; Branch-and-Price;

Resumo

Castilla Peñaranda, Fabián Arturo; Aragão, Marcus Vinicius Soledade Poggi de. **Problemas de Roteamento de Veículos com Janelas de Tempo e Sincronização Exata de Operação**. Rio de Janeiro, 2013. 68p. Dissertação de Mestrado – Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

Uma generalização do problema de roteamento de veículos (VRP) presente em aplicações práticas em portos e operações em minas é o objeto desta dissertação. Nesta variante do VRP cada cliente pode demandar diferentes tipos de veículos para cumprir tarefas colaborativamente. Nesta atividade, os veículos podem aguardar o início da operação no local porém, devem iniciar as tarefas ao mesmo tempo. O objetivo é determinar as rotas dos veículos disponíveis de modo a maximizar a soma (ponderada) dos clientes atendidos enquanto a distância total percorrida é minimizada. O caso específico onde todos os clientes são atendidos e a distância total percorrida é minimizada determina o problema central estudado nessa dissertação. Este caso particular pode ser visto como uma generalização direta do, muito estudado e conhecido problema de roteamento, VRP com janelas de tempo (VRPTW) onde a capacidade dos veículos é suficientemente grande. Esta escolha de um problema mais restrito é justificada por permitir uma clara comparação de sua dificuldade através da sua relação com o VRPTW. A partir da classificação dos casos de sincronização em problemas de roteamento proposta por (DREXL, 2012), denominamos o problema aqui estudado de Problema de Roteamento de Veículos com Janelas de Tempo e Sincronização exata da Operação (VRPTWEOS). Neste trabalho damos uma definição formal ao VRPTWEOS. Modelos de programação inteira são propostos e analisados. Também apresentamos métodos de resolução baseados na decomposição Dantzig-Wolfe, dos quais são derivados algoritmos exatos e aproximados. Com o propósito de avaliar a eficiência desses algoritmos, foi criado um grupo de instâncias de teste baseado no benchmark do Solomon para o VRPTW. O método usado para criar o conjunto de instâncias de teste é descrito em detalhe. Experimentos computacionais sobre este conjunto de instâncias mostraram que o método de resolução proposto é promissor para a resolução do VRPTWEOS.

Palavras-chave

Roteamento de Veículos; Janelas de Tempo; Restrições de Sincronização; Programação Inteira; Geração de Colunas; Branch-and-Price;

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