

Chapter 21

Robust Vehicle Routing Solutions to Manage Time Windows in the Case of Uncertain Travel Times

Gerrit K. Janssens
Hasselt University, Belgium

Tharinee Manisri
Sripatum University, Thailand

Kusuma Soonpracha
Kasetsart University, Thailand

Anan Mungwattana
Kasetsart University, Thailand

ABSTRACT

The vehicle routing problem requires mostly meta-heuristics to find approximate solutions. Congestion makes it hard for planners to find good routes because travel times are uncertain. The problem is handled by building scenarios with a range of possible travel times to represent the uncertainty. The main goal is to find a robust solution, which performs “well” in bad scenarios. The experiments show that robust results are obtained in a computationally reasonable time, which means that the concept can be used by practitioners. Most applications are commercial, but also social applications exist. An earthquake or a flood might lead to road disruptions. Higher traffic delays appear due to lower speed on flooded roads or due to time spent on finding alternative routes. Routing like evacuation of wounded or delivery of food is hardly studied. The work is inspired by the 2011 flooding in Thailand.

INTRODUCTION

Vehicle Routing Problems (VRPs) are a class of combinatorial problems which are challenging to the scientific society of operations researchers. On the one hand, this popularity is due to the high level of difficulty of finding optimal solutions to the problems of a rather large size. On the other hand, the popularity relates to the fact that this problem appears in many practical situations and mostly in a variant which is even much harder than the classical VRP.

DOI: 10.4018/978-1-4666-7258-1.ch021

From a computational point of view, the field of Operations Research, during decades, has spent an enormous effort on the Traveling Salesman Problem (TSP). The importance that the TSP got from the scientific community deals with the wealth of applications, but even more by the fact that it is a typical problem in its genre: combinatorial optimization. While the problem setting of a TSP is easy to understand in terms of minimizing a total distance with some constraints, the problem has not been solved satisfying some formal standards of efficiency. A selection of the abundance of literature on the TSP, its history, its variants and its solution methods has been published in the classical book, edited by Lawler, Lenstra, Rinnooy Kan, and Shmoys (1985).

The last chapter in that book is dedicated to the Vehicle Routing Problem (Christofides, 1985). The vehicle routing is of higher complexity than the TSP as it concerns a (previously unknown) number of vehicles (and not just one salesman) and it takes capacity of the vehicles into consideration. That chapter opens the door to researchers in the field of combinatorial optimization to take up the challenge to look for efficient solution methods for a problem which is much more complex than the TSP.

The basic version of the VRP is called the capacitated VRP. All customers relate to deliveries, have fixed demands, known in advance and cannot be split. The vehicles are identical, leave from and return to a single depot and only the capacity is considered as a vehicle-related constraint. The objective is to minimize the total cost (expressed in terms of total distance, or total travel time, or total number of vehicles). Due to its interest from the transport and logistics industry, the VRP needed to be enriched with more features from the real world.

While each application might introduce its case-specific constraints leading to multiple variants on the VRP, a number of classical variants appear abundant in literature. Four classical extensions are formulated in Toth and Vigo (2002), which relate to the following practical aspects: maximal route-length (distance-constrained VRP), time windows (VRP with time windows), separated line-haul and backhaul customers (VRP with backhauls), and mixed services (VRP with pick-up and delivery).

In the distance-constrained VRP the capacity constraint of a route is replaced by (or combined with) a maximum length or time of the route. In the VRP with time windows a time interval (called a time window), defined by a lower and an upper bound, and a service time is associated with each customer. The service at the customer should start within the time window and the vehicle stops at the customer's site for a time period, called the service time. In the VRP with backhauls the set of customers is divided into two subsets: line-haul customers and backhaul customers. Line-haul customers require a quantity of product to be delivered and are served first, while backhaul customers require a quantity of product to be picked up and are served after the line-haul customers in the route. In the VRP with pickup and delivery each customer is associated with a quantity of product to be delivered and a quantity of product to be picked up (operated in that sequence).

Before moving into solution methods for these variants, a few interesting review papers should be mentioned to the interested reader. Laporte (2009) reports on fifty years research on VRP from a historical perspective. Next to Toth and Vigo (2002b) mentioned earlier, full books on the topic and its recent advances include Cordeau, Laporte, Savelsbergh, and Vigo (2007) and Golden, Raghavan, and Wasil (2008).

Solution methods for the VRP can be separated into exact solution methods and heuristics. While exact solution methods can be used only for small or medium size problems, it is worth mentioning a few important results. The exact algorithms can be further divided into dynamic programming (DP) and integer programming (IP) methods. The DP approach is rather limited because of the large state space and the main reference is Christofides, Mingozzi, and Toth (1981a). Most methods follow the IP approach

22 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:
www.igi-global.com/chapter/robust-vehicle-routing-solutions-to-manage-time-windows-in-the-case-of-uncertain-travel-times/123095

Related Content

A Fuzzy Clustering Model for Fuzzy Data with Outliers

M. H. Fazel Zarandi and Zahra S. Razaee (2011). *International Journal of Fuzzy System Applications* (pp. 29-42).

www.irma-international.org/article/fuzzy-clustering-model-fuzzy-data/54240

Human-Data Interaction in Healthcare

Federico Cabitza and Angela Locoro (2017). *Smart Technology Applications in Business Environments* (pp. 184-203).

www.irma-international.org/chapter/human-data-interaction-in-healthcare/179038

Opportunities and Challenges of AI/ML in Finance

Komal, Kavita Singh, Mahadi Hasan and Ragu Prasad Rajendran (2023). *The Impact of AI Innovation on Financial Sectors in the Era of Industry 5.0* (pp. 238-260).

www.irma-international.org/chapter/opportunities-and-challenges-of-aiml-in-finance/330120

A Lexico-Syntactic-Semantic Approach to Recognizing Textual Entailment

Rohini Basak, Sudip Kumar Naskar and Alexander Gelbukh (2020). *Innovations, Algorithms, and Applications in Cognitive Informatics and Natural Intelligence* (pp. 187-227).

www.irma-international.org/chapter/a-lexico-syntactic-semantic-approach-to-recognizing-textual-entailment/247903

How Intelligent Are Ambient Intelligence Systems?

María J. Santofimia, Francisco Moya, Félix J. Villanueva, David Villa and Juan C. López (2010). *International Journal of Ambient Computing and Intelligence* (pp. 66-72).

www.irma-international.org/article/intelligent-ambient-intelligence-systems/40351