A Re-optimization approach for the Dynamic Capacitated Vehicle Routing Problem for Flash Flood Victim's Relief Operations

Florent Dubois[1], Paul Renaud-Goud[1], Patricia Stolf[1]

Université de Toulouse, Institut de Recherche en Informatique de Toulouse (IRIT), Toulouse, France
{florent.dubois,paul.renaud.goud,patricia.stolf}@irit.fr

Mots-clés : *vehicle routing problem, crisis management.*

1 Context

Flooding events have high impact on people and infrastructures every year. The work is conducted on the ANR e-flooding project that aims at reducing the impact of flooding events both on long term through the study of territories resilience, and short term through the improvement of rescue teams response. In collaboration with the SDIS 31 (in charge of rescue operations in flooding context), this work focuses on the short term response to flooding and more precisely flash floods. Flash flood is a type of floods where the water level rises in a very short time period, leaving no time to rescue teams for preparation. The optimization problem is modelled as a Vehicle Routing Problem (VRP) where service at nodes are victim relief operations.

One of the challenges in this problem is to plan interventions for all the vehicles available and optimize their routes. Furthermore by rescuing victims at locations, the vehicles capacity have to be considered. Vehicles may have different capacities which makes this problem a Heterogeneous VRP. In addition some of the demands (points of demands) have too much victims to be rescued by a single vehicle so demands have to be split. When planning routes, it is considered that vehicles should try to optimize their load. Hence, a vehicle returns to the rescue center to put victims to safety once it has no operation left or when its full. The emergency aspect of the problem has also to be taken into account. Rescue teams indeed associate to each demand a priority based on several factors such as vulnerability of victims or impact of the flooding on location. This priority is also associated with a deadline which is the date when rescue teams want the demand to be served the latest. The problem is also dynamic since most of the demand is not known at the beginning of the crisis but requests are released during the operations in opposition with static problems where all demands are known at the beginning of the crisis and the plan can be computed only once. [3] Offers a review of the Dynamic VRP. It differentiates purely dynamic approaches from stochastic ones.

In [1] humanitarian logistic is studied but under a stochastic approach which is not suited for our work since there is no data about future events. It also solves the VRP in advance to prepare logistic plans and therefore does not have to compute plans in real-time. [2] studies the delivery of various types of supplies during relief operations after a crisis but the problem does not consider vehicles capacity, they serve each demands in a single visit.

2 Contributions

A static resolution of the problem has been presented in a previous publication [4]. Two static algorithms have been introduced and compared to a greedy algorithm modeling the current behavior of the SDIS 31 and an algorithm from the literature. The first one Best Flow-time Insertion (BFI) algorithm is inspired from bin-packing algorithms. It is based on the objective function of the problem we established on flow-time, which is the time between the release of a demand and its full service. It is weighted by priority and quantity in the objective. BFI sorts the demands by priority and then by decreasing quantity and inserts them in the route of the vehicle, and at the position where the impact on the objective value is minimal. The second algorithm BFI with Order Questioning (BFIOQ) follows the same routine, but after each insertion, the order in which demands are served in the route is questioned to find a better configuration in term of impact on the flow-time (called objective score).

In this work, these algorithms have been adapted to address the dynamic version of the problem following a re-optimization approach. This approach is the most appropriate for the problem in order to answer computation time limitations induced by the dynamic of the crisis. Exact methods are used when the computation time is not as much an issue, but the size of problems we study is too important and the computation time of such solutions would be too important. A lot of articles also study stochastic methods but it is not appropriate for our work as stated above. However using BFI and BFIOQ in a re-optimization approach leads to re-compute all routes at every step. In order to try less computation time expensive solutions, another algorithm has been developed : Flow-time Insertion Phase-out (FIP). This algorithm does not re-compute the routes from scratch but only inserts the new demands in the existing ones at the position where the best benefit on the objective score is observed.

These algorithms are coupled with strategies that determine when routes need to be updated dynamically. Three are presented and evaluated in this work : Continuous strategy launches re-optimization immediately when the previous one ended if events have been released while computation was running, Periodic strategy only runs a re-optimization at fixed time intervals with dynamic events released since previous computation and Preemptive strategy interrupts re-optimization at every dynamic event release to re-launch it with the new information.

These solutions have been evaluated through a simulator developed in this work to run dynamic crisis scenarios. The scenarios have been generated through a graph generator we implemented to create graphs with parameterized characteristics. The experimentation have been led on scenarios similar to the Luchon flood from 2013 (60 nodes and 500 victims). A second experiment has also been led on larger scale, three times the Luchon scale (180 nodes and 1500 victims). A dynamic scenario is composed of the graph with issues and dynamic events generated randomly but with characteristics similar to Luchon study case. A total of 360 scenarios have been used to test each combinations of strategy and solution (9) and for both scales of experimentation. The simulations are entirely reproducible.

Results show that BFI and BFIOQ used in a re-optimization approach perform better in solutions quality than FIP. The dynamic insertion heuristic displays better computation time performances but at the scales experimented on, the difference of computation time is not significant enough to prefer this solution.

Références

[1] Mahdieh Allahviranloo, Joseph Y.J. Chow, and Will W. Recker Selective vehicle routing problems under uncertainty without recourse. *Transportation Research Part E : Logistics and Transportation Review*, 62 :68-88, 2014.

[2] Djamel Berkoune, Jacques Renaud, Monia Rekik and Angel Ruiz Transportation in disaster response operations. *Socio-Economic Planning Sciences*, 46(1) :23-32, 2012.

[3] Victor Pillac, Michel Gendreau, Christelle Guéret and Andrés L. Medaglia A review of dynamic vehicle routing problems. *European Journal of Operational Research*, 225(1) : 1-11, 2013.

[4] Florent Dubois, Paul Renaud-Goud and Patricia Stolf Capacitated Vehicle Routing under Deadlines. *International Conference on Information and Communication Technologies for Disaster Management*, 1 :1-8, 2019.