Dynamic Ambulance Routing for Disaster Response

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1 Introduction

Emergency logistics refers to systems and procedures devoted to manage the distribution of aid by means of resources and specialists to areas affected by a man-made or natural disaster. The main aim in those situations if to provide an urgent relief. In this work the Ambulance Routing Problem (ARP) proposed by Talarico *et al.* [2] that arises in a disaster response scenario is addressed. This problem considers a set of equal ambulances, K, a set of patients, P, which is divided into a subset of red code patients, R, and a subset of green code patients, G, such that $P = R \cup G$, and a set of hospitals, H. Each hospital $h \in H$ counts with a number of ambulances K_h such that $\sum_{h \in H} K_h = |K|$. Moreover, in order to provide an appropriate aid to the injured persons different type of actions have to be performed. Namely, depending on the severity of the injury, different types of patients arise:

- Set of red code patients (R): It is composed by those patients that are seriously injured and need to be brought to a hospital by an ambulance.
- Set of green code patients (G): It is composed by those patients that are slightly injured and can be helped directly in the field for a given amount of time $d_i, i \in G$.

Therefore, according to the previous classification, ambulances have to perform different actions. Namely, in the case of a red code patient the ambulance has to depart either from a hospital or from its current position in the given scenario and bring him/her to a hospital. On the other hand, in the case of green code patients the ambulance has to reach that injured person and provide an assistance for a given time d_i without needing to return to the hospital.

As can be noticed, a wealth of combinations of actions to be performed by the ambulances emerges in order to minimize a given objective function. In this

regard, the quality of a solution for the ARP is evaluated by means of the weight service completion time for all red code patients and the latest service completion time among all green code patients.

2 Dynamism in the Ambulance Routing Problem

The static problem (*i.e.* the problem not considering any changes or additional events besides the initial data) has been solved in the literature using a Large Neighborhood Search (LNS) [2]. Nevertheless, the ambulance routing problem appears in a context with a particular tendency to dynamism, since patients could change their condition or new patients could appear meanwhile ambulances are developing their routes. Following the nomenclature given in [2], the patients who can be assisted directly in the field are green code patients, and those who need to be brought to hospitals are red code patients. Thus, we can define three different kinds of dynamic events that could come up over the time horizon:

- Either new green or red patients appear along the execution of a given response plan and have to be incorporated in the solution that are working.
- A green patient becomes a red patient due to unforeseen difficulties, this leads to changes in the assistance and service provided by the ambulances. For instance, a green patient converted to red would make the ambulance to return to the hospital.
- Either a green or red patient deactivates due to other sources of assistance.

These three kinds of dynamism have to be taken into account in order to properly offer medical aid while improving the quality of the assistance and schedules provided. In this sense, to the best of our knowledge, this problem with this special casuistry has not been tackled in the literature. For this reason, the goal of this work is two-fold. On the one hand, a particular implementation of a Variable Neighborhood Search (VNS, Hansen and Mladenovic [1]) is proposed to solve the initial static problem and, on the other hand, the dynamic version of the problem is dealt extending the above-mentioned VNS implementation.

References

1. P. Hansen, N. Mladenovic, and J.A. Moreno Perez. Variable neighbourhood search: methods and applications. *Annals of Operations Research*, 175(1):367–407, 2010.
2. Luca Talarico, Frank Meisel, and Kenneth Sörensen. Ambulance routing for disaster response with patient groups. *Comput. Oper. Res.*, 56(C):120–133, April 2015.