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MDPI

Extended Abstract

A Vehicle Routing Problem with Periodic Replanning †

Guido Ignacio Novoa-Flores *, Luisa Carpente and Silvia Lorenzo-Freire

MODES Research Group, Department of Mathematics, Faculty of Computer Science, University of A Coruña, 15071 A Coruña, Spain; luisacar@udc.es (L.C.); slorenzo@udc.es (S.L.-F.)

* Correspondence: guido.novoa@udc.es; Tel.: +34-981-167-000

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Abstract: In this work we focus on the problem of truck fleet management of the company GESUGA. This company is responsible of the collection and proper treatment of animals not intended for human consumption. On a daily basis, with the uncollected requests, the company designs the routes for the next day. However, these routes have to be replanned during their execution as new requests appear from customers that the company would be interested in attending. The problem treated belongs to the family MDCVRPTW with the particularity of the route redesign. For its resolution we have adapted linear programming models, simulation techniques and metaheuristic algorithms.

Keywords: combinatorial optimization; heuristic algorithms; vehicle routing problems

1. Introduction

After the spread of Bovine Spongiform Encephalopathy, typically known as mad cow disease, the European Union took a number of measures (e.g., Regulation (EC) No 999/2001) to prevent its spread and transmission. This regulation forbids the burial of carcasses of dead animals at livestock farms. In Galicia, one of the main companies responsible for this task is GESUGA. This company focuses its business area on the integrated management of meat by-products not intended for human consumption. Its main activity consists of the collection and transport of the different meat by-products, generally animal carcasses, from livestock farms to treatment plants, for their appropriate treatment.

To serve customers, the fleet of the company is composed by 32 trucks (12 in Cerceda, 10 in Outeiro de Rei and 10 in Vilamarín) which, from Monday to Friday, visit the different farms and transport the products to the intermediate plants. Taking into account the characteristics of this problem, it could be classified as a MDCVRPTW. A general review of VRP can be found in [1].

2. Description of the Problem

As mentioned in the introduction, the company has to visit its customers all over Galicia on a daily basis. Some of the restrictions that define this problem are the following:

- The trucks leave and return from the plant to which they are assigned only once a day.
- Truck drivers have a maximum working day of 8 h which includes a rest and disinfection of the vehicle at the end of the day.
- Trucks have a maximum loading capacity.
- Orders must be picked up within 48 h from receipt.

Currently, route planning is manually made by the logistics department and the organization is as follows:

- At 19:00 there are some pre-routes with the notices not collected until that moment.
- At 20:00 these pre-routes are reviewed with the logistics manager adding new requests and making the necessary changes.
- At 21:00 drivers receive the set of places that they must visit, but they are free to organize it.
- During the day, incoming requests are assigned manually by the logistics department to drivers in order to free up work for the next day.

Note that the route design is manually made by the logistics department. Therefore, the company is interested in a tool to calculate the routes automatically, satisfy the needs of customers and achieve the following objectives:

- Minimize the total distance traveled by trucks.
- Minimize the number of trucks used.
- Maximize the number of collected requests.

3. Implementation of the Algorithm

The implementation of the algorithm was made in JAVA language using the libraries lpsolve and jsprit. The second library includes the Ruin and Recreate principle (see [2] and strategies inspired by [3]. The problems mentioned above are solved automatically according to the following scheme:

1. Requests that are not collected during a day are assigned to a plant by solving the GAP problem with lpsolve library.
2. For each plant, the corresponding VRPs are resolved with jsprit library.
3. The requests that arrive online are assigned to each truck automatically taking into account the position and the load of each truck.

Currently, we are considering two strategies to address this problem:

- Lazy: No orders are collected during the online phase, i.e., the routes computed the day before collecting are not modified.
- Minimum-*k*: A truck leaves the plant when, at least, *k* orders are assigned to it.

Note that the Lazy strategy can only be used from Monday to Thursday since on Fridays no orders can be left uncollected. Thus, Lazy strategy must be combined with Minimum-*k*.

4. Results

Many scenarios have been considered for the different strategies varying different parameters: cost of taking out a truck, minimum number of orders needed to take out a truck and time at which the optimization online is performed.

The appendix shows the best results obtained for each of the strategies as well as the real case. We see that the real case (Table A1) collects 6040 requests using 309 trucks. The Lazy strategy (Table A2) can collect 5782 requests using 275 trucks and the Minimum-*k* (Table A3) collects 6224 using 304 trucks. Therefore, we can conclude that the Lazy strategy always picks up fewer requests and uses fewer trucks than the real case. On the other hand, the Minimum-*k* strategy collects more requests and uses more trucks than the real case but the proportion between trucks and collected requests improves with respect to the real case.

Author Contributions: The first author carried out the experiments and the implementation of the algorithm. The remaining authors were responsible for the design of the algorithm.

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Appendix A

The following abbreviations are used in this manuscript:

- GESUGA Gestora de Subproductos de Galicia.
- MDCVRPTW Multi Depot Capacitated Vehicle Routing Problem with Time Windows
- VRP Vehicle Routing Problem

Appendix B

Table A1. Results obtained by the company.

Day	Requests	Previous Requests	Online	Collected Requests	Trucks
31 August 2016	675	271	404	527	29
01 September 2016	624	148	476	482	28
02 September 2016	563	142	421	504	29
05 September 2016	1126	362	764	639	28
06 September 2016	950	487	463	644	28
07 September 2016	757	306	451	569	31
08 September 2016	628	187	441	480	27
09 September 2016	584	148	436	529	29
12 September 2016	1011	313	698	567	27
13 September 2016	908	444	464	564	27
14 September 2016	754	344	410	535	26
Total	8580	3152	5428	6040	309

Table A2. Results obtained with Lazy strategy.

Day	Requests	Previous Requests	Online	Collected Requests	Trucks
31 August 2016	675	271	404	271	17
01 September 2016	880	404	476	404	20
02 September 2016	897	476	421	706	32
05 September 2016	1267	503	764	503	23
06 September 2016	1227	764	463	725	31
07 September 2016	953	502	451	502	24
08 September 2016	892	451	441	451	21
09 September 2016	877	441	436	702	32
12 September 2016	1144	446	698	446	21
13 September 2016	1162	698	464	685	31
14 September 2016	887	477	410	477	23
Total	10861	5433	5428	5872	275

Table A3. Results obtained with Minimum-*k* strategy.

Day	Requests	Previous Requests	Online	Collected Requests	Trucks
31 August 2016	614	138	476	403	24
01 September 2016	632	211	421	465	25
02 September 2016	1243	479	764	760	32
05 September 2016	946	483	463	702	32
06 September 2016	695	244	451	536	30
07 September 2016	600	159	441	450	25
08 September 2016	586	150	436	426	24
09 September 2016	1129	431	698	733	32
12 September 2016	860	396	464	653	31
13 September 2016	617	207	410	459	27
14 September 2016	614	138	476	403	24
Total	8597	3169	5428	6124	310

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