ODYSSEUS 2018

Seventh International Workshop on Freight Transportation and Logistics

June 3-8, 2018, Cagliari, Sardinia - Italy

TOPICS OF INTEREST

Topics of interest cover a broad spectrum and include but are not limited to:

-Vehicle Routing
-Fleet and Crew Management
-Modal/Intermodal Transportation
-Intelligent Transportation Systems
-Terminal Management
-Supply Chain Logistics
-Network Design and Planning
-City Logistics
-Facility Logistics
-Humanitarian Logistics

CONTACT DETAILS

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Dear ODYSSEUS 2018 participant,

The Organizing Committee has great pleasure to welcome all participants and accompanying guests to Cagliari (Sardinia, Italy) for the 7th International Workshop on Freight Transportation and Logistics, ODYSSEUS 2018. This workshop is organized by the members of the Department of Mathematics and Computer Science of the University of Cagliari.

ODYSSEUS is a triennial series of international workshops providing a high quality forum on recent developments, trends and advances in the theory, practice and application of mathematical models, methodologies and decision support systems in the field of Freight Transportation and Logistics. This year ODYSSEUS continues to build upon the great success of our earlier meetings in Crete (2000), Sicily (2003), Altea (2006), Cesme (2009), Mykonos (2012) and Ajaccio (2015). It brings together more than 180 academics, researchers and practitioners from around the world to discuss recent experiences, exchange ideas, disseminate research results, and present advanced applications and technologies. ODYSSEUS 2018 has enjoyed an enthusiastic reception from the Freight Transportation and Logistics community, as shown by the large number of submissions. We believe the rigorously selected contributions will continue this tradition of excellence and advance the field.

There are 144 presentations grouped into 50 sessions arranged in three parallel streams. The program covers a wide range of topics, featuring sessions on various facets of Routing (e.g., Vehicle Routing, Arc Routing, Inventory Routing, Location-Routing, Dynamic Routing, Stochastic Routing), Logistics (e.g., Supply Chain Logistics, Humanitarian Logistics) and Transportation Networks (e.g., Freight Transportation Networks, Network Design and Planning), as well as several sessions on emerging topics (e.g., Drones, Car and Bike Sharing). We hope that you will be inspired by the presentations, as well as by the less formal discussions with friends and colleagues participating to ODYSSEUS 2018.

A two-day school for young researchers and PhD students is organized by VeRoLog in conjunction with the workshop. Four lectures will be given within the workshop venues on Friday 1st and Saturday 2nd of June by Teodor Gabriel Crainic, Guy Desaulniers, Ola Jabali, Thibaut Vidal on different methodologies for Vehicle Routing Problems.

Several social events are offered to the conference participants and their guests: a welcome party on Sunday, a guided visit of the city of Cagliari on Monday evening, a visit to the Nuraghe of Barumini and a typical dinner on Tuesday evening, a visit to the beach of Chia and the old city of Nora on Wednesday evening and the conference dinner on Thursday.

We are grateful to the organizations and the individuals that have supported the organization of this event. In particular, we are grateful to the ODYSSEUS 2018 Scientific Committee, as well as to all the individuals who either contributed abstracts or served as reviewers of these abstracts. We wish you all an excellent week, an exciting meeting with informative presentations and stimulating discussions, and an unforgettable staying in Cagliari.

Looking forward to welcoming you in Cagliari, The Organizing Committee of Odysseus 2018

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Book of Extended Abstracts

A matheuristic for the Biomedical Sample Transportation Problem with Interdependent Pickups

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1 Introduction

We study a Laboratory Network, formed by a set of sample collection centers (SCCs), visited by patients, and a central laboratory (lab). Although large hospitals often own on-site laboratories, most of the SCCs in a network are not equipped for performing samples' analyses. Therefore, given specific collection periods at the SCCs, one or several pickups need to be scheduled to take the samples to the lab. This is one of the many challenges faced by our partner, Quebec's Ministry of Health and Social Services (i.e. the MSSS), who seeks to improve their service to the population and the system's efficiency by optimizing the sample transportation plan. To create routes that ensure safe and timely shipment of all samples over the province is an interesting, yet difficult, problem to solve.

Inspired by the MSSS context, we study the Biomedical Sample Transportation Problem (BSTP), a Vehicle Routing Problem (VRP) in healthcare logistics, which is challenging due to the short lifetime of samples. According to their biological characteristics and the type of tests to be performed, a sample has a maximum timespan to be analyzed before it perish (i.e. a sample has to be taken to the lab no later than T_{max} minutes after been collected). This short lifespan causes a interdependence between all the pickups and the routing decisions. In addition, this interdependence is also related to the beginning of the collection period of each center (i.e. when the first sample is collected) and the number of visits to be scheduled.

VRP with time restrictions have been studied for a long time in the literature (e.g. VRP with time windows or the pick up and delivery problem). However, fewer contributions consider temporal precedence constraints and/or synchronization between visits, which are common in healthcare logistics [1]. To the best of our knowledge, only two papers consider interdependence between the pickups and the routing decisions like is done in this paper. Doerner et al. [2] proposed a model to build interdependent routes when collection periods are known whereas Anaya-Arenas et al. [3] introduced some flexibility to collection periods, but imposing a fixed number of pickups at each center and considering softer time restrictions than the ones faced in practice. Although the latter showed the benefits of introducing flexibility in the SCCs' opening schedule, there is still a need for a model that will address simultaneously several aspects of the real problem. Hence we propose in this study to model the BSTP as a VRP with interdependent pickups, in which both the number of visits to be performed at each SCC and the beginning of their collection period is optimized along with the routing decisions. This is a much more interesting, but also harder, problem to solve, and we propose a matheuristic algorithm to tackle the real instances provided by our partner.

2 Mathematical model

The proposed VRP with interdependent pickups is defined over a complete digraph $G = \{V, A\}$, where $V = \{v_0, v_1, \ldots, v_P\}$ is the set of nodes composed by the P potential pickups over all the SCCs and the laboratory (v_0), and A is the arc set. We define $N = 1, \ldots, n$ as the set of indexes of the SCCs, $Q = 1, \ldots, P$ as the set of indexes pickups and I_g as the set of indexes of pickups associated to SCC c_g. T^i_{max} denote the maximum time limit to analyze the samples collected in pickup i, T_{max} the maximum over all T^i_{max}, and δ_g the difference between them (if any). Finally, O_g is the length of the collection period of SCC c_g, α_g is the current beginning of c_g's the collection period and ϕ_g is the flexibility granted to this decision.

As in the classical VRP formulation, arc variables x_{ij} are set to one if pickup i is performed right before pickup j. However, to introduce the flexibility with respect to the number of pickups and SCCs' opening schedule, new variables are defined. The first group of variables is related to pickups: binary variables y_i are activated only if the pickup i is performed, and binary variables z_i are activated only if the pickup i is performed after the end of the collection period and no other pickups are required at the SCC (i.e. $y_{i+1} = 0$). The second group is related to SCCs' schedule and timing of pickups: decision variables a_g and b_g are the beginning and end of the collection period for SCC c_g, variable u_k correspond to the time that pickup k is performed, and f_i is the maximum remaining time to bring the samples picked up at node i back to the lab. The objective is to minimize the total route duration. Besides the classical constraints sets for the VRP, we formulate the following constraints to ensure the precedence and the maximum timespan restriction on the samples life utility.

$$\alpha_g - \phi_g \leq a_g \leq \alpha_g - \phi_g \qquad g \in N \tag{1}$$

$$b_g = O_g + a_g \qquad g \in N \tag{2}$$

$$b_g - u_k \leq -M(z_k - 1) \qquad g \in N, \quad k \in I_g \tag{3}$$

$$u_k - b_g \leq 0 \qquad g \in N, \quad k \in I_g \tag{4}$$

$$\sum_{k \in I_g} z_k \geq 1 \qquad g \in N \tag{5}$$

$$y_k = 1 - z_{k-1} \qquad k \in I_g | k > (I_g)_1, g \in N || P_g| > 2 \tag{6}$$

$$f_0 \geq +f_i - M(1 - x_{i0}) + t_{i0} + \tau_i \qquad i \in Q \tag{7}$$

$$f_j \geq +f_i - M(1 - x_{ij}) + u_j - u_i \qquad i \in Q, \quad j \in Q, \quad j \neq i \tag{8}$$

$$f_0 = T_{max} \tag{9}$$

$$f_k \leq T_{max} \qquad k \in Q \tag{10}$$

$$f_k - (u_k - a_g) \geq \delta_k \qquad k = (I_g)_1, g \in N \tag{11}$$

$$f_k - (u_k - u_{k-1}) \geq \delta_k \qquad k \in I_g | k > (I_g)_1, g \in N || P_g| > 2 \tag{12}$$

Constraints (1) and (2) are related to the *flexibility* in the opening time for each SCC. Constraints (3)-(6) ensure that the entire operation period of each SCC is covered and *no samples are left* at the SCCs. Constraints (7)-(10) control the timing over all pickups and, finally, constraints (11) and (12) ensure that the time available for transportation and the time that samples are kept in the SCC respect the maximum time limit. The corresponding model was solved with CPLEX version 12.6.0.0. However, the solver was not able to tackle the real-data instances efficiently (within a CPU time of 10 hours or a memory limit of 50GB), which motivated the development of an approximated method.

3 Matheuristic

We propose a matheuristic with two main phases. The construction phase is first applied to obtain a feasible solution. Due to the strong interdependence and our large-size instances, we propose a **clustered-based decomposition** to create subproblems that can be solved to optimality by CPLEX in a short computational time. We hence adapt a *k-means* algorithm, with a relevant distance function that considers both spatial and temporal compatibility, and define an appropriate number of clusters using iteratively the *elbow method* for each instance. After each subproblem has been solved, the solutions are merged to find a first feasible solution for the global problem. This solution will be improved in the second phase through a **fix-and-optimize variable neighbourhood search**. Different attributes of the solution are considered to define three neighbourhood structures: the *route structure*, the *the pickup time* and the *number of pickups*. To explore

Instance			CPLEX				First Solution			Final Solution		
	N	P	Obj.	CPU(s)	GB	Gap	Obj.	CPU(s)	%BKS	Obj	CPU(s)	%BKS
1	9	22	1328	17317	50	95%	1407	627	5.9%	1328	2142	0.0%
2	13	26	1266	23776	50	99%	1280	423	1.1%	1214	2952	-4.1%
3	17	36	1914	15169	50	98%	1812	361	-5.3%	1783	4252	-6.8%
4	14	45	2565	13134	50	100%	2498	365	-2.6%	2475	3465	-3.5%

Table 1: Preliminary Results

a neighbourhood, the algorithm constraints the value of the objective function, sets the structure to explore (fixing the value of the respective variables) and the model is reoptimized by CPLEX. The search is stopped after a given number of iterations are performed without improvement.

4 Numerical Results

We compile 25 real-data instances provided by our partners from eight service areas in the province of Quebec, each one with different schedules, geographical density and distribution. We report in Table 1 preliminary results for four instances, reporting their size in number of SCCs (N) and potential pickups (P); CPLEX objective function (Obj), computational time in seconds (CPU), memory consumption (GB), and optimality gap (Gap); and finally, the results of our algorithm : objective function (Obj), computational time in seconds (CPU) and the gap to CPLEX best known solution (%BKS), for both its first solution (found with the clustering method) and the final one. As it is shown in Table 1, CPLEX fails to solve our problem efficiently, even for small instances. However, we have encouraging results with our algorithm, which is able to improve CPLEX best solution (found after five hours) by more than 3% (in average) and this in less than an hour. Notice that even if we were inspired by Quebec's BSTP, our algorithm could be later applied to other context as VRP with perishable items or a generalization of the Dial-and-Ride Problem.

References

[1] M. Drexl, Synchronization in vehicle routing, a survey of vrps with multiple synchronization constraints, Transportation Science 46 (3) (2012) 297–316.

[2] K. F. Doerner, M. Gronalt, R. F. Hartl, G. Kiechle, M. Reimann, Exact and heuristic algorithms for the vehicle routing problem with multiple interdependent time windows, Computers & Operations Research 35 (9) (2008) 3034–3048.

[3] A. M. Anaya-Arenas, C. Prodhon, J. Renaud, A. Ruiz, An iterated local search approach to solve a vehicle routing problem with interdependent pickups, Submitted to Journal of the Operational Research Society (JORS-17-0716-P) on 27-10-2017.