INTERNATIONAL
THESIS PROPOSAL

TITLE

Development of heuristics and matheuristic approaches to solve a family of transportation problems arising in the healthcare field

CANDIDATE CHARACTERISTICS

The thesis is for a master student (*tesi di laurea magistrale*).
The ideal candidate should be a Master student of Mathematical Engineering with:

- Background in Optimization (classes of group MAT/09)
- Strong programming skills (.Net / Java)

However, master students from other faculties are also considered.

DURATION AND GENERAL INFORMATION

This is a joint thesis project in collaboration with:

- the Istituto di Matematica Applicata e Tecnologie Informatiche (IMATI) of the Consiglio Nazionale delle Ricerche (CNR), Milan, Italy;
- the Département d'Opérations et Systèmes de Décision of the Université Laval, Quebec City, Canada.

The expected duration of the thesis is about 8 months.

The student will spend **about 4 months at the CNR-IMATI** and **4 months at the Université Laval.**

⇨ *thanks to the support of the Université Laval, the student will receive **500 euros per month** for the accommodation for the period abroad; moreover, one flight to Quebec City and one flight back to Milan are **reimbursed**.*

CONTACTS

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ABSTRACT



The biomedical sample transportation problem (BSTP), introduced by [1], is a challenging vehicle routing problem arising in the context of healthcare logistics. The problem aims at organizing routes to collect perishable items (biomedical samples or specimens) at given locations, which are referred to as specimen collection centers (SCC), and to transport them to facilities having adequate treatment equipment (the laboratories or labs).

This centralization of analysis into a single lab per region brings important economic and management advantages. It allows decision managers of the healthcare system to seek efficiency, to control the quality of the specimens and to harmonize the efforts of all the facilities. However, it imposes also an important challenge in logistics' planning due to the short lifespan of the specimens that are transported. The main constraint is that specimen needs to arrive to the Lab to be analyzed in a maximum of five hours after being collected from the patient. Otherwise, it will perish causing an important loss in logistics and material costs. Most importantly, it will affect the quality of the service offered to the patient because the sample need to be retaken and diagnosis is delayed. To avoid this, the SCCs have to be visited several times in a day and the route duration needs to be controlled, which creates a strong interdependency between two consecutives pick-ups and the routes' maximal length.

Previous work in the literature study a simplified version of the problem where the maximum time to arrive to the lab is limited, but with a single pick-up (so no interdependency in route planning) or with the number and hours of the pick-ups selected inside a time windows. However, very few approaches deal with the problem globally ([2] and [3]). We seek to define an efficient set of routes to perform the optimal number of pick-ups at each SCC, coordinating SCC's opening hours, to minimize billable time (total route duration) and to warrant that none of the samples perish, neither at the SCCs nor during transportation (which is a more complex, and harder to solve, optimization problem). Past results on the BSTP [1] and the VRP with interdependent time windows [2] proved the complexity of the problem and how commercial solvers were ineffective finding optimal solutions in reasonable short computational time. An efficient metaheuristic have been proposed [3], but there is still a challenge in the quality of the solutions proposed.

The goal of the thesis is to develop efficient heuristics and/or matheuristic approaches to solve this complex new version of the BSTP and to study its performance.

This research work is an extension of the partnership between the Laval University and the Ministère de la Santé et des Services sociaux (MSSS) of the province of Quebec in Canada. Therefore, the model and algorithm will be validated on test instances and realistic data.

[1] Anaya-Arenas, A.M., Chabot, T., Renaud, J. & Ruiz, A., 2016. Biomedical sample transportation in the province of Quebec: a case study. International Journal of Production Research, 54(2), pp.602–615.

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

[3] Anaya-Arenas A.M., Prodhon, C., Afsar, H.M. & Prins, C., 2015. An ILS approach to solve the biomedical sample transportation problem in the province of Quebec. Actes de conférence de la 11e édition du Congrès international de génie industriel CIGI 2015, Organisé par l'Université Laval, 26 au 28 octobre 2015, Québec, Canada.