New Optimization Techniques for Cross-Docking

PhD Thesis (Grant at Univ. Artois, France)

Context. In Artificial Intelligence (AI) and Operations Research (OR), we are interested in developing techniques for solving hard combinatorial (optimization) problems. The main objective of this thesis proposal is to conceive new original approaches for optimization, inspired from both AI and OR methods, with cross-docking as a preferred application domain. It will be led as a collaboration between two research laboratories of the University of Artois (France), namely, LGI2A and CRIL. On the one hand, a part of the research work carried out in the LGI2A focuses on sustainable logistics optimization problems belonging to various fields of application, such as healthcare, transport and so on (see LGI2A projects). To solve this class of NP hard problems, the LGI2A has developed an expertise in metaheuristics (e.g. VNS, GA) and hybrid approaches. On the other hand, some research conducted at CRIL aims at developping generic approaches (i.e., AI-related) for both CP (Constraint Programming) and SAT (Satisfiability Testing) domains. Useful tools for conducting innovative research at CRIL include state-of-the-art academic solvers (the CP solver AbsCon and the SAT solver Glucose), the integrated representation format XCSP^3, and the modeling Python library PyCSP^3 [4].

General Description. To deal with difficult combinatorial problems, such as those arising in cross-docking applications (described below), one needs some advanced tools developped in AI and OR communities. Among the various proposed approaches, some are built on backtrack-based complete approaches (branch and bound) while other perform some forms of (possibly population-based) local search. Sucessful techniques for accelerating the convergence of automatic solving systems toward good solutions include LNS (Large Neighbourhood Search) and VNS (Variable Neighborhood Search). Among various perspectives for improving the search towards robust solutions (or, even, optimality), we can imagine to:

- use some aggresive cuts to learn from both successes and failures,
- apply some best search algorithms,
- build hybrid methods, as those introduced for transport problems [3, 2],
- exploit unsupervised learning techniques in multi-objective optimization (so as to improve the quality of Pareto fronts).

This will be the research background of this PhD thesis, with cross-docking being the target application domain.

Cross-Docking In production systems, logistics and supply chain management have a capital importance. Indeed, they constitute the critical elements for the overall performance of the system, and not the means of production. Thus, and although production logistics do not increase value added to manufactured products, the associated resources must however be taken into account when it comes to optimizing flows (materials, information and finance) in order to to respond to a customer request under the best economic conditions. The planning of these resources must be both robust, to cope with the hazards and disturbances, and capable of responding to the challenges of sustainable development, namely: economic, environmental and social issues.

Among the sustainable development issues encountered in these companies, we wish to provide planning based both on the pooling of delivery flows and the adoption of an organizational method for order preparation which eliminates the intermediate stage of product storage, known under the name of cross-docking. The objectives of this planning approach based on the pooling of flows are to: (1) save storage space by freeing up shelf space; (2) decrease the number of logistics operations and therefore contribute to increasing the productivity of logistics staff; (3) shorten delivery times and thus increase the agility of the logistics chain; and (4) reduce the chain's carbon footprint logistics thanks to energy savings compared to the transport of goods to inside and outside the warehouse. Much research has already been undertaken on this sustainable planning, both on static as well as dynamic aspects [1]. However, the problem is still far from having been satisfactorily resolved, that is to say in conformity with the concrete problems found in industry. In addition, many variations of this sustainable planning problem remain to be explored due to the functional complexity related to the structure of the logistics network and its constraints.

Application. The candidate should have an outstanding degree in computer science (a perfect knowledge of programming with a language such as C++ or Java or Python is required - a good knowledge of Unix/Linux is appreciated), and a solid background in optimization (algorithms) in general. A first experience in research is recommended. Prior knowledge of french is not mandatory. **Between May 1, 2021 and May 25, 2021**, every applicant must submit in a zip file a CV, a copy of his university degrees, a list of publications if any, and a covering letter by email to `francois.delmotte@univ-artois.fr,adnen.elamraoui@univ-artois.fr,lecoutre@cril.fr` with the following subject: Thesis:Vivah. Selected candidates are expected to come for an interview by visio-conference. Interviews will be conducted before May 28, 2021.

Supervision.

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- Adnen El-Amraoui, assistant professor in industrial engineering, LGI2A.
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Labs.

- LGI2A: Laboratoire de Génie Informatique et d'Automatique de l'Artois
  UR 3926, Béthune, France.
- CRIL: Centre de Recherche en Informatique de Lens
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References

[1] A. Ardakani and J. Fei. A systematic literature review on uncertainties in cross-docking operations. *Modern Supply Chain Research and Applications*, 2:2–22, 2010.

[2] A. Baniamerian, M. Bashiri, and R. Tavakkoli-Moghaddam. Modified variable neighborhood search and genetic algorithm for profitable heterogeneous vehicle routing problem with cross-docking. *Applied Soft Computing*, 75:441–460, 2019.

[3] M. Karimi-Mamaghan, M. Mohammadi, A. Pirayesh, A. Karimi-Mamaghan, and H. Irani. Hub-and-spoke network design under congestion: A learning based metaheuristic. *Transportation Research Part E: Logistics and Transportation Review*, 142, 2020.

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