2018-00406 - Post-doctoral - Dynamic aggregation techniques for formulations mixing integer linear programming and dynamic programming

Level of qualifications required: PhD or equivalent
Fonction: Post-Doctoral Research Visit

About the research centre or Inria department
Our aim is to develop tight formulations for combinatorial problems by combining the latest reformulation techniques, such as Lagrangian and polyhedral approach, non-linear programming tools and graph theoretic tools. Through industrial partnerships, the team targets large scale problems such as those arising in logistics (routing problems), in planning and scheduling, in network design and control, and in placement problems (cutting stock problems).

Context
Scientific priorities:
- Modeling and simulation of systems of systems, large scale hybrid models
- It will also help dealing with uncertainty as an efficient tool for robust optimization
- Several applications to energy, sustainable development and resource management, such as operations management in vineyard.

Scientific Research context:
Integer Linear Programs (ILP) are widely used for modeling combinatorial optimization problems (in transportation, planning, cutting, scheduling...). A classical approach for solving an ILP (which is NP-hard in general) is to use a reformulation splitting the problem into "easy" constraints, typically associated with totally unimodular (T.U.) matrices, and "difficult" constraints. A number of practical problems rely on the consumption/production of limited resources, such as primary materials or time, that enable the use of the Dynamic Programming paradigm to obtain T.U. models of some of their subsystems. Such subsystems can be casted as shortest path problems in graphs whose nodes represent states of the subsystem, whereas arcs are linked with transitions related to decisions. The great quality of those reformulations is obtained at the price of a very large number of states and transitions that forbids solving them directly, even if the problem is theoretically easy to solve. This calls for the design of sophisticated algorithmic strategies.

Assignment
The work aims at solving very large scale ILP formulations obtained by T.U. reformulations of subsystems using dynamic aggregation and disaggregation of variables and constraints, by projecting the subsystems into lower dimension spaces. The expected work contributes to the design and implementation of a generic framework proposing several solving methods based on successive relaxations and restrictions of the state space, such as the Successive Sublimation Dynamic Programming algorithm [Ibaraki and Nakamura, 1994].

Main activities
More specifically, the mission consists in extending the existing framework to cases with multiple T.U. subsystems. Expressing the link between several subsystems requires to mix graph-modeled subproblems with a Linear Programming-modeled master problem, through the use of Dantzig-Wolfe reformulation or Lagrangian decomposition techniques. In this context, the post-doctoral researcher will contribute from a methodological point-of-view to the adaptation of key component techniques (in priority, Lagrangian cost variable fixing) to the case with multiple subsystems. The hybridization of state space relaxation techniques and branch-and-price algorithms might be addressed depending on the time required to achieve priority tasks. The methods developed will be implemented and integrated in the generic framework, and their efficiency assessed on a variety of combinatorial optimization problems.

Keywords: mathematical optimization, dynamic programming, mathematical programming

References:


**Skills**

- Required knowledge and background: mathematical programming, decomposition techniques, Lagrangian relaxation, dynamic programming, good programming skills in C++

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport

**Remuneration**

- 2653€ / month (before taxes)