M2 internship / PhD: Multi-objective optimization for the vehicle rescheduling problem

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This is a joint project between the research laboratory IRISA (Rennes) and the software development company NewLogUp (Bruz). We are hiring a PhD student on the topic described below; ideally, they can start with an internship. But direct applications for the PhD are welcome as well.

1 Internship

This internship will be between IRISA and NewLogUp. The expected duration is between 3 and 6 months.

The general field targeted in this internship is that of optimization of transportation costs using algorithm design, optimization techniques, and heuristic search algorithms. Currently, transportation companies mostly handle unexpected events (delays, accidents, etc.) manually. For instance, when a truck is delayed, the truck driver informs the transport manager that has then to think how to revise the daily plan in order to meet the goals, while maintaining the costs low.

In the literature, several papers have considered this problem called vehicle rescheduling [SGD14, DK17, GB18]. However in the state of art, most algorithms only focus on particular aspects (such as rescheduling due to excessive demand only); moreover, the multi-objective aspect is not addressed: in fact, it is preferable to optimize several objectives in the updated solution, such as, the overall cost, the number of modified routes, the added delay etc.

NewLogUp plans to develop software to help transportation companies automatically handle unexpected events. Our goal is to develop optimization algorithms to improve these solutions. There are several objectives to satisfy when computing updates to a given schedule:

- optimality of the cost of the new schedule,
- quality of service (e.g. minimizing delays),
- favoring robust schedules, that is, those that can be easily revised in case of further incidents,
- the simplicity of the revision, for instance, changing the routes for the least number of trucks.

The intern is expected to read and understand the literature about this problem, write a short summary on the state of the art. Many papers use integer linear programming techniques, so a basic understanding or a strong motivation to read about this is required. We plan two tasks for the internship:

- The candidate will discuss with NewLogUp in order to understand the details of the problem. Then, based on the literature, they will build a formal model, and suggest an associated algorithmic problem.
- They will adapt existing algorithmic techniques from the literature to solve the new algorithmic problem.
2 PhD

Ideally, we would like the internship to be followed by a PhD under a CIFRE contract. We expect several directions of research.

1. The candidate will improve the modeling started in the master’s internship. The model could be based on logic, namely linear temporal logic to express temporal constraints between events, or propositional logic over linear constraints. The candidate will also create benchmarks to evaluate the gain in using these techniques.

2. The candidate may study how genuine algorithmic techniques (integer/mixed linear programming, local search, variants of A*, SMT solvers) could be used to solve instances of the problem. The objective would be to develop new and perhaps simpler algorithmic techniques to solve the problem at hand.

3. The candidate may incorporate probabilistic beliefs about future tasks, in order to optimise the current plan. Probabilities can model frequencies and types of future incidents, and the expected costs at the next day.

4. The candidate may also provide a theoretical study of the multi-objective formulation in terms of exact algorithms and theoretical complexity.

5. The candidate is expected to implement the algorithms they will have developed. The algorithms will be then incorporated in the products developed by NewLogUp.

During this PhD, we expect 1) to publish several high quality research papers, and 2) to provide a complete and working solution for the above problem that is ready to be deployed. After this PhD, the candidate can expect to pursue a career in academic research, or in the private sector, for instance in research and development.

3 Requirements

The candidate is expected to have followed basic math courses, and ideally advanced algorithms such as linear programming or approximation algorithms. Alternatively, their background must be such that they are capable of learning about these techniques themselves.

An early experience as a research intern is a plus but not mandatory.

The candidate is expected to have good programming skills since theoretical developments in this work will be implemented and evaluated.

The location of the internship is flexible depending on the requirements of the master’s programme: this can be an internship at NewLogUp (and can be qualified as a software development internship), or at Irisa (as a research internship). In practice, the candidate will work tightly between the two.

References

