Dauphine Université Paris PSL / Nantes Université / Université de Picardie	INTERNSHIP PROPOSAL 2024 **Benders decomposition for robust assembly line balancing** Profile: Operations research Gratification: €4.05 per hour (*i.e.*, €614.25 net per month)

Supervision teams

Name	André Rossi (Professor)
Research laboratory	LAMSADE (UMR CNRS 7243)
Affiliation	Université Paris Dauphine - PSL, FRANCE

Name	Evgeny Gurevsky (Associate Professor)
Research laboratory	Équipe MODELIS, LS2N (UMR CNRS 6004)
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Content of the internship

The design of production systems is an important object of study that often involves massive investments and poses numerous optimization problems, known in the literature as *balancing problems*. In general, these problems consist of assigning all production tasks to workstations in such a way as to satisfy a given objective under certain technological constraints such as *precedence constraints, cycle time, exclusion, inclusion or constraints storage*.

One of the important objectives when designing these systems is to anticipate uncertainty in task duration, in order to obtain a robust long-term configuration. This necessity has several origins:

- The characteristics of the products and those of the workstations may evolve during the lifespan of the system, in order to satisfy market demand or to adapt to available components,
- Unplanned delays and shutdowns may occur during system operation.

The choice of an approach adapted to taking into account uncertainty over task duration depends on the information available on the origin of these uncertainties. Thus, the use of traditional methods such as stochastic programming or fuzzy logic can prove difficult in practice, particularly in the case where there is not enough data to establish a probability or possibility distribution. This is especially true when the production system has never been put into service. On the other hand, identifying a subset of tasks that are presumed to be subject to uncertainty in their durations requires little information, and is a much more frequent situation in practice. This is why we have been proposing and promoting since 2012 (see Gurevsky et al., 2012, 2013, 2022; Rossi et al., 2016; Pirogov et al., 2021; Shibasaki et al., 2024) an alternative approach for evaluating the robustness of production systems in such situations. The evaluation is based on the notion of stability radius, introduced by Sotskov et al. (2010) in the context of scheduling, and which has since found other areas of application. The stability radius of an admissible configuration can be interpreted as being equal to the maximum amplitude of variations in the duration of tasks identified as uncertain, which does not compromise the admissibility of the considered configuration. The stability radius is therefore a natural measure of robustness, because the larger it is, the more the production system, in its current configuration, is able to resist hazards. In addition, it has the advantage of not requiring any history to be implemented, and can therefore be considered as an alternative to stochastic programming and fuzzy logic.

Designing the configuration of a production system with the largest possible stability radius is a difficult and novel combinatorial optimization problem, which was only recently introduced by our work (Rossi et al., 2016; Pirogov et al., 2021), in the framework of assembly and transfer systems, and has opened up numerous algorithmic and practical perspectives.

The main goal in this internship is to develop algorithmic methods based on Benders decomposition to obtain a maximum robustness configuration of the assembly line, especially for large instances. To do this, we will exploit existing results on the reduction of task assignment intervals which has the effect of limiting the combinatorics of these assignments. This first model can then be solved directly by a MILP solver. We will then apply a Benders decomposition to this model, selecting the assignment variables as complicating variables. This has the advantage of leading to a master problem which can be formulated as the classic SALBP decision problem: can we assign tasks to a set of workstations while respecting the cycle time, precedence and integrity constraints? The Benders decomposition sub-problem is very easy to solve since it consists of calculating the stability radius of the solution obtained by the master problem. An implementation of Benders decomposition in the form of a cutting plane generation algorithm called Branch-and-Benders-Cut (BBC) will be developed and compared to the results of the non-decomposed model.

The successful candidate will be employed by the University of Nantes and attached to the MODELIS team at the LS2N laboratory (UMR CNRS 6004), or by Paris Dauphine University - PSL at LAMSADE laboratory (UMR CNRS 7243). The desired duration for this internship is 6 months, ideally from February 1st, 2024 to July 31, 2024. The candidate will benefit from the supervision of three professors located in Amiens, Nantes and Paris. He or she will be able to freely choose one of these three sites to carry out their internship.

The desired candidate must have solid skills in C++, JAVA, Julia or Python programming as well as a good level of English and/or French, both written and oral.The mastery of commercial solvers like CPLEX or GUROBI and their API would be a real plus. He or she must be a student in the final year of an engineering or university course (BAC + 5). Their main training should preferably focus on computer science, operations research or industrial engineering.

The application file must contain:

1. detailed CV
2. The marks of academic year 2022-2023
3. A copy of the last internship report
4. Cover letter

Applications will be processed as they are received. The complete file must be sent to the following address: `research.ls2n@gmail.com`

References

Borisovsky P.A., Delorme X. and Dolgui A. 2013. Balancing reconfigurable machining lines via a set partitioning model. *International Journal of Production Research* 52(13): 4026-4036.

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