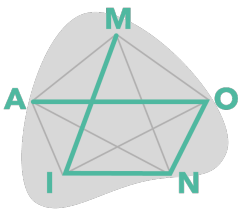

MINOA Research Challenge: Rules

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Version 1.2, September 8, 2021

Contents

MINOA has received funding from the Europeans Union's EU Framework Programme for Research and Innovation Horizon 2020 under the Marie Skłodowska-Curie Actions Grant Agreement No 764759.

1 Introduction

The topic of the MINOA challenge is finding the solution of a *Non-Periodic Integrated Timetabling and Vehicle Scheduling Problem* (ITTVS) with a mixed fleet of electric and Internal Combustion Engines Vehicles (ICE). A detailed description of the problem can be found in [1, 2, 3]. The formulation of the problem and the test instances are proposed by M.A.I.O.R. S.r.l. in collaboration with the University of Pisa. The participants, divided into three categories, are supposed to develop an algorithm that is able to solve the proposed problem. For each category, the team that will produce the best algorithmic solution (as measured by the performance indices specified below), will be the winner.

2 General Rules

Participants can compete as a team. Each team must respect the following rules:

1. A team can be composed by at least one and at most ten participants.
2. A participant cannot belong to different teams.
3. A participant cannot be a M.A.I.O.R. S.r.l. employee or an external collaborator involved in the preparation of the challenge.
4. Each team can submit only one algorithmic proposal.
5. Each team has to declare to which of the three possible categories it belongs:
   (a) Junior: all active members of the team are at most high-school students;
   (b) Senior: all active members of the group are at most undergraduate or Master-level university students;
   (c) Professional: members of the team can be Ph.D. students or researchers in academia or industry.

   For Junior and Senior teams, a mentor with higher qualifications is allowed, but (s)he cannot participate in the actual development of the algorithmic solution; a written declaration by the mentor that (s)he has abided by this rule will be required.
6. There are no restrictions for using existing software tools (in particular, commercial or open-source optimization solvers) for the implementation of the algorithmic solution.
7. The teams will be required to provide a detailed recount of the optimization techniques employed by their code for the Award Committee to examine, together with the results. Disclosing the source code is not required, but it is appreciated.
8. In case the source code is not provided, or it uses hardware/software that would make it impossible for the Award Committee to be confident on the correctness of the results, the teams will be required to fully and proactively collaborate with the Award Committee to allow reaching a sufficient level of confidence. This may entail, for instance, organizing a live event where the on-the-spot solution of new instances is performed to confirm the capabilities of the developed approach.
9. In any case, the winning teams will demonstrate their result and solution procedure during the award ceremony, if the pandemic allows it (see Section 3).

2.1 Organization of the challenge

The challenge consists of three phases: the opening, the preliminary phase, and the final phase.

During the opening phase, the teams will have the possibility to register for the competition using the form available at the web page https://minoa-itn.fau.de/?page_id=1123.

During the preliminary phase, the organizers will provide a set of instances and a validator, available on the web page https://minoa-itn.fau.de/?page_id=1171. This will provide the teams with a test bench for the algorithmic solutions they will be implementing, as well as a way to verify that the solutions they generate are feasible and have the right objective function value. The input format of the instance, the output format of the solution and the output report of the solution are described in detail in [4]. New teams can still register during the course of the preliminary phase.

At the beginning of the final phase, the set of the competition instances will be published. Before the final deadline, the teams must solve the proposed instances and deliver the solutions and all the other information required for scoring (see next section), among which a document describing the algorithmic approach used to solve the problem, using the tool made available at the web page https://minoa-itn.fau.de/?page_id=1171. Teams failing to provide the required information by the deadline will be disqualified, with no recourse available. A team may submit their solution more than once, but each submission will entirely replace the previous ones, i.e., only the very last submission before the deadline will count towards the challenge.

At the end of the final phase, the commission will evaluate the produced results and draw up the final ranking.

2.2 Scoring

The teams will be required to provide, for each of the competition instances, a single file with the format described in [4] containing all the information required for ranking the algorithmic approach:

- The description of the obtained solution that must necessarily pass the correctness tests implemented in the checker made available at the web page https://minoa-itn.fau.de/?page_id=1171, at the cost of being declared invalid; issues with the checker are supposed to be fully sorted out during the preliminary phase. The checker also produces the value of the objective function that will be used as the upper bound on the optimal solution value for the scoring.

- A valid lower bound on the optimal value of the instance ('dumb' valid lower bounds can surely be produced extremely quickly even if the chosen algorithmic approach does not naturally use them). Note that, unlike for the solution, no certificate of the validity of the lower bound can reasonably be required of the teams, which potentially leaves wiggle room for (intentional or not) reporting of lower bounds of questionable validity. Teams will be supposed to make their best efforts for ensuring the correctness of their reported lower bounds, in particular by careful testing during the preliminary phase.

- The CPU time required to obtain the solution and the lower bound, excluding the time required to read the instance from file and to write the solution to file, but including everything else. If the solution method makes use of more than one core, the maximum number of cores available to it during the whole execution process (if a core has more than one hardware thread, each thread counts as one core unless the feature is disabled)

must be provided. If heterogeneous cores are used, the available number of each type must be separately provided.

Failing to provide any of these information for an instance, or providing wrong ones, will result in the team being placed last in the corresponding ranking; in case this happens for more than one team, these will all be placed last, and the order between them will be that of the time in which they have provided the results. Providing wrong or suspicious information and not fully collaborating with the Award Committee to justify it could lead to a team being disqualified entirely to the exclusive and unappealable decision of the Award Committee.

Each team will also have to provide:

- A single document describing the implemented algorithmic approach with an appropriate level of mathematical detail.
- Within each solution file, estimates of the performances of the used CPUs obtained by running the open-source benchmark `NBench`, available at

  https://www.math.utah.edu/~mayer/linux/bmark.html

  and reporting the corresponding `INTEGER INDEX` and `FLOATING-POINT INDEX` in the `ORIGINAL BYTEMARK RESULTS` section, whose average will be taken to be the measure of the performance. Teams are supposed to use the benchmark responsibly, i.e., at the very least compiling it with maximum standard optimizations in order not to underreport their CPUs performances and therefore artificially inflate their efficiency score. To help in avoiding (intentionally or not) issues of this kind, full hardware details of the used CPUs must also be provided. If heterogeneous cores are used, the performance indices and hardware details will have to be separately provided for each type. If the employed computer system has GPUs or other accelerators available (FPGA, quantum processors, ...), and the solution process makes significant use of them, then the team will have to disclose this early on during the preliminary phase and agree to assist the Award Committee in performing meaningful ad-hoc benchmarks to evaluate their computational power. According to Point 8 of the General Rules, the Award Committee retains the right to ask each of the teams to perform a live demo event of their approach to verify that the provided figures are correct, save if the team makes the source code available in a way that makes it practically possible for the Award Committee (at their exclusive judgment) to be confident in the correctness of the provided results.

With this information, for each instance, three Key Performance Indicators (KPI) of the solution process will be computed:

- The value of the provided solution, an Upper Bound (UB) on the optimal value of the problem.
- The provided valid Lower Bound (LB) on the optimal value of the problem.
- The estimate of the total expended computational effort obtained by multiplying the CPU time by the maximum number of available cores and by the performance index (with the obvious adaptation if heterogeneous cores are used).

Each KPI will be compared, separately, with those produced by all the teams of the same category for the same instance, and an ordered list will be formed. For the UB and computational effort the list will be increasing (smaller values first), for the LB the list will be decreasing

(larger values first). In case two teams have the very same KPI value, the team having provided the results sooner will be placed higher in the list. If n teams of the category have provided a result for that instance, the team in position i in the list will receive a score of $^{n-i+1}/_{n}$ for the corresponding KPI (i.e., the team having produced the best value will receive score 1 and the team having produced the worst value will receive score $^{1}/_{n}$). The final score for each instance will be the *average of the best and the worst* of the three individual KPI scores. The total score of a team will be the sum of the scores for each instance for which a solution was provided. The team with the highest score in their category will be the winner for that category. In the event that the top teams obtain extremely close scores, indicating a draw, the Award Committee retains the right to choose the winner based on their expert judgment on the quality and novelty of the solution process as described by the accompanying report.

The rationale for the scoring system is that, while an extremely fast heuristic producing extremely good solutions but no "serious" lower bound (or, symmetrically, an approach computing extremely good lower bounds but very bad solutions) should still have a chance to win, an approach that provides a good balance of quality of the solution, quality of the lower bound and expended computational effort should be preferred. This scoring system therefore corresponds to the (debatable, but deliberate) stance that, for any given expended computational effort, good upper bounds and good lower bounds are "equally important" in a solution process.

On another account, this being a problem about (more or less) "green" logistics we found it appropriate to also favor "green" approaches, i.e., that require as less computational power—and therefore energy—as possible. This is another debatable but deliberate stance, since wall-clock time might have been deemed more appropriate in view of it better taking into account the operational needs of the service providers. However, in doing so, teams with disproportionate access to computational resources would have been unduly advantaged, therefore rewarding brute force above ingenuity, which we believe is not the right approach for a scientific challenge.

We remark that, by not knowing the KPIs provided by competing teams, each team will not have a clear measure of how much an improvement in one KPI at the cost of the deterioration of another will impact their final competitiveness. This will leave each team with having to make their own nontrivial choices about the algorithmic solutions (and their algorithmic parameters) that attain the best compromise between the three KPIs, not entirely ruling out that the use of significant computational resources may ultimately prove to be the better choice.

The Award Committee will produce a detailed report comprising all the data (in tabular/spreadsheet form) necessary for producing the ranking and make it available to all the teams for review before the final ranking is announced. However, the Award Committee will retain the right to have the final and incontestable decision should any controversy arise about the ranking.

3 Awards

If the pandemic situation will allow it, winners of each category will be invited to FAU Erlangen-Nürnberg to hold a presentation at the Long Night of Sciences 2022, with travel and lodging expenses up to 2500 Euro per team reimbursed by the MINOA project. Should this not be possible, winners of each category will receive a prize money of 2500 Euro.

4 Milestones

The important dates of the challenge are:

1. First call of the challenge: **December 1st, 2020**
   (a) Publication on a web page of the problem to solve, input/output formats and rules of the challenge. Publication of few (i.e. 1 small, 1 medium, 1 large) test cases
2. Second call of the challenge: **January 11th, 2020**
   (a) Publication of a further set of (trial) instances
   (b) Availability of a validator to check solutions feasibility and objective function values
3. Final Challenge Phase: **May 15th, 2021**
   (a) Publication of the final set of tender instances
   (b) Competitors provide a report describing the approach they want to use.
4. End of the Challenge: ~~**May 31st, 2021**~~ **Extended June 9th, 2021**
   (a) Competitors provide the tender instances solutions and additional reports to describe them endenumerate
   (b) Approaches and solutions evaluation. Publications of the winners and of the final ranking: **September 1st, 2021**
   (c) Award ceremony: FAU Erlangen-Nürnberg at the Long Night of Sciences, **May 21st, 2022**

5 Contact us – questions

The participants are invited to contact the organizers by a dedicated forum for any question, doubt or clarification. The organizers will reply as soon as possible. Matters or issues of common interest will be made public on the webpage.

6 Intellectual Property

1. Teams retain the full intellectual property on the computer programs developed during the challenge. However, they will be required to publicly disclose enough details about their solution process to allow the Award Committee to properly evaluate it. The Award Committee will have absolute authority to set the amount of required detail; any team failing to provide, upon request, the necessary information will be disqualified.
2. MAIOR and any third party may freely use the information publicly provided by the participants for the purpose of the challenge, but cannot use the corresponding computer program implementation without the agreement of the team.
3. Should a team make the source code of their implementation available for the purpose of Point 8 in the General Rules, they can ask for the code to remain confidential. In this case the code will only be available to the Award Committee and possibly to technical staff for the only purpose of verifying the correctness of the submitted results.
4. Participants to the challenge cannot claim to have a partnership or a contract with MAIOR, even if they win the challenge. They can only claim to be participants or winner if it is the case. MAIOR may (but has taken no engagement to) sign contracts with some participants after the challenge. Any such contract would be independent of the challenge.

References

[1] *MINOA Research Challenge: Description problem - Professional*. https://minoa-itn.fau.de/?page_id=968.

[2] *MINOA Research Challenge: Description problem - Senior*. https://minoa-itn.fau.de/?page_id=968.

[3] *MINOA Research Challenge: Description problem - Junior*. https://minoa-itn.fau.de/?page_id=968.

[4] *MINOA Research Challenge: Input-Output description format*. https://minoa-itn.fau.de/?page_id=968.