

I-LAB Artelys / TAO

*a general framework for decision
making with uncertainty plus
energy-specific applications*

This document presents a future collaboration between Artelys and INRIA around optimization, supervised learning and energy savings applications, emphasizing smart grids. The principle is (i) to start with existing software, from all partners (in particular the MASH and IOMCA platform, and the tools from Artelys); (ii) to add new components developed during the collaboration; (iii) to redevelop components requiring an industrialization.

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A Goals

The goals of the collaboration are methods and tools integrated in the platform Artelys Metis:

- for prevision and optimization (jointly);
- based on automated choices, for user convenience, between algorithmic options;
- with a special attention to energy savings and smart grids.

B Partners, people

Artelys (www.artelys.com):

- modelization
- mathematical programming and optimization
- energy

TAO team (tao.lri.fr):

- modelization
- evolution strategies & optimization
- portfolios of optimization algorithms
- portfolios of machine learning algorithms

An ITI and a PhD student will be hired (cf Annex II Annexe Financière)

C Workpackages

1. WP1. integration of the platform Artelys Metis and management

Head: Olivier Teytaud and Nicolas Omont

Other members: all members

- decision of which components should be kept / removed in the platform
- global architectural choices on the platform Artelys Metis

2. WP2. Machine learning (ML) part of the platform

Head: Olivier Teytaud

Other members: PhD student, Stéphane Gaubert

- decision around new ML tools to be developed
- decision around new ML tools to be included
- development of new ML tools
- including new ML tools

3. WP3. Optimization packages

Head: Marc Schoenauer

Other members: PhD student, Olivier Teytaud, Stéphane Gaubert

- decision around new optimization tools to be developed
- decision around new optimization tools to be included
- development of new optimization tools
- including new optimization tools

4. WP4. Decision making with uncertainty (DMU)

Head: Stéphane Gaubert

Other members: ITI, Marc Schoenauer

- decision around new DMU tools to be developed
- decision around new DMU tools to be included
- development of new DMU tools
- including new DMU tools

5. WP5. Energy-specific applications

Head: Olivier Ratier (Artelys)

Other members: Fabrice Busecaylet, Louis-Philippe Kronek, Olivier Teytaud, PhD student

- finding relevant applications
- developing the required models for these applications
- developing the interface to these applications

6. WP6. Portfolios

Head: Marc Schoenauer

Other members: PhD student

Definition: portfolios algorithms are aimed at choosing dynamically which algorithm is best for a given task.

E.g. a portfolio algorithm for optimization has several optimization algorithms at hand, has an optimization problem to solve, and chooses which ones to discard and which one(s) to use. Components can be discarded just from the characteristics of the problem, or depending on early runs.

Tasks:

- choosing which portfolios algorithms should be included
- developing these portfolios algorithms

D Competences

The following competences are required for the project.

* Optimization (TAO, Artelys)

- optimization (mathematical programming + evolution strategies)
- portfolios of optimization algorithms

* Decision making with uncertainty tools (TAO, Artelys)

- Those from the OpenDP platform
- Those from the MASH platform (<http://www.mash-project.eu>)
- Those from the IOMCA project (<http://www.lri.fr/~teytaud/iomca.html>)

* Machine learning & statistics (TAO)
regressions

- neural networks
- support vector machines
- other regression tools and conditional distribution estimators (many of them are already developed in OpenDP / MASH)

* Portfolios of algorithms: bandit literature (TAO)

* Energy applications (Artelys)

E Relevant existing software components

1. *Relevant software components in INRIA*

MASH/OpenDP/IOMCA is a framework from INRIA / LRI (Univ. Paris-Sud) / CNRS and contains many free source codes including those developed in MASH and IOMCA:

- statistical tools:
 - SVM
 - Weka (many classical tools, including polynomial regression and decision trees)
 - Neural Networks
 - Interpolation methods
- optimization tools
 - evolutionary algorithms
 - LBFGBS
 - Direct Search Methods
 - Beagle (genetic programming)
- decision making with uncertainty
 - the MCTS component from IOMCA
 - the value iteration and dynamic programming from OpenDP
 - the Q-learning component from MASH

There are also several MCTS implementations are maintained in the team (MASH, Baal, Shakti...) which might be of some use.

2. *Relevant software components in Artelys*

Artelys:

- is worldwide distributor of Knitro, a leader in differentiable non-linear optimization.
- is the distributor in French-speaking Europe of Xpress MP, a strong tool for linear, quadratic, mixed integer and constraint programming.
- has the property of Artelys Kalis, a constraint programming component.
- has the property of Risk Manager.

F Organization

The partners have access to various optimization tools and machine learning tools; they will first:

1. develop missing optimization and machine learning components;
2. integrate the optimization tools in a single platform: Artelys Metis;
3. integrate the machine learning tools in a single platform: Artelys Metis;
4. develop selection tools on top of portfolios above.

Then, this platform will be specialized towards energy saving applications, e.g.

- district heating (predict temperatures and consumptions depending on choices, optimize choices);
- more generally speaking, smart grids (predict effect of various time distributions of

consumption; optimize this time distribution in order to reduce peaks of consumption);
-yet more generally speaking, tools for predicting outcomes as a function of actions and then
optimizing these actions.

The tools will be generic, but the applications under work will be limited to energy savings.

G Deliverables

Publications:

- on portfolios of optimization algorithms
- on portfolios of machine learning algorithms
- on joint prediction/optimization (including DTU)

Software components for joint prevision and optimization:

- including automated algorithmic choices for users' convenience.
- with clear interfaces with classical and emerging energy saving problems.

H Calendar

The calendar will be highly flexible in the sense that early developments (e.g. workpackages 2, 3) might have to be reactivated depending on the needs of WP4, WP5, WP6.

Workpackages calendar:

WP1 (management): T0 to T0+36 months

WP2, WP3: T0 to T0+16 months

WP4: T0+10 to T0+26 months

WP5: T0+24 to T0+36 months

WP6: T0+16 to T0+30 months

Meetings: A regular meeting of the I-lab technical committee composed of participants to WP1 is required. Visio conference is allowed, and the frequency of meetings should be at least once per two months. This technical committee will report to the I-lab steering committee (cf. Article 4-2).

I Missions

The project will require missions for presenting/diffusing the corresponding publications.



ANNEXE II : ANNEXE FINANCIERE

Estimation de l'investissement INRIA :

- Ingénieur Transfert et Innovation pour une durée de 3 ans : 180 200€
- Doctorant sur 36 mois : 221 205€
- Encadrement du doctorant, de l'ingénieur et gestion du projet par les chercheurs : 87 344€
- Lancement de l'étude et spécifications, suivi de projet, par les chercheurs de TAO : 80 734€
- Frais de missions : 15 000€
- Frais de matériel : 6 000€

Soit un coût total de 590 483 € sur 3 années.

Estimation de l'investissement d'Artelys :

Sur la base des moyens engagés au cours des trois ans, le coût global des travaux de R et D engagés par Artelys engagés dans ce Ilab est évalué à 1 150 000 Euros. Ce coût ne prend pas en compte les efforts commerciaux pas plus que la contribution d'Artelys aux investissements de l'INRIA.



ANNEXE III : LISTE DES CONNAISSANCES ANTERIEURES DES PARTIES

LISTE DES CONNAISSANCES ANTERIEURES DE L'INRIA :

L'équipe-projet MAXPLUS développe la théorie, l'algorithme, et les applications des algèbres de type max-plus, en relation avec les domaines où celles-ci interviennent: théorie de la décision (commande optimale déterministe et stochastique, théorie des jeux), analyse asymptotique et théorie des probabilités, modélisation et évaluation de performance de systèmes à événements discrets(réseaux de transport ou de télécom, systèmes de production), et recherche opérationnelle.

Publications de l'équipe MAXPLUS :
<http://www.inria.fr/equipes/maxplus/%28section%29/publications>

Présentation de l'équipe MAXPLUS : <http://www.inria.fr/equipes/maxplus>

Les thèmes de recherche de l'équipe-projet TAO sont l'optimisation, l'apprentissage et les méthodes statistiques. Les connaissances antérieures en optimisation sont les méthodes d'optimisation stochastiques bio-inspirées ou par évolution artificielle pour l'optimisation mono-objectif: ES, CMA-ES, PSO, DE, EDA, pour l'optimisation multi-objectif ainsi que les couplages de ces méthodes avec des méta-modèles, l'utilisation de ces méthodes dans des contextes bruités, pour des problèmes avec contraintes (ces trois derniers points utilisant des techniques d'apprentissage statistique) et la parallélisation de ces méthodes.

Publications de l'équipe TAO : <http://www.inria.fr/equipes/tao/%28section%29/publications>

Présentation de TAO : <http://www.inria.fr/equipes/tao>

En particuliers pour ce projet, ces équipes Inria apporteront leur savoir-faire en :

- Machine learning algorithms ;
- Optimization algorithms ;
- Knowledge around bandit techniques (no software requirement, bandit techniques are usually straightforward to implement) ;
- Reinforcement learning software + knowledge

LISTE DES CONNAISSANCES ANTERIEURES DE Artelys :

- Plate-forme d'optimisation d'actifs à court terme (du jour pour le lendemain) Artelys Energy Planner (<http://www.artelys.com/fr/plateformes/crystal/EnergyPlanner.html>)
 - Plate-forme d'optimisation d'actifs à moyen terme Artelys Risk Manager (http://www.artelys.com/fr/plateformes/crystal/EnergyPlanner_index.html)
 - Plate-forme Artelys Crystal (<http://www.artelys.com/fr/plateformes/crystal/index.html>)
 - Composant de programmation par contrainte Artelys Kalis (<http://www.artelys.com/fr/composants/kalis.html>)
 - Composant de programmation dynamique Artelys Dynopt