Optimised energy management of a fleet of electric vehicles in a large-scale smart grid based on reinforcement learning, game theory and multi-agent systems

Supervisors
- Anne Blavette
CNRS Permanent researcher, SATIE Lab, ENS Rennes, France (anne.blavette@ens-rennes.fr)
EDEN4SG ANR project coordinator
- Hamid Ben Ahmed
Professor, SATIE Lab, ENS Rennes, France (benahmed@ens-rennes.fr)
- Patrick Maillé
Professor, IRISA lab, IMT Atlantique, Rennes, France (patrick.maille@imt-atlantique.fr)
- Raphaël Féraud
Researcher, Orange Labs, Lannion, France (raphael.feraud@orange.com)
- Guy Camilleri
Assistant professor, IRIT lab, Toulouse, France (Guy.Camilleri@irit.fr)

Topic

In order to integrate more and more renewable energy, the power system is being transformed into a smart grid. However, this transition will require shifting from a centralized management of flexible entities (power sources (e.g. PV, etc.), electric vehicles, …) to a highly decentralized, smart and dynamic energy management. It will also require considering a large number of flexible entities, multiple sources of uncertainties, constraints in the electrical network, etc. This represents a very complex problem that conventional methods are not able to address. In this context, there is a clear need for research works contributing actively to the development of decentralised energy management strategies for large-scale smart grids under uncertainty.

Some methods have been used on related, but only small-scale problems (up to 50 flexible entities [Pacaud2018]) as a greater number would lead to an explosion of the required computing time. On the contrary, methods based on multi-agent systems may present high scalability capabilities which render them particularly suitable for the real-time operational management of large-scale smart grids [Rizk2018]. In this perspective, research works are already being conducted in collaboration between SATIE, IRIT and Orange Labs on the problem considered here, and for which promising results have already been obtained [Zafar2021].

The goal of this internship, and of the envisaged follow-up PhD thesis, is to build upon this research work by introducing contributions from the field of game theory and different machine learning tools. Game theoretical approaches have shown to present a high scalability potential, especially when combined with reinforcement learning approaches. These approaches aim to learn an optimal policy using the observations and feedbacks of the environment. The reinforcement learning algorithms have to explore the state-action space

to reach the performances of an optimal policy in the long run. The work will be based on recent advances in the field [Féraud2019].

This internship will be carried out in the frame of the EDEN4SG ANR project.

Tasks description

The position will include the following non-exhaustive list of tasks:

- Bibliographical search in the scientific literature
- Mathematical formalization of the considered scientific problems
- Numerical simulations (code development, testing and validation, experimentation, results discussion)
- Regular reporting to the supervising team
- Scientific publication writing

Skills

Student in Master 2 at the University, an Engineering School or equivalent, in the field of machine learning, applied mathematics, statistics, computer science or electrical engineering with a strong multi-disciplinary background.

The internship is envisaged to be pursued as a PhD thesis, so a strong motivation for embarking on doctoral studies is required.

Knowledge in machine learning (especially reinforcement learning), game theory and/or power systems is required. Good programming skills on object-oriented programming would be highly appreciated.

A strong capability to work in a team and communicate within a multidisciplinary team, both onsite and at a distance, would be very appreciated.

Knowledge on renewables, smart grids and energy storage would be a plus.

Application deadline
10th October. Please send your CV and cover letter to all the supervisors.

Starting date
From January 2023, but a later starting date is possible. (Follow-up PhD thesis starting date: September 2023).

Stipend
Around 600€/month. In addition, the student may be eligible to additional subsidies in the housing allowance (https://www.adele.org/en/housing-aids).

Location

The internship will be carried out mainly at ENS Rennes and IMT Atlantique, in collaboration with Orange Labs and University Paul Sabatier.

References

[Zafar2021]	S. Zafar, V.Maurya, A. Blavette, G. Camilleri, H. Ben Ahmed, et al.. « Adaptive Multi-Agent System and Mixed Integer Linear Programming Optimization Comparison for Grid Stability and Commitment Mismatch in Smart Grids". In Proceedings of ISGT Europe, Oct 2021, Espoo (online), Finland.
[Féraud2019]	R Féraud, R Alami, R Laroche , Decentralized exploration in multi-armed bandits, ICML 2019.
[Pacaud2018]	François Pacaud, « Decentralized optimization for energy efficiency under stochasticity», *Doctoral thesis*, Université de Paris Est, 2018.
[Rizk2018]	"Decision Making in Multiagent Systems: A Survey", Y. Rizk, M. Awad, E. Tunstel, *IEEE Trans. on Cognitive and Developmental Systems*, vol. 10, no. 3, pp. 514-529, Sept. 2018.