# Open Ph.D. position

**Title** : Safe and Optimized Design of Distributed Systems Integrating Renewable Energies

**Context and motivation.**

Over the last decade, information technology (IT) infrastructures, e.g. data centers, have been confronted with a crucial energy issue. This is due to the explosion in computing demands of large-scale applications and services in the cloud. The share of the data centers by 2025 is estimated at more than 5% of global electricity consumption [6]. As for their carbon footprint, it would exceed 2% of global $CO_2$ emissions. To address this situation, innovative approaches are being considered [1]. Major actors in the digital sector, such as Google, Amazon and Facebook, are making massive use of renewable energies in their data center infrastructures [2]. This trend is expected to grow in the next decade. It will not only help reduce the energy costs of data centers, but also reduce their $CO_2$ emissions. However, to fully achieve this goal, a major challenge is to design data centers that are robust to the intermittent nature of renewable energies.

The so-called energy packet network (EPN) paradigm [3] enables to formulate and optimize the dynamic behavior of energy consumption in IT infrastructures. A hardware realization of this paradigm has been recently proposed [4]. The developed prototype system consists of independent modules combining computing functions (computing and storage servers, communication) and energy management (renewable photovoltaic energy harvesting, energy storage in batteries and energy transfer electronics allowing to allocate and route energy between modules). In order to scale up this system and study its potential overall energy gains, a central issue is the dimensioning of its resources according to fluctuating energy harvesting conditions and the considered quality of service (QoS) requirements, e.g., availability of the system, acceptable response times. Unfortunately, there is no existing tool to address this issue.

**Goal of the project.**

This project aims to develop a reasoning framework based on formal methods, via mathematical concepts, in order to safely study the favorable conditions for deploying an EPN under QoS constraints [5]. The expected results include :

- a modeling of large-scale EPNs, including workload processing, energy collection and storage, data and energy transfer;
- a modeling of the EPN environment, taking into account the intermittent nature of renewable energy sources;
- a formal analysis of the operational conditions with respect to the QoS requirements, including scenarios of executions using only renewable energy. These scenarios are typically relevant for deployments in isolated areas without access to the electricity grid.

In this project, the successful applicant is expected to have a good background in formal modeling and verification. He or she will first explore the most suitable modeling and verification approach to address the problem. The selected approach will be then applied to EPN design and assessment.

**Keywords.**
Distributed systems, energy-efficiency, design and modeling, resource allocation, predictable system, formal verification, model-checking, SAT/SMT solving, energy-driven computing.

**Deadline for online application : May 9th, 2022 (see https://www.adum.fr/as/ed/voirproposition.pl?langue=fr&site=I2S&matricule_prop=40192)**

**Contact information.**
Applications (including a CV, academic records, motivation letter and appreciation letters if available) are to be sent to the following persons:


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The LIRMM laboratory is a cross-faculty research entity of the University of Montpellier (UM) and the National Center for Scientific Research (CNRS). Located in Montpellier (France), LIRMM is one of the largest multi-disciplinary research laboratories in Europe. Its Microelectronics department carries out cutting-edge research in the fields of design and testing integrated systems and micro-systems, with a focus on architectural aspects, modelling and methodology.

**References**.

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