DEMI: Digital twin technologies for the energy management of the connected infrastructures of E4C

Supervision team: Dr Daphne Tuncer (ENPC) and Dr Georgios Bouloukakis (TSP)

Context

Digital twins [1,2] constitute novel approaches to improve the operations and performance of connected infrastructure for energy-saving purposes. A digital twin is a virtual representation of a physical environment that mimics the characteristics of the system (*e.g.,* IoT infrastructure, smart grid, building management system technologies) and helps analyse and predict its behaviour under multiple, possible operating conditions. Recent literature has illustrated how digital twins can assist in realistically modelling specific infrastructures and services, such as for communication networks [3], smart buildings [4,5] or electric vehicle charging networks [6].

In previous work, we created a set of digital twins for the smart building and electric vehicle charging network demonstrators of the Energy4Climate (E4C) multidisciplinary center of research of Institut Polytechnique de Paris [7-9]. We demonstrated through simple use cases how the digital twins can be used to test new approaches for energy management on the infrastructures of the demonstrators, for instance to assess the impact of different electric vehicle charging session planning strategies [9]. The current implementation is however tailored to custom-made scenarios, primarily designed for testing purposes. The next step is to develop a systematic approach for the integration of energy management strategies into the digital twin platform that can be used by the researchers and the operational team of the demonstrator to test new ideas before deployment, and / or trouble-shoot existing solutions.

Objectives

The objective of the placement is to implement a working digital twin platform of the connected infrastructure of the E4C demonstrators (smart buildings and charging networks) together with its management system so as to offer a test environment for current research on energy optimisation at E4C.

More specifically, the project will involve three main tasks.

Task 1 – To conduct a survey of the current approaches developed by the researchers of E4C to manage energy on the infrastructures and demonstrators of the campus (*e.g.,* smart charging algorithms, flexibility management approaches, *etc.*), and to create a library of the specifications of each approach (in the form of intents and input / output data) to be made available to the E4C community.

Task 2 – To integrate the referenced approaches in the digital twin platform composed of the federation of twins of the DRAHI-X, SIRTA, Building 103, and the charging infrastructures developed as part of 2024 and 2025 E4C-supported internship projects [8,9], co-supervised by Dr Bouloukakis and Dr Tuncer.

Task 3 – To develop a high-level interface that will enable to easily add, configure, remove energy management scenarios onto / from the digital twin platform of the demonstrators of E4C, and to

develop a training program targetted to the contributors of E4C on how to use the platform to test new energy management methods.

The student undertaking the project will be responsible to run consultations with the different researchers of E4C and to interact with technical team of E4C throughout the course of the project.

About the placement

- 6 months – starting March or April 2026
- Located at Ecole des nationale des ponts et chaussees, Institut Polytechnique de Paris, France
- Joint supervision between Ecole nationale des ponts et chaussees et Telecom SudParis
- Part of the Energy4Climate (https://www.e4c.ip-paris.fr/#/fr/) multidisciplinary research center of Institut Polytechnique de Paris
- Open to final year engineering school / master (MEng / MSc) student

Skills and competence

- Fluent in English
- Good knowledge of programming (preferably Python and Java) and data structures.
- Good knowledge of standard data format (JSON, CSV, XML)
- Good knowledge of the REST architectural style and RESTful APIs
- Knowledge of Semantic Web Standards (RDF, OWL) is an asset but is not required.
- Good interpersonal skills to interact with different contributors

Contact

To apply, contact
- Daphne Tuncer, Ecole des nationale des ponts et chaussees, daphne.tuncer AT enpc.fr
- Georgios Bouloukakis, Telecom SudParis, georgios.bouloukakis AT telecom-sudparis.eu

by providing the following documents:
1. CV
2. Motivation letter
3. Transcripts of the last 3 years
4. A course report or article written in English (if any)

Incomplete applications and / or applications sent to only one of the supervisors will be automatically rejected.

Relevant references

[1] Adil Rasheed, Omer San, and Trond Kvamsdal. Digital twin: Values, challenges and enablers from a modeling perspective. Ieee Access, 8:21980{22012, 2020.

[2] David Jones, Chris Snider, Aydin Nassehi, Jason Yon, and Ben Hicks. Characterising the digital twin: A systematic literature review. CIRP journal of manufacturing science and technology, 29:36-52, 2020.

[3] L. Hui, M. Wang, L. Zhang, L. Lu, Y. Cui, Digital twin for networking: A data-driven performance modeling perspective, IEEE Network. 2022 Jul 25;37(3):202-9.

[4] R. Yus, G. Bouloukakis, S. Mehrotra, and N. Venkatasubramanian, Abstracting interactions with iot devices towards a semantic vision of smart spaces, In Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation, pages 91-100, 2019.

[5] A. Chio, D. Jiang, P. Gupta, G. Bouloukakis, R. Yus, S. Mehrotra, and N. Venkatasubramanian. SmartSPEC: Customizable Smart Space Datasets via Event-driven Simulations. In The 20th International Conference on Pervasive Computing and Communications (PerCom), 2022.

[6] W. A. Ali, M. P. Fanti, M. Roccotelli, L. Ranieri, L. (2023). A review of digital twin technology for electric and autonomous vehicles. *Applied Sciences*, *13*(10), 5871.

[7] N. Papadakis, N. Khoder, D. Tuncer, K. Magoutis, G. Bouloukakis, "Adaptive and Interoperable Federated Data Spaces: An Implementation Experience," in the proceedings of the 20th International Conference on Software Engineering for Adaptive and Self-Managing Systems (SEAMS), Artifact Track, April 2025.

[8] N. Khoder, A Federation of Digital Twins for Sustainability in the E4C Ecosystem, MSc dissertation, 2024.

[9] C. Zhao, DigiEV: Design and integration of a digital twin for electric vehicle charging infrastructure in the E4C ecosystem, MSc dissertation, 2025.