

DEMI: Agent models for the digital twins 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 [7-10] and demonstrated how they 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 [9,10].

In this project, we aim to extend the current capability of the digital twins by implementing agent models that can facilitate 1) access to data by enabling information retrieval through natural language; and 2) the control of the sub-systems of the different buildings for energy management tasks by automating the execution of new configurations (*e.g.*, change the scheduling of vehicle charging, reduce the consumption between a given time interval, *etc.*).

The goal is to make the digital twins an operational platform that can be used by the researchers and the technical team of the demonstrator to test new ideas before deployment, and / or troubleshoot existing solutions.

Objectives

The objective of the placement is to augment the functionality of the digital twin platform of the connected infrastructure of the E4C smart buildings demonstrators with agentic AI-capabilities. The deployment of agents can facilitate the retrieval of information regarding the current status of the systems in the smart buildings (for electricity production, consumption and flexibility), as well as the control and configuration of these systems. The project contributes to developing a test environment for current research on energy optimisation at E4C.

More specifically, the project will involve three main tasks.

Task 1 – To extend the current digital twin implementation of the X-novation and Building 103 smart buildings, and their charging infrastructures, developed as part previously E4C-supported internship projects [8-10] and co-supervised by Dr Bouloukakis and Dr Tuncer, with agentic capabilities for information retrieval and system control.

Task 2 – To develop a software-tool to emulate different types of user interactions with the digital twins, including technical team, researchers and general users. To do so, the student will build on

previous work [11] and will also 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.*).

Task 3 – To create a demo of the implementation and to organise training sessions with the technical team of E4C to showcase how the digital twins can be used on concrete scenarios taken from current research carried out on the systems of the X-novation and Building 103 smart buildings.

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 2027
- Located at Ecole 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 LLM and generative AI agents.
- 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 presenting relevant, previous experience
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.

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- [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, "A review of digital twin technology for electric and autonomous vehicles," *Applied Sciences*, 13(10), 5871, 2023
- [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.
- [10] M. Djerboua, "DEMI: Digital twin technologies for the energy management of the connected infrastructures of E4C," MSc dissertation, 2026.
- [11] M. Vlachou-Economou, "From Dashboards to Dialogue: Generative AI as a People-Facing Interface to Residential Energy Digital Twins," MSc dissertation, 2026.