A new framework for integrated distributed data management, processing, and advanced analytics supporting Digital Twin systems: a Proof of Concept

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The AVANT Project

The goal is to facilitate the transition towards distributed and cognitive Clouds, capable of adapting to the ever-changing needs of users. AVANT also aims to improve coordination in the fragmented European market, reducing the time to implement advanced resources for data analysis and the development of DTs. and efficiency.

AVANT (dAta and infrastructural serVices for the digitAl coNTinuum) is the project started in 2024 by ENGINEERING within the **Important Project of Common European Interest on Next Generation Cloud Infrastructure and Services** (IPCEI-CIS) , which saw a total of 19 implemented projects with an overall budget of 3.5 billion euro.

The main objectives are:

1. Digital Twin as a Service: making DTs scalable and accessible in various sectors;
2. Cognitive Cloud: creating flexible ICT infrastructures, improving sustainability.

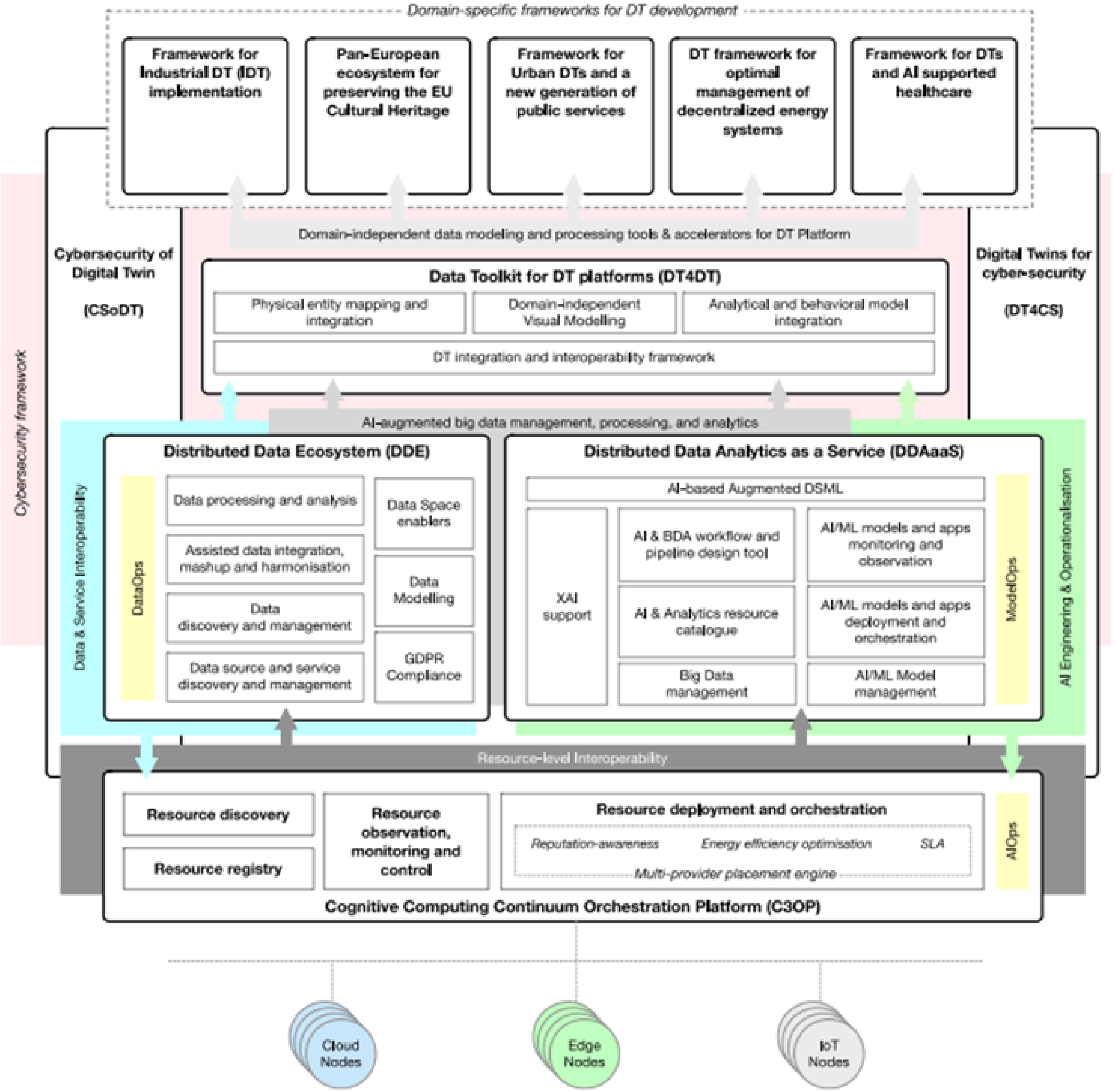
The AVANT Project

AVANT will deliver **six domain-specific specialized frameworks and platforms** aiming at designing, developing, deploying, and operationalizing cloud-edge applications and services based on and exploiting the potential of DTs at several different levels of complexity and granularity, involving multiple and heterogeneous types of entities, both physical and logical.

The following picture shows the **logical architecture** of the whole AVANT outcome.

The following main integrable and interoperable, yet independent infrastructural, domain-independent frameworks and platforms will be delivered:

- Cognitive Computing Continuum Orchestration Platform (C3OP).
- Distributed Data Ecosystem (DDE).
- Distributed Data Analytics as a Service (DDAaaS).
- Data Toolkit for DT platforms (DT4DT).
- Cybersecurity of Digital Twin (CSoDT).
- Digital Twins for cyber-security (DT4CS).



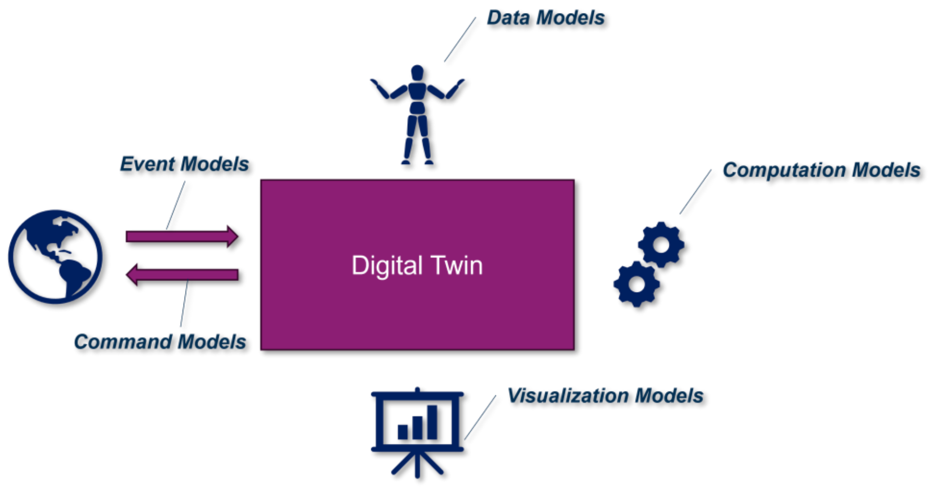
The AVANT framework: Proof-of-Concept on smart-buildings Digital Twins systems

Use case: **development of a Digital Twin for a building**.

PoC: **Digital Twin of two rooms, each equipped with IoT sensors** (temperature, humidity, people counting, etc.) **and actuators** (air conditioning, sprinkler system, smart blinds).

Goal: **to monitor indoor environmental conditions** through a dashboard, using real-time data streams from the physical world; and **to predict the future conditions providing interpretable explanations** for the forecast and **to suggest optimal actions** on the actuators, in order to maintain a comfortable and controlled environment.

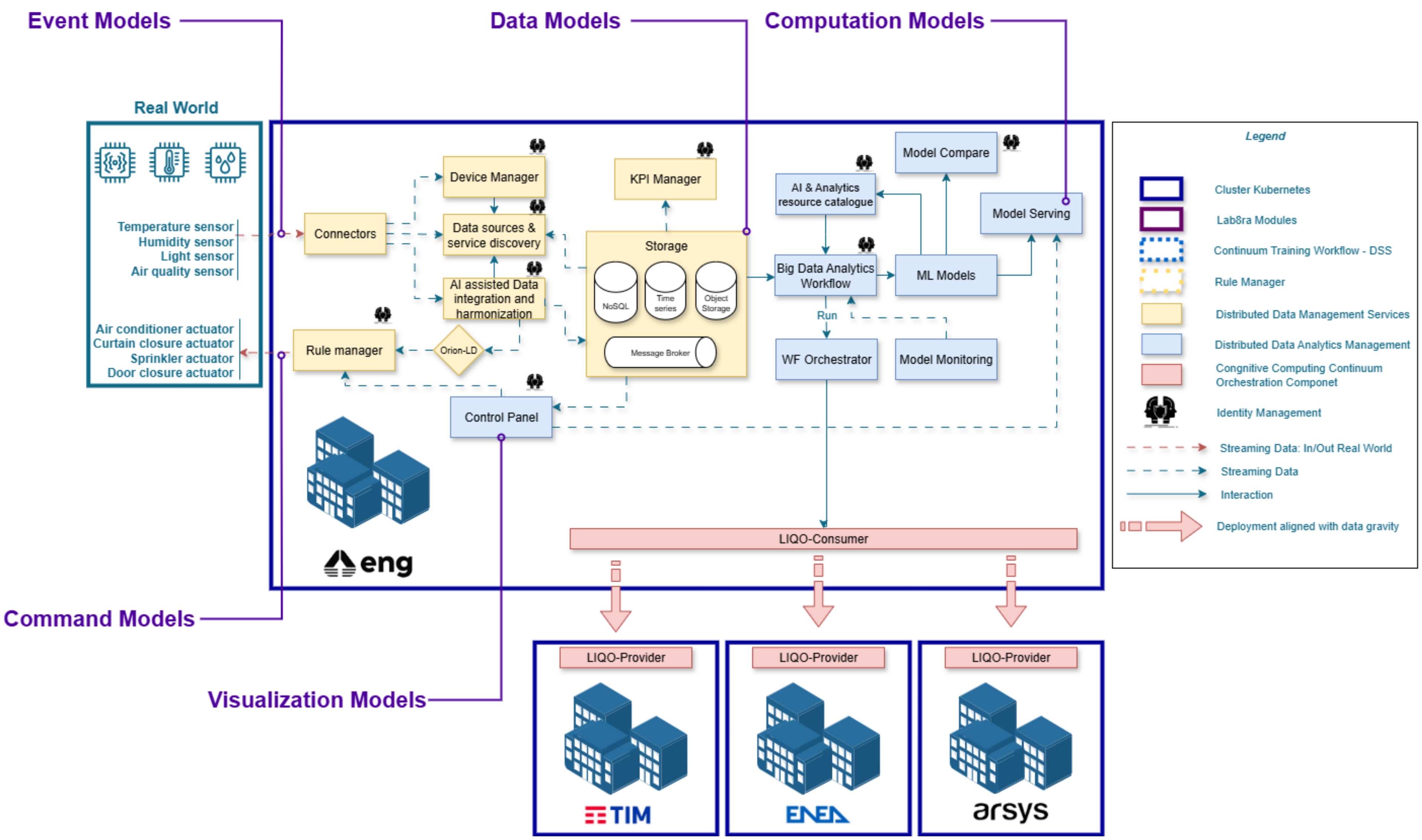
Predictive models were trained, also leveraging services **based on eXplainable Artificial Intelligence** (XAI). Moreover, **collaboration with Tim, ENEA and Arsys companies enabled the federation of new clusters**, which were then used during the model training phase.



Several **models** were used in order to define a Digital Twin in the AVANT project:

1. Event Models: describe how to collect data from the real world;
2. Data Models: represent the physical structure of the Digital Twin;
3. Computation Models: define the behavior of the Digital Twin;
4. Visualization Models: allow the visualization of the obtained results;
5. Command Models: enable actions to be taken in the real world.

The Proof of Concept



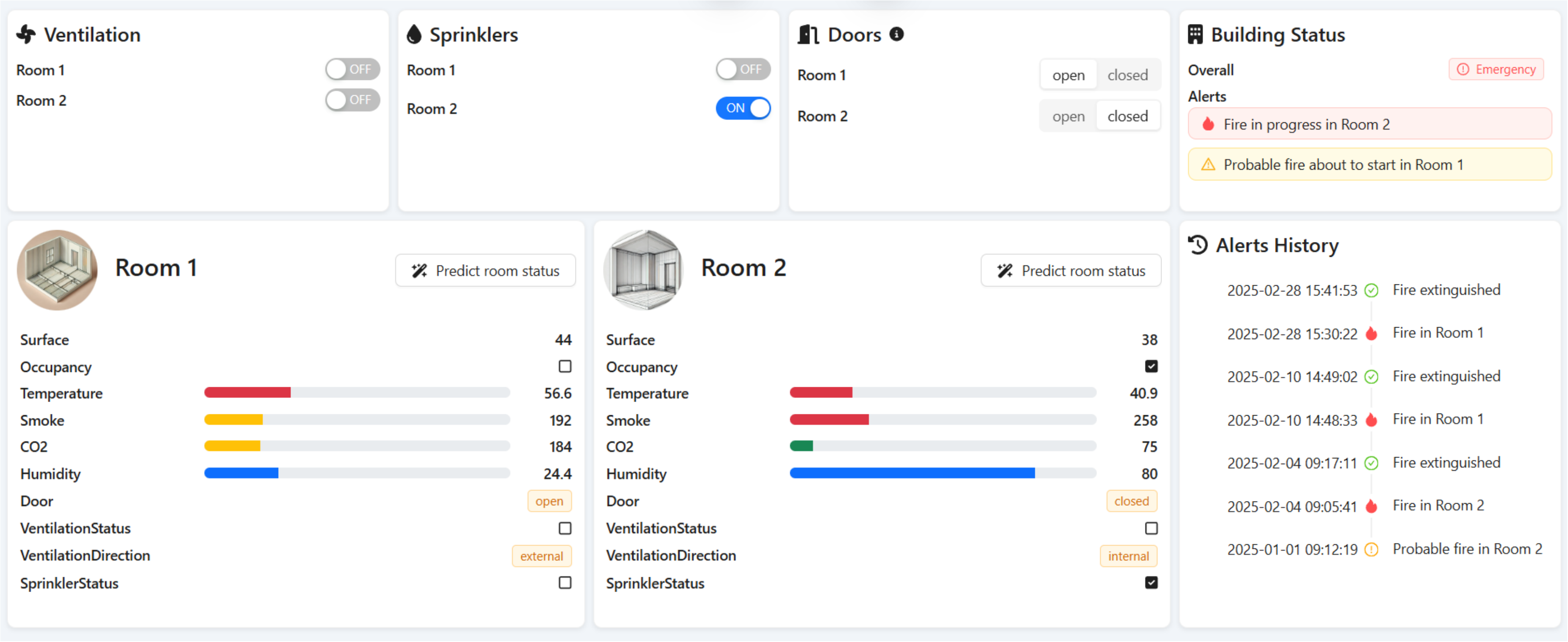
Decision Support System

Users can **manually control** ventilation, sprinklers, and doors for each room.

For example, the sprinkler in Room 2 is currently active, and the doors are open in Room 1 and closed in Room 2. The "Building Status" section summarizes the overall situation. An **emergency alert** is currently active, with a fire in progress in Room 2 and a potential fire predicted in Room 1. Each room section displays information such as surface area, occupancy level, temperature, smoke, CO2, and humidity.

These values are presented both numerically and through colored bars for quick interpretation. **Additional indicators** show the state of the door, ventilation, and sprinkler systems. A button allows the user to trigger a prediction of the room's future condition, likely based on machine learning models.

Overall, the DSS allows users to monitor current conditions, predict upcoming risks, receive explanations for predictions, and take immediate action through actuators. It supports both proactive and reactive decision-making for improved safety and energy efficiency.



Thanks!

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