

Semantic Digital Twins for the Built Environment - a Key Facilitator for the European Green Deal? (Keynote)

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Keywords: Digital Twins · Open Standards · Ontologies · Buildings · Infrastructure

1 Abstract

1.1 Environmental Impact and Challenges in the Built Environment

Reducing the amount of resources that are used in the creation, maintenance and use of the Built Environment from buildings to infrastructure is a key factor in achieving the climate goals. A vast amount of primary resources is spent during the construction of buildings, which uses 50% of raw materials taken from earth. The energy needed to heat, cool, illuminate, connect the fabric of the built environment contributes 36% to global energy use and 39% of energy-related CO₂ emissions.

At the same time, the building industry is one of the most fragmented, decentralized and diverse industries with nearly 3 million workers organized in 800.000 predominantly small enterprises. The vast spectrum of trades and sub-domains along with the diversity of its products ranging from residential buildings to tunnels and bridges leads to a wide spectrum of information exchanged in temporary processes with fragile value chains. At the same time, the building sector as a whole is trailing in many productivity indices and in its state of digitalization.

The potential to save energy and to contribute to the reduction of the carbon footprint from the sector can be approached from a number of different angles: Improved design and planning for the few new and the many existing buildings; re-use and circular economy for the materials involved and synergetic effects through increased vertical and horizontal integration of processes, and subsystems. All this requires the integration of knowledge domains.

1.2 Semantic DTs in the Built Environment

The individual cyberphysical sub-systems that comprise the built environment from individual buildings to vast and highly connected infrastructure networks including traffic, energy, water and waste networks, are designed, operated and maintained in completely separated, heterogeneous information silos with a very

low rate of digitalization. Representing, monitoring, simulating and optimizing even of single nodes in these interconnected, multi-layered networks using digital twins has only just begun. Within a single domain of these networks such as an individual building, a road-network or bridge, the current and past system states, their long-term monitoring and improvement requires comprehensive semantic models digital twin models. Such models are still in their infancy. Current and evolving information models are still mostly designed to capture static as-planned individual lifecycle stages, have bespoke and disparate insular solutions and little to no vertical and horizontal connectivity with other nodes in the network. Information exchange models for different aspects at various levels of granularity from geospatial superstructures (GIS) to building components (BIM) often have hundreds or even thousands of semantic entities and the sheer size of the structured vocabularies to describe products range in the tens of thousands of concepts which often differ on national or even regional levels.

1.3 Use cases and examples

In the presentation an overview of ongoing research, development and standardization efforts regarding the creation, integration and interoperability of semantic Digital Twins for the built environment is provided. Concrete challenges and solution approaches of past and ongoing research from different use cases and application domains of Semantic Digital Twins for

- the assessment and **energy refurbishing of residential buildings**
- monitoring and **predictive maintenance of bridges**
- **road network interoperability** with Linked Data across European borders

are used to illustrate these challenges. These include the semantic lifting of legacy data models, the alignment and integration of vast domain vocabularies, multi-modal integration of heterogeneous status information (sensor, images, measurements) and ongoing efforts to create reference frameworks for semantically rich Digital Twins in the built environment.