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Ontologies in the Construction and Real Estate Sectors

Part I: What exactly are Ontologies?

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In this article series, we will discuss ontologies with a focus on the construction and real estate sectors. This by posing questions to some of the industry's leading ontology experts: Erik Wallin from ProptechOS, Joakim Eriksson at RISE, Karim Hussain at Schneider Electric, Rikard Strid at KTC, and Farhad Basiri at Iquest.

Ontologies – what exactly are they?

"Ontologies" is a term frequently discussed in relation to smart buildings and digitalisation, but what does it actually mean? What advantages do ontologies bring, and how can they contribute to smarter and more sustainable buildings?

An ontology is a structured framework that organizes and represents knowledge within a specific domain. By defining and organising data, as well as showing the relationships between various concepts, ontologies create a common language that allows different systems and stakeholders to understand each other and exchange information efficiently. In the real estate sector, this is especially important since buildings today feature complex technical systems for energy optimisation, ventilation, heating, cooling, and security. These systems need to communicate seamlessly to create smart and sustainable solutions. Moreover, information must be interpretable by various stakeholders throughout a building's lifecycle to enable circular material flows, ESG reporting, asset management, energy exchange**,** and much more.

An ontology contains a digital representation of knowledge for a specific purpose, but how does it differ from a document or a wiki? Ontologies – at least those discussed in this article series – are primarily designed to facilitate information exchange within and between IT systems. There are several formats for developing ontologies, and the most widely used are part of the semantic web's conceptual model. Therefore, let us take a brief detour to explain the "semantic" or meaningful web. Tim Berners-Lee, the inventor of the World Wide Web, coined the concept in 1999. Tim envisioned a world where computers could understand and analyse all web data and communicate with humans and other computers to make people's lives easier. Since the early 2000s, the W3C (World Wide Web Consortium) has taken on the task of standardising and promoting the building blocks of the semantic web. Two of the most important building blocks are RDF (Resource Description Framework) and OWL (Web Ontology Language). RDF simplifies how information on the semantic web can be constructed and linked across the internet using three-word sentences (triplets). OWL provides a grammar that enables the construction and linking of knowledge models based on RDF (where a knowledge model is a structured representation of information and concepts within a specific area, built around how the knowledge is used and applied).

The ability to link data between disparate systems and data sources is a fundamental premise of the semantic web because the aggregated web content within a particular domain can never be assumed to exist within a single data source. Today, millions of

websites publish data in accordance with the semantic web standards. The extensive information and knowledge described and made available according to these standards, such as in the form of knowledge graphs, can also be used to facilitate the implementation of the language models and AI services that many use today.

What is the difference between ontologies, tagging, and taxonomies?

Ontologies, tagging, and taxonomies are all tools for structuring and organising information, but they serve different purposes.

A *taxonomy* is a hierarchical classification of information into categories and subcategories (think of Carl Linnaeus' system for classifying plants). It helps create order but often lacks the ability to show relationships between various concepts.

Tagging involves labelling data with keywords or tags to make it more searchable and understandable but does not show how different pieces of information are connected.

An *ontology* takes it one step further by not only defining concepts, but also describing the relationships between them. This allows machines to understand not just what a concept means but also how it relates to other concepts and data, even across different knowledge models. In the real estate sector, this means ontologies can provide a deeper understanding of how various systems in a building – such as ventilation, heating, lighting, and energy optimisation – are interconnected and function together. Ontologies can also be combined to link data across different domains, for example, between the smart building and the smart city, or between the smart building and processes for sustainability reporting, lease management, and so on.

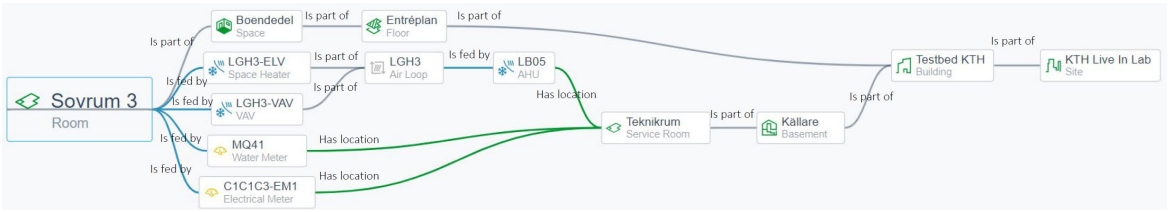

Figure 1 – Tagging and graphic representation of bedroom 3 in KTH Live-In Lab. In this case the languages used are RealEstateCore (REC) and Brick Schema.

When did the real estate sector start using ontologies?

The need for ontologies in the real estate sector grew alongside digitalisation and the increasing introduction of technical systems in buildings. As properties began incorporating diverse smart technologies—ranging from energy-efficient systems to automated operations—the need for a unified framework to describe and structure data across different systems became increasingly apparent. Ontologies provided a solution by enabling different systems to communicate with each other in the same "language." This need reflects advancements in industries like IT and manufacturing, where

ontologies have been widely adopted to standardize information exchange and enhance system integration.

For decades, there have been many open digital frameworks for systematising and exchanging property-related information, but these were not structured according to semantic web formats. In Sweden, for instance, Fi2XML has existed, and within the “smart building” domain, the BACnet communication protocol could arguably be viewed as an ontology. Standards in areas such as BIM (Building Information Modelling) can also be viewed as knowledge models and thereby ontologies.

The most important standards for the semantic web were developed in the first decade after the turn of the millennium. The shift toward “the cloud” made it easier to create scalable systems and databases. As a result, the semantic web gained momentum in the early 2010s, although interest has since somewhat subsided. The development has been most intense in other information-heavy industries, such as biochemistry, medical technology, finance, and security. Many property-related initiatives based on RDF were launched in the second half of the 2010s, and the pace of development is currently high.

Why did the need for ontologies arise in the construction and real estate sectors, and are there parallels with other sectors?

With the growing automation and digitalization of processes in the construction and real estate sectors, vast amounts of data need to be managed. This data is often complex and challenging to define or handle within isolated information sources. There is a need to describe and manage systems and processes both within and between buildings, as well as at the intersection between properties and societies. Buildings are also evolving from static physical entities into dynamic units with both physical and digital assets. As a result, information related to service delivery, property transactions, and financing options has become crucial. This shift creates a need for technologies and standards that support the development of dynamic, resilient databases that can be expanded and evolve over time. This is partly why open technologies for information exchange and knowledge building, such as those developed for the semantic web, can be considered suitable alternatives within the real estate sector.

Another area where ontologies have become particularly relevant is in the development of digital twins (virtual representations of physical buildings or systems). A digital twin uses real-time data from a building’s systems to reflect and simulate its operations. Ontologies play a central role in digital twins by structuring data, enabling system interoperability, and providing an accurate and dynamic picture of the building. This is a powerful solution that enables better decision-making in everything from energy optimisation to maintenance and creates entirely new ways of monitoring and managing buildings.

Standardizing how data is organized and exchanged between systems enables seamless interconnectivity, optimizing building operations. This integration supports the creation of more sustainable buildings and cities, ultimately driving greater climate benefits.