Modelling Engineering Products

Individual Assignment I – Ontological Modelling

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Table of Context

1 Introduction

Modern office buildings are complex ecosystems of interconnected systems that work together to provide a comfortable and functional environment for occupants. Managing and optimizing these systems effectively requires a comprehensive understanding of their components, functions, and relationships. This is where the office building system ontology comes into play.

1.1 Purpose and Scope

The purpose of the ontology is to define and organize the components, functions, and relationships within an office building system.

This ontology focuses on the physical, functional, and logical aspects of an office building's systems, mainly focused on structural elements.

1.2 Intended Use and End-Users

The ontology is intended to provide an organized structure that assists in grasping how different systems within an office building are interconnected, dependent on one another, and interact together. This ontology can guide decision-making during design, construction, and management phases.

The intended end-users are architects, engineers, building designers, construction teams, and stakeholders involved in the design, construction, and operation of office buildings.

2 Office Building System's Taxonomy

Taxonomy of concepts for office buildings should be comprehensive and well-structured representation of the key concepts and their relationships within the domain. For this aspect, the ontology is separated categories.

2.1 Physical Components

First category includes the physical components of the office building. This topic defines the physical components of office building systems, such as structural elements. To define what are main the structural elements of building systems, Building Construction Illustrated by CHING is used. Also, from a sample project report which is Office Building Project by Dr. Muhannad Haj Hussein is considered for defining the components. With respect to sources the physical components of the office building represented as:

Physical Components

- Substructure
    - Basement
    - Foundation
- Superstructure
    - Beams
    - Columns
    - Walls
    - Floors

Each of these components plays a specific role in the overall operation of the building. For example, walls provide structural support and help to define the interior spaces. Floors provide a walking surface and distribute the weight of the building and its occupants.

2.2 Main Material and Office Use

Main material typically the material that provides the building with its structural support and integrity. The main material can also have a significant impact on the building's energy efficiency, sustainability, and overall appearance. For example, Dr. Muhannad Haj Hussein says in his report about steel frames that “Steel frame is considered more freedom to architectural design and enabled the construction of towers. Steel is a flexible, strong, and durable material and in steel frames the supports are slender."

The materials that can be main material for the construction are defined as:

Main Material

- Concrete
- Steel
- Wood
- Masonry
- Others

The taxonomy captures the functional aspects of office building systems, such as the intended use. For the use of office building systems, the potential users can be defined as:

Office Use

- Clients
- Employees
- Managers

3 Modelling the Ontology with Protégé

The class hierarchy was made with respect to the office building taxonomy that mentioned previous part. The classes and the subclasses of the hierarchy is created and shown in Figure 1.

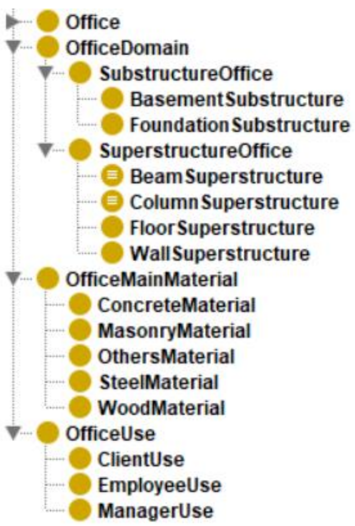

Figure 1: Class hierarchy.

While setting the hierarchy, disjoint was made for Office, *OfficeDomain*, *OfficeMainMaterial* and *OfficeUse.* By doing that an individual which was asserted to be a member of a specific class cannot be member of another class. For example, for class *OfficeDomain* performed disjoint operation is shown in Figure 2.

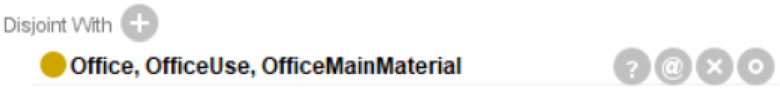

Figure 2: Description view of the OfficeDomain class after performing disjoint operation.

After completing the class hierarchy, the OWL properties were created. The object property hierarchy is presented in Figure 3.

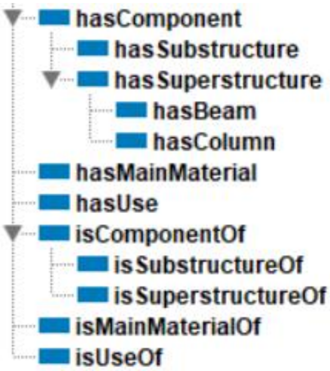

Figure 3: Object property hierarchy.

The range and the domain of the properties/sub-properties and inverse properties/sub-properties was specified. After the operations, the results is shown for hasSuperstructure in Figure 4.

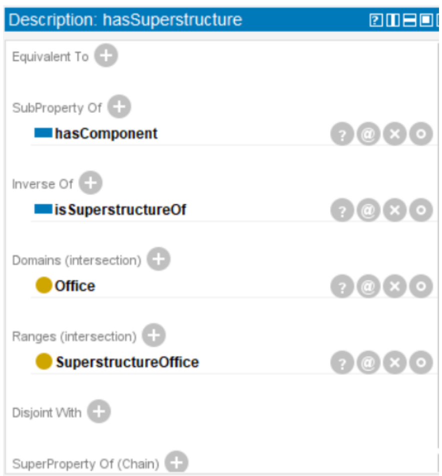

Figure 4: Description of hasSuperstructure.

As existential restriction, an office must have substructure, superstructure and a main material. For this the existential restrictions were defined for office class. The obtained result can be seen in Figure 5.

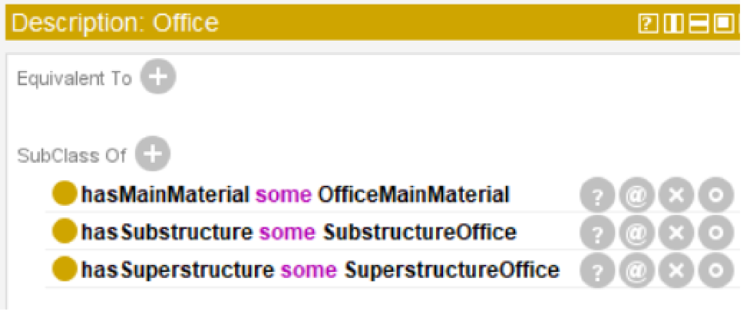

Figure 5: Description of office class.

For the office class the two different design options were generated (Figure 6). And for the design options existential restrictions added (Figure 7).

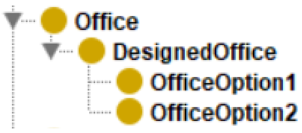

Figure 6: Design options.

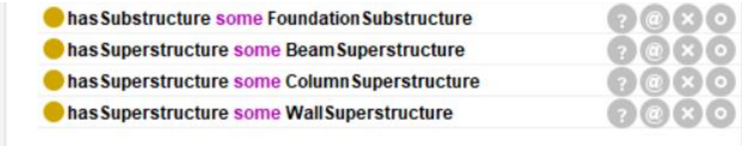

Figure 7: existential restrictions added for OfficeOption1and OfficeOption2

Creation of individuals and defining the data properties was made for both options. Two design options for the office were defined. OfficeOption1 and OfficeOption2 have the different values and the properties for the concrete based building. The engineer can use the provided values as a starting point for optimizing the beam size based on structural load requirements and desired architectural aesthetics.

Individuals and properties were defined for the subclasses which are BeamSuperstructure and ColumnSuperstructures. Two different beam and column option were generated with the different properties that shown in the Figure 8.

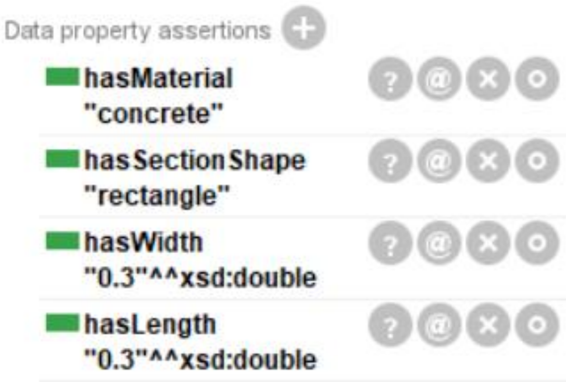

Figure 8: Data properties for BeamOption1

After completing the all the definitions with respect to the tutorial the visualized ontology was obtained in Figure 9.

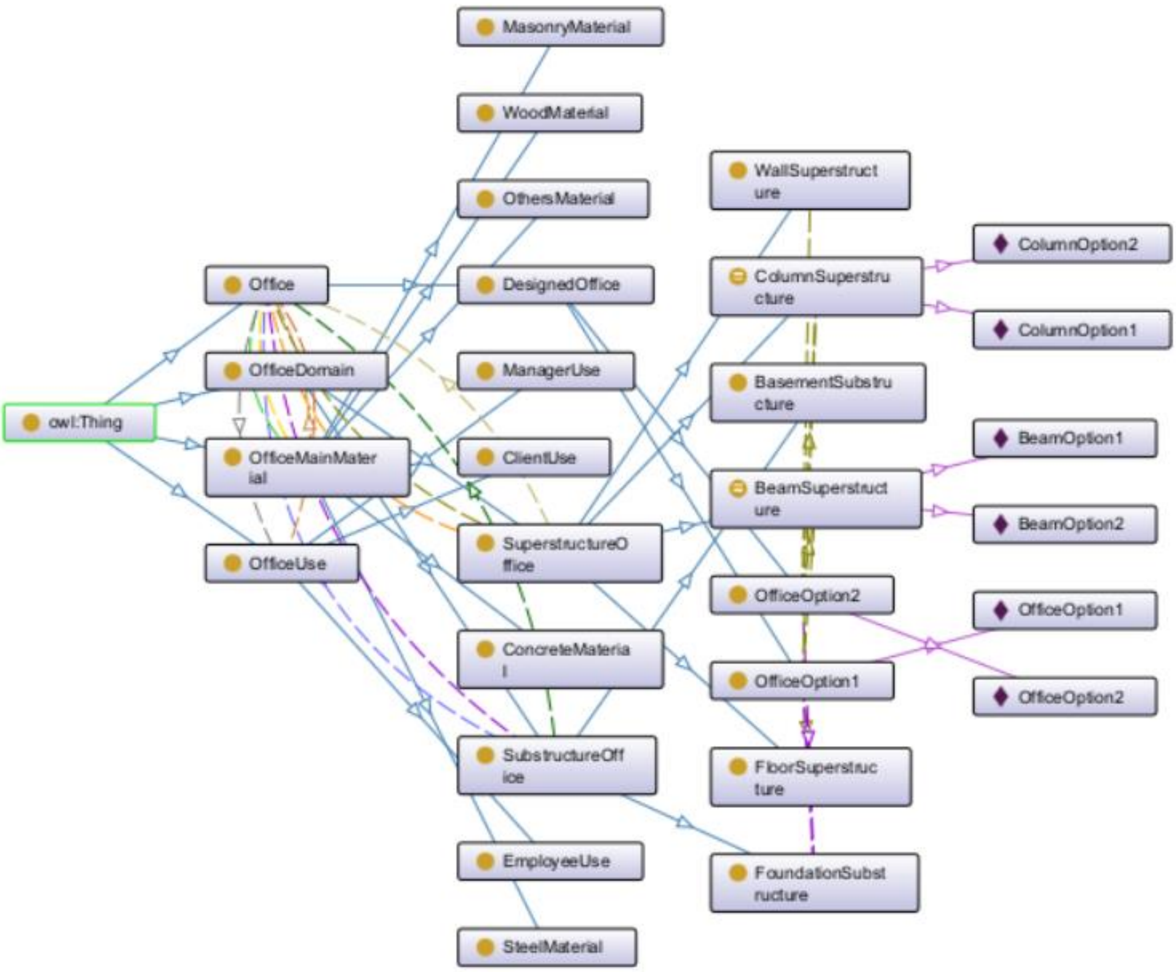

Figure 9: Visualizing the asserted hierarchy of the created ontology.

4 Engineering Examples

4.1 Structural Design Optimization

Scenario: During the renovation of an office building, the structural engineer needs to assess and improve the design to handle new loads and architectural changes.

Use Case: The ontology—basically a comprehensive representation of the building's structural parts, their characteristics, and how they're connected—comes in handy. The engineer can use this tool to check the current design, spot any potential weaknesses, and try out different design options. It's a way to pick the right materials, beam sizes, and column dimensions that can handle the updated load requirements.

4.2 Space Planning and Layout Optimization

Scenario: An office company is expanding its workforce and requires a new office space layout that maximizes space utilization, enhances collaboration, and promotes productivity.

Use Case: The ontology can be employed to model the office space, its occupants, and their activities. The designer can play around with different office layouts—like open spaces, individual rooms, or a mix—and see how they affect things like space use, how comfy people feel, and how workflows. Using the ontology, they can figure out which layout suits the increased number of people best.

4.3 Architectural Design Generation and Evaluation

Scenario: An architectural firm is designing a new office building for a client who seeks a modern, sustainable, and occupant-centric workspace.

Use Case: The ontology provides a comprehensive representation of architectural design concepts, building code requirements, and sustainability principles. The architect can utilize the ontology to generate and evaluate different design options. The architect can use it to come up with different design choices—like how rooms are set up, what the building looks like outside, what materials to use, and even ways to save energy. With this toolkit, they can find the perfect design that ticks all the boxes: it meets the client's wishes, makes the most of the space, keeps everyone comfy, and helps the environment too.

5 References

Ching, Frank. *Building Construction Illustrated*. Hoboken, New Jersey, Wiley, 2020.

Hussein, Dr. M. H. (n.d.). Office building project - an-najah national university. https://repository.najah.edu/server/api/core/bitstreams/52ea166c-b9b9-40f2-b34e-c3fbd4668ec3/content

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