Experience of ontological modeling as bases for use in BIM

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Abstract. The traditional technology for designing building documentation uses a staged approach: first, an architect expresses a conceptual idea, which is then specified by planners and a constructor embodied in the building documentation. The transition to BIM technologies creates a fundamentally new environment for design. The article discusses how an architect have to adapt to new working conditions in order to maintain his leading role as a conceptual developer. It is demonstrated that the solution to the problem can be the use of the ontological modelling language by the architect.

1. Introduction

In the traditional technology for designing building documentation, including using IT technology, the staged principle is used: first, an architect expresses a conceptual idea, which is then specified by planners and constructors embodied in the building documentation. The general process diagram is shown in Figure 1.

Figure 1. The process of designing building documentation in traditional technology
2. The problem
The transition to BIM-technologies radically changes this scheme due to the fact that BIM-designing takes place in a multi-user environment, when each member of the project team has equal access rights to the information model (final product). And this, in turn, makes it difficult for an architect to play the role of a conceptualist, or at least leads to competition for this role with other members of the project team. Here is the opinion of one of experts at BIM: «But it can be different when the project does not begin with an architectural concept, but comes from a design idea or technological necessity (for example, an industrial building). However, in any case, the model is complex in nature and works for everyone. The concrete sequence of participation of specialists in information modeling can be very different – it is dictated by the specific expediency and logic of creating the objects» [1, p. 194].

As a solution to the problem, the authors previously suggested that the architect have to master the new competency - the competence of a system analyst in order to become the initiator of the creation of the necessary information resources [2]. The purpose of this work is to practically verify whether an architect can create a primary information model of a design object.

3. Methods
To solve the problem of creating a primary information model, an architect must have completely different thinking skills than those that are taught to him in the process of traditional training. The traditional way of teaching instils an architect skills of figurative associative thinking, they even say that an architect «thinks with his eyes», meaning that an architect must translate any thought into a visual form, into a sketch. A system analyst creating an information model requires formalized abstract thinking skills. To verify this, it is enough to familiarize yourself with the specifications of the GOST 57296 standard, «An Integrated Approach to Information Management of the Life Cycle of Anthropogenic Objects and Environments. Description of data for mathematical modelling of life cycle processes. Key Points» [3].

In order for an architect to fulfil the task of a system description of a subject area, it is extremely important to choose a language for describing a subject area. As a language for describing the subject area, we used the language of the ontological modelling standard IDEF5 [4]. The modern interpretation of the term «ontology», not philosophical, applied, is formulated by T. Gruber: «The ontology is an exact specification of conceptualization». By «conceptualization» it is meant an «abstract, simplified view of the world that people use to achieve some goals» [5]. Actually, architects are also taught to create conceptual models, but only expressed in a different, visual, form. «In the system of scientific disciplines, ontology is understood as the organization of a certain subject area of knowledge, presented in the form of a conceptual scheme, which consists of a data structure containing a set of objects, their classes, relationships between them and rules adopted in this field» [6]. Thus, in his elemental ontology, the architect expresses objects and relationships between them in a visual form, in the context of information technology, he is required to translate descriptions of objects into an abstract verbal form.

The idea of using an ontological approach to transition to a BIM model is not new in itself. Typically, an ontology is used to extract data and complete BIM models [7], [8]. In this paper, the ontology is used to initiate the BIM model by the architect.

There is no place in this publication to describe in detail the ontological modeling language IDEF5. The ontological modeling language IDEF 5 contains two parts: a glossary containing the main entities (objects) of the domain and a graphic part that describes relationships between entities. It is the presence of graphic part in the language standard that makes the IDEF5 standard so convenient for architects.

4. Results
It was said above how specific skills of architectural thinking are brought up; therefore, the hypothesis that the architect can master the skills of a system analyst is advisable, it is also advisable to check it
during the educational process. For this, the ontology creation exercise was introduced into the master's course in landscape architecture. The task is offered in the second semester of the course on the methodology of scientific research in the magistracy. The task was formulated as follows: using the ontological modeling language IDEF5, create an ontological model of the subject area.

The appendix contains part of one of tasks performed by undergraduates. The appendix presents a graphical diagram illustrating the relationship between concepts of the subject area and examples of the ontological description of classes of some objects, as well as representatives of this class (object instances in ontological terminology). The presented ontological description is easily translated into the information model according to the regulatory requirements for BIM technologies [9], taking into account that class descriptions are metadata, and class instance descriptions are object descriptions. The description of the class as metadata follows from the definition of “component metadata: structured data representing characteristics of the described component for identification, retrieval, evaluation and management.” Class properties according to information models are attributes of the component.

Further clarification of types of objects and their presentation requires the use of corporate standards [10], [11]. Nevertheless, the figure 3 shows that the gradual refinement of the ontological description allows us to move on to specific components.

5. Conclusion
The volume of this article does not allow us to present all completed tasks, but using the given single example it was possible to show the following: a) modern information technologies can be introduced into the practice for training architects; b) modern information technologies make it possible to choose an adequate language for understanding of architects who are accustomed to the visual presentation of their ideas; namely, the ontological description can serve as the bridge that allows us to move from a general architectural concept to an information model.

Figure 2. Scheme for the preparation of building documentation with the participation of an architect with new competencies
All of this allows us to hope that using BIM technologies it is possible to change the work technology, the scheme of which is shown in Figure 2. Thus, the leading role of the architect as the ideologist of the architectural project is preserved.

6. Appendix A. The example of the ontological description of a domain

The example of an ontological description of a domain according to IDEF5 model is demonstrated below. Figure 3 shows the graphic part of the ontological description, which demonstrates the relationship between main objects.

**Figure 3.** The graphical part of the ontology that describes relationships between entities

The semantic part of the glossary

| Property | Value of property |
|----------|-------------------|
| Object «City» | |
| Unique name | |
| Definition | type of settlement, classified under current conditions as a city by the legislation of the state in accordance with the criteria for number and predominantly non-agricultural nature of employment |
| Link: | A N Gushchin Theory of sustainable development of the city [12] |
Classification: small, large, largest
Number of inhabitants measured in humans
Geometric Type: Areal
Location: Measured in degrees

**Instance of the City Object**

Unique name: Orenburg
Classification: Largest
Number of inhabitants: 570,329 people officially registered in 2018
Location:
Latitude, Longitude: 51° 46′ N, 55° 06′ East

**Object «Natural ecological frame»**

Unique name
Definition: urban forests, forest parks, forest protection zones, ponds, agricultural land and other lands that, together with parks, gardens, squares and boulevards located in residential areas, form an open space system
Geometric Type: Areal
Total area: hectare
The proportion of green areas: %

**Instance of the Object «Natural ecological frame»**

Unique name: Natural ecological frame of Orenburg
Total area: 159,59 hectare
The proportion of green areas: 0,43%
Acknowledgments
The authors thank the undergraduate Natalya Leusheva, who played an important role in the preparation of this article.

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