Chapter 18
Query Support for BIMs using Semantic and Spatial Conditions

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ABSTRACT

A query language for Building Information Models allows users and third-party application programmers to not only analyze the digital building under specific criteria but also to extract partial models from a full building model. This functionality is of crucial importance, since the full BIM is meant to comprise the information of all domains involved in the planning process, but an individual user or programmer is normally interested in only a small subset of it. To specify this subset, a formal language is required which makes it possible to formulate conditions the resulting data set has to fulfill. This concept is also known as providing a certain view of the data available. This chapter gives an overview of the currently available query technologies for BIMs and compares the different options in terms to expressive power and ease of use. The emphasis of the chapter, however, lies in the introduction of spatial query technology for BIMs that has been developed by the authors. Spatial operators extend the analysis and submodel specification capabilities of a query language substantially by providing an intermediate level of abstraction that is close to the human understanding of the geometric-toplological properties of building components and the relationships between them.

1 INTRODUCTION

The computer-based modelling of buildings has been an important topic of the construction informatics research community for more than 15 years now. An object-oriented Building Information Model (BIM) that not only captures the 3D geometry of the building elements but also their semantics and the relationships between them promises to enable a seamless integration of design software and downstream applications, and hence to serve as a solid basis for the highly collaborative work in AEC projects.

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Sophisticated digital building models can facilitate the collaboration between the various participants involved in the design and engineering process, including architects, structural engineers, HVAC engineers and interior designers, to only name a few. Though in modern AEC processes these participants work in parallel on the same building, they only use specific subsets of the entire building information model tailored to the needs of their particular domain and/or their specific task. To store these sub-models in separate files for further processing, they need to be extracted from the full building model.

As the resulting partial models represent a certain view of the shared BIM, they are of considerable value also for the aforementioned downstream applications, such as the various visualization, analysis and simulation tools that form an integral part of modern construction engineering. In most cases, these tools require only a subset of the full building model data to perform their specific task.

A well-established technology for retrieving parts of digital models is the use of a declarative query language, which is most familiar from the context of database management systems. In general, a declarative query language enables the user to define conditions that need to be satisfied by the required model subset, while simultaneously hiding the complex task of an efficient query processing.

Besides creating partial model, however, a query language for BIMs also enables the *analysis* of building models with respect to its components, their properties and the relationships between them. A sophisticated query language can accordingly be used to define rules or conditions that need to be fulfilled by the building model. In contrast to employing a programming language for this purpose, these rules are defined independently of the processing algorithms and thus provide an excellent basis for the future encoding of national and international building regulations.

This chapter gives an introduction to the query techniques currently available for Building Information Models and compares them with respect to their expressive power and ease of use. It meanwhile focuses on two different types of conditions: *Semantic conditions* that rely on the values of the attributes and relationships predefined in the building information model, and *spatial conditions* that concern the topological and geometrical properties of the building model and its entities.

Since spatial operators are not yet available in current commercial implementations of BIM query languages, this chapter gives a detailed account of the development of a spatial query language for BIMs including the formal definitions of the spatial operators and their technical implementation.

2 BUILDING INFORMATION MODELS AND PRODUCT MODEL SERVERS

2.1 Building Information Models and STEP

A Building Information Model (BIM) is a digital representation of a building that is either at the planning stage or has already been built. It describes the structure of this building by means of an object-oriented model, capturing the 3D geometry of the building elements, their semantics and the relationships between them.

In order to achieve interoperability between different software applications used in the design and construction process, it is necessary to use a standardized data model (schema) representing a blueprint for the digital models of actual buildings. The most mature data model standards in the AEC domain are the Industry Foundation Classes (IFC) (International Organization for Standardization, 2005) and the CIS/2-Standard (Eastman, Wang, You, & Yang, 2005).