Application of graph databases and graph theory concepts for advanced analysing of BIM models based on IFC standard

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Abstract. In this paper we present a workflow for automatic transformation of IFC schema and IFC models into an IFC Meta and object graph databases. The aim of this research is to study and demonstrate the potential of using graph theory concepts and graph databases in order to manage, visualize and analyse the huge information and complex relationships of BIM models based on IFC standard. For the validation a set data retrieval queries and advanced model analysis for model topology analysis and comparison of different IFC models are carried out in order to demonstrate the flexibility and advantages of the suggested approach.

1. Introduction

The very fast development in the sector of information technology has been successfully exploited in construction and engineering field to adopt new digital methods such as Building Information Modelling (BIM) for construction project managing. However, BIM models may contain a huge amount on information with complex relationships between the model entities. This information could remain inaccessible in several cases due to the use of closed property formats or the absent of suitable data management tools in case of using open standard formats like Industry Foundation Classes (IFC).

A lot of data retrieval queries are hard to be accomplished using currently available software's and most of them operate on single IFC models. The rigid and complex hierarchical structure of the IFC schema prevents simple manual extraction of building information and requires deep understanding of the IFC object model itself. The BIM query languages introduced so far have certain limitations, particularly with respect to the high level of knowledge about the IFC object model and about data mapping mechanisms required by the user (Tauscher, Bargstädt, & Smarsly, 2016).

Evidently, graphs have shown great capabilities in understanding and accessing complex and rich datasets in many different domains. Graph models are extremely useful for representation and description of the complex relationships among building elements and data within BIMs (Isaac, Sadeghpour, & Navon, 2013), hence converting of BIM models based on the IFC standard into an effective information retrievable model based on graph databases could significantly facilitate the efforts of exploring and analysing BIM highly connected data.

A graph-based schema, termed the graph data model (GDM) was presented by (Khalili & Chua, 2015). This schema can be used to employ semantic information, to extract, analyse, and present the topological relationships among 3D objects in 3D space, and to perform topological queries faster. Another generic approach towards information retrieval using the IFC object model based on graph theory was presented recently by (Tauscher, Bargstädt, & Smarsly, 2016). In this approach a directed graph was generated that serve as semantic data pools facilitating generic queries. This approach is limited to apply queries on single IFC models.