PARAMETRIC BIM OBJECTS EXCHANGE AND SHARING BETWEEN HETEROGENEOUS BIM SYSTEMS

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ABSTRACT

Over the past two years, the construction industry has increasingly recognized the benefits and capabilities of building information modeling (BIM) for information integration, visualization and parametric design, reducing the duplication of work and complexity of interface integration, while significantly saving both time and cost. However, due to the variety of participants in engineering projects, the differences between data definition, data format, and data storage increase the difficulty of integrating data from diverse sources. Therefore, buildingSMART has developed a common data schema, called Industry Foundation Classes (IFC), that makes it possible to hold and exchange relevant data between different software applications, to increase the efficiency of BIM work and to ensure a consistent and high-quality output. This paper presents a novel methodology that assists in facilitating the import and export process for parametric BIM objects between heterogeneous BIM systems. This methodology is based on the IFC data schema and includes graphical and non-graphical description data. The objective is to retain the geometry, parameters, unit, texture and links of an object during exchange and sharing to ensure that data integrity is maintained. To sum up, this research addresses the issues of transferring parametric BIM objects between heterogeneous systems to increase data integrity and reduce transfer and integration times.

KEYWORDS

Building Information Modeling (BIM), Industry Foundation Classes (IFC), Parametric, Heterogeneous Systems, Data Exchange and Sharing

INTRODUCTION

Over the last decade, the construction industry has invested considerable effort into integrating project information. Recently, the Industry Foundation Classes (IFC) data model, rather than traditional CAD data models like the DWG, DXF, and DGN formats, has become an international industry standard for CAD data exchange and sharing, even for Building Information Modeling (BIM) data exchange and sharing. The interoperability of the IFC data model has been studied in many research projects. Researchers such as Eastman *et al.* (2010) have said that the IFC standard building model schema is necessary for achieving full interoperability between building information modeling (BIM) tools. Zhang *et al.* (2011) proposed a semantic Web Services framework utilizing IFC-based industry ontology to address the interoperability problem. One such effort was the definition of IFC to facilitate data sharing heterogeneous systems through a shared project model (Kim, 2012).

Nevertheless, several papers have reported problems in data exchange using IFC. Lee *et al.* (2011) discovered that, when importing and exporting BIM software, the IFC model of the object file suffered incomplete data or data loss, as well as material queries raised by the coordinates of dislocation, which require modifications to the model. Some of the issues identified and discussed include the classification of objects, instances, geometry, relationships, and rules, which are supported in the IFC schema, and the complexities of exchanging such information accurately between applications (Venugopal, 2012). From the above-mentioned research, the shortcomings of IFC data loss between heterogeneous BIM systems, especially in the loss of non-graphical attributes, can be seen. Therefore, this research develops a parametric BIM object exchange mechanism based on the IFC schema that completely retains all attributes, including graphic and non-graphic data during export and import processes. In addition, this exchange mechanism takes the data structures of heterogeneous BIM systems, such as Autodesk Revit and Bentley AECOsim, into consideration to interoperate seamlessly.

PARAMETRIC BIM OBJECTS

This research shall concentrate on Autodesk Revit parametric objects and Bentley AECOsim parametric objects because they are currently the most popular BIM systems.

Autodesk Revit Parametric Objects:

Families are the heart of the internal data structure of Autodesk Revit. Every parametric object is part of a family. Families come in three types: (1) System Families, (2) Component Families, and (3) In-Place Families. Only component families can be created and customized, and they can be stored in an external library for exchange and sharing. A Revit component family is a unique file type, with an extension of ".RFA".

Bentley AECOsim Parametric Objects:

For Bentley AECOsim, dataset information is organized into two main areas. The first is the Family and Part System; this defines a building object's graphical representation in both the 3D model and 2D drawing views. Second is the DataGroup System; this drives not only the sizes of parametric building objects, but also drives any other non-graphical building data. Both these systems store dataset information in the .XML file format. Other graphical information is also stored in the dataset, such as in DGN files and the cell library.

It may be useful to look more closely at the parameters of a parametric object in detail. Table 1 displays the common parameters of the heterogeneous BIM systems. It is clear that it is difficult to exchange data between different data structures of different heterogeneous BIM systems. Based on an analysis of parametric BIM objects, this research filters and defines the

necessary data for parametric BIM objects to be exchanged and shared as shown in Table 2.

Table 1 – Autodesk Revit parametric objects vs. Bentley AECOsim parametric objects about "Column" example.

Categorization		Bentley AECOsim	Autodesk Revit
Identification	Object ID	☑	☑
	Object Name	☑	☑
	Object Type	☑	☑
	Object Description	☑	☑
Classification	OmniClass Number	☑	☑
	OmniClass Description	☑	☑
Geometry	Width	☑	☑
	Height	☑	☑
	Length	☑	☑
Quantities	Areas	☑	☑
	Volume	☑	☑
Manufacturer			☑
Fire Resistance		☑	
LEED Properties		☑	
Material		☑	☑
Phasing		☑	☑
Cost			☑
Thermal Transmittance		☑	
Structural Framing Common		☑	

Bentley AECOsim Building Designer only Autodesk Revit only

Table 2 – The necessary data for parametric BIM objects.

Parametric BIM object	
Basic Object Data	Identification
	Classification
	Geometry
	Quantities
	Phasing
Representation	Material

BIM OBJECTS EXCHANGE MECHANISM

Figure 1 demonstrates the concepts behind a BIM objects exchange mechanism using BIM Object Adapter. The heterogeneous BIM systems employ different data models to define and store all object information. This research attempts to access a parametric BIM object from one BIM system and then import it into another BIM system. A software tool called BIM Object Filter has been developed that allows a user to filter and format IFC data that was generated from a BIM system (Wu *et al.*, 2013). From these, the BIM Object Filter will automatically generate the necessary file for the parametric BIM object, which is then fed into BIM Object Adapter.

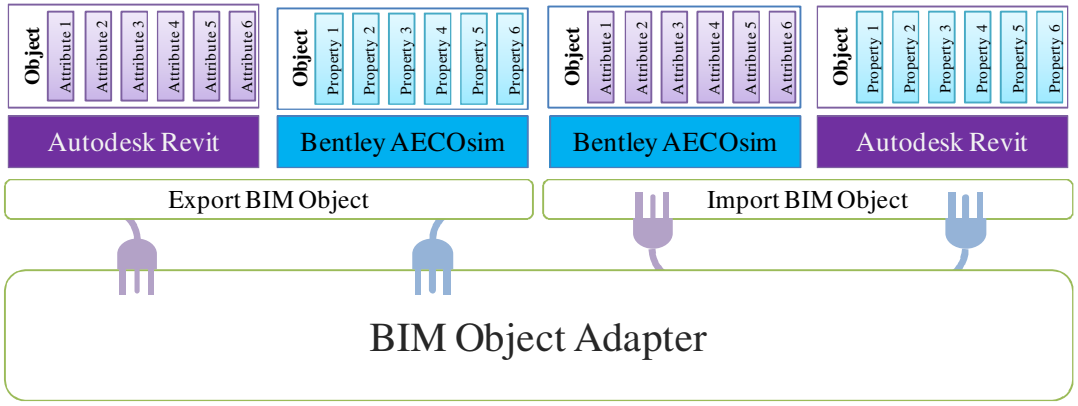

Figure 1 – The concepts of a BIM object exchange mechanism.

DESIGN AND IMPLEMENTATION OF BIM OBJECT ADAPTER

File Definition of a Parametric BIM Object

This research uses two types of file format to define the parametric BIM object for exchange and sharing. One is the .IFC file, which is used for describing the basic object data. The IFC model defines a set of internationally standardized objects for building construction based on the STEP (ISO, 1992) technology. It represents not only tangible building components such as walls, doors, beams, ceilings, and furniture, but also abstract concepts such as schedules, activities, spaces, organization, construction costs, and so on (Liebich, 2004). Another file type is a .JPG file for object representation. All of these are put into one folder for BIM Object Adapter to access.

System Design

Object-oriented technology is employed for the development of the BIM Object Adapter, as shown in Figure 2. The "frmMain" consists of the GetData and SetData components. The

GetData component uses a combination of folder-like and list-like interfaces to manage the hierarchy and attributes of the objects that are retrieved from the folder of the parametric BIM object. Meanwhile, the SetData component executes a back-end service for importing the parametric BIM object into heterogeneous BIM systems, such as Autodesk Revit and Bentley AECOsim.

System Implementation

The implementation of BIM Object Adapter is carried out in a Visual Basic for Applications (VBA) environment. This research implemented two types of add-in program for both the Bentley AECOsim API and the Autodesk Revit API for different BIM systems. In addition, IFCsvr.R300.dll is employed for implementation of IFC data access.

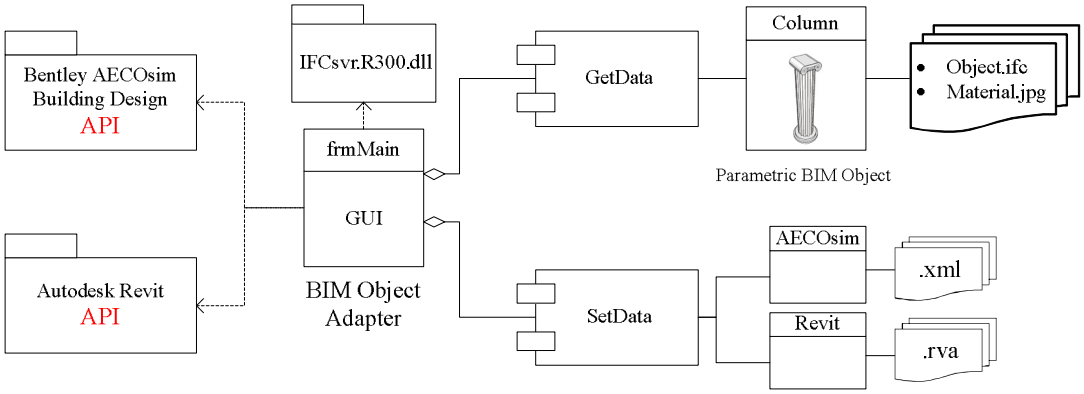

Figure 2 – Design of the BIM Object Adapter.

DEMONSTRATION OF BIM OBJECT ADAPTER

This section demonstrates BIM Object Adapter using a parametric BIM object for testing the exchange mechanism and the status of data loss.

Figure 3 shows the user interface of BIM Object Adapter. The left-hand-side window (as indicated by Frame A) is used to manage the imported parametric BIM objects, and the right-hand-side window (as indicated by Frame B) is used to display the important attributes of the BIM object, while the bottom-left window (as indicated by Frame C) is used to preview the 3D model of the BIM object. Figure 4 demonstrates how to use BIM Object Adapter with Bentley AECOsim Building Design to import a new parametric BIM object into the BIM system. In addition, a user can view the related parameters inside BIM Object Adapter to check whether it is the required object.

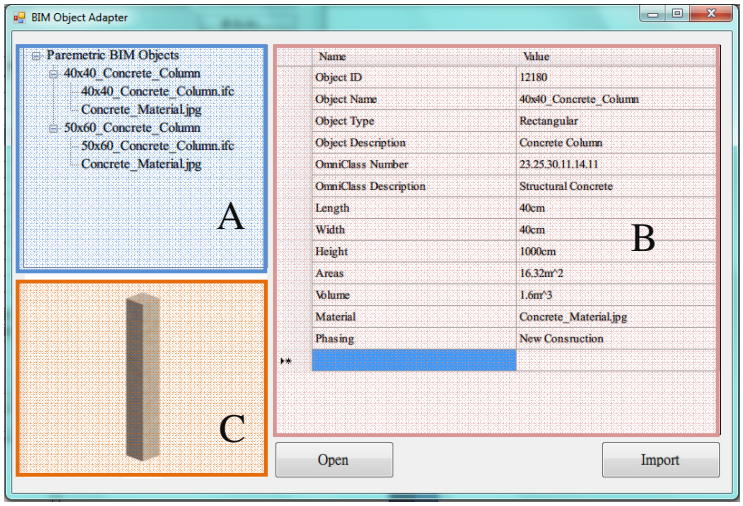

Figure 3 – The user interface of BIM Object Adapter.

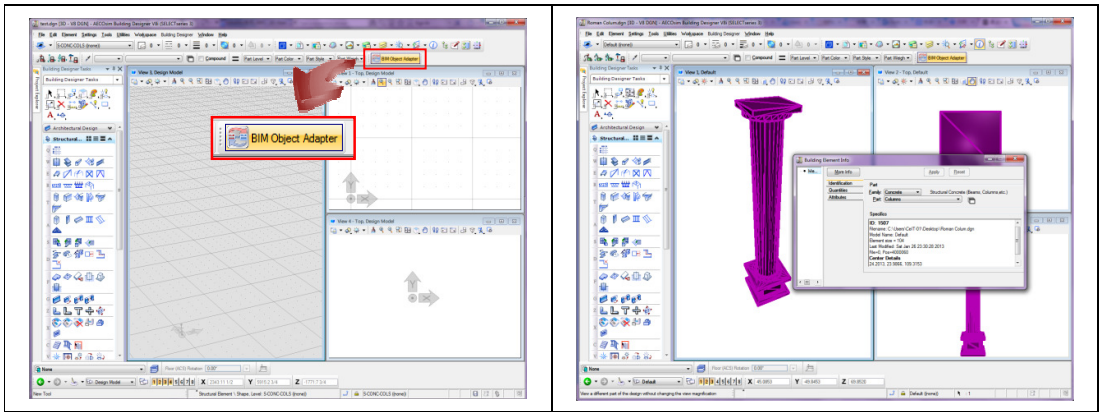

Figure 4 – Importing a parametric BIM object into Bentley AECOsim Building Designer via BIM Object Adapter.

CONCLUSIONS

Data exchange and sharing is an important task for integrated design in a building information modeling (BIM) system. For this reason, this research developed a BIM object exchange mechanism and defined standard parametric BIM objects based on the Industry Foundation Classes (IFC) standard data model for exchange and sharing. This research also designed and implemented a program called BIM Object Adapter, which can efficiently transfer a BIM object, including the graphical and non-graphical data, even its material type, into other heterogeneous BIM systems. This tool can not only increase data interoperability for parametric objects between heterogeneous BIM systems, but can also prevent incomplete data or data loss during exchange and sharing.

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