AN ONTOLOGY DRIVEN BIM COMPONENTS REPOSITORY: A NEW WAY TO SHARE BIM COMPONENTS

Vojtěch KUSÝ
Czech Technical University in Prague, Faculty of Civil Engineering, Department of Engineering Informatics, Thákurova 7, 166 29 Praha 6, Czech Republic, vojtech.kusy@fsv.cvut.cz

Summary

In the recent years Building Information Modeling (BIM) has been finally widely recognized as the next evolutionary step in the architecture, engineering and construction (AEC) industry and also as a step towards the sustainable construction. However for the effective work with the BIM design tools an extensive library of atomic building blocks – BIM components – is needed. Due to the limitation of built-in libraries provided by the software vendors, several BIM component portals emerged in the recent years enabling vendors and manufacturers to share the components with the designers. This paper addresses this issue as well and proposes a solution for a better ontology-driven knowledge management, categorization, conversion, enrichment and querying of these components.

Keywords: BIM, ontology, IFC, COBie, IFD, OWL, RDF, semantic interoperability

1 Introduction

1.1 Motivation for BIM

At the current time, the creation of the BIM model is usually more expensive than creation of the buildings plan in a traditional way. However the investment should be returned by savings on site during the construction (less wasted material, less coordination mistakes) and most importantly during the facility management (FM) of the building.

Possible added value of the BIM models:

- Interoperability among various computer aided design (CAD), facility management (FM) and analysis software, using the Industry Foundation Classes (IFC) format
- Better cooperation, including easier and accessible remote cooperation
- Canonical knowledge resource about the building during the whole life-cycle
- Faster and more transparent procurements (with support on the side of contractor)
- Faster building permit procedure (with support on the side of local government)

1.2 Reasons of expensive BIM models

As I've mentioned in the previous section, the complexity of the BIM model implies currently more demanding and thus more expensive creation phase in the comparison to designs and documents created during the traditional process of the building design.

This issue has various reasons:

- Much greater complexity of the model.

- Lack of staff experience.
- Lack of best practices and standardized approaches.
- Design tools immaturity in the field of BIM.
- Lack of needed components with appropriate quality.

The BIM components libraries try to resolve especially the last described reason.

2 Ontology-driven BIM components repository

2.1 Existing component repositories

Nowadays, there are few central component repositories provided by CAD/BIM software vendors[1] or independent organizations[2] and many local repositories provided by building manufacturers[3]. However all of them have at least one of the following issues:

- The provided components are proprietary format of particular CAD software; sometimes the component is bound even to a specific version.
- The quality of components varies; often there is no authority who guarantees the quality of the provided components.
- The standards used to build the components are different to national or company standards of the consumer.

However, there is at least one BIM components repository which addresses most of these issues: National BIM Library (NBL)[4], which is developed and managed by NBS[5] for the UK construction industry. This library uses IFC as the core format and offers conversion to other proprietary formats. The content of the library is provided by BIM Academy[6] and its quality is guaranteed by NBS. The library offers generic BIM objects which are common for the UK construction industry and also proprietary objects of those vendors who paid for the portfolio creation. NBS also developed set of tools which help in the development of the library components and conversion between IFC[7], COBie[8] and the proprietary formats.

The library offers download of the BIM component data in the IFC format by default and usually also in one or more proprietary formats such as ArchiCAD, Bentley, Revit, Tekla or Vectorworks. The reason is that IFC is not fully supported by the software vendors. In most cases the software supports only small subset of the IFC defined in the "Coordination View" Model View Definitions (MVD)[9], which always means loose of some information when importing or exporting BIM model data in the common BIM/CAD applications.

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[1] BIM components by Graphisoft <https://bimcomponents.com/> or Autodesk components libraries <http://revit.autodesk.com/library/html/index.html>

[2] bimstore <http://www.bimstore.co.uk/>, RevitCity <http://www.revitcity.com/downloads.php> or SmartBIM Library <http://www.smartbim.com/content/>

[3] Bradley BIM Revit Resources <http://www.bradleycorp.com/bim/products/bim> or Lindab Revit Library <http://www.lindab.com/uk/pro/software/building-components/>

[4] National BIM Library <http://www.nationalbimlibrary.com>

[5] NBS (acronym for National Building Standards) is part of RIBA Enterprises Ltd, which is owned by the Royal Institute of British Architects (RIBA)

[6] BIM Academy <http://www.bimacademy.ac.uk/>

[7] Industry Foundation Classes (IFC) – the future international standard ISO/PAS 16739

[8] Construction Operations Building Information Exchange (COBie), approved by U.S. National Institute of Building Sciences as part of its National Building Information Model (NBIMS-US) standard in December 2011

[9] Model View Definitions (MVD) is de facto standard related to IFC implementation and it is provided by buildingSMART Alliance.

2.2 Motivation for an ontology-driven BIM components library (OBCL)

While the solution of UK NBL library based on the IFC and COBie seems to be nearly perfect there are still some limitations. With conversion of IFC to some common ontology format such as ontology web language (OWL) using the International Framework for Dictionaries (IFD) Library[10] we can employ the power of ontologies:

- To reuse the components in the other knowledge domains or enrich the knowledge contained in the components with other knowledge, e.g., knowledge about materials.
- Robust conceptual, rule- and axiom-driven knowledge base, which could be used, e.g., for automatic constraints checking.
- To publish the IFC data through the Semantic Web as a Linked Data using the OWL and Resource Description Framework (RDF).
- To query the components repository using the ontology query language such as SPARQL Protocol and RDF Query Language (SPARQL).

2.3 Selected related research

In [1] is described a methods for conversion of the IFC/EXPRESS schema to OWL/RDF. In [2] is proposed a component library based on IFC and PLIB[11] standard. An open platform for processing construction product model data is described in [3]. In [4] is presented development of an open source IFC model server. In [5] is proposed solution for automatic constraint checking of IFC models. In [6] is presented ontology-based semantic modeling of regulation constraint for automated construction quality compliance checking.

2.4 Future research and discussion

Good starting point for the next research is a review of the existing IFC-to-ontology solutions and methods such as the ifcOWL conversion presented in [1] and IFD.

The optimal architecture of the OBCL is also questionable. The main question is whether to use (1) IFC repository as a the primary knowledge resource and use IFC-ontology only as a layer for communication with other services or whether it will be better to use (2) ontology as a primary knowledge resource and use IFC as an interoperable format for the BIM domain. Supporting meta-ontology with the description of the specific behavior of the particular versions of the common BIM tools could help to overcome problems with the conversion to the proprietary formats.

Interconnection with the international or national standards repository will help with validation of the component qualities against constraints specified by the particular technical norm. This research aims towards the automatic building permit procedure or automatic building certification – such as carbon footprint and energy efficiency certification or total cost of ownership (TCO) optimization.

By having such ontology-driven BIM component repository we can perform advanced queries with specific contexts such as: “find all components from category ‘roof windows’ which have height 116 mm, width 114 mm and which satisfy technical standard ČSN 73 0540”. This new level of categorization and querying will make the search for

[10] International Framework for Dictionaries (IFD) <http://www.ifd-library.org> is provided by buildingSMART alliance and it is built on top of ISO 12006-3:2007 Building construction – Organization of information about construction works – Part 3: Framework for object-oriented information

[11] ISO 13584 – Industrial automation systems and integration – Parts library (PLIB)

appropriate component much more precise and it could be also first step for more advanced solutions such as a semantic BIM component recommender system.

3 Conclusions

BIM method brings a consistent and systematic approach to the construction industry and thus it helps to build and maintain buildings in a more sustainable way.

According to current research in progress (see 2.3), ontology extension of the IFC--based BIM component libraries, represented e.g. by the UK NBL (see 2.1), will add better possibilities for the automation and knowledge reuse. While IFC and COBie standards are enough to solve the most current interoperability issues in the BIM domain, they have some limits in terms of consistency, efficiency and integration with the other knowledge domains. Ontology-driven BIM component repository (see 2.2) seems to be a natural successor of the current IFC-based solutions and it will open new possibilities for the construction industry and further enhance the sustainable buildings construction.

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