Towards an Open Building Information Model Server

Report on the progress of an open IFC framework

Jakob Beetz, Ruben de Laat[1], Léon van Berlo[1] and Pim van den Helm[1]

Eindhoven University of Technology
[2]TNO Built Environment and Geosciences
Den Dolech2 5800 MB Eindhoven
The Netherlands
j.beetz@tue.nl, ruben.delaat@tno.nl, leon.vanberlo@tno.nl, pim.vandenhelm@tno.nl

Abstract: In this paper we report on the progress on an Open Source model server for
collaboration between several stakeholders based on models of the Industry
Foundation Classes. After a general introduction on the topic of model servers,
a review on past and present research and development efforts in the field, we
illustrate the general architecture of the framework and report on existing and
planned features.

1.   INTRODUCTION

Building Information modelling (BIM) – although it has been on the research agenda for decades now – has received increasing public interest by the building and construction industry in recent years. From the early years of information that was modelled following the approaches defined in the STandard for the Exchange of Product data (STEP) onwards, the need for common models shared by stakeholders in an engineering project has been identified as one of the crucial concepts for a successful increase in efficiency of collaboration in the building and construction industry (Hannus et al 2003, Froese 2003). The ISO-certified Industry Foundation Classes (IFC) which have been modelled in close relation of the STEP initiative, have seen a number of research projects and approaches to design a

dedicated server for AEC/FM models. However, to date the use of IFC-based model servers is still not a widely adopted business practice and only a few experimental real-world light-house projects have made use of model-based, heterogeneous collaboration in the design, construction and maintenance of buildings (Plume and Mitchell, 2007, Lê et al 2006,) . Available commercial model server applications have been developed mainly focusing on industries other than building and construction. The amount of resources that are spent on model maintenance in other model-based engineering processes is significantly higher than in the AEC/FM field. Here, generally agreed upon implicit knowledge in the form of local conventions, best practices and rules of thumb often prevents the careful capturing of 'the obvious' in an explicit form in the model. While the main form to convey information in the field to date still is the technical drawing and its interpretation by humans, benefits of automation can only be achieved with good underlying machine-readable data models.

Apart from political and economical issues that have been illustrated by (Howard and Björk, 2008, Kiviniemi et al 2008) among others, technical reasons can be identified for low acceptance of IFC models in the field: Conceptually, their lack of unique identifiers on the level of objects makes the management of different versions challenging. Even though higher level objects descending from IfcRoot are equipped with a globally unique identifier (GUID), the bulk of information – their geometric and topologic representations – is anonymous and has to be compared with complex, content-based operations. Even though research projects have aimed at work-arounds such as heuristic graph-topology comparisons (Weise 2006), implementations are still not available for end-users.

By providing the Open Source (GPL v3) platform bimserver.org platform we are aiming at a number of goals:

a) To provide a customizable environment that enables researchers and developers to re-use, modify and adapt implementations of low-level tasks such as EXPRESS schema and instance parsing, persistency management and visualization.

b) Even though the platform is still in a development stage, we would like to encourage SMEs to make acquaintance and test business processes based on model server concepts by providing a platform that is easy to install and use and that can be run on standard PC hardware.

c) To provide room for experimentation with new business models such as BIM management consultancy and project hosting.

2.   EXISTING WORK

In the past, a number of individual and collaborative efforts have been initiated to provide common platforms and frameworks for the management of shared IFC models. Several projects have investigated different approaches for persistency-related research questions for general STEP-based and IFC models, and a number of prototypical implementations have been reported upon, none of which seems to have been taken up by a broader community. The family of BLIS, IMSvr and SABLE (Adachi 2002, Kiviniemi et al 2005) initiatives which were among the most referred ones unfortunately have been discontinued. However, experiences, and concepts that have been made and designed during these projects have been valuable milestones for further research and more recent developments such as the Information Delivery Manual (IDM) and the Model View Definition (MVD) initiatives. The IMSvr project followed the approach of a relational data base developed from the IFC EXPRESS schema and adding a XML SOAP API calls on top that exposed server functionality to the web. In the SABLE project, a domain specific API was added that allowed the retrieval of sub models categorized by disciplines. In addition to these 'hard-wired' query calls, Adachi developed a query language that allows the retrieval of complex model subsets, which has been reported in (Adachi 2003), which we consider an interesting candidate to be implemented in the platform presented here.

3.   FRAMEWORK ARCHITECTURE

The architecture of the bimserver.org framework is based on a number of flexible model based layers. At the core is an original model schema defined in ISO 10303 EXPRESS. Although subsequently generated meta models and code fragments have been manually optimized for the use of current IFC schema in the 2x3 version, other model schemas, such as earlier or future versions of the IFC model or other models such as the ISO 12006 "International Framework for Dictionary" (IFD) could in principle be used with some additional adaption. From this initial model layer, a Meta Object Facility (MOF) described as an XML Metadata Interchange (XMI) model is generated. The specific implementation is based on the Eclipse Modelling Framework (EMF). The current state of implementations is limited to basic model information and uses straight-forward mappings between EXPRESS and EMF. Basic Information such as EXPRESS TYPE, SELECT, ENTITY, and attributes are mapped to their respective XMI/EMF counterparts classes, interfaces, and attributes. Particular differences in each modelling languages'

characteristics and features require creative software engineering solutions. Difficulties and specifics of such a transformation have been reported by other authors in the past (Arnold and Podehl, 1999, Lubell et al 2004, Krause and Kaufmann 2007). One such prominent example is the necessity to box simple TYPEs which allow the extension/aliasing of simple data types (integer, float, bool etc.) in EXPRESS into fully fledged classes in EMF and the subsequently generated Java code, since inheritance from primitive data types is disallowed in this environment. Other necessary work-around solutions concern inverse relationships which occasionally cannot be automatically transformed due to inheritance issues. Even though all data found in part 21 STEP Physical File Format (SPFF) or part 28 ifcXML instance models can be processed by our framework, at present, the conversion from STEP to UML/XMI/EMF is far from feature complete. Advanced modelling features such as derived values WHERE rule constraints and STEP FUNCTIONs are striped off of the initial schemas, we are very interested at looking into possible solutions such as the Object Constraint Language (OCL) to preserve the richness of the IFC model in other modelling languages. Even if a complete automation of a transformation between these rule language might not be achieved, manual conversions seem feasible, since only few occasion are found in the IFC schemas and their change over the last version revisions has been minimal.

Based on the EMF meta model, a code generator is included in the platform that creates early-binding Java classes from the model. Although the number of alternative libraries and implementations in different languages is currently growing, we would like to encourage fellow researchers and developers to use parts of the bimserver.org platform as a convenient development tool for their own purposes on this level.

To achieve the main goal of the bimserver.org project – a free, Open Source model server for IFC information - a persistency layer is added on top of the layers described earlier. As a reference implementation, the open source Berkeley-DB has been chosen as its concrete realization, but other database implementations – both key-values-based or traditional relational databases – might be used as a replacement. Earlier attempts to manually craft object-relational and object-oriented database mappings from the model or to use automated frameworks such Hibernate have not been successful due either to structural mapping issues or performance and scalability limitations. Similar issues have been reported by (Nour 2009).

Concrete instances of IFC objects that are uploaded to the model server system are stored on a per-object level. A unique object key is generated for every new instance. This makes it possible to unambiguously identify, retrieve and manage even those instances that have not been equipped with a Globally Unique Identifier (GUID) by its source application as required by

the IFC schema only for a small fraction of entire model population. This mechanism is a first step to track changes between different model versions over its entire lifecycle. However a number of problems have yet to be solved before fully overcoming some of the inherent structural shortcomings of STEP-based data models concerning their versioning and the integration of multiple domain specific models stemming from different applications. We are investigating approaches suggested by (Weise 2006) and (Arthaud and Lombardo, 2006) and an approach based on a spatial heuristic that is in the early stages of planning. A sub-project mechanism implemented in the database core allows the creation of model branches and design variants.

Upon this database layer a number of operations – referred to a as 'actions' – are implemented which are exposed in the form of SOAP calls. These operations include general database administration routines such as user management and access right management. Query operations include the possibility to request all instances of a specific (EXPRESS entity) type, objects descending from the IfcRoot entity identified by a Globally Unique Identifier (GUID) and more sophisticated queries in the form of Java code snippets that can be uploaded and compiled at server runtime. Configurable and flexible filter mechanisms that allow the explicit inclusion or exclusion of object types or specific instances will be extended in future versions aiming at MVD functionality.

4. FUNCTIONALITY OF THE CLIENT REFRENCE IMPLEMENTATION

Based upon the aforementioned SOAP API which is published by a WSDL interface, clients interacting with the server can be written by third party developers. A reference implementation has been created in the form of a web-browser based client which is included in the binary distribution of the server platform. With this client, basic interactions such as the creation and management of users and their access rights, projects and subprojects can be executed by non-technical end-users. Import and export filters that have been added to the system include ifcXML, KMZ, Collada and CityGML. Basic navigation and inspection of the model content is provided by a structural browser that presents a revision sorted by the corresponding IFC Entity types. A graphical visualization module that is based on Google's O3D format allows the interactive navigation of complete model revisions or the result of queries model queries issued through the client. While at present all geometrical operations are facilitated by a multi-platform version of Bonsma's IFCEngine.dll (TNO IFC engine, 2002) that operates on the server side, we are looking for a tighter integration of alternative geometry engines

in future. Also based upon this external engine, clash detection functionality has been added that allows the investigation of potential design and engineering issues during a construction project.

5.   PRELIMINARY USER FEEDBACK

The bimserver.org platform has received quite some attention both by an international community of developers through mailing lists and the end-users such as architects, engineers and consultants. On several occasions works-shops and presentation have been organized, targeting mainly the Dutch landscape of software developers and design and construction practitioners. Based on feedback provided by the community which is very positive in general future developments, refinements and extensions are being planned. Among the important concerns of end-users is the usability of the client interface. Most frequently requested features are the improvements of model merging capabilities, finer control and tracking mechanisms of different users working on the model and advanced model consistency checkers.

Features that are appreciated the most include the ability create dynamic links to Google Earth that allows clients to monitor a project's progress at any given moment. A compression feature that reduces bandwidth is similarly popular as is the automated update of project changes through RSS feeds.

Several developers across different domains and countries are currently making experiences with tailoring the platform to their own needs, and their feedback and contribution are very valuable to the advancement of the project.

6.   SUMMARY, DISSCUSSION AND FUTURE WORK

In this paper we have reported on the ongoing research and development of an Open Source IFC Model server based on a scalable, extendable and multi-platform architecture. We illustrated our approach using a modular architecture with a key-value based database and described functionality of the server that is exposed through web service interfaces. With outlined functionality that has been implemented in a reference client and reported on feedback we received both from developers as well as end users.

Using an extensive suite of test models that in some cases exceed one million entity instances, we experienced the platforms capability of handling real-world models stemming from a spectrum of different applications with

IFC support. Future investigations will include benchmarks and comparisons to existing applications. The bimserver.org platform is not intended to be a full alternative to the few existing commercial solutions, but we hope that it may serve as an experimentation environment both for end-users as well as the research and development community and especially the work of the buildingSMART organization.

Although at present there are many possible areas for enhancement, we hope a broader community is developing an interest in the project and considers the platform for own collaboration projects, developments, or extensions. In future, we would like to enhance the merging functionality and further work on queries to allow MVD partial model extraction. An interface more convenient for non-technical end users and further enhancements of the revision control on an object level are additional items on the project's agenda.

7. REFERENCES

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