Management of Best Practices in Construction through Interfacing with Product Models

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Abstract

Compliance with best practices is seen as a key enabler of successful project delivery. This is seen as a key requirement in particular in industries such as construction where multiple partners share complementary competencies to deliver a unique product. Information integration and exchange in construction is being pioneered through the use of product data technology. Relying on common standards such as the Industry Foundation Classes (IFC) from the International Alliance for Interoperability (IAI), is seen as a main instrument for information exchange between heterogeneous information sources and applications. YIT Corporation is one of the pioneers in the use and exploitation of IFCs in the Finnish construction industry. Many of their construction related applications make use of IFCs for product (building) modelling, cost estimation, etc. At the same YIT makes use of its best practices library to provide information to its employees on how to best perform a particular task. This paper presents an approach that is being investigated at YIT through the IMS GLOBEMEN and e-COGNOS projects for the use of product models as an interface to best practice management in construction. In essence the approach relies on pre-populating a product model with references to relevant best practices. The results are available through a multi-

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1 To be presented as, “Product models as an interface to best practice management in the construction industry”, at eSM@RT 2002, November 19-21, University of Salford, UK.
dimensional visual interface for use by different categories of end-users. These end-users can be differentiated not only on the technical nature of their work, but also as to belonging to different types of organisations.

1. Introduction

The business of construction is a complex one as it involves the cooperation of different organisations in an inter-enterprise setting working together in a parallel or even sequential form to deliver a one-of-a-kind product such as a building. A well known fact and reality is that not only do participant organisations work on multiple projects at a given time, but there is a lack of homogeneity in the applications and data standards that are used across organisations. The classic mode of product delivery in virtual enterprise (VE) settings is the norm rather than the exception in the construction industry as illustrated in figure 1 [Hannus and Kazi, 2000] for a typical building construction project.

![Figure 1: Key actors, information flows and contract networks in a construction project.](image)

As may be noted from above, two types of inter-enterprise collaboration exist a virtual enterprise one in addition to a traditional supply chain one. Another point of interest is that while information flows seem to stem from the architect, contractual flows are around the client. While several variants of the above exist, rarely, if at all, information flows and contractual flows are in parallel [Kazi, et al. 2001a]. Key characteristics of distributed engineering in construction for settings as shown in figure 1 were identified by Hannus and Kazi [2000]:
• temporary relationships
• some participants are not known in advance
• complementary competence is provided by distinct companies
• absence of a dominant actor
• disparity between contractual relationships and information flows
• participation of some actors in other distributed engineering settings concurrently

The aim of this paper is to present the use of Product Data Technology (PDT) as a solution for information exchange in distributed engineering environments as seen from the perspective of a contractor, capture, sharing and re-use of best practices that are built on past experience, and finally to demonstrate a solution that would combine the two.

2. Background

2.1 Product Data Technology

Product data technology is "the application of information technology to all aspects of product developments, manufacturing and operation. It is based on a unified view of information captured in products throughout their life cycle” [PDTAG, 1998]. Significant developments in this area have led to the formulation, adoption, and exploitation of standards such as the Standard for exchange of product model data, STEP (ISO 10303) and Industry Foundation Classes (IFC) [IAI, 2002]. Based on these standards, first commercial CAD tools have started to emerge in addition to toolkits for developing file conversion software.

The belief that product models are the foundation for information sharing in the future is becoming generally accepted. Data transfer in the future will be based more on sharing than sending. A key problem however with product data technology is that data models are constantly evolving. This instigates the continuous upgrading of software to remain compliant. While significant developments have been noted in EU projects, CONCUR (2001), PROCURE (2002), ToCEE (2000), ISTforCE (2002), there still seems a gap in terms of support for product data warehouses, partial product model data exchange, server-client architectures, model merging, etc.
2.2 Knowledge Management

Knowledge management entails the capture, consolidation, dissemination, and reuse of knowledge in addition to the translation of new best practices to tangible programmable processes to be automated through IT [Kazi, Hannus, and Charoenngam, 1999].

Currently, knowledge management is not available as a packaged point solution, but needs to be built up through the combination of different "infrastructure" elements: open interoperable computing platforms, communication networks, knowledge creation analysis tools, external and internal content, collaboration tools, enterprise-wide and inter-enterprise-wide messaging, web content management tools, "push" and "pull" technologies, intelligent agents, case-based retrieval, portable documents, object databases, document management, process management tools, etc. State of the art tools today, facilitate concept classification to help identify knowledge, and then use either semantic, collaborative, or visualisation retrieval technologies to extract the knowledge from applications.

While there is evidence of support in terms of "process" knowledge management, there is a lack of solutions for "product" knowledge management.

3. YIT: In a Nutshell

YIT Corporation Ltd is the largest construction company in Finland, consisting of several production divisions and subsidiaries around the country and abroad. The main product lines are Building Construction, Huber, Civil Engineering and Industry. The fields of business for Building Construction are building construction, and the property business as well as property services. Huber’s field includes servicing and maintenance for industry, mechanical contracting and related engineering fabrication.

As a construction company YIT in most cases receives design information from external companies which are beyond its reach of influence. In order to solve problems related to heterogeneous IT environments and standards used by other companies in the industry YIT has developed knowledge based tools allowing a rapid transformation of incoming design data into a consistent product model. This approach has already demonstrated an opportunity for integral use of IT in a heterogeneous environment where open standards are still emerging and are not yet supported by available IT tools. Based on this approach YIT is developing model based IT applications and related operational practices for internal use as well as for enhanced collaboration with other companies in the construction value chain.
4. Distributed Engineering: The Case for Product Models

An analysis of the main building life cycle stages that could be impacted through the use of product models in distributed engineering was conducted. Current in-efficiencies (process as is) were identified as were potential resolutions (process will be) through the use of shared product models by Kazi et al. [2001b].

Table 1: Analysis of current vs. to be processes

<table>
<thead>
<tr>
<th>Stage</th>
<th>Process as is</th>
<th>Process to be</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briefing</td>
<td>- Sketches are done by architect manually</td>
<td>- All sketches are based on a product model</td>
</tr>
<tr>
<td></td>
<td>- No systematic analysis</td>
<td>- Visualisation (interface) is automatically available for end-user in the form of graphs, 3D models, key figures, etc.</td>
</tr>
<tr>
<td></td>
<td>- Key figures manually calculated on a case by case basis</td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>- Only advanced architect and designers can produce product model information</td>
<td>- Product model is utilised by all stakeholders including structural designers, HVAC engineers, etc.</td>
</tr>
<tr>
<td>Production</td>
<td>- No systematic feedback from contractor to architect/designer</td>
<td>- All partners have access to contractor’s experience (available in the form of structural types, etc.)</td>
</tr>
<tr>
<td>Planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>- Information management is restricted to simple document management</td>
<td>- Shared product model is available for and used by all partners</td>
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<tr>
<td></td>
<td>- Only some partners are able to use product models in their internal works and associated applications</td>
<td></td>
</tr>
<tr>
<td>Use &amp; maintain</td>
<td>- No as built model is created</td>
<td>- Contractor and suppliers add as built information to product model</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Product model information is exploitable for a long period</td>
</tr>
</tbody>
</table>

The results from the analysis reported in Table 1 do have certain implications with regard to the roles different actors play. An analysis of the shift was presented by Kazi et al. [2002].
Research in GLOBEMEN [2002] identified some common end-user requirements for distributed engineering in construction through the use of product models. These were:

- Ability to utilise shared product models based on current standards network standards
- Management of concurrent use of product models
- Ability to use partial models
- The solution should rely on international data exchange standards such as the IFCs by the IAI
- The solution should be flexible enough to allow for frequent change of actors (consortia typically vary not only from project to project, but across different project phases as well)
- Set-up and configuration time must be extremely short (hours … few days)
- User rights and access control needs to be efficiently handled.
- The system must be easy to use and require minimal training (if at all any)

It was observed that product model management was to be done with the aid of a product model server. Requirements from the product model server were identified as:

- Upload product model schema (e.g. IFC schema) into model server
• Initialise the model in the model server through pre-defined standard templates (structural types, composites, etc.)

• Insert a new product model into the model server

• Append a new product model into the model in the model server

• Modify a partial product model

• Delete a partial product model

• Merge two or more product models together

• Merge documents (could be in the form of references to different document repositories) into the product model

• Read a specified product model or partial model in different formats (e.g. EXPRESS, XML, etc.) from the model server

• Read specified parts from the product model (e.g. value of a specific attribute, component or instance)

• Read specified pre-defined standard templates (e.g. structural types, composites, etc.)

• Possibility for concurrent access of product model by different users

Based on the above requirements identification and in line with the findings of Tables 1 and 2, three main high level use cases were identified for a shared product model-based solution: data exchange, manage models, and link documents with models. A more elaborate presentation of these use cases has been reported elsewhere [Kazi et al., 2002] as has been the implementation architecture for the same [Hannus and Kazi, 2000].

5. Knowledge Management: The Case for Best Practices

Construction, being a project based one-of-a-kind production industry, knowledge and experience from past projects can be detrimental to the non-repetance of past mistakes and the re-use of good solutions. This however is not very easy as project partners typically change from project to project and new partners are little if at all aware of past experiences, good or bad. As such, a means to capture good/best practices is essential by the main contractor to then be provided to other partners for use in the joint delivery of a building.
Work towards the capture and reuse at YIT of best practices started in 1997. The initial focus was towards the standardisation of different structural components that they regularly used in buildings. Relying on this as a foundation, YIT’s best practices database was launched in 1998. This tool (used in parallel with several other ones) provides employees with access to best practices in the form of cards. Figure 2 is a high level illustration of the best practice card system used at YIT. The current system operates under Lotus Notes and is available only through the Intranet. All updates are done manually by a knowledge manager.

An analysis of the current best practice database has revealed some inefficiencies. A few are reported below:

- Best practices are not properly systematised in accordance to YIT’s ontology
- Database updates are only a few times a month and are not done automatically
- Knowledge workers are not able to update items or comment on them
- When no knowledge is available, clear indication as to whom could be a potential knowledge provider is missing
- Customisable user interfaces both at user group and individual level are missing
• All information is accessible (only in Intranet)
• There is no possibility to access (in full or partiality) the best practices from outside YIT offices
• People replicate the database on their computers, hence they may not have access to the latest correct information

Within the context of the e-COGNOS [2002] project, YIT have identified the means to resolution of some of the above inefficiencies. This has been presented in the form of IDEF0 diagrams describing the situation “to-be”. A high level view is shown in figure 3 followed by a brief description of the main processes.

**Figure 3: YIT best practices database – “To-Be”**

**User and system administration:** The aim here is to create some generic user profiles based on certain user group classification. Once a user logs in, they are shown the customised user interface for the group(s) in which they partake. Furthermore, each end-user is given the flexibility to further customise the interface and profile based on personal application and knowledge needs. Access rights too are controlled here with a clear differentiation between rights based on whether the user is an employee of YIT, employee of a partner in an ongoing partner, etc. User rights to knowledge and application service invocation are typically based on contract conditions.

**Seek and send new knowledge:** The aim here is mainly to seek, comment, and then send for further processing the relevant knowledge (items). A user may seek knowledge from two main sources, internal (YIT’s resources) and external (external third party resources). Results are retrieved in alignment of the profile of the user and the rights
which the user has. The user would check the received results for validity and satisfaction of the needs for which the search was conducted, thereby filtering out the relevant knowledge. Users would also comment the selected knowledge items (including where relevant some corrective actions). Selected items would then be submitted for further systematisation.

**Knowledge systematisation:** The aim here is to primarily maintain YIT’s ontology based on user needs and experiences. It involves the processing and systematisation of knowledge in accordance of the ontology and YIT’s knowledge presentation formats. This includes the organisation, classification, and modification of knowledge items. Processed knowledge items would be ready for use by different users and presented in accordance with different user profiles and made visible on the basis of a user’s access rights.

**Knowledge deployment:** The aim here is to make available (publish) that knowledge which has been processed, systematised and retained for use. User’s would be able to retrieve this knowledge through queries to the YIT best practice database and provide further comments when relevant. New knowledge needs may emerge on the basis of this knowledge and as such requests for the same will be directed to the relevant knowledge sources and experts.

### 6. The Solution: Product Models + Best Practices

Product models are at the heart of building design and are packaged with volumes of parametric information. This information on its own however is not structured in a meaningful way for a simple user to make use of it. Intelligent means and applications need to be developed to make the product model more “smart”. As an example, the automatic generation of a project status report for an executive manager, or the generation of a detailed cost estimate report for the finance department.

At the current state of implementation in YIT, product models and the best practice database, though sharing a common data structure (as close as feasible) are distinct entities with no physical links. As such, it becomes necessary for one to perform specific searches to find for example construction techniques for a beam.

A means to make the use of product models in the daily lives of construction personnel (e.g. at the site) is currently under investigation at YIT. This involves the linking of the best practices database with a product model server. Linking (relationships between product model objects and best practice cards) would be done though an intermediate application. The main ambition being that once a product model is loaded into the
product model server, it would be pre-populated with relevant best practice links from the best practices databases. It would for example automatically attach construction techniques, safety directives etc. for all walls that have a thickness of 20 cm or less. Concept implementation of the above is presented with the e-COGNOS infrastructure acting as a bridge between the product model server and the best practices database as shown in figure 4.

Figure 4: Connecting product models and best practices

It is worthy to mention here “visual” experience that an end-user (e.g. at the site) would experience. The user would see a 3-Dimensional representation of the product model. This would be navigateable. Once a user clicks on a certain object (e.g. door), a menu would pop-up containing different best practice cards and report options. From here, one could select a particular report (e.g procurement details), or a best practice card (e.g. methods of work). These would be printable if needed.

7. Conclusions

This paper has concentrated on the presentation of three main issues: product models in distributed engineering, best practices in knowledge management, and a combination of the two.
YIT has for long been amongst the pioneers of the adoption of product models in its design work. This has been necessary to enable automation of certain tasks like cost estimation “on-the-fly” whenever a product model is updated. Furthermore, in distributed engineering environments, product models act as the common working dataset between different project participants.

The standardisation of different frequently used structural components and the capture and reuse of best practices has been an activity in place at YIT for near 5 years. This significantly reduces rework and furthermore, contributes towards better quality of the built building as it is based on identified successes. In the past, best practice information was only available internally within YIT, but now relevant information is to be made available to partners involved in joint projects.

The future lies in the convergence and interlinking of relevant applications and knowledge sources to the relevant objects in a building product model. Some background automation (transparent to the end user) will ensure that a product model is pre-populated with the latest information in terms of best practices and similar knowledge items. A simple approach to the same was recommended in this paper. This was complemented with a simple example of what the end-user would see.

References


