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A BIM collaboration lab for improved through life support

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Abstract

To improve construction performance and sustainability there is a need for improved through life support. Customers, clients, suppliers and society have needs and requirements that have to be captured and formalized to govern the goals of design and production and finally operation and maintenance. This requires continuous information about the real estate and city properties, all in open and transparent standards. The information needs to be collected, stored, processed, integrated, extracted, visualized and interpreted, something that requires advanced information systems and deep domain knowledge. BIM repositories will become a necessity for the ability to manage changes and consolidations/synchronizations of heterogeneous applications. Integrated planning, integrated design with multiple alternatives and functional, spatial interfaces, and integrated supply chains with system performance requirements and specifications, the important functionalities of IDDS, Integrated Design and Delivery Solutions, are examples on possible usages of a BIM repository. This paper presents the planned and also performed studies of a BIM collaboration Lab, which are based on the experience and results from the BIM Collaboration Hub and the research in the EU project InPro. It also demonstrates how the experiments in the lab are supported by through life support standards.

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Keywords: BIM repository; change management; construction projects; requirements management; through life support.

1. Introduction

The political and economic focus towards the issue of climate change is driving the adoption of sustainable construction practices within the construction industry, which must now also consider the environmental, social and economic performance of buildings. With the emergence of sustainable practices in engineering, the organizations have begun to analyse and develop new standards for the application of sustainable principles in the field of

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engineering. To improve collaboration in an industry with temporary project organizations and fragmented processes the challenge is to integrate information and stakeholders (Dainty et al., 2006, Emmitt, 2010, Emmitt and Gorse, 2003, 2007, Winch, 2010). This integration must also meet the needs of through life support (Owen, 2009, Amor, 2009). Needs and requirements from customers, suppliers, clients and society have to be captured, interpreted and formalized to govern the goals of design, production, operation and maintenance. This requires continuous and updated information about the real estate and city properties in open and transparent standards. The information needs to be collected, stored, processed, integrated, extracted, visualized and interpreted, something that requires advanced information systems and deep domain knowledge.

The integration through life enables improvements of the processes. Design assessment can be done early and often, time to market can be shortened, costs can be managed more reliably and the functionality of the final product can be improved when actors collaborate over time. (Eastman et al., 2011)

With project information becoming more and more complex and focus going from files to a multitude of objects, BIM repositories will become a necessity for the ability to manage changes and consolidations / synchronizations of heterogeneous applications (Eastman et al., 2011). BIM, Building Information Models, are object oriented models of buildings with information linked to the individual building element objects in 3D (ibid.). The alternatives to BIM repositories - open or proprietary, file or object based - are document management systems (DMS) or archives with BIM files where the links between files and objects from the different actors are not managed or stored. One of the advantages of BIM repositories is the ability to relate information between disciplines and project stages.

The evolutionary change within the industry "from managing files to the managing of information objects has only begun to take place" according to Eastman et al. (2011). When object level information management is required, there will be a need for support by a building model repository, also known as BIM repository (ibid.).

This paper proposes a collaboration model for sustainable information practices based on the experience and results gathered during a previous EU project - InPro (Sebastian et al., 2011). Real-life issues related to efficient collaboration and information management studied in the BIM Collaboration Lab are presented including visions for future studies.

The functionalities of the already developed prototype platform, the BIM Collaboration Hub, to support stakeholder collaboration in research projects and activities are described. Finally important and planned research issues related to collaboration such as information management and stakeholder management are presented.

2. Purpose, goals and challenges for the Lab

The main purpose with establishing the BIM Collaboration Lab is to perform advanced research and development on through life support in close collaboration with industry and society to support stakeholders collaborating over the whole life-cycle of a construction project (buildings and infrastructure), and thereby support the loosely coupled processes starting from planning over design, production and via handover into facility management and operation of the final construction work. The validation of the design solutions including redesign, alternatively requirements changes, can form the goals for the production phase if managed correctly. This is a field which still is unexplored. (Amor, 2009). Optimization of facility management and operation will be dependent on the requirement specification early in the process, thus dependent on early commitment from the FM organization of the client (ibid.). This is not the current situation. Hence the main goal for the Lab research is to support the integration of information from all stand-alone software applications over all the life-cycle stages.

Fig. 1. illustrates the vision of the unbroken information-flow when using BIM, i.e. the value of the information in the project will increase over the various processes and actors compared with the traditional ones (Eastman et al., 2011).

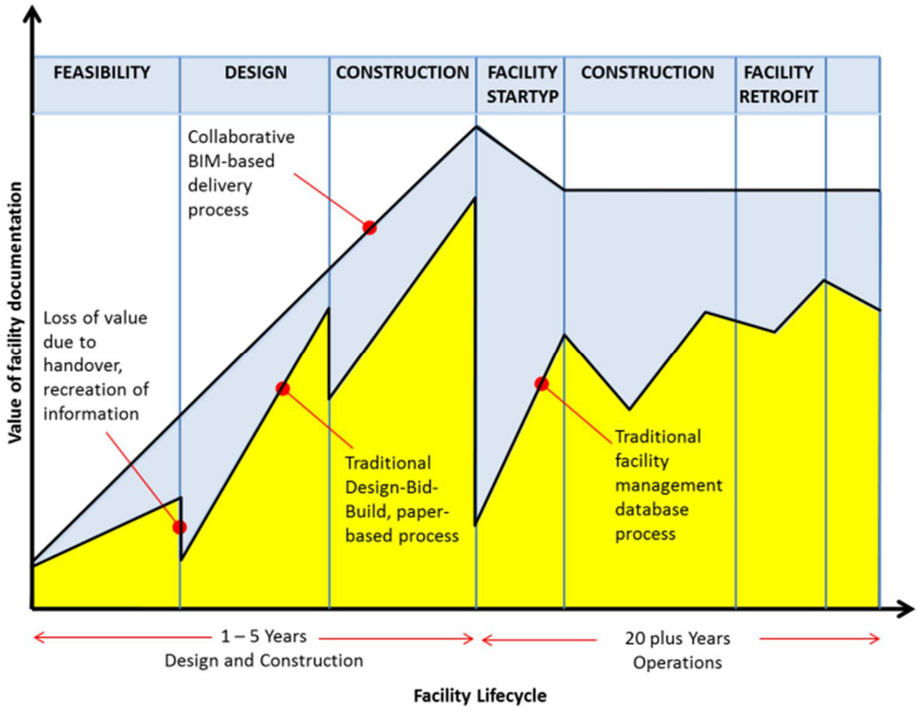


Fig. 1. Facility Lifecycle comparing Collaborative BIM-based delivery process with traditional, after Eastman et al. (2011)

The cost of inadequate interoperability in the processes – between the lifecycle stages and actors - has been estimated in a NIST report in USA 2004 (NIST, 2004). In the United States alone it was up to a $15.8 billion/year loss of capital in the architectural, engineering, construction and facility management industries. Continuous information management has the potential to reduce this loss (ibid.). To achieve these benefits, collaboration based on well-defined processes and standardized information can be one alternative.

One challenge is the motivation for using BIM, when at the same time IT-tools still are primarily used to make existing processes faster and more efficient (Karrbom Gustavsson et al., 2012). Increasingly complex projects with shorter process, more functionality, new functionality like parametric design, and Engineered To Order (ETO) will require new processes and new ways of collaboration (Eastman et al., 2011, Owen, 2009). Systems engineering as utilized in the manufacturing industry, with their through life supporting view on information management supported by standards like PLCS, ISO 10303-239 (2012) should be explored. In the systems engineering phase, where requirements are broken down into functions and systems, followed by design to fulfil these goals, better solutions could be achieved if the requirements are well specified – a challenge in itself. And finally, who will benefit from improved interoperability?

The research question for the Lab is – ***how can trough life support improve the construction processes, and what does it require from the information models?***

The research method is based on experiments - ***The BIM Collaboration Hub is built to support experiments testing collaboration with end users in the laboratory***. As this is one way of testing the theories of through life support during a short period of time, interviews with the users will be very important for the evaluation.

3. Current state in applying BIM repositories

Few initiatives exist in the field of open BIM repositories based on the building element object level, i.e. exchanging and managing the information on the granularity level of building elements. Eastman et al. (2011) list

BIM repositories and model servers which have some of the characteristics needed. Some examples are Autodesk Collaborative Project Management, Bentley ProjectWise Integration Server, BIM Server, Eurostep Share-A-space Model Server, Graphisoft ArchiCad BIM Server and Jotne EDM Model Server. The BIM Collaboration Hub, based on Share-A-space, has a through life support based on open international standards, in this case the ISO PLCS standard (ISO, 2012).

3.1. Process integration

BIM can enable an improvement of the construction processes (Eastman et al., 2011, Amor, 2009, Owen, 2009). The information exchanged in the processes has to be explicitly defined to enable automatic deliveries between actors and their software applications. To do this, activities are broken down into smaller tasks which are corresponding to exchange requirements. These can be fulfilled by information deliveries, which are starting to be defined by standardisation organisation like buildingSMART (2011). The basis for these information deliveries to be efficient are common definitions of the building elements, their properties and relationships. The IFC standard ISO 16739 (buildingSMART, 2011) is the only open international standard for BIM today.

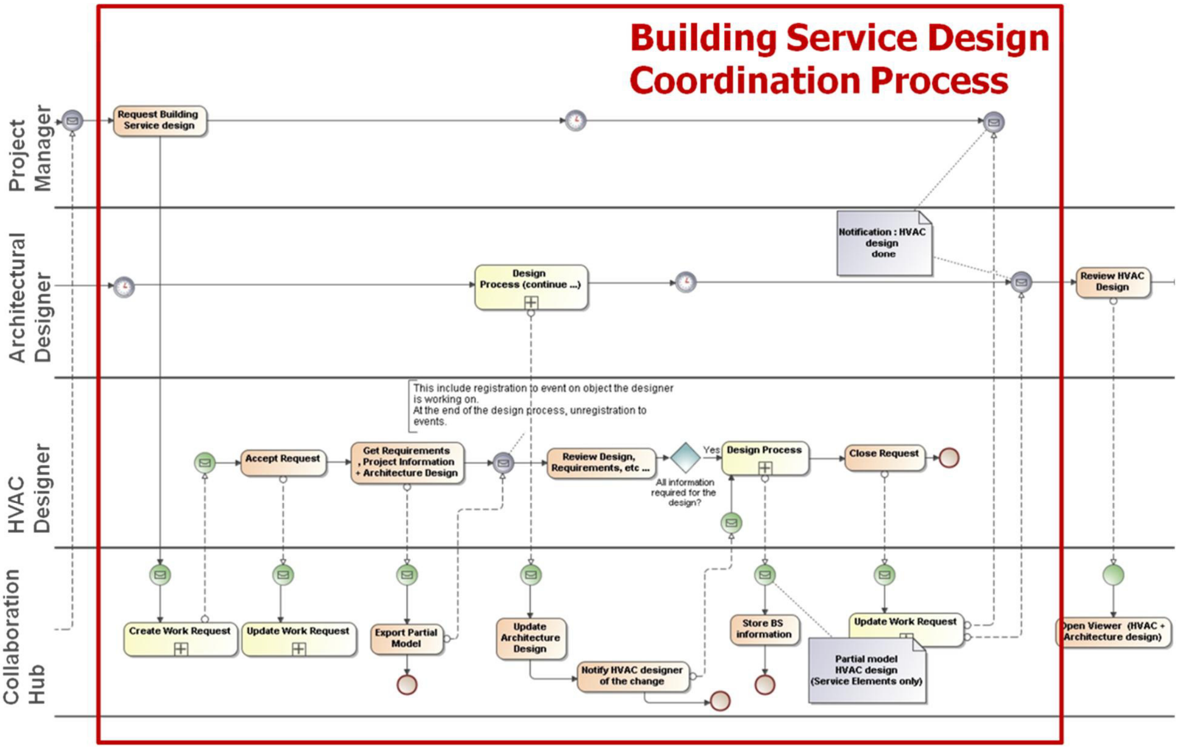


Fig. 2. The coordination process applied on a Building Service Design process (Tarandi, V. & Houbaux, P., 2010)

In the InPro project 7 key processes were defined and analysed using Business Process Model and Notation (BPMN), a notation utilizing the swim lane concept. Fig. 2. illustrates a part of the Building Service Design process which is structured to utilize the BIM Collaboration Hub, i.e. the BIM repository where all changes and versions are traced and stored. This way of managing the processes requires strict and formalized routines for versioning of objects and properties as well as the change management procedures (Dumolin et al.,2011).

In the InPro project, Engineering Change Processes from the car manufacturing industry were applied as one approach also for the construction industry.

3.2. Organisational integration

Extended and virtual enterprise

Depending on contractual agreements, the organisations interacting in the processes can utilize different solutions for information management.

Two types – extended and virtual enterprise – can be seen as the main alternatives when using a BIM repository for the information sharing in the more advanced types of integration. The access to the shared information is important as well as the openness and transparency of the content. In an extended enterprise the OEM, original equipment manufacturer, traditionally sets the rules for the collaboration. In construction this could be the contractor. That can mean that rules, formats and also tools to use are decided by the OEM for designers and suppliers. In the case of a virtual enterprise, the organizations are on equal terms when setting rules and formats. They have common agreements regarding information management, giving them freedom of tools as long as they fulfil the information sharing they have agreed upon. In this alternative there is a place for open formats based on open and international standards.

The BIM repository supporting the collaboration should preferably be designed as an information hub, as illustrated by Fig. 3. (Hallberg and Tarandi, 2011). This enables configuration management with tracing of changes and decisions. It also gives the partners freedom to use their existing software or select the best on the market, as long as they fulfil the exchange requirements set up for the project, the collaboration.

Fig. 3. Separate systems joined point to point (left) or via information hub (right) (Hallberg and Tarandi, 2011)

Owen (2009) lists integrated planning, integrated design with multiple alternatives and functional spatial interfaces, and integrated supply chains with system performance requirements and specifications as important functionalities of IDDS, Integrated Design and Delivery Solutions. They are examples on possible usages of a BIM repository.

3.3. Information Integration

The information in the BIM repository has to be open and standardized, preferably on international basis. The IFC standard 2x3, ISO 16739 (buildingSMART, 2011) is today the only open, international standard covering the buildings with their building elements, geometry, topology, properties, activities and more needed for an efficient collaboration among all the different types of actors in the industry. The main requirements on a BIM repository is to store, access and retrieve integrated and consolidated information based on business objects like building elements. Identities, geometry and properties, as well as versions over time, should be managed.

4. The Collaboration HUB / Lab

The BIM Collaboration Hub has a common data base with the information accessible via the standardized interfaces based on open standards like IFC, see Fig. 4. (Tarandi, 2011). The loosely coupled business processes can access the information based on access rights.

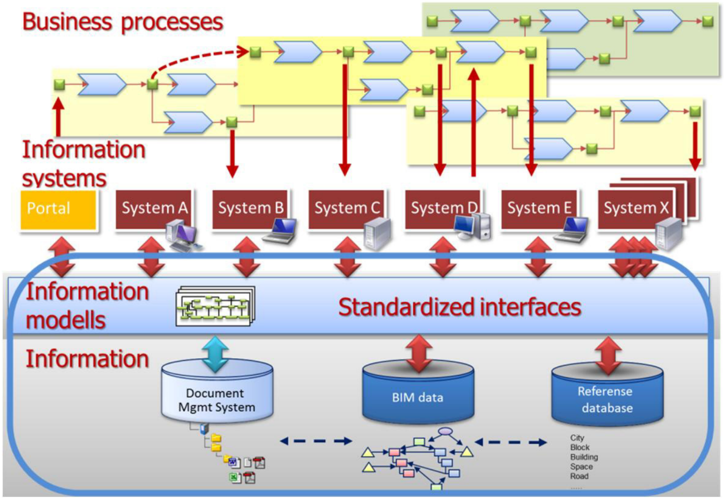


Fig. 4. The architecture of the BIM Collaboration Hub (Tarandi, 2011)

4.1. Basic functionalities of the BIM Collaboration Hub

The BIM Collaboration Hub (Tarandi, 2011), is based on the framework for life-cycle support of products, PLCS, and to that framework industry specific models like IFC are mapped.

Information model: The BIM Collaboration Hub supports not only heterogeneous sets of applications, but also heterogeneous information models. They can be added by being mapped to the PLCS information model. As the Hub is based on PLCS, it also supports open PLM standards, which is important when PLM is getting more attention in the industry.

Information management: Partial model exchange, complete information creation and change history, support for automated change propagation and notification of changes are parts of the BIM Collaboration Hub, coming from the PLCS framework.

Interoperability: Correct mappings of the information models will always be a difficult case until the classification systems are becoming international. The network model of the BIM Collaboration Hub with a single central repository is important for consolidation, integration and versioning.

Integrated information and automation systems: Configuration management and integrated information are supported. Knowledge management systems using the framework of the hub can easily find the proper place holders for their codified knowledge.

Changes and consolidation: The BIM Collaboration Hub, supports Engineering Change, including notifications and work flows. In the PLCS environment, and the BIM Collaboration Hub, the concepts of consolidation and integration are used for keeping the model consistent.

Access control and information ownership: In PLCS this is managed by view definitions, with context. The integrated and consolidated model of the building, site, and related infrastructure is available for all actors with access rights. Reference data libraries are linked as external references in PLCS.

4.2. Research issues

The research at the lab will focus on collaboration over the life cycle of buildings. This includes all the different actors in the sector. Examples of current and potential research issues regarding the collaboration processes are (Tarandi, 2012):

- Requirements management and evaluation
- Versioning and Change management
- Partial model exchanges

- System and service integration throughout the whole lifecycle
- Capabilities for knowledge sharing and development
- Long transactions and consolidation of information.

These issues are technically oriented and follow formalized exchange scenarios. Another view that will be studied is the more dynamic alternative where information can be exchanged ad hoc. Fig. 5. illustrates the goal defining process during the design phase and the goal governed process during the construction phase. Based on this proposal, the change management during the early design phase should be less formal than during the construction phase where also small changes can have significant consequences.

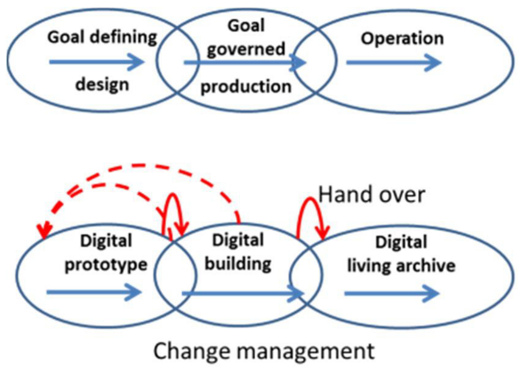


Fig. 5. The processes during design, production and FM/operation for a goal defining design and a goal governed construction phase.

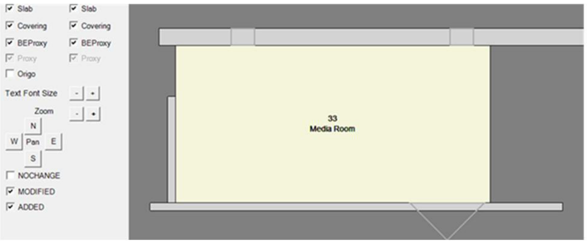
5. Case study

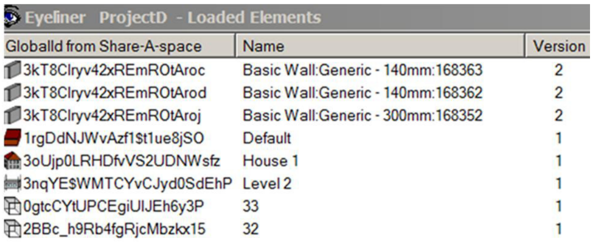
The BIM Collaboration Hub is now built to support collaboration research based on both input from academia and industry. The first experiments have been carried out (Versioning and Change management). One input came from a large consultant company. Their issue was how to over time manage the BIM during operation and facility management, based on open standards. How can a part of the model be used by a new designer and a new design software to perform the modifications in the future? How can the modified building elements be used to consolidate the existing BIM repository?

One floor was exported as an IFC 2x3 file and opened in Revit to be modified, see Fig. 6. One wall was taken away and doors were moved. A new IFC 2x3 file was exported from Revit with the modified building elements having a change status to enable version update in the BIM repository.

Fig. 6. The floor to export as IFC-objects in the Hub, the planned changes to do in Revit and the consolidated floor in the Hub

In Fig. 7. the version of the modified building elements is 2 (3 walls) and the unchanged and new have version 1. The floor is shown with the new status of the building elements. At the same time all the old versions are accessible when going back in time in the repository. The changes and new versions are now available for the FM usage.




Eyeliner ProjectD - Loaded Elements

GlobalId from Share-A-space	Name	Version
3kT8Clryv42xREmROtAroc	Basic Wall:Generic - 140mm:168363	2
3kT8Clryv42xREmROtArod	Basic Wall:Generic - 140mm:168362	2
3kT8Clryv42xREmROtAroj	Basic Wall:Generic - 300mm:168352	2
1rgDdNJWvAzf1$t1ue8jSO	Default	1
3oUjp0LRHDfvVS2UDNWsfz	House 1	1
3nqYE$WMTCYvCJyd0SdEhP	Level 2	1
0gtcCYtUPCEgiUlJEh6y3P	33	1
2BBc_h9Rb4fgRjcMbzkx15	32	1

Fig. 7. A 2D view of the IFC modified and added objects, a list with 3 walls with version 2 and the new room 33 with version 1, all in the Hub

6. Conclusions

This paper presents the functionalities of the recently developed BIM Collaboration Lab at KTH which functions as the centre for advanced research and development within BIM collaboration in co-operation with industry, academia and society.

It proposes a collaboration model for sustainable information practices based on the experience and results gathered during a previous EU project – InPro. Real-life issues related to efficient collaboration and information management will be studied, to support stakeholder collaboration in research projects. The currently performed studies support the theories of through life support based on a framework of open PLM standards to improve the design and construction processes.

The whole built environment will be in the scope of the lab research, and use cases supporting the processes of the future will be identified. Integrated design and delivery solutions are of specific interest.

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