REQUIREMENTS FOR MODEL SERVER ENABLED COLLABORATING ON BUILDING INFORMATION MODELS

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The application of Building Information Modelling (BIM) has demonstrated enormous potential to deliver consistency in the construction collaboration process. BIM can define an explicit configuration for digitized information exchange, however the technology to collaborate on models has not yet delivered the industry requirements for BIM collaboration. This research project is intended to provide a fresh review of industry requirements for BIM collaboration and will analyse how these requirements can be supported using a model server as a collaboration platform. This paper presents a review of existing collaboration platforms, with a particular focus to evaluate the research and development efforts on model servers as a collaboration platform. This paper also reports on the findings of three focus group sessions with industry practitioners to identify any problems in the available collaboration systems. The focus group findings identify a number of issues in current collaboration environments which help to understand the main domains of user requirements for BIM collaboration. These requirement domains will be further analysed to identify functional and technical specifications for a model server enabled collaboration platform.

Keywords: BIM; User requirements; Model Server; Design Collaboration.

INTRODUCTION

The architectural engineering and construction (AEC) industry has been criticized because of poor coordination and inconsistency in the way that multi-disciplinary practices manage and exchange project information. The application of Building Information Modelling (BIM) can overcome these problems by transforming the established document oriented collaboration practices into integrated model based collaboration of construction information with embedded intelligence. The full potential of BIM requires open standard collaborative working to produce semantically correct Building Information Models and a collaboration platform to share and exchange design models seamlessly across the various construction disciplines. BIM can deliver an explicit configuration for merging and approving design revisions, however, there lacks a

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rigorous and testable methodology for capturing the workflows that define the exchange processes in the BIM design collaboration.

The use of project extranets over the last decade has improved the exchange of 2D project data across distributed project teams but the model based information exchange is still limited and experimental. Mostly emails are used to exchange the model data as files which is against the industry collaboration standards, such as BS1192 (2007) which recommends to exchange information using a common data environment (CDE) avoiding the ad-hoc exchange of information. In addition, emails and file based extranets cannot support model collaboration because of much larger file size and requirements of partial data exchanges in case of models. A proposed solution for model centric collaboration is use of model servers coupled with extranets based on open data standards such as Industry Foundation Classes (IFC). Model servers are a type of database systems which host model data and allow multiple users to perform coordination operation on the models or components of models (Jørgensen et.al, 2008). There are few model server based collaboration solutions available (EXPRESS Data Manager [8], Share a space [9], Activefacility[2], ArchiCAD Teamwork [10], BIMserve [7], G Team [16], BIMstroms [4] etc.), yet their BIM collaboration features are either basic or very costly, complex, on-premises (non-collaborative) or supports only proprietary BIM data. Another key problem with the existing BIM collaboration systems is that these are developed in isolation with a diverse range of functions which do not integrate with the established work practices in the industry. There are very few studies on how these functions have evolved in the available model collaboration systems and how these correspond to the user requirements and the established industry standards for collaboration (e.g.BS 1192:2007). Therefore, the research will provide a fresh review of Industry requirements for BIM collaboration, the potential of model servers as a collaboration platform and a methodology to manage the BIM collaboration process integrated with the industry collaboration standards using model server as a collaboration platform. This paper presents the preliminary research investigations of the industry requirements for BIM collaboration based on three participatory focus group interview sessions.

REVIEW OF EXISTING COLLABORATION SYSTEMS

In the past 20 years, a number of research and commercial efforts have been initiated to provide model collaboration capabilities based on model servers using STEP and IFC methodologies. For example, IMSvr, (Adachi, 2002) was developed to manage the sharing of IFC models but the essential features were missing web support and simple graphical user interface. The SABLE server (SABLE, 2003) was developed to resolve the issue of multiple application interfaces to support IFC model sharing across distributed work environments. Unfortunately these model servers have been discontinued, (Beetz et al, 2010). EDM (Express Data Manager) by Jotne EPM technologies [8] and Share a space by Eurostep [9] are well established model servers which work well for model collaboration, however these are developed on the manufacturing industry’s business model and only suit large companies due to the software cost implications. The user interface in the EDM products is complex and users have to buy several products for full functionality (Taylor et al, 2009). The cost of buying the licences for the full range of products is considerable and restricts widespread use and therefore effective collaboration of SMSs (small and medium enterprises) in the construction process. Activefacility [2] is a web based model server designed to host and manage the project data for clients, (Taylor et al, 2009). The Graphisoft BIM Server [10] allows multi user collaboration on models but it only supports

ArchiCAD native models. Tekla BIMsight[15], and BIMserver [7] (Beetz et al., 2010) are very good initiatives yet their implementation in the industry is limited because of installation pre-requisites, complex interface and limited features. Several extranet providers have also upgraded their products to provide some model collaboration features, for example Asite[3], 4Projects [1]. There are also a few other web based tools which offer basic model viewing and navigation, for example IFC SDK[13], OpenIFCTools [14], ifcOpenShell [12], B-Processor [5] and BIM surfer [6]. The available collaboration products have been developed in isolation and their functions heavily depend on the business model and origin of the developers. These collaboration systems provide a variety of functionality including document management, on site coordination, workflow management and limited model coordination & management. These BIM collaboration technologies are developing at a fast pace and more service providers are embedding model server capabilities in their services or products.

In the last two decades, a number of research projects have supported the technology developments including Lockley et al. (1994), Eastman and Jeng (1999), Adachi (2002), Wise (2003), Kiviniemi et al (2005), Nour (2007), Plume and Mitchell (2007), Jørgensen et al. (2009) but these research efforts have been dedicated to the technical and functional aspects of model servers in which user requirements are completely neglected. Only few development projects like InPro (Nummelin et al., 2006) and BIMServer (Beetz et al., 2010) and a couple of research efforts (Gu et al. 2009 and Singh et al., 2011) have attempted to analyse the industry needs and functions of collaboration systems, however their focus has been to provide a descriptive set of the functionalities of a collaboration system rather than how these functions corresponds to the industry requirements and established collaboration protocols. A fresh review of industry needs for BIM collaboration is essential, as these studies have a short life span due to repositioning of the industry with changing BIM requirements and fast pace developments in the collaboration technologies.

METHODOLOGY: PA FOCUS GROUP SESSIONS

This paper presents the findings of three studies carried out using Participatory Appraisal (PA) focus group sessions. PA focus group is an approach involving in-depth group interviews, in which participants represent a specific population, and investigations are focused on a common area of interest among participants. The participants share some socio-technical characteristics, and selection is based on "applicability", which means subjects are related to the topic under investigation and they would have something to say about the study area, (Rabiee, 2004). There are literally hundreds of tools and activities for focus group for example , SWOT analysis, Brainstorming, Graffiti wall, Timeline, H-form, Spider diagram, critical ranking, impact ranking, force field mapping and drawing etc., (Langfordand and McDonagh, 2002). For this research, brainstorming, graffiti wall, H-form and spider diagram were frequently used because they are easy to understand for participants and they provide a problem exploration to a solution oriented approach.

Research Data

Three such PA focus group sessions were conducted with active participations from an architectural practice, a general contractor and a product manufacturer organization. The architectural practice is a regional leader in BIM adoption which is practicing BIM from last five years. The general contractor is a large, national size company and very actively involved in the developing and implementing BIM standards in the UK. The manufacturing company is a huge size multi industry product manufacturer who are developing their BIM product libraries. Each focus group was a 90 minute interactive session with the aim to investigate the problems in current collaboration systems and industry requirements for BIM collaboration platforms. Data collected was in the form of post-it notes, hand notes and recording of conversations. All the data was recorded and processed anonymously using the methodology described in Krueger (1994). The data analysis process is shown in figure 1

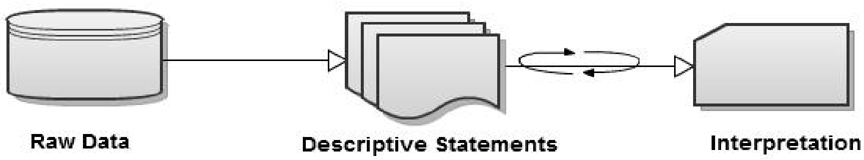

Figure 1: Krueger's (1994) data analysis model for focus groups

Following this model, the data was fully transcribed as comment segments in order to analyse it as open ended research data. Krueger & Casey (2000) advocate using a long table approach for focus group data; this technique was applied electronically using the MAXQDA 10 software package to apply a coding schema to the comment segments. Table 1.1 presents the summary of research data.

Focus Group	Participants	Role representation	Tool/Activity	No. of segments
Architectural practice	9	Architect	Brainstorming	
		Architectural Technician	Graffiti wall	
		Architectural Technologist	Timeline	94
		BIM development leader		
General contractor	7	R & D Project Manager	H-Form	
		BIM Engineers	Spider diagram	
		BIM Modeller		
		Senior Design Manager		143
		Senior Project Manager		
		Planning manager		
Product manufacturer	12	Marketing managers	Brainstorming	
		Business development manager	Graffiti Wall	127
		Technical Manager		
		BIM modellers		

Table 1: Summary of research data

The comment segments were grouped into the three main themes of focus technology, process and people in order to summarise the discussion relating to issues in current collaboration systems. The technology related segments indicate that discussion has revolved around technical flaws in current collaboration technology, for example segments like "*that's a downside within the extranet; the tool forces you to use the naming convention it follows*". The process related segments reflect the process inefficiencies in current systems, for example "*There should be standard gateway for enquiries because we get enquires from a wide range of construction roles*". The people related segments discussed the issues related to constant training, learning curve, and adaptability and resistant towards change in human nature. The start-up questions, follow up questions, general inquires or other information from participants are grouped under the general category. These content segment categories reflect the focus of a particular population is the three studies, which is presented in figure 2.

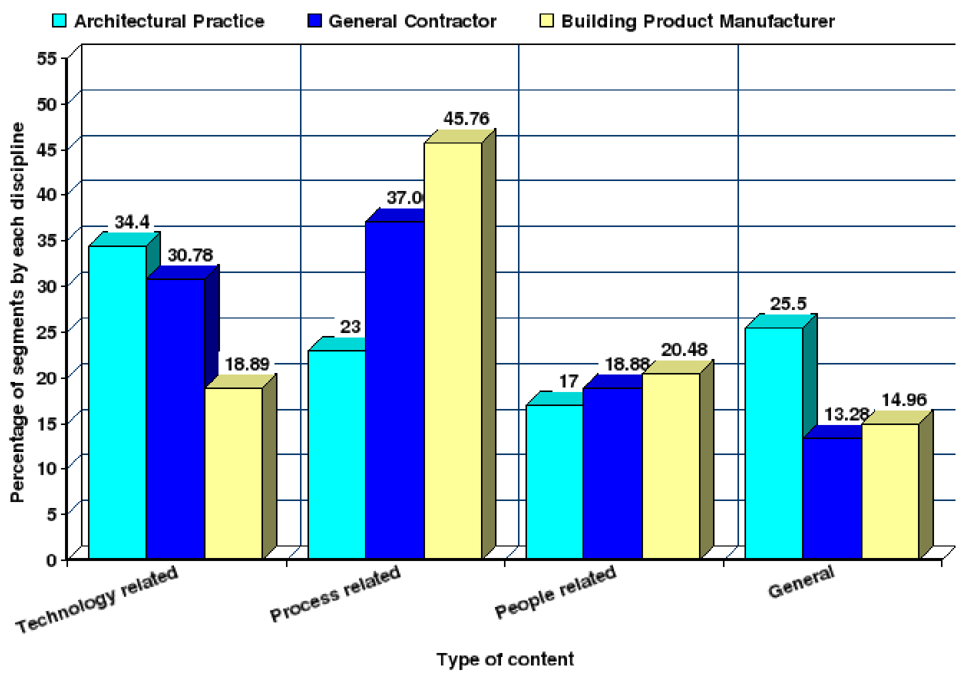

Figure 2: Focus group organization and type of content

The analysis of comment segments has showed that the technical content has been the main focus of architects, which is also supported by Taylor et al (2009) as they claimed that the architects are centric towards technical aspects as they perceive BIM collaboration as an extension of their current CAD capabilities. They are more concerned about improving the modelling technology for better visualization and efficient document generation form the models. The architects expressed that there is not enough push form clients and other industry stakeholders to transfer towards model centric collaboration. It is expected that this situation will rapidly change after this new wave of BIM adoption in the UK construction industry because of Government initiatives to make BIM mandatory on all public sector projects. The contractors and manufacturers are centric towards process related issues as they consider BIM collaboration as an value adding active to their business, however they are unclear how to execute this process correctly, which also reinforce the direction of this research.

Research Findings

The following are the key observations from the focus group investigations:

Diversity of collaboration systems:
The available collaboration systems are developed independently and their functions, features and operation are very diverse which means it is very difficult to master them all. Even individual collaboration products have multiple versions, so the migration among fundamentally different collaborating systems and versions is a real problem in managing collaborative working.

Nomenclature & Compatibility:
The construction companies tend to use their internal standards for naming conventions which requires a lot of rework during information exchange with other stakeholders. Moreover, available collaboration platforms are based on different nomenclature systems and they restrict the user to following and collaborating within the same system. The available collaboration standards (e.g. BS:1192) are not being implemented as the participants found them difficult to access, complex and ever changing. The participants suggested that use of certain communication protocols and collaboration standards should be agreed at the start of a project and the collaboration systems should have flexibility to implement these standards from project to project.

Training and learning curve:
The constant training and learning curve is another issue related to technology updates and migration among different collaboration systems. Participants were concerned that there is a steep learning curve along with extensive resource utilization to adopt these emerging collaboration solutions in order to survive in the current competitive market. This issue is associated with human nature.

Drawing is the currency:
The industry roles are using collaboration platforms to exchange information which is only complete with a drawing or a reference to a drawing. It is the output that is of interest rather than how to collaborate to generate that output and at this moment, the only acceptable output is a drawing, (electronic or paper). The participants were agreed that drawings and numbers work better than models for clients, especially for commercial clients. There were some very strong comments in favour of drawings, for example “we are never going to work without paper”, “drawings can’t be replaced” reflecting the clarity of information within drawings which need to be defined for models to make it work for the construction industry.

Email is the wrong medium:
The collaboration products generate a lot of automated emails to communicate updates or changes within existing information and everybody dislikes this. Unwanted emails cause distraction from work and are perceived as wasting a lot of time, particularly as it is very difficult to know which email is important. People tend to send drawings, instructions, requests for

information, reports, building models and other documents via email even though they felt it was not the right medium for official communication of information.

BIM is uncontrolled:
The focus group raised the concerns about controlling the information content generation in a BIM collaboration environment. Models cannot be treated the same as drawings. Models contain hundreds of drawing views of a building. One change in a model can potentially update any number of these drawing views and it is extremely difficult for the model author to know which views have been impacted. It is essential to have some kind of control over content being created and exchanged in BIM environments.

Model change and version management:
Model based information exchanges are not feasible unless there is a mechanism for defining the ability to hold back any changes in the working models. BIM tools currently generate updated drawings from the model but don't have any mechanisms to help identify what has changed since previous versions, which can lead to coordination failures. This raises the issue of small design change management and version management of models in a model collaboration setting. The same piece of information could be at two places on drawings belonging to a same model and other design roles could not be aware of any changes or updates on someone else's responsibility in that model. Even with different versions of models it is difficult to identify what has changed from previous version and who hold the responsibility for it, hence knowing which version of the model is up to date is key while referencing any piece of information from a model. There has to be a definite version of model as a reference to all project roles until they provide their input to generated next version of that definite model for further reference.

Ownership and responsibility:
There was major concern surrounding the exchange of models and whether this resulted in an associated shift in the ownership and responsibility. For example, if a structural engineer submits a version of a model, whose responsibility is it to check if all walls are unchanged? There are advantages in working collaboratively using models but industry can't work if information is constantly modified with undefined authority and responsibility. Currently, in the case of drawings, information exchange is controlled and signed off by someone with authority. However, in the case of models it is often unclear what the implications of a seemingly small change are and consequently difficult to know which bits of the models are approved and which are still under progress. There was a general agreement among the participants that information should be owned by a role with defined responsibility, with the ability to submit updates to a definitive model for further deign development. To this end a responsibility matrix needs to be defined for permissions across roles on a project.

Intellectual property:
The participants showed a deep concern about the data security and intellectual property rights associated with collaborative BIM. For example, if manufacturers issue their product information in model format to other project stakeholders what's to stop their competitors using their work, with small changes, to create their own product models.

Model reliability:
The focus group discussion indicated that confidence in the model contents is currently quite low among the industry. The participants argued that the model is next to useless from a collaboration perspective in present working practice. Models are being created for discipline

specific functions and exchanged for information only rather than for decision making. The receiving role has to double check models with the drawings to make sure that the model represents an accurate design. So the time saved in modelling the information content is shifted in checking the accuracy of that information content. The participants were unclear about which project to collaborate in terms of BIM and suggested that their early involvement in a project and setting up collaboration protocols at the start of a project will help to reduce such uncertainties.

DISCUSSION

The issues identified in the focus group sessions are based on either the user's experiences, or their perceptions of future collaboration scenarios. It was noted that the current procurement system, volatile nature of models and uncertainty of the BIM market inhibit the scope of BIM collaboration. The participants suggested that the new collaboration platforms should include project start up support, the ability to define responsibility matrix on early stages, provide formal and informal communication channels and support static viewing of information i different reports generated from a model. It was noted that the contractors and manufacturers perceive BIM collaboration as an extension of existing collaboration products which run alongside their business process with minimum training requirements. The non-design disciplines are more concerned about the data content within the building models. For example, the product manufacturers are issuing information to a very wide range of industry stakeholders. They have created CAD product libraries which designers have been using for years for detailed design and now they are converting their product range with BIM based product libraries. This will increase the business potential for product manufacturers that are pioneers in developing such product libraries; however this will also raises issues related to data interpretability, intellectual property, data security, liability and insurances etc.

The focus group investigations reflect an overall picture of industry requirements towards BIM collaboration. The process related issues are dominant and industry stakeholders are expecting improved business collaboration with the adoption of these BIM collaboration platforms. The experience from focus groups and literature study suggests that there are four domains of functional requirements for model collaboration, which are model content management, model content creation, viewing & reporting and system administration.

- Model content management domain covers inter disciplinary collaboration tasks which are required to manage the integrity of model contents on a collaboration system (i.e. model server). For example model checking, model splitting, model merging, clash resolution etc.
- Model content creation domain requirements are related to create the information content in a Building Information Model. In a collaborative setting, this domain reflects the discipline specific line of development where users can add, delete, edit, modify, rename or update the contents of their discipline models using their native modelling tools and reference content from other discipline models.
- Viewing and reporting domain reflect the requirements which are related to review, mark-up and consult the information in the models. This include tasks like model/multiple model viewing, navigation/walkthrough, clash detection, colour

customization etc for design discussion or reporting on a stage gate or as per client/project requirement.

- System administration: System administration contains the requirements which related to system, users and data management, for example user profiling, access control, data backup, security etc.,

These requirements domains also indicate that a user could be of three types: a user could be a “contributor” who can perform model content creation operation; a user could be a “coordinator” who can perform model content management operation; and a user could be a “consulter” who has view only permissions to review and consult the contents of a model. For example, generation of various reports is mandatory on projects which could be a part of the project management process or client requirement or contractual obligations. This is a user requirement to generate such reports from the model contents (spread sheet, pdf etc.) or a progress model or an integrated model for facility management. For example, in the UK, all public sector projects will require COBie data (BIM task Group, 2012) at designated data drops in a project life cycle, so it will become a key industry requirement to generate, validate and share COBie data in a model collaborate process.

CONCLUSION AND FUTURE WORK

The aim of this research project is to investigate the industry requirements for BIM collaboration and evaluate the potential of model servers as a BIM collaboration platform. The literature study, desktop audit of existing collaboration systems and research investigations have been conducted to gain a fresh view of problems in current collaboration systems and industry expectations in future. Three focus group sessions with an architectural practice, general contractor and product manufacturer have highlighted a number of issues in current collaboration environments which are centric towards process improvement and technology update. The next generation of collaboration platforms are expected to be more accessible, flexible, use open standards and provide the technical functionality to embed business intelligence. The research has identified four domains of user requirements which are model content management, model content creation, viewing & reporting and system administration. These requirement domains will help to categorise the existing features of model collaboration platforms and a comparative analysis of these features will identify completeness or gaps in collaboration features according to user requirements in these domains. The user requirements are analysed into “use cases” for each of these domains and suggested user types (i.e. contributor, coordinator and consulter) reflect the level of permissions to be granted for each user in these case cases. The next step of research is to consolidate and validate these use cases using more detailed research investigations. Subsequently, the research results will provide functional and technical requirements for model servers which will be validated by implementation on the 4BIM collaboration platform which is developing model server capabilities on a existing commercial extranet.

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