ADOPTING BUILDING INFORMATION MODELING (BIM) AS COLLABORATION PLATFORM IN THE DESIGN INDUSTRY

NING GU, SINGH VISHAL, LONDON KERRY, LJILJANA BRANKOVIC
School of Architecture and Built Environment,
University of Newcastle, Australia
Ning.Gu@newcastle.edu.au

AND

TAYLOR CLAUDELLE
Nexuspoint solutions, Sydney, Australia

Abstract. This paper discusses the preliminary findings of an ongoing research project aimed at developing a technological, operational and strategic analysis of adopting BIM in AEC/FM (Architecture-Engineering-Construction/Facility Management) industry as a collaboration tool. Outcomes of the project will provide specifications and guidelines as well as establish industry standards for implementing BIM in practice. This research primarily focuses on BIM model servers as a collaboration platform, and hence the guidelines are aimed at enhancing collaboration capabilities. This paper reports on the findings from: (1) a critical review of latest BIM literature and commercial applications, and (2) workshops with focus groups on changing work-practice, role of technology, current perception and expectations of BIM. Layout for case studies being undertaken is presented. These findings provide a base to develop comprehensive software specifications and national guidelines for BIM with particular emphasis on BIM model servers as collaboration platforms.

Keywords. Building Information Modelling, Collaboration Platform

1. Introduction

BIM implementation in general involves a client-server model. BIM Model Server hosts the building data and usually does not include any application. Each discipline uses its own native applications to work on the data. This research aims to provide specifications and guidelines for facilitating collaboration in design through the use of BIM model servers. Specifications and guidelines will be generated based on the evaluation of current BIM applications, their usage scenarios, the industry work-practice, and processes and issues inhibiting the transition from isolated-discipline-based-3D-modeling to integrated model sharing and development; as envisioned in the BIM approach. This research involves the following steps: (a) A critical review of literature on BIM has been conducted to understand the background; (b) A desktop audit of BIM application tools has been conducted to understand the BIM process and functionalities; (c) Workshops with industry focus groups have been conducted to gain an understanding of their knowledge, interest, perception and expectations from the BIM approach; (d) Case studies with real world project data using different types of model servers are being conducted to test the key issues.

2. Desktop audit

A desktop audit of the different types of commercial applications that form a part of BIM approach has been conducted. This involved live demonstrations and trials, data gathered from product brochures (GehryTechnologies, Navisworks, EPM Technology 2004, etc.) and analysis of tools reported by other sources (www.aecbytes.com, CyonResearch 2003, STATSBYGG 2006). Products evaluated include BIM model servers, discipline specific design tools, planning tools, analysis tools, design review and viewing tools, FM tools, product libraries and so on. The desktop audit provided an overview of the technological capabilities and applications, their role in BIM approach and trends in development of commercial BIM applications.

A wide range of products are available for various applications that form a part of the BIM approach ranging from product suites to very specific products for design, analysis and libraries (Khemlani 2007a). There is a rapid growth in the number of supporting technologies and products, and only few of these are IFC (Industry Foundation Class) (Khemlani 2004) compatible, which means they can only be integrated with specific tools that accept those formats. Tools for early design phase (Pentilla 2007) and integration of conceptualization tools is lacking at the moment. The most popular design tools like ArchiCAD, Revit and Bentley are all weak in supporting conceptual design activities. Web-based product services are growing, benefiting from the object-based modelling that has gained a widespread acceptance. Object intelligence, which brings associativity and relationships within objects and object properties, and enables modelling constraints (Eastman et al 2004) has allowed emergence of more efficient analysis tools (Mitchelle et al 2007) that can automate a lot of processes that were so far primarily manual and time consuming.

3. Literature review

Extensive literature review on BIM has been conducted. Surprisingly there are very few academic papers on BIM. The literature reviewed includes white papers and technical reports from vendors (Autodesk, Bentley and Workman 2003, GreenwayConsulting 2003, Graphisoft, etc.), research conducted by academic institutes, guidelines and reports generated by regulatory and government institutions (AGC, GSA 2007), and newsletters and articles (www.aecbytes.com) on the practice and trends in AEC industry.

Though there are few real world examples of BIM usage (Khemlani 2007b, 2007c), in general the adoption rate has been rather lethargic. The primary reasons discussed in literature (Holzer 2007, Bernstein and Pittman 2004, Khemlani 2004a, 2006) include lack of initiative and training, varied market readiness across geographies, and reluctance to change the existing work-practice. In an industry where most projects are handled in multi-organizational teams the lack of clarity on the responsibilities, roles and benefits in using a BIM approach is an important inhibiting factor.

A recent survey by AECbytes (Khemlani 2007d) gives a good overview of the current status of BIM in the AEC industry. Some of the findings of earlier studies have been reinforced in the survey. These include: (1) Despite each disciplines working in 3D environment, collaboration is still primarily based on exchange of 2D drawings. (2) There is greater demand for object libraries and modelling capabilities. (3) Significance of technologies supporting distributed collaborative works has increased. (4) Smaller firms prefer more intuitive design and workspace environments, as reflected in popularity of Revit and ArchiCAD. Larger firms, often involved in large scale projects, prefer tools with greater flexibility in setting up project environments, and tools with strong modelling capabilities. Accordingly, Bentley Systems is more popular with large firms. (5) 3D visualization is no more a major concern. Users want to get more out of accurate models than just visualization. (6) Need for better training guides

and help on tools is emphasized. (7) Support on analysis, performance simulations and interoperability is important, but it is not a burning issue as per the survey.

4. Workshops with industry focus group

Two workshops have been conducted in two different metropolitan cities with active participation of national and international representatives from various sectors of AEC industry including architects, contractors, vendors, consultants, project managers, academicians and government agencies. The workshops were conducted to gain industry inputs, expectations and apprehensions. Discussions were recorded on tapes and analysed first using an open-ended approach to identify the main themes that were also reflected in literature review. Based on the main themes identified a coding scheme (Table 1) was developed for in-depth analysis.

Coding scheme: An open-ended analysis of workshop data and literature suggests that reasons for low adoption of BIM in the industry are not only technological, but also a matter of work-practice, the kind of training available to users, organizational structures, and business interests of the parties involved. Introduction of BIM and BIM model server as collaboration platform will require a different approach to data organization and structuring, and some legal/ contractual measures to deal with safety and work-practice related issues. Knowledge about BIM varies significantly across the different disciplines within the AEC industry. Discipline and type categories are used to cluster the data such that we can identify the pattern of BIM awareness, interest and knowledge across these disciplines. Keywords allow identification of major issues across the content categories for which we can set priority based on frequency of occurrence.

TABLE 1. Coding scheme and annotations of terms

	Categories	Annotations
Discipline		The role/ work background of the participant
Type		The purpose of the statement
	Suggestion/ideas	Discussing solutions
	Concern	Doubts and inhibitions
	Opinion	Indicative statement
	Observation	Information based on experience
	Query	Asking about
	Inform	Information on as-it-is
	Strategy	Discussing measures and approach
	Wishlist	Expressing wants "would like to"
Content		The main subject of statement
	Technical	About tools, formats/standards, features and capabilities
	Cultural/work-practice	About the way of working
	Structural/ data organization	How to organize data, what form, data sets, and so on.
	Training	Skill and knowledge acquisition
	Legal/ contractual	Regulatory, about
	Organizational- team	About the team-responsibilities, roles and collaboration
	Process/ method	Protocols, procedures and methodology
	Business case	Economic and market feasibility- benefits

4.1. PATTERNS OF WORKSHOP DATA

Three kinds of correlations have been mapped. **Discipline vs. content:** indicates what contents are main issues for specific disciplines; **Type vs. content:** indicates knowledge, interest and awareness about the content; and **Discipline vs. type:** indicates knowledge, interest and awareness across disciplines.

Figure1 shows the **discipline vs. content** graph for the second workshop. Patterns are similar to first workshop. During the second workshop, application vendors mostly provided information on technical aspects, suggesting a lack of awareness amongst the other industry players. Design disciplines talked more about the processes, methods and the work-practices than any other disciplines.

Data organization was primarily a concern for the architecture and design disciplines and vendors but the contractors were not much interested as expected. There was almost no discussion on legal/contractual aspects related to BIM approach in the first workshop, which was little different in the second workshop. This can be attributed to two main reasons: (a) Presence of a government architect in the second workshop. (b) The application vendor in the second workshop is a service provider and hence needs greater clarity on legal agreements and contracts, while the application vendors on the first day were product suppliers.

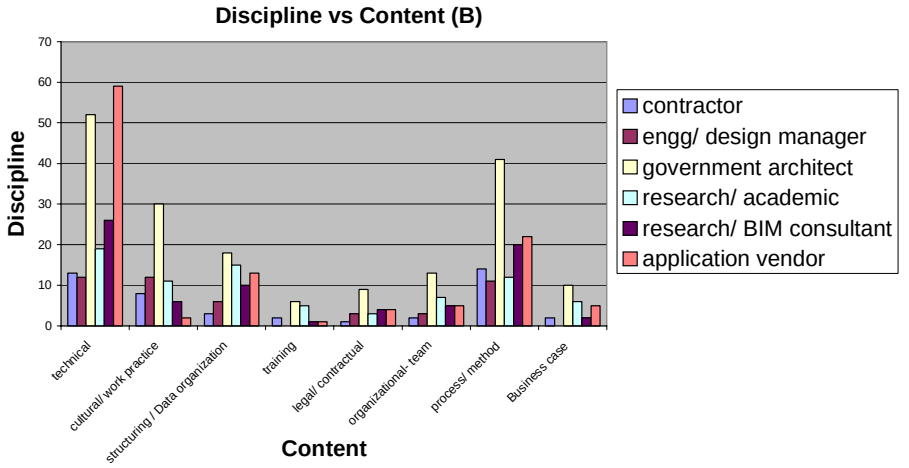

Figure1: Contents discussed by specific disciplines

Figure2 shows the **Type vs. content** graph for the second workshop. In both the workshops, technical discussions was primarily information sharing. Most opinions were related to technical and process related issues. Concerns raised were mainly related to technical, cultural/ work-practice and process/methods. While there were very few strategies discussed in the first workshop, more strategies were discussed in the second one relating to technical aspects, processes and business. The application provider in the second workshop being a service provider saw greater potential in new strategies for BIM adoption as they emphasize on customized services according to client requirements. Being a service provider they are more willing to have a flexible approach.

Figure3 shows the **discipline vs. type** graph for the second workshop. Architects shared views and opinions the most, mainly on technical, data organization and process related topics. Most of the concerns raised came from the architects, who also discussed strategies in both the workshops. In both workshops application vendors spent most of their time providing information. In the second workshop the vendor spent considerable time discussing strategies, primarily looking at BIM model server from a service point of view. Design managers provided information on current processes and work-practice.

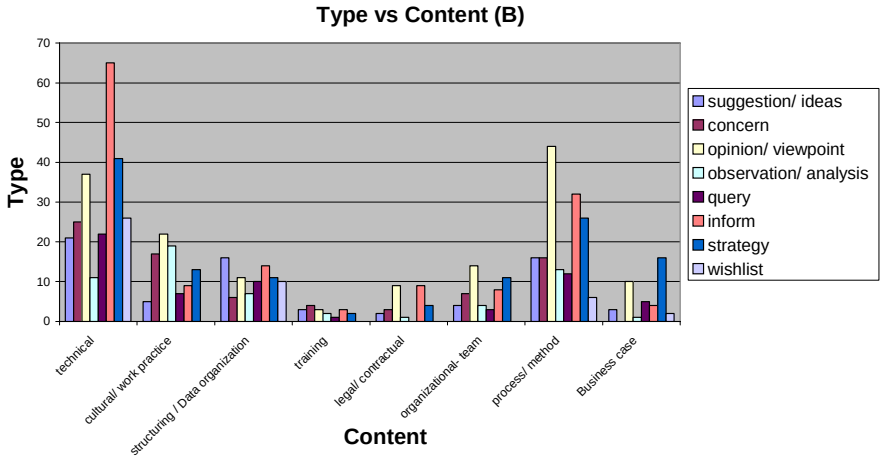

Figure2: Type of statements on specific contents

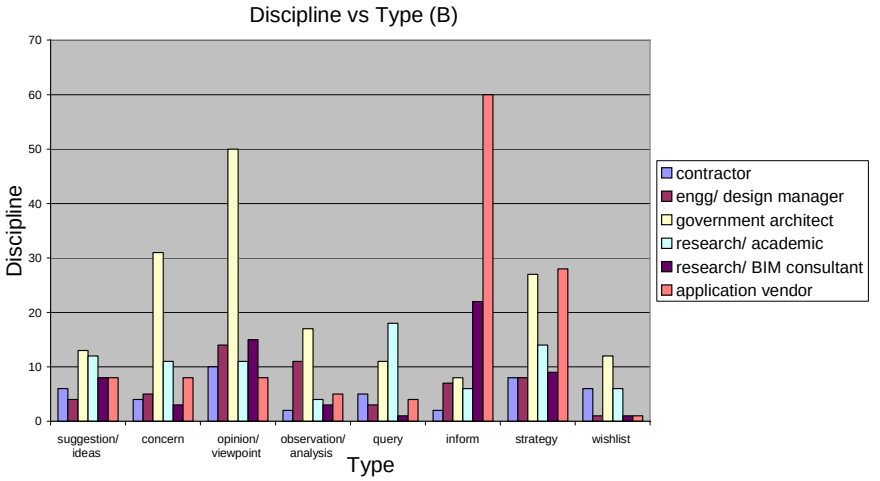

Figure3: Type of statements by specific disciplines

4.2. DISCUSSION

Technology and processes were the most prominent points in the workshop. While many issues discussed echo our findings from the literature review, the workshop gave greater insight into the causes for the inhibitions to BIM adoption. Main observations from the workshop are:

1. **Exchange of data** across disciplines is limited to 2D drawings due to lack of trust in 3D models, which may be due to the lack of agreed protocols in validating 3D models (though 3D model checkers are available), and the practice of often leaving models incomplete.

2. **Version control** raises various concerns: (a) **Version of project data:** if the BIM approach is to be adopted using an integral database on a model server, where each discipline maintains, modifies and updates the data then technical measures, work procedures and methods need to be in place to ensure data integrity, allowing different versions of the project to be maintained. (b) New **versions of the applications** keep coming, and quite often with significant differences. This brings in problems such as data loss and compatibility issues for teams using different versions. (c) **Version of IFC:** At present the IFC standards are still evolving, and have changed significantly in the last five years often making many of the earlier IFC data almost unreadable in the present format.
3. **Training in design schools:** In most schools CAD courses are independent of design sessions, and the design methodology taught in schools fails to integrate CAD in conceptual design. Similarly, students need to be trained in use of collaborative tools in team projects to be able to appreciate the benefits and processes involved.
4. **Key drivers:** Discussions in the workshops and experiences from the few examples of BIM implementations in real world projects suggest that there has to be a strong driving force to bring about the change. In most cases BIM usage has been enforced by the dominant partners in the project. Government and regulatory authorities can go a long way in promoting BIM usage, as seen in examples like CORENET (www.corenet.gov.sg).
5. **New roles and relationships:** 3D modelling has already become common place, and since 2D drawings can be generated out of 3D models, modellers have increasingly taken the place of draftsmen. What used to be "Architects and Draftsman" is changing to "Architects and modellers", and hence, roles and responsibilities are changing. Dedicated roles like BIM managers will be useful for improved project collaboration.
6. **As-built data:** Ability to support FM is an important value-added aspect for the BIM approach, making a strong business case for it. However, there has been no process so far in place for updating the designed model, to incorporate the changes made during construction. As-built drawings are useful for sustainability assessment and other performance measures. Projected building performance can be compared against as-built performance to evaluate design and construction quality.

5. Summary and Current Studies

The technical, work-practice and process related discussion dominates the workshops. Successful examples of BIM implementation in practice suggest that even in its present form, with suitable processes and work-practice in place, we can improve design development and collaboration using BIM. Current phase of our research involves case studies using available tools and data from real projects to verify the key issues identified from the literature review and workshop analysis. These include version management, data organization and structuring, data exchange, data ownership and control, activity coordination, and protocols for 3D model validation.

Data from two projects (a mid-size government project and a commercial project) have been obtained. A BIM approach is being adopted in these projects using two different commercial applications. EDM Model Server™ license has been obtained and ActiveFacility's service as model server will be used for the two case studies.

In using EDM Model Server™, users can directly structure and manage the building data. Main issues for verification and testing are: the IFC data export and import, check-in/check-out permissions and processes in the model server, the communication flow within the team, the kind of organizational re-structuring for project collaboration, and processes that need to be in place to co-ordinate the activities and model integrity.

Working with ActiveFacility, a BIM service provider, the issues are quite different because ActiveFacility manages the data for the client. Main issues likely to arise in this case are: legal/contractual issues, security concerns of the clients, and data co-ordination and ownership issues.

Factors relating to version management such as how to maintain history, what data-subsets to generate, how to structure model hierarchy for effective usage, and so on have emerged repetitively, and will be considered in both the cases. The two types of case studies will highlight issues that arise in in-house BIM development, and those where BIM service is provided by an external agent. Tested strategies and measures will be evaluated for their effectiveness in collaboration support using BIM model servers.

6. Conclusion

A comprehensive study of available BIM applications, literature review, and workshops with focus groups has been conducted to gain industry inputs, expectations and apprehensions on BIM adoption. A coding scheme was devised to analyze the workshop data, which allows prioritizing issues that emerged from the workshops, outlining their inter-connections. Based on this, layout for the case studies has been planned and presented. Case studies are currently being conducted to verify the identified issues, and test different strategies and measures. In the next stage of the research, earlier analysis and observations from the case studies will be used to generate software specifications and national guidelines, as well as establish industry standards for implementing BIM in practice, with particular emphasis on BIM model servers as collaboration platforms. These specifications and guidelines will be evaluated at the follow-up industry workshops.

Acknowledgements

This project is funded by Australian Cooperative Research Center for Construction Innovation (CRC-CI). The authors wish to thank all participants from the industry workshops.

References

AGC, America: The Contractors Guide to BIM, URL: http://iweb.agc.org/iweb/Purchase/ProductDetail.aspx?Product_code=2926

Autodesk: Building Information Modeling in practice, *Autodesk Building Industry Solutions*, URL: http://images.autodesk.com/adsk/files/bim_in_practice.pdf.

Bentley, K and Workman, B: 2003, Does The Building Industry Really Need to Start Over? A Response from Bentley to Autodesk's BIM/Revit Proposal for the Future, Bentley.

Bernstein, PG and Pittman, JH: 2004, Barriers to the adoption of Building Information Modeling in the building industry, Autodesk Building Solutions, URL: http://images.autodesk.com/adsk/files/bim_barriers_wp_mar05.pdf.

CyonResearch: 2003, The Building Information Model, A Look at Graphisoft's Virtual Building Concept (CyonResearch white paper), URL: http://www.cyonresearch.com

Eastman, C, Lee, G and Sacks, R: 2004, Development of a Knowledge-Rich CAD System for the North American Precast Concrete Industry, *ACADIA 22, Connecting Crossroads of Digital Discourse*, Indianapolis, IN. Ball State University, pp. 208-215.

EPM Technology: 2004, *EXPRESS DATA MANAGER™*, *Information* **1**(6), URL: http://www.epmtech.jotne.com

Gehry Technologies: Construction Industries Transformation (Brochure), *Gehry Technologie*, URL: http://www.gehrytechnologies.com

Graphisoft: A Strategy for Design, Construction and Management Services Collaboration, Sharing information based on the Virtual Building™ and the IFC™ object sharing protocol: IFC brochure, *Graphisoft*.

GreenwayConsulting: 2003, Revolution and Achievement: New Practice and Business Models Emerge in Study of Architecture, Design, and Real Estate, URL: http://images.autodesk.com/adsk/files/greenway_consulting_report.pdf

GSA: 2007, GSA BIM Guide Series, URL: http://www.gsa.gov/bim

Holzer, D: 2007, Are You Talking To Me? Why BIM Alone Is Not The Answer, URL:http://epress.lib.uts.edu.au/dspace/bitstream/2100/476/1/Holzer_Are+you+talking.pdf

Khemlani, L: 2004, The IFC Building Model: A Look Under the Hood, *AECbytes Feature*, March 30, 2004, URL: http://www.aecbytes.com/feature/2004/IFCmodel.html

Khemlani, L: 2004a, AEC Landscape and technology Adoption in India, *AECbytes Newsletter*, July, URL: http://www.aecbytes.com/newsletter/2004/issue_12.html

Khemlani, L: 2006, BIM Symposium at Uni. of Minnesota, *Building the Future AECbytes*, URL: http://www.aecbytes.com/buildingthefuture/2006/BIM_Symposium.html

Khemlani, L: 2007a, Supporting Tech. for BIM Exhibited at AIA 2007, Building the Future, *AECbytes*, URL: http://www.aecbytes.com/buildingthefuture/2007/AIA2007_Part2.html

Khemlani, L: 2007b, 2007 Third Annual BIM Awards Part 1, Building the Future , *AECbytes*, URL: http://www.aecbytes.com/buildingthefuture/2007/BIM_Awards_Part1.html

Khemlani, L: 2007c, 2007 Third Annual BIM Awards Part 2, Building the Future, *AECbytes*, URL: http://www.aecbytes.com/buildingthefuture/2007/BIM_Awards_Part2.html

Khemlani, L: 2007d, Top Criteria for BIM Solutions, A survey conducted by AECbytes, URL: http://www.aecbytes.com/feature/2007/BIMSurveyReport.html

Mitchelle, J, Wong, J and Plume, J: 2007, Design Collaboration Using IFC, A case study in thermal analysis, *Proceedings of CAADFutures 2007* (Eds.) Dong A, Vander Moere A & Gero JS, Springer; pp: 317-329.

Navisworks: JetStreamv5 from Navisworks, URL: http://www.navisworks.com

Pentilla, H: 2007, Early Architectural Design and BIM, *Proceedings CAADFutures 2007* (Eds.) Dong A, Vander Moere A & Gero JS, Springer; pp: 291-302.

STATSBYGG: 2006, Experiences in development and use of a digital Building Information Model BIM according to IFC standards from the building project of Tromsø University College (HITOS) after completed Full Conceptual Design Phase (report), R&D project no. 11251 Pilot project, Tromsø University College (HITOS) for testing IFC.