IDENTIFICATION OF A TECHNOLOGICAL FRAMEWORK FOR IMPLEMENTING BUILDING INFORMATION MODELLING IN SRI LANKA

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ABSTRACT

Building Information Modelling (BIM) is an important component in sustainable procurement strategies. With the rise in popularity, it is gaining the potential to be industry standard for building projects. By taking the digital design data to a new level, BIM promotes better integration and optimum use of resources for the sustainability in all aspects of construction. This is being experienced by more developed countries, which have gained benefits after successfully implementing BIM. Although BIM has not yet been implemented in Sri Lankan building industry, it is likely to be an option for consideration in the near future. As BIM is fully dependant on technology, determining a proper framework is an essential prerequisite. Considering the differences in the building industry among Sri Lanka and other countries, a generic framework will not be practically capable in facilitating such implementation successfully. Under this context, a research is conducted with the broader aim of determining a BIM technological framework for Sri Lanka, a special case where the current technology is minimal and funding ability is low. With preliminary findings from a literature review on the technological prerequisites of adopting BIM, this paper presents logical conclusions developed for technological aspects of implementing BIM for Sri Lankan building industry. The findings shall be a valuable source for all parties who are interested in utilizing BIM technology in the future for the sustainability in building industry of Sri Lanka.

Keywords: *Building Information Modelling; BIM; Construction; Sri Lanka; Sustainability.*

1. INTRODUCTION

The problems associated with the traditional design-bid-build procurement method are often conducive to Building Information Modelling (BIM) is a technology that is gaining worldwide attention which indicates the possibility of a paradigm shift in the building industry. Implementation of BIM is filled with challenges, adoption of technology being one. As Sri Lanka is yet to initiate BIM, developing a technological framework can be helpful in such implementation. This paper is a review of the current status of BIM in practice and technological prerequisites for it, which aims to build logical conclusions from the available knowledge. The work is a part of an ongoing research with the broader aim of developing a technological framework to facilitate implementation of BIM in Sri Lankan building industry.

2. BACKGROUND

The building industry is a well known latecomer to the productivity advantages offered by technology and its fragmented nature precludes widespread change of any kind, particularly to design tools that are based on the traditions of paper (Bernstein and Pittman, 2004). BIM is one such outcome of technology where a digital representation of physical and functional characteristics of a building is created with a shared knowledge resource for information about it that forms a reliable basis for decisions during its life cycle, from earliest conception to demolition (Construction Project Information Committee, 2011). Similarly Penttila (2006) stated that BIM is a methodology to manage

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the essential building design and project data in digital format throughout the building's life-cycle. BIM activity results in a 'Building Information Model', which is a three-dimensional parametric virtual model that enables a wide range of applications. BIM is not a software application. Instead it is an IT solution for integration of software applications and IT tools to design a building in a common platform, a platform which is independent of the software we use (Jayasena and Weddikkara, 2012). Therefore BIM can be clearly differentiated from traditional Computer Aided Design (CAD).

3. CAD VS BIM

BIM has to be differentiated from CAD. According to Royal Institution of Chartered Surveyors (2012), BIM changes the emphasis on a typical CAD model by making it the primary tool for documentation. It has enhanced information contained in virtual models (Grilo *et al.*, 2013) that are data-rich, object-oriented, intelligent and parametric in nature (Associated General Contractors of America, 2005). In contrast, Bernstein and Pittman (2004) explained the non-computable nature of CAD by comparing an output for a financial model created with a word processor and a spread-sheet. Although the output maybe visibly similar, the amount of work done may differ as a spread sheet has 'computable' data. Furthermore they stated, "The building industry, for the most part, has adopted the word processor approach to documenting building designs over the past 20 years" (Bernstein and Pittman, 2004). Luthra (2010) suggested that, the computable data of BIM puts it a step ahead of CAD files which constitute of raw data. Hence BIM can be considered as the better choice for the progression for the building industry.

4. SUSTAINABLE PROCUREMENT AND BIM ADOPTION

United Nations Global Marketplace (2010) defined 'Sustainable Procurement' as procurement which integrates requirements, specifications and criteria that are compatible and in favour of the protection of the environment, of social progress and in support of economic development, namely by seeking resource efficiency, improving the quality of products and services and ultimately optimizing costs. Building procurement deals with design, construction and operation, in which the sustainability is a major requirement in all these stages. Wong and Fan (2013) stated that BIM is a critical element in reducing industry waste, adding value to industry products and decreasing environmental damage.

The importance of BIM adoption is becoming increasingly recognised and BIM implementations and discussions continue to increase in intensity (Succar, 2009) due to its value adding potential to the building industry that has been facing barriers and challenges to improve productivity, efficiency, quality and sustainable development (Khosrowshahi and Aryici, 2012). Therefore BIM is now being increasingly used as an emerging technology in many countries, where they are currently in the process of or have released BIM guidelines (Wong *et al.*, 2009). The UK Cabinet Report published on May 2011 has announced the Government's intention to require collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016 (Poletayeva, 2011). BIM's use is promoted collaboratively by public and private sectors in the USA (Underwood and Isikdag, 2011) where it has gained a quick momentum with a 75% increase in usage between 2007 and 2009 with 93% of users believing it having the potential to gain more value in the future (Smart Market Report, 2009). Therefore it is evident that, BIM is getting wider attention and acceptance throughout the world.

5. BIM IMPLEMENTATION

Implementing BIM is a challenging task. Bernstein and Pittman (2004) had the view that, the transition to BIM based paradigms will be a greater shift than that of paper to CAD, as it entails a change in both tools and process. Smart Market Report (2009) highlighted the non-user perspective for BIM, in which lack of time to evaluate BIM, high costs for software/hardware upgrades, non identification of sufficient BIM compatible content for the relevant field are listed as some of the key setbacks. Eastman *et al.* (2008) recognized the most significant change that companies face when implementing BIM technology is intensively using a shared building model during design phases and a coordinated set of building models during construction and fabrication, as the basis of all work processes and for collaboration. To overcome most of these challenges, Arayici *et al.* (2011a) suggested a bottom-up approach for BIM implementation. However, such approach should be backed by a suitable basis for implementation.

As BIM is fully dependant on technology, utilizing a proper technological framework is an essential prerequisite. According to AEC (UK) BIM Protocol Project BIM Execution Plan (2012), the exchange of information between all stakeholders is a key factor in execution of a successful BIM project. To support this, even though a multitude of guidelines and reports are available, they do not provide sufficient foundational framework suitable for the systematic investigation of the BIM domain (Succar, 2009).

5.1. BIM SPECIFIC SOFTWARE

BIM software tools are characterised by the ability to compile virtual models of buildings using machine-readable parametric objects that exhibit behaviour commensurate with the need to design, analyse, and test a building design (Sacks *et al.*, 2004). Over the years, many software vendors have developed off-the-shelf software focusing on BIM, such as Autodesk Revit, Autodesk Navisworks, Bentley Architecture, Graphisoft ArchiCAD, Innovaya Visual BIM, Vico Estimator, Exactal CostX, Solibri IFC Optimizer to name a few. When considering implementation of BIM in any level or scale, selection of software can be a key aspect. Table 1 summarizes the findings of three separate researches regarding requirements and aspects to consider when selecting software to implement BIM.

Table 1: Prerequisites of Selecting BIM Specific Software

Criteria	**(Khemlani, 2007)**	**(Won and Lee, 2010)**	**(Arayici *et al.*, 2011b)**
Ability to input data to dimensional accuracy			√
Ability to issue BIM information to other Consultants			√
Ease of export to other formats and re-import accuracy			√
Compatibility with various formats (ifc, gdn, skp, dwg, dxf, pdf etc)	√	√	√
Ease of creating fixed export (eg: PDF) and 3D PDF capability			√
Ease of multiple team members working on the same model	√		√
Ease of setting up drawing sets, schedules, standards, templates			√
Ease of creating the model and adding new libraries	√	√	√
Ease of navigating around the BIM model			√
Scalability (ability to work on large scale projects)	√	√	
Full support for producing construction documents	√		
Market share position of the BIM software vendor	√		√
The use of the same software by other major competitors		√	
Built-in ability to generate photo realistic renderings and animations	√		√
Smart objects connecting with other objects/ parametric features	√		√
Object types and libraries available	√	√	√
File sizes of the models created			√
Multidisciplinary capability	√		
Initial investment cost including training and license costs		√	√
User support, tutorials, manuals and learning curve	√	√	√
Contractual requirement of use of BIM software		√	

Apart from the prerequisites mentioned in Table 1, Luthra (2010) identified some of the common problems associated with technological aspects of BIM implementation and areas that need better attention, as listed below.

- Incompatibility problems (file formats/standards/ versions) and application programming interface (API) customization problems need to be addressed at the initiation.
- BIM technology should be exploited to improve present workflows rather than adapting organization work flows to match BIM software's workflows, emphasizing the value of information exchange to support design processes.
- Database normalization should be given a high priority, while all input data should be collected in detail at the first time.
- An integration plan amalgamating software acquisition plan, training schedule, hardware update schedule, explanation of technological shift, and strategy roll-out plan needs to be developed to determine efficiency of new systems as a yardstick.
- The existing information storage, retrieval and exchange capabilities of the firm will need to be critically assessed, especially for Industry Foundation Class (IFC) compliance. IFC is an open, neutral data format developed by buildingSMART. Furthermore, data creation needs to be maintained, filed, indexed and documented.

5.2. HARDWARE AND OTHER REQUIREMENTS

In order to set up a functional BIM platform, essential hardware and network requirements need to be fulfilled.

- Computers (Personal computers or servers) – These requirements are specified according to the software vendor depending on the scale of usage and functions (such as rendering capability and details)
- Connectivity – Data transfer mechanisms need to be set up. Basically a Local Area Network (LAN) within the central design office/ site office is required to connect all the relevant computers to facilitate data exchange among them. Wired or wireless connection facilities need to be associated for this purpose. Furthermore, when files need to be transferred to different locations via internet, a broadband or higher category connection has to be used as the files become larger in size with added information and complexity.
- Servers and Databases – These can be within a design or site office, enabling a central data repository for BIM usage.
- OpenBIM - This is a free, open-source, software development toolkit that allows developers to create bespoke BIM middleware for IFC-based applications (OpenBIM, 2012). It is a good alternative to the high cost off-the-shelf BIM applications and provides the basis to write software that focuses on the actual requirement. The free and open-source application development is highly beneficial to especially the developing countries which cannot afford the application packages for BIM.
- Mobile Applications – BIM enabling software such as BIMX which is developed for Android based devices (Smart phones, tablets etc) allow the users to extend the BIM capabilities by providing the much needed mobility. With sufficient processing power of the device, it allows to regenerate BIM models with walkthrough capabilities, allowing a better platform for BIM usage.
- Cloud computing – According to Varkonyi (2011), the most basic approach to cloud computing is when the cloud is considered as a giant server that anyone can access for a fee

(via internet), where users can store their files in the cloud with virtually unlimited storage space that dynamically scales; data can be remotely accessed from any computer in the network; files can easily be shared with others; and the data itself is stored in a much higher security environment. This concept is used for BIM via 'Cloud-BIM' approaches. It is a method to share resources (both software and hardware that are highly expensive) and improve information sharing for BIM purposes. Chuang *et al.* (2011) stated that the Cloud-BIM system is able to present significant information in multiple modes such as text and graphical formats, by accessing the database of the Cloud-BIM system. Figure 1 is an extraction from the same work which illustrates the arrangement of Cloud-BIM.

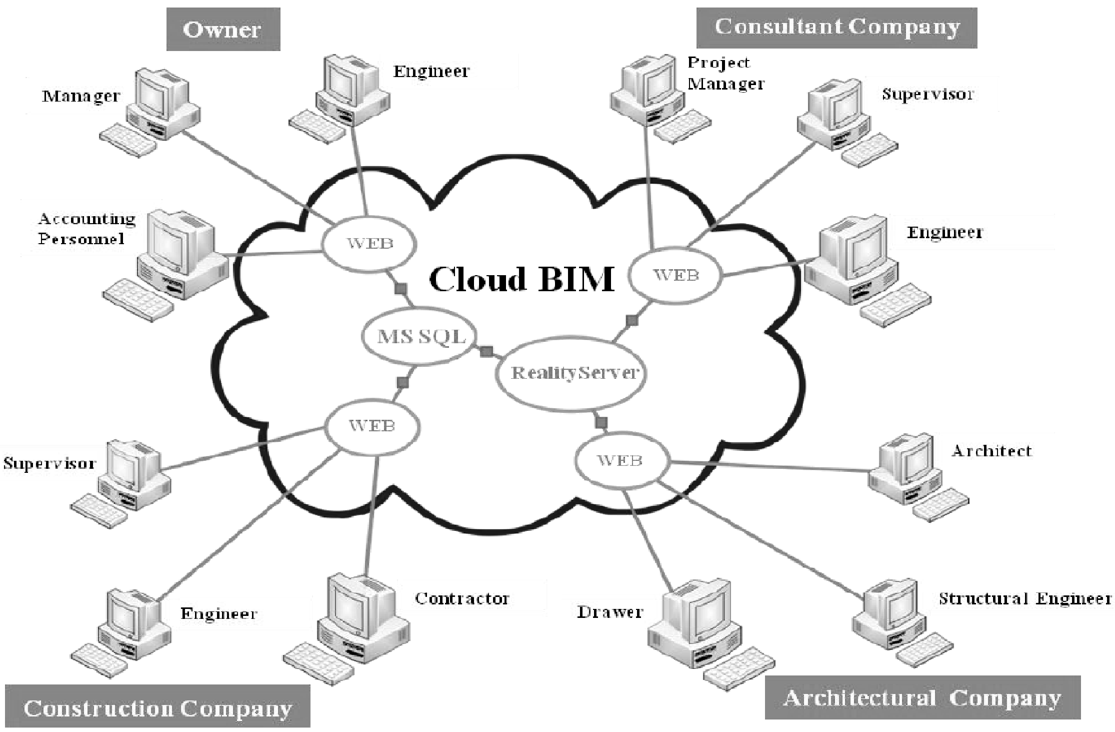

Figure 1: The Concept of Cloud-BIM (Chuang *et al.,* 2011)

5.3. *BIM PLATFORMS*

There are different approaches for BIM platforms when considering the data sharing methodology adopted. Basically two significant platforms can be identified.

There is, on the one hand, a group that strongly believes in working with a central data repository based on a single homogeneous software environment. On the other hand there are the believers of freedom for a project partner to choose its own software tools. This group also tends to believe in a shared data repository, but finds this has to be based on an open data model like IFC. We call these groups 'homogeneous software environment' and 'plural data environment'. Both propagate arguments on different levels of technology, usability and efficiency (Van Berlo *et al.,* 2012).

Based on the findings and conclusions of Van Berlo *et al.* (2012), Table 2 summarizes a comparison between Homogeneous software environment and Plural data environment.

Table 2: Comparison between Homogeneous and Plural Data Environments for BIM Platforms

Criterion	Homogeneous Software Environment	Plural Data Environment
Data sharing platform	Uses central data repository	Can use shared or central data repository
BIM Software	Proprietary applications/suites – Forced to select the same software for all collaborating parties. Cost of software is high and license sharing capability varies.	Bespoke middleware created for IFC based applications – Collaborating parties are free to choose own software tools to achieve higher performance in their engineering tasks
Data exchange	Mostly based on file formats that depend on the selected software	Mostly based on IFC data model
Data amalgamation/ Data fusion	Performed via live synchronization of data. Data duplication is possible	Performed via model fusion with fusion algorithms Data duplication is possible
BIM software modelling expertise	All team members require equal expertise	All team members do not require equal expertise when using reference models and IFC
Selection of project partners	Focus on the competency of a specific BIM software tool may overlook the actual competency in performing engineering tasks.	The use of reference model concept with IFC reduces the needed competency in BIM, there by maintaining the requirement of actual competency in performing engineering tasks.

6. TECHNOLOGICAL ASPECT OF BIM ADOPTION IN ASIA

In comparison to most Western countries that have already implemented BIM in major scale, Asian countries still have not initiated it in a similar extent yet. But a notable exception is Singapore where there is direct government involvement in implementing BIM. Even though there is no separate technological framework for BIM introduced, Building and Construction Authority (2012) mentioned some guidelines, for instance; collaboration parties should agree upon the BIM exchange protocol and submittal format (proprietary or open standard) in the BIM execution plan. Khemlani (2012) stated that China is indirectly advocating the use of BIM although it is not mandating BIM outright. Considering the construction sector of Hong Kong, Wong *et al,* (2009) suggested that a possible BIM policy should encourage open standard software development in relation to BIM. Meanwhile Luthra (2010) suggested that software licensing and training should be looked at as components of a strategic investment, while it is required to develop an integration plan amalgamating software acquisition plan, training schedule, hardware update schedule and explanation of technological shift for the Indian construction industry. Therefore it is clear that the technological aspect of BIM adoption in Asia is in different levels of maturity at present.

7. TECHNOLOGICAL ASPECT FOR FACILITATING BIM ADOPTION IN SRI LANKA

Sri Lankan building industry lags behind in any sort of BIM implementation compared to more developed countries that have successfully adopted and gained benefits of it. The following are some findings that provide insight to this situation.

- According to Reginold (2009), it was identified that the low level of usage of Information and Communication Technology (ICT) can badly affect to the construction productivity in Sri Lanka, hindering the ability to reach sustainable construction practices.

- Navaratna (2006) emphasized that Sri Lankan authorities have not given sufficient attention to improve construction productivity with use of ICT. This affects the ability to adopt BIM in the country.
- The general observations, especially in the public sector of construction which holds 74% construction value (Department of Census and Statistics Sri Lanka, 2011), suggested that, there is a high reluctance to invest in Architecture, Engineering and Construction (AEC) related software. As a result, there will be a significant impact when shifting to BIM specific software and hardware, which will require a high initial investment.
- The expenditure of only 0.11% of Gross Domestic Product in 2008 for research and development (The World Bank – Research and development expenditure, 2013) is significantly less than that of most other BIM implemented countries.

However, Jayasena and Weddikkara (2012) predicted that, once available, adoption of technology would not be a challenge in a nation with comparatively high ICT literacy and AEC professionals with fair computer knowhow.

8. CONCLUSIONS

BIM is a technology that provides the long awaited edge to the building industry over other manufacturing industries that benefit from automation. In comparison to traditional CAD which has its own uses, BIM enables totally machine readable building data with the use of strong information schema. It is gaining popularity and the countries that have implemented BIM have reaped its benefits already. The adoption of BIM has many aspects to consider, technological aspect being one. A systematic approach is required to identify the key components that require for implementing BIM. Sri Lankan building industry lags behind most of the Information Technology based advances. Therefore there is an essential need to overcome the technological barrier of BIM that hinders any progress in Sri Lanka. Hence a proper technological framework for BIM adoption will be a key requirement. Deciding on this framework, the first decision to make would be the choice between homogeneous software environment and plural data environment. The lack of technological advancement in the industry may further become a blessing in disguise in this context since it offers high flexibility to choose the right technology for strategic investors in BIM for their projects.

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