BIM SOFTWARE ENVIRONMENT FOR PROJECTS IN SRI LANKA

Himal Suranga Jayasena* and Chitra Weddikkara
Department of Building Economics, University of Moratuwa, Sri Lanka

ABSTRACT

The term Building Information Modelling, or BIM, is not alien to Sri Lanka anymore; yet BIM has not become a reality in its construction industry. Being a BIM infant industry, Sri Lanka may wait a long time to adopt BIM by its own initiative. But the scenario will be different if a client demands for BIM. This creates the need that industry is aware of the best strategies suite them to effectively implement a project based on BIM. One of the key questions being asked is; what software should we use? In absence of empirical local knowledge, the only option is to device a solution from published knowledge. In order to achieve this, this paper presents a literature synthesis aimed to identify a suitable BIM software environment for Sri Lanka. By reviewing various aspects such as capabilities of applications, accuracy and sharing of data, information documenting, popularity of software and affordability against the technological aspects, a Plural Software Environment based on IFC data exchange was found to be the preferred solution for Sri Lankan context.

Keywords: *Building Information Modelling; Software Environment; Sri Lanka.*

1. INTRODUCTION

Building Information Modelling, or BIM as it is widely known, is still not a reality in Sri Lanka. Being a BIM Infant Industry (Jayasena and Weddikkara, 2013) and a developing Asian economy (IMF, 2012), Sri Lanka would require unique adoption strategies to make the use of BIM worthwhile. The strategies adopted by the industries in BIM matured or maturing countries in different economic backgrounds are unlikely to be readily suitable for Sri Lankan industry. On the other hand, lack of maturity provides the flexibility to adopt from wider options since the choice is less constrained by losses from current technological investments.

Integrated information and automated systems are key components of BIM workflow. While these may not have been fully achieved even in BIM matured industry due to practical limitations and pending developments (Owen *et al*., 2010), significant achievements are likely to be possible even for a BIM infant industry if technologies are wisely selected. A wide variety of software has been developed for BIM since its early concepts were adopted in building industry more than two decades ago. Arbitrary selection of software can give rise to issues in terms of integration, consistency, accuracy and affordability. To minimise potential issues, an assessment of varying software environments for their suitability for Sri Lankan context is necessary. This paper presents a literature synthesis aimed to identify a suitable BIM software environment for Sri Lanka.

2. ABOUT BIM

BIM is in fact is an acronym representing two separate but consecutive functions and a product; Building Information Management, Building Information Modelling, and Building Information Model (Wong and Fan, 2013). The US National BIM Standards defines "Building Information Modelling (BIM) is digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition" (buildingSMART alliance, n.d.). This is the widely sighted definition for BIM though it is not much helpful for a reader who knows nothing about BIM.

Though BIM became buzzword in recent times, it is not very new. The concept of BIM has been talked about even in early 70's (refer Eastman *et al*., 1974). However, the earliest experience in BIM was presented

*Corresponding Author: E-mail - suranga@uom.lk

to the building industry only in late 80's with the introduction of Graphisoft's ArchiCAD (Laiserin, 2003). However, it was not yet known as BIM. Graphisoft called it Virtual Building. The earlier concepts were presented with variable terms such as Building Description Systems (Eastman *et al*., 1974) and Building Product Models (Eastman *et al*., 2011). Nevertheless, they all were rooted in the concept presently known as BIM.

BIM as a three letter acronym representing Building, Information, Modelling was coined by architect and Autodesk building industry strategist Phil Bernstein in 2002 who used the actual terms for BIM (Beck, 2008). Autodesk (2003) envisaged at this early stage that, BIM would support the continuous and immediate availability of project design scope, schedule, and cost information that is of high quality, reliable, integrated, and fully coordinated. It may be interesting to critically review how much Construction Software Industry has really achieved in two decades.

The beauty of BIM is that most BIM users need not understand technology behind it. All that is needed for a practitioner to be BIM ready is the capability of effectively using BIM software application(s) relevant to his/her practice. A good example is that many used ArchiCAD for years without knowing that it was a BIM tool. The associated technology opened numerous opportunities by enabling full construction of a building virtually in a computer. In addition to possibility for various simulations for quality and functional performance, BIM enabled automation of number of manual processes in conventional practices.

Most building professionals think that BIM is synonymous to 3D (3 Dimensional) modelling. This is an unfavourable perception that would hinder the proper understanding of BIM. BIM, being an information model is in fact nD. Conceptually, BIM is designed in a manner that it can hold information of any "n" number of information dimensions. For broader comprehension, probing into "open BIM" standards of buildingSMART (2013) is worthwhile.

The international standard for BIM data is Industry Foundation Classes (IFC). It is open source that anybody can freely adopt it (ISO, 2005). Figure 1 is a small portion of IFC BIM model viewed in a Word Processing application. Information is readable by human. For example, #9806 describes a wall element, giving some unique information about it and refers to some other locations in the model file viz. #13, #9803 and #9876, where each refers to model ownership, placement of the building, and geometrical placement of the wall. A particular data is recorded only once in the model and all other instances are reference to this information using hashtags (#"number") (Jayasena and De Silva, 2013). This enables a change in one design parameter of a building element (e.g. storey height) to be automatically reflected in all other related elements (e.g. vertical pipes).

```
…
#13= IFCOWNERHISTORY(#12,#5,$,.ADDED.,$,$,$,1286451639);
...
#36= IFCDIRECTION((0.,0.,1.));
..
#9792= IFCDIRECTION((-1.,0.,0.));
#9796= IFCCARTESIANPOINT((12.,0.,0.));
#9800= IFCAXIS2PLACEMENT3D(#9796,#36,#9792);
#9803= IFCLOCALPLACEMENT(#593,#9800);
#9806= IFCWALLSTANDARDCASE('16DNNqzfP2thtfaOflvsKA',#13, 'Wand-Ext-ERDG-
        4',$,$,#9803,#9876,'A6C3DE63-3731-4F6A-94-7E-DE8A8295779F');
#9825= IFCCARTESIANPOINT((0.,0.));
```

Figure 1: IFC Building Information Model
Source: Jayasena and De Silva (2013)

A BIM model "written" in this manner can be read and interpreted by computers to construct it virtually in their memory to the fullest detail it provides. A BIM is therefore a "computer interpretable digital description" of physical and functional characteristics of a facility. BIM models contains not only the geometrical information, but also many other information about the building. Since computers can interpret information, BIM enables virtual modelling for many domains such as energy modelling, safety modelling, and cost modelling. The software industry produces numerous tools for building practitioners to work in a convenient interface (e.g. 3D graphical for Architects) while communicating with (reading from and writing to) BIM in software backend.

3. BIM SOFTWARE

The term "BIM Software" may often become misleading. It cannot be construed in the same manner we used to understand "Draughting Software". Any draughting software had common feature that computer screen was a "drawing sheet" on which the drawings were created with lines and curves using common input methods available for computers. In contrast, a BIM Software is not a single type; it can be any computer tool that works BIM data format. Within this scope, even a spreadsheet application like MS Excel may become a BIM Software by use. Thus, a simplified definition is; BIM Software is computer software used to automate or support managing, modelling or visualising of BIM data. However, it is often the software used for modelling that is talked about under BIM Software.

Wide variety of BIM (or BIM compatible) software applications have been developed during the past two decades. Autodesk Revit, Bentley Architecture, Graphisoft ArchiCAD, Tekla Structures, Innovaya Visual BIM, Vico Estimator, Exactal CostX, Autodesk Navisworks, Solibri IFC Model Checker, and Synchro are among the popular applications. While some of them are for modelling, others are for reading the models for optimising, costing and scheduling. The following list of factors affecting the choice of software were expressly or impliedly had been identified by number of authors who discussed about BIM adoption (viz. Arayici *et al*., 2011, Khemlani, 2012, Won and Lee, 2010, Luthra, 2010, Gunasekara and Jayasena, 2013, Eastman *et al*., 2011).

1. Modelling and viewing capabilities of application
2. Accuracy of data in models
3. Sharing capability of models
4. Information documenting capabilities
5. Spread of usage or popularity of application
6. Affordability

This list provides a checklist and also can act as the framework for selection of suitable software applications.

3.1. MODELLING AND VIEWING CAPABILITIES OF APPLICATION

In selecting an application, emphasis is given on the features of the application and the ease of using them. Features can primarily be divided into two areas as (1) Model Viewing, and (2) Model Authoring. Model viewing includes ease of navigation around the model, filtering for object types and properties, and computed information such as areas and volumes. While authoring may primarily understood as 3D (3 dimensional) modelling, it also includes modelling with other parametric information such as materials, thermal properties and costs. Since the value of BIM becomes significant in large and complex projects, scalability is often considered to be of high importance.

3.2. ACCURACY OF DATA IN MODELS

Parametric accuracy of data in the model is a key advantage of BIM technology. However, accuracy of the data in the model depends on the input accuracy. Thus, ability given by the application for the user to input data accurately is an important aspect. Often talked about feature under this is "dimensional accuracy". Another concern is the accuracy of data exchanged between parties, which is in fact related to sharing capabilities of models authored.

3.3. *SHARING CAPABILITY OF MODELS*

Sharing capability may relate to the ability to issue BIM data to other parties in Temporary Multi Organisation (TMO). This arises from application's capability to import from and export to various file formats used by others (e.g. ifc, dxf, gdn, dwg, skp, pdf etc.). Capability so defined may not be nominal, accuracy of data in such exchange is crucial. Alternatively, sharing capability may be construed as the ease of multiple parties working in the same model. Either way, it is about the multidisciplinary capability of the system in use.

3.4. *INFORMATION DOCUMENTING CAPABILITIES*

Documenting capabilities of the software can vary on the type of application. In general, this refers to the capability of generating fixed exports necessary for construction and contract documents. Primary features includes export of models to 2D and 3D PDF (Portable Document Format), information and schedules to PDF, spreadsheet of document formats and direct printing. The features are enhanced by ease of setting up drawing sets, schedules, standards, templates. This also includes the ability to generate photo realistic renderings and animations

3.5. *SPREAD OF USAGE OR POPULARITY OF APPLICATION*

The spread and popularity of an application or vendor indicated by its market share in the region is often considered by the fresh adopters, and they usually favour them. While the most popular may not be the best in terms of capabilities, it generally offers ease of adoption since object types and libraries, and skills and knowledge for use and troubleshooting are likely to be widely available. In addition, it will help positioning the adopter among other major competitors. Therefore, the selection should not simply be the popular choice, but an informed judgment.

3.6. *AFFORDABILITY*

It is the affordability what matters at the final decision. However, it does not limit to the initial software cost (which includes licence and training), but also includes hardware, network upgrade and running costs. The running costs include user support, trouble shooting, server management, hardware maintenance and licence renewal (or subscriptions). Employee turnover cost will also be high as more orientation and training will be required. Thus the availability of user support, tutorial and manual, and the learning curve of applications are also of primary concern.

4. BIM SOFTWARE ENVIRONMENT

In absence of a national initiative, a bottom up approach for BIM implementation is suitable for Sri Lanka. Currently, there is no known initiative at any Sri Lankan organisation to adopt BIM. In this context, it likely that a client demands for BIM will be the strongest short-term enabler for BIM in Sri Lanka. How would the TMO respond to such demand? Will the varying types of software used by individual party in TMO support BIM? If not, how easily will they able adopt compatible software? These may be the questions one would ask; but in fact the answers to these depend on what BIM Software Environment is used.

In general, identifying the software used for authoring (modelling) in BIM implementation helps to understand the work arrangement and possibilities. For example, if Autodesk Revit is used for architectural modelling, it is generally preferred that other members of the team use Autodesk products or software supporting exchange of data in DWFx file format. Since there is however a large number of BIM authoring software, analysing them individually under each of the factor above is not the way forward.

The BIM Software Environment (BIMSE) has two aspects of concern.

1. Software Operating Environment, and
2. Runtime Environment

The Software Operating Environment or the Integrated Application Environment is about the environment in which the users run Application Software. Operating Environment (OE) is not synonymous to Operating

System (OS). OE is form of middleware that rests between the OS and the application. For BIM implementation, it is primarily related to the interface the users interact with BIM.

The Runtime Environment (RE) executes the activities of a computer language used in software environment. RE is what programme language uses to invoke various functions in a computer. For the spatial issue of the study (i.e. BIMSE), RE relates to the efficiency of interaction between (among) different software applications.

For the purpose of the study, analysis of core technological aspects is not necessary; instead, it demands the review of the practical implications of the technology. For ease of comprehension, a classification of BIMSE is helpful. The basic classification based on data model as (1) homogeneous software environment, and (2) Plural Software Environment identifies two widely different approaches to set up BIMSE for a BIM based project implementation. Table 1 presents a comparison between these software environments.

Table 1: Homogeneous and Plural Software Environments - Comparison

Criterion	**Homogeneous Software Environment**	**Plural Software Environment**
Data sharing platform	Central data repository	shared or central data repository
BIM Software	Proprietary applications/suites – Forced to select the same software by 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 AEC tasks
Data exchange	primarily based on file formats that depend on the selected software	primarily based on IFC data model
Data amalgamation/ Data fusion	Performed via live synchronisation 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.

Source: Gunasekara and Jayasena (2013)

The key feature of Homogeneous Software Environment is that one software (or more often a suite of software from one vendor) is selected to be the primary tool. Most such software (or vendor of the software) comes with a “server module” to act as the central data repository; alternatively, the primary software itself may have the built-in facility for this (refer Autodesk, n.d., Bentley, 2014, Graphisoft, n.d.). Working in these types of Software Environments offer live synchronising of all data among model contributors. The ownership of the elements of each contributor is flagged in model. Modification of an element by a different user than the original owner results in a duplication of the element in the model with a new flag. However, real-time synchronisation is not often preferred in the industry and they usually set it to manual or periodical (hourly/daily/weekly) synchronising primarily due to hardware (including network) limitations.

It is beneficial to construe the BIM working environment using the concept of “BIG BIM, little BIM” as described by (Jernigan, 2008). The BIM within the influential boundaries of a company is “little BIM”. The

BIM beyond the boundary is "BIG BIM". This occurs when a TMO is established for a project. In this context, BIG BIM represents the Central Data Repository, which is the Central Model in the native format of the selected Homogeneous Software Environment. The project partners (i.e. the members of TMO), will have to match their in-house software to support selected BIG BIM software environment. The practical approach would be to select the partners who can match their little BIMs to selected Software Environment.

An extension to this is that most proprietary systems have exchange formats for which supports the software from other vendors. For example, the Quantity Surveyor (QS) need not implement a software supporting native format. Instead they would use a QS specific software which supports exchange format of the selected Software Environment (Exactal, 2012). The drawback of this method is that exchange format may not include all necessary data.

Figure 2 graphically illustrates the Homogeneous Software Environment. Data sharing is shown for entire design and construction lifecycle where builder's as built model data is also shared with the architect. Engineer in the figure represent all different types of engineers involved in the project. It should be noted that this representation does not account contractual requirements. Certain exchange of data shown may not become contractually proper depending on the contractual arrangement.

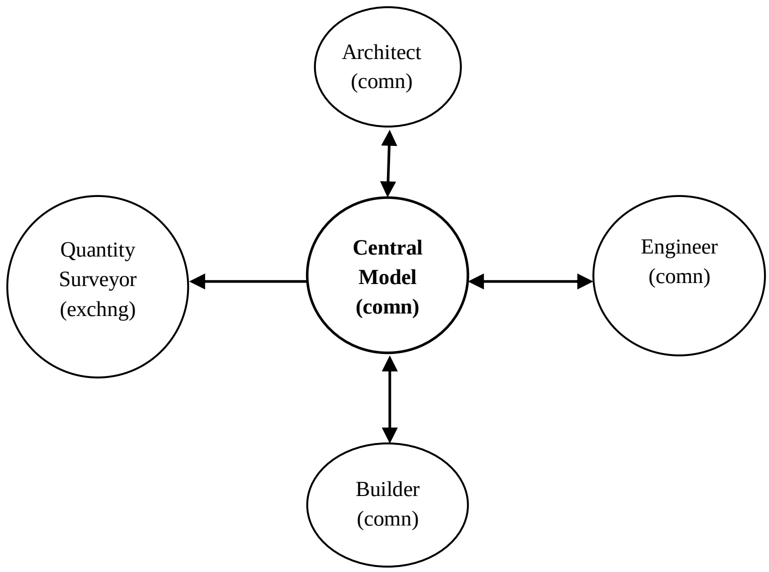

Figure 2: Data Exchange in Homogeneous Software Environment

Plural Software Environment relies on open standard IFC for data exchange. The traditional practice has been the model sharing; i.e. the native model is exported to IFC by the software, and this IFC model is sent to the other partners for further development and modification. Received IFC files are often converted to native format of the software they use for further authoring, and once done exported to IFC format to share with other partners. The software supports updating the current internal native model with the received IFC data to incorporate the development from other partners.

Illustrating the above with example, an Architect uses Archicad and models in its native format. She exports it to IFC to share with engineers. The Structural Engineer receives it and imports it to Tekla Structures native format and performs the structural modelling. It should be noted that IFC does not contain all data available in Archicad native model, but a set of predefined data that has been identified as necessary and satisfactory for collaborative working. What data is to be exchanged is defined by Model View Definition (MVD: refer buildingSMART alliance, n.d. for more informaton). Once done (to a level that he is ready to share), the Structural Engineer will export his model to IFC (note that this will not contain all data in his native model) and share with others. On receipt of it, the Architect, Electrical Engineer, HVAC Designer, etc. updates their native models with new data in received IFC.

The practical methods of data sharing in traditional practice of Plural Software Environment are shown in Figure 3. The figure should be construed by referring the generic description given for Figure 2 above.

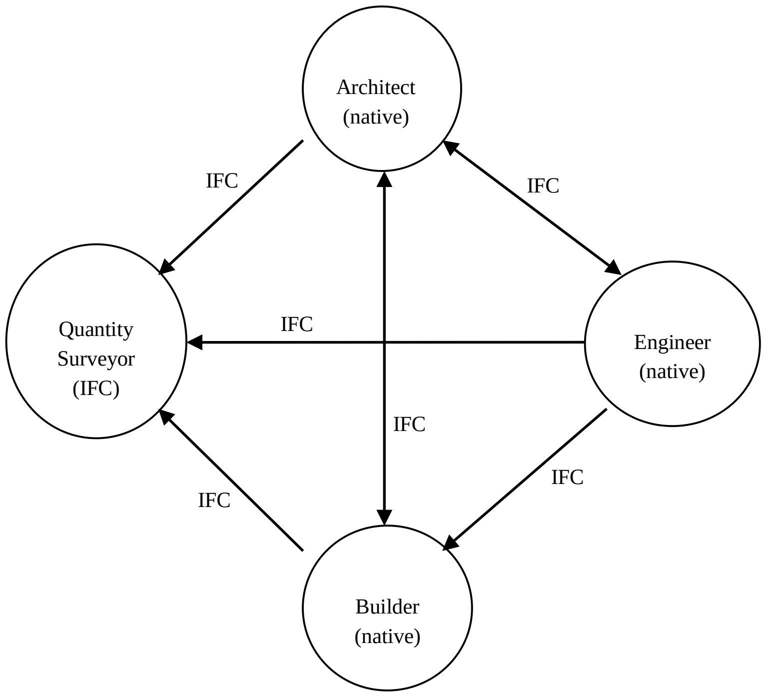

Figure 3: Data Exchange in Plural Software Environment

A successful experimental case of using Central Data Repository (based on IFC data exchange) in a Plural Software Environment has been reported by van Berlo *et al*. (2012). They used open source BIM server (refer BiMserver, n.d.) for their experiment. They share that "it is true that IFC will not contain the full dataset of the original, native data-base from the source software, but often the receiving user does not require all details. Occasionally some data became unreliable (objects are misplaced or gone) during import, but the overall quality of contemporary implementations was considered satisfying. The imported data is used as a reference during engineering. For example the MEP engineer uses some data from the structural engineer to design the location of the piping. The piping is not added to the original dataset of the structural engineer, but exported to IFC as a new dataset that is send to the central data repository" (van Berlo *et al*., 2012). Thus it is likely that the use of Central Data Repository in a Plural Software Environment is a practical reality.

5. ANALYSIS AND SYNTHESIS

While it has been popular for many to adapt Homogeneous Software Environment initially, the latest survey by National Building Specification UK (NBS, 2014) shows significant use of Plural Software Environment in BIM matured industries. However, BIM maturing and infant industries are likely to prefer Homogeneous Software Environment offered by software vendors as proprietary solutions due to accompanied customer support including structured learning resources. However, it is important to review such preference also in terms of overall effectiveness.

BIM practices are not totally alien to the Sri Lankan construction industry. Though there are no clear reports, it is known that BIM capable software such as Revit, Archicad and CostX being used by some in the industry. However, these uses are not in BIM based project environment, but used as in-house tools to generate non-BIM information such as 2D drawings and 3D graphics.

Multiparty collaborating using a central model may not be readily acceptable for the industry participants. Members of TMO will prefer to use private repositories (or models) to keep their unshared data within the little BIM, and as the design (or model) develops exchange the permissible data with the BIG BIM (Nour, 2009). Ideally, the software tools must be selected based on the tasks performed by the member, but not on the ability to share data with others. Accordingly, it is likely that a Plural Software Environment to be the most favoured solution for Sri Lankan industry.

In an industry of a developing economy, affordability will be a significant factor in selection of software applications. Plural Software Environment will allow the flexibility, and the increasing support for IFC with the development of free and/or open source software will make the technology affordable for participants with limited affordability (budget constraints).

It is not necessary that all data is available for everybody to perform good collaborative AEC project; but what is important is that all necessary data for each partner is available. The data that is shared by other partners shall be exchanged via BIG BIM; private data can reside in their own repositories. There is no requirement that a model is exchanged via few software tools using IFC (i.e. import and then export by one software to another) to contain all data it has in the first model. Therefore, it is unwise to be misled by the concept of "round tripping" which is discussed by some authors highlighting that some information is lost during the trip. However, the consistency of information during the trip is critical for interoperability.

There can be limitations in using IFC but these may not become significant barriers if the limitations are understood and accounted for (Bazjanac and Kiviniemi, 2007). The experiment of van Berlo *et al*. (2012) was before the release of IFC4 which should be better than IFC3 (IFC4 is described in detail in Liebich *et al*., 2013). Powerful free to use IFC model viewers such as Solibri Model Viewer (Solibri, n.d.) provides anybody to access any information in IFC data models through a user friendly graphical interface. Thus the use of IFC is unlikely to cause issues in dissemination of information to downstream.

6. CONCLUSIONS AND RECOMMENDATIONS

The synthesis of current knowledge from literature combined with generic knowledge about the Sri Lankan context shows that Plural Software Environment likely to be the preferred solution for Sri Lankan context. It will offer the flexibility for participants to select the software tools for their requirements, preference and affordability. Open source BIM Server, which is freely available, is recommended to be used as the central data repository. Implementation will obviously require the support of Information Technology Experts.

Initial adoption may become very much challenging due to required changes in practices (not much influenced by BIMSE), and cultural and legal barriers which were not considered in this paper. These aspects are also to be reviewed in decision making regarding adaption of BIM.

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