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BUILDING INFORMATION MODELLING (BIM) IN BUILDING LIFE CYCLE

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Abstract:
Building Information Modelling (BIM) is a methodology that influences data to analyze and predict outcomes through different phase of a building life cycle. It helps in terms of facilitating the delivery of building information to the building stakeholders. In today's modern era, the emergence of Building Automation System (BAS) gives a significant impact on the life cycle of building by introducing a new way of how energy usage of a building is managed. As a new technological system, BAS obviously has its challenges in implementation and management. The paper's objectives are to identify the challenges in building management of BAS and determine how BIM can contribute for the growth of BAS and to integrate both platforms for increased building life cycle efficiency. By integrating both platforms through creating a BIM software plug-in for BAS protocol, the issues in BAS can be overcome by accessing the same data as in the BAS control panel but in an easier working and customization interface with comprehensive detailing.

Keywords: Building Information Modelling (BIM); Building life cycle; Building Automation System (BAS); Energy usage; Implementation and management

1.0 INTRODUCTION

Building Information Modelling (BIM) is a methodology enabled by a set of software tools and processes in facilitating the creation and use of the digital representation of the physical and functional characteristics of a facility (Domingues et al., 2016). In terms of software, BIM introduces exchangeable information formats, among others, International Foundation Classes (IFC), for modelling and visualizing building entities in 3D. Whereas in processes terms, BIM facilitates the conveyance of building information from the design phase throughout the building life cycle, supporting cost management, construction management and facility management (Domingues et al., 2016).

A building life cycle is a process that consists of programming (concept & analysis), design, preconstruction (cost, sequence of works), construction and post-construction (operations and maintenance) phases of a building (Lilis et al., 2017). The implementation of BIM through the building life cycle is massive especially in concept, design and pre-construction phase. However, there seems to be limiting in its usage for the post-construction phase. This limitation is not to be taken for granted as the operations and maintenance is the major part (60%-85%) of the overall building life cycle budget (Hardin, 2009). Also, building's sector is a major source for energy consumption, accounting for 30% of primary energy consumption in most countries and more than 55% of global electricity demand (International Energy Agency, 2015). Thus, there is the pressing need to properly manage the resources and energy used to operate a building in ensuring that efficiency of resources and energy is well maintained and subsequently reduce whole-life costing.

Nonetheless, recent rapid revolution of era in information and communication technology (ICT) such as Industrial Revolution 4.0 and Internet of Things (IoT) led to the emergence of building energy management system in the name of smart building or Building Automation System (BAS). BAS consists of a system installed in buildings that controls and monitors building services responsible for heating, cooling, ventilation, air conditioning, lighting, shading, life safety, alarm security systems, and many more (Turk, 2016). For this reason, BAS is believed to be able to utilize its technological and computerized means to achieve greater energy efficiency.

Unfortunately, as usual for a new and advanced technology, there are always issues and challenges in implementing it in construction industries. For instance, complications are found in the attempts to customize the established solutions and rules (Sinopoli J. , 2013). In addition, BAS also involves how smart objects interact with the environment. The smart objects are situated in a specific surrounding to carry out their tasks and they often require the input of space data, such as building floor plan (Zhang, 2015). Thus, with a more organized and user-friendly interface like BIM, the customization and analysis works will be less time consuming.

Moreover, rising energy use and more frequent occupant comfort complaints are the most common warning signs that BAS optimization is needed (Tatum, 2018). Incorrect building or room pressurization is also a challenge in implementing BAS as the occupants or a room's function may experience changes over time (Tatum, 2018). Moreover, it is common for facility managers to complaint about either incomplete or inaccurate (outdated) documentation (East, 2016). So, this issue highlighted the need of space re-arrangement and re-utilization with help of visualization for the system to operate accordingly to the latest demand and for the latter, in case the company that owned the building is no longer in business, building management can continue to function properly with reliable documented information database (Zhang, 2015). This paper discusses the challenges in building operation and maintenance management of BAS and how BIM can contribute to the development of BAS to improve building life cycle efficiency. Hence, to propose a BAS plug-in application for BIM software to integrate the two systems to achieve greater operations optimization.

2.0 LITERATURE REVIEW

This section will review the current management of BAS and the BIM to-date features.

2.1 BAS management

There are three hierarchical levels of functionality in a BAS. The management level is where all the information from the entire system is collected, aggregated and represented in a unified way to the operator. This is where the different control and management decisions are introduced by the operators or an automated optimization agent. The long-term data storage, analytics and performance reports are also generated at this level (Lilis et al., 2017). Another concept by authors in (Domingues et al., 2016) also stated that the architecture of this distributed system can be organized into three layers: (i) The lowest layer is known as the Field Layer where the interaction with field devices (sensors, actuators) happens, (ii) the middle layer is the Automation Layer, where measurements are processed, control loops are executed and alarms are activated, (iii) the top layer is the Management Layer, where activities like system data presentation, forwarding, trending, logging, and archival take place. So, this paper will discuss issues and problems at the top tier of the system which is the Management Layer which is very difficult because of the heterogeneity nature of the existing system with no standard solutions from the various vendors that can provide inter-operability among the solutions (Domingues et al., 2016).

2.2 BIM Implementation

BIM is a well-known process and method for support in managing a building through its life cycle. Currently, BIM capabilities in storage of detailed data of a component, simulation and analysis are still held at the highest regard. In BIM, we know more about real world objects than their geometry. The more we know the better. We should be able to do more to the objects than move them around. For example, we should be able to put a load on them and see what happens or let the sun shines on a building and see how it heats up. This is because the objects include behaviour (Turk, 2016). But, as time evolve, the BIM is also in need of additional features to maintain in line with the technological relevance and this is nothing more than integration with the much-advanced BAS. The added ability of real-time controlling the objects like in BAS system in the model will be a massive improvement in BIM implementation, in building life cycle.

3.0 METHODOLOGY

In this research, to determine the BIM application in building life cycle, two approaches will be used to ensure that the data is gathered comprehensively. The approaches are desk study and simulation of the collaboration between BIM software and BAS communication protocol. The desk study is to gather data and information about the challenges in building operation and maintenance of BAS and the current functional of BIM. The data will be gained directly from web sites, books, articles and other printed resources from international and national journals that discussed about the pertinent issues related to the objectives of this research. Then, all information obtained will be compared to clearly underline the issues and the possible solutions before working on the simulation.

As for the simulation, the BIM software that will be used is Autodesk Revit (Revit) while for the BAS protocol, it will involve American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)'s Building Automation and Control Networks (BACnet). Revit will be used in this research because it is the most popular BIM platform around the world developed by word leading software developer, Autodesk (Vysotskiy et al., 2015). The application of the software covered a wide range of scope from the top professionals to the educational sectors. Moreover, the software is also very flexible in terms of modifying or expanding its capabilities and interoperability such that even the Construction Industry Development Board (CIDB) Malaysia has developed its own extension application with Revit to assist industry players in Malaysia in designing the precast building according to the standard specified by them (CIDB, 2017). With all the reasons, it can be said that the selection of Revit as one of the methodology components in this research is justified.

While for the selection of BACnet as the BAS communication protocol in this research is because according to Building Operating Management survey in 2011, 62% of respondents had at least one BACnet application; for LonWorks the percentage was 40%, while for Modbus the number was 30% (Sullivan, 2013). This survey result indicates that BACnet is preferable among the industry players in addition to its open protocol system and unrestricted growth and the ability to add new innovations and new features anytime (Pongchit, 2016).

The simulation process will involve the creating of Revit plug-in application for the BACnet protocol where the data from the Management Layer as discussed in Section 2.1 can be accessed or even imported to the Revit. Then, after opening the assigned smart building model file in Revit, open the installed BACnet plug-in from Revit and navigate to the file of the BACnet protocol and load into the software. Then, after the data from the protocol finished loading, assign the smart object or the Field Layer category objects to their respective data or logs from the BACnet file. With this, all the smart objects such as sensors, actuators objects have been inserted with the protocol data and can be monitored, modified or projected in the Revit software in accordance to the specified or up-to-date occupants needs.

4.0 ANALYSIS AND FINDINGS

4.1 Identification of challenges in operation of BAS and current features of BIM.

There were challenges (Table 1) that have been identified during the desk study of BAS operation and maintenance: modification and customization. For instance, complications in fault detection applications in BAS. Fault detection is the process of analyzing real-time data from a service system against a set of rules which addresses the relationships and interoperations of different services equipment. In the end, one must customize the fault detection rules and that requires time (Sinopoli , 2013).

Next, the BAS management challenge also includes where most protocol providers are not able to inter-operate with other provider's solutions without additional overhead result in locking costumers to specific product lines—a major issue if such lines get discontinued. Moreover, the system has closed specifications, is too complex to be used by nonspecialized personnel for that technology, whether they are end-users or other system developers, only perform satisfactorily in the exact conditions they were tailored for, not performing so well if the working environment changes, thus lacking flexibility (Domingues et al., 2016).

Nevertheless, managers of BAS can utilize the building knowledge of BIM for planning the layouts of sensors, tags, actuators and meters. The performance of smart objects can be verified against known constraints and their layouts optimized for the best functional performance. Secondly, BIM also serves as a data source for the physical information of smart objects. For maintenance and asset tracking in the building post-construction phase, the hardware information of smart objects can be recorded, and their installation locations can be documented and visualized in 3D (Zhang, 2015).

On the other hand, BIM provides a perfect ontology database for SBE. Smart objects may be designed and manufactured by different vendors. The data they provide may vary in structure, and they may communicate using different protocols. Middleware is a popular approach to addressing such issues with heterogeneous smart objects (Zhang, 2015). With the collaboration of BIM, each smart and automated component can be profiled through its information exchange interface. Because BIM is standard compliant, the middleware can extract data formats of smart objects and other building information for viewing as an ontology database (Zhang, 2015).

Table 1: Cross-referencing between the challenges in BAS optimization and the current features of BIM.

Challenges in BAS Optimization	Features of BIM that can contribute to BAS
Modification and customization.	Building knowledge of BIM for planning the layouts of sensors, tags, actuators and meters.
System has closed specifications, is too complex to be used by non-specialized personnel for that technology.	The hardware information of smart objects can be recorded, and their installation locations can be documented and visualized in 3D with a user-friendly interface.
Most automation solutions are not able to inter-operate with other vendors' solutions.	Provides a perfect ontology database for Smart Built Environment (SBE).

4.2 Integration of Building Information Modelling (BIM) and automated building system.

From the analysis above, it can be said that the challenges in operating and managing the BAS can be overcome by collaborating with the BIM platforms that are well known for its convenience in conveying and modifying building information throughout a building life cycle. Therefore, by creating a BIM application extension or plug-in for the BAS communication protocol systems, the data can be accessed or even imported to the BIM and can be monitored, modified and projected in a much easier user environment and comprehensively. The conceptual framework for integration of BAS and BIM in optimizing the building life cycle operations and maintenance management can be referred in Figure 1 below.

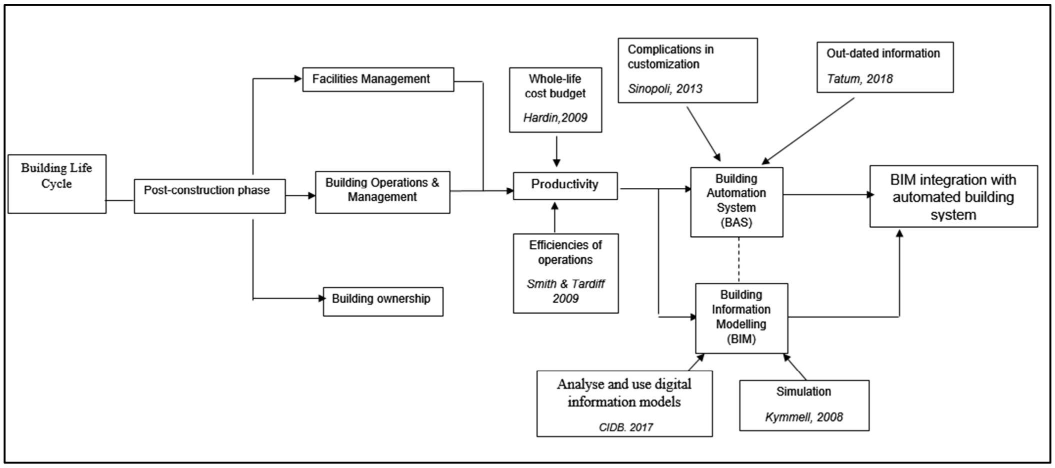

Figure 1: The conceptual framework for integration of BIM with BAS.

5.0 CONCLUSION

In this paper, the findings gained from a study of how BIM capabilities can be implemented to accommodate the challenges for operation and maintenance management of BAS. This study covers the major challenges of optimizing BAS and the functions of BIM that complement the challenges derived from the desk study taken. As in an era where automation is concerned, the construction industries are also not excluded from developing strategies to better optimization of BAS for a building operations and maintenance. Thus, by integrating BIM and BAS, a building life cycle will be ensured to achieve greater energy efficiency and sustainability. Having said that, in realizing the collaboration between these two types of platform, it is recommended that there are key things that should be firstly emphasized and addressed. Among others: i) Current BAS Management Strategy, ii) Degrees of Integration, iii) Accessing BIM Data, iv) Target Specific Objectives for BIM Adoption and v) Understanding the Interface Required

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