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SocioBIM: BIM-TO-END USER INTERACTION FOR SUSTAINABLE BUILDING OPERATIONS AND FACILITY ASSET MANAGEMENT

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Abstract: Building and facility asset management is a strategic approach to the optimal capital and operational spending on assets to ensure control of cost and risk, asset life, performance, and stakeholder satisfaction. The decisions for sustainable building operations and infrastructure asset management ultimately rests on owners, stakeholders and building occupants. This paper introduces SocioBIM, an approach for building occupants to interact with their building and to provide valuable feedback to the building management. Our research takes advantage of the state-of-the-art and the-state-of-practice Building Information Modeling (BIM) technologies, sustainability assessment techniques, advanced analytics, decision support systems, and integrator platforms. The valuable insight derived from SocioBIM can solve important issues related to model-reality performance gaps, post-occupancy evaluation, sustainability and service level assessment, sustainable building operations and facility asset management. Furthermore, SocioBIM adds value and provides improved competitive advantage to any asset management organization.

1 INTRODUCTION

There has been considerable and well-documented concern about the current state of Canada's infrastructure (Froese & Vanier 2014), and this warning applies to many of the developed countries of the world. With respect to buildings infrastructure and their sustainable operations and management, the model-reality performance gap and failed post-occupancy and sustainability assessment techniques are the major problems with the current sustainability paradigm identified by many researchers in the field of sustainable building science (Froese 2014):

> *"In the current paradigm, sustainability is often achieved by assessing models of building performance during the design phase. However, these predictions often fail to agree with the facilities' post-construction performance, and actual performance of many green buildings has been poor. Further, post-occupancy assessment techniques themselves are often weak, using inaccurate, un-validated tools and sampling strategies inconsistent with statistically significant results. The consequence is that we are currently re-tooling the built environment industry to meet sustainability goals in a way that, in many cases, is not succeeding."*

Froese and Vanier (2014) believe that the solution to the challenges associated with sustainable management of infrastructure lies in the investigation of the following three technical domains:

- Sustainability assessment for infrastructure: To build upon emerging frameworks to develop practical and meaningful techniques for evaluating the sustainability of infrastructure assets.

- Advanced analysis and decision-support for infrastructure management: To provide analysis and decision support that is compatible with—but extends beyond—the capability of current software. The focus includes performance prediction, multi-objective optimization, and data visualization.
- Integrator platform: To develop, test and validate a software system related to decision support and sustainable infrastructure that is compatible with existing commercial systems, integrates disparate data sources, and provides a platform to analyze and visualize infrastructure management data.

This paper introduces SocioBIM, an effective approach for building occupants to interact with their building and provide valuable comments and feedback to the building management, as the decisions for sustainable building operations and asset management ultimately rests on owners, stakeholders and building occupants. The paper presents a preliminary research and conceptual approach for SocioBIM that the authors are currently pursuing. Our research takes advantage of the state-of-the-art and the-state-of-practice Building Information Modeling (BIM) technologies, sustainability assessment techniques, advanced analytics, decision support systems, and integrator platforms [1].

2 BUILDING AND FACILITY ASSET MANAGEMENT

Building and facility asset management is a strategic approach to the optimal capital and operational spending on assets to ensure control of cost and risk, asset life, reliable performance, and stakeholder satisfaction (E. Teicholz 2013). “Asset and property managers are faced with many difficult decisions regarding when and how to inspect, maintain, repair and renew their existing facilities in a cost-effective manner” (Vanier 2000). To enhance making these challenging decisions at different operational, tactical and strategic levels, asset managers need to collect and run analytics on key data systematically to create business intelligence (E. Teicholz 2013). Furthermore, a Knowledge-based BIM has the capability to enhance the competitive advantage of a facility management organisation (Charlesraj 2014).

Facility management is knowledge and information intensive and relies heavily on historical information as well as operational data. To effectively collect and manage such a variety of data for sustainable asset management decision making, data support is required in all phases of the building life cycle, including assessment (sustainability audit, condition assessment, and data gathering), planning (cost/benefit analysis, scope & goal setting, and budgeting), implementation (process documentation and execution, and organizational buy-in) and management (certification, documentation and reporting, and policy management) (E. Teicholz 2013). The insight derived from such a variety of data can be used to answer the following key questions (E. Teicholz 2013):

- What investments are needed in repairs, renewals, and modernizations?
- Which investments should be made with limited funds?
- What are the risks and outcomes of investments made and not made?
- How can those risks be managed with proper investment?

Conventional building and facility management answer these questions in an unsatisfactory way. The conventional management approach would induce high risk, high costs and inferior performance such as: inability to locate the nearest shut-off valves after a water pipe break, overlooking ordering spare parts for a faulty elevator, or failure to access proper exit procedures in the time of a natural disaster or fire (Xu & Zhang 2013). Recently, Building Information Modeling (BIM) has become the preferred method for not only the design of buildings, but it is also gaining a foothold in the domain of building operations and management. BIM creates a digital database of all building assets and can serve as virtual 3D coordination of the construction and operational activities (Liao et al. 2012). Furthermore, BIM techniques are used during post-occupancy evaluation to effectively promote work efficiency of the operation organization, improve quality of service to customers, reduce emergency situations, improve safety, and reduce waste. The post-occupancy and operation phase of buildings and facilities is said to be the most important period of the building’s whole life cycle (Liao et al. 2012).

For example, Frankfurt Airport started using BIM for its operations and facilities management in 2003 to manage more than 2.4 billion Euro worth of a multitude of asset types, property, plant and equipment (Exton 2003). The Frankfurt BIM system aggregated existing documents and large and complex sets of

facility data to form a federated database that is visualized through interactive facility maps. This enabled the engineering, finance, operations, maintenance, security and emergency response teams to visualize mission critical facility information through interactive facility maps, to find relevant data more quickly, and to minimize operations downtime (Exton 2003).

Nonetheless, most BIM models utilized for facility management incorporate asset property information and building inspection data including: asset geometry, spaces, location, age, condition and scheduled maintenance. Moreover, the data is typically gathered by designers, building managers or building inspectors whose works are costly and, more often than not, do not address the concerns of building occupants.

3 SocioBIM – A NEW PARADIGM FOR SUSTAINABILITY ASSESSMENT OF THE BUILT ENVIRONMENT THROUGH INHABITANT ENGAGEMENT

Almost all applications of BIM to date have been targeted at professional users—designers, contractors, facilities managers, etc. While it is appropriate that these are the main users for BIM, this approach excludes an important segment—non-professional or general public users and, in particular, building occupants or infrastructure users. We refer to approaches that link BIM with the general public as "SocioBIM", an approach for building occupants to interact with their building and its assets and to bring their own view of the issues on the table.

SocioBIM approaches not only strive to make information from BIM models available to the public for appropriate uses and in appropriate ways, but it also strives to obtain input from the public, largely by linking the technology of BIM with the technologies of social interaction, i.e., social networking. This approach goes beyond maintenance issues: SocioBIM provides a means for the end-user to interact with the BIM model and to provide invaluable social information necessary for the sustainable operation of the building. With reference to any particular component (asset) of the building, SocioBIM can provide the building occupant with the ability to:

- Comment on both design issues and service levels
- Comment on the usability, functionality and performance of any asset,
- Comment on the maintenance issues and asset condition,
- Comment on the decorations and visual appearance,
- Comment on indoor climate and raise concerns on socio-environmental issues,
- Express their feelings and sentiments about their living/work condition, comfort level and well-being,
- Make recommendations and propose solutions to existing problems,
- Provide their perceived value of the sustainability features,
- Make recommendations for upgrades and improvements, and
- Attach relevant photos, videos and voice memos or any other document to the comments.

This data can be input and stored for each asset in a BIM model and be accessed, viewed, and evaluated by the facility manager.

3.1 SocioBIM Benefits – Sustainability Assessment & Post Occupancy Evaluation:

SocioBIM exploits Building Information Modeling (BIM) technology to provide a holistic computational platform for integrated sustainability assessment. SocioBIM converts "occupants" (passive recipients) to "inhabitants", who have a sense of place in, and engagement with, the building. It addresses the sustainability issues by measuring performance of the building after occupancy and the level of service as perceived by inhabitants.

The aim of SocioBIM is to exploit advances in computational sustainability and BIM to empower inhabitants to engage and participate in the operation of their facilities and take control of their management in real-time to optimize their well-being. In fact, SocioBIM shifts "snap-shot", "one-time" or

"discrete" measurement techniques (such as surveys and interviews) to "continuous" assessment techniques and "real-time" monitoring systems.

SocioBIM assists in comparing operational performance with predicted performance and identify “performance gaps”, strengthening understanding of how innovative green buildings are performing once built, assessing whether they are meeting expectations, and identifying the design lessons that can be learned from these buildings. Furthermore, SocioBIM helps with understanding the interactions between comfort factors (thermal, acoustic, lighting) with inherent trade-offs that affect occupant health, comfort and the environmental sustainability.

In fact, SocioBIM leads to more sustainable building operation and facility management, increased occupant well-being, enhanced level of service assessment, and greater community investment in sustainable solutions.

3.2 SocioBIM Benefits – Sustainable Building Operation & Facility Management:

Other valuable insight derived from SocioBIM that can solve important issues related to sustainable building operations and facility management include (Jensen 2008; Hungu 2013):

- Flexibility and ability to adapt to the changing needs of inhabitants over time;
- Enhancement in maintaining the facility and the surrounding area;
- Improvement in health, safety and security of the facility, people and assets;
- Optimization of energy and resource consumption (electricity, heating, cooling, water etc.);
- Greater assessment of socio-environmental impact;
- Enriched assessment of level of service;
- Better analysis of indoor climate and working conditions; and
- Informed decisions on facility management and procurement of new systems.

Therefore, facility managers, using the information received from the building occupants, can better plan for the maintenance of individual assets and assess the social impact of their decisions: from the type of light bulb in any particular fixture to the socially responsible investments decisions using a holistic information system.

4 SocioBIM DATA MANAGEMENT AND ANALYTICS

The SocioBIM database, containing data from building occupants can be comprehensive and include data from all other types of sources: facility inspectors and streamed data sensors, all of them feeding social, environmental, economic, condition and operation data. The analytics performed by the facility manager on this data could include descriptive analytics (what has happened), diagnostic analytics (why it happened), predictive analytics (what will happen) and prescriptive analytics (what, when and in what order are the best courses of action).

The vast potential data sources, however, need to be prepared for analysis. Although some information collected from users may be fully structured data, much of it may be unstructured. To prepare the data received from the previously described sources, we are considering employing advanced computing science techniques such as text mining and machine learning. Therefore, the design of the data-structure system to receive and store the data in the SocioBIM database is an important factor on which we are currently working on. Text comments may include many types of the occupant’s concerns mentioned above such as usability, performance, condition, visual appearance, maintenance issue, sentiments, and recommendations. Therefore, some of the design consideration for the comment analytics tool include:

- understanding the database structure,
- performing data analytics on the structured data of the database (e.g. priority rating),

- performing text analytics on the comment section (unstructured part of the database) and ability to break down the comments into different sections: e.g. usability, performance, condition, visual appearance, maintenance issue, sentiments, and recommendations, and
- performing further text analytics to present statistical inference on individual sections to answer important questions such as: what is the overall performance of an asset based on users' comments, how do users feel about a particular asset and how to adapt to their changing needs over time.

5 SocioBIM INTEROPERABILITY

Additional work is also needed to research the interoperability between different systems in SocioBIM: the BIM model, the data management system and the facility management system. As the data may not be entered into one single model, the data needs to be relayed from the upstream for downstream system use and the systems need to be updated to reflect the changes made. Our research to date has reviewed the applicability of the following multiple approaches to data integration (P. Teicholz 2013):

1. Capture the data into a spreadsheet: This option is mostly suitable for small projects and lacks formal structure. This approach may be prone to errors due to absence of a validation mechanism.

2. Use the Construction Operations Building information exchange (COBie): This option is convenient but does not provide graphic data to show where equipment is located.

3. Create two-way links between the BIM model and the facility management systems: This option is suitable for integrating graphic views with the data (e.g. EcoDomus system).

4. Have direct integration of BIM with the facility management system using APIs: In this option, graphics data is updated in BIM and the data is entered into COBie or directly into the facility management system. A cloud-based server can also be implemented to access data content from anywhere.

Our approach to interoperability between data systems, BIM model and the facility management systems is to develop a cloud-based SocioBIM application interacting with external dynamic databases for facility management systems.

6 USER- SocioBIM INTERACTION

Our research also explores user-SocioBIM interaction. We are considering today's technological advancements in mobile computing and systems (smartphones and tablets) to enhance the process. These smart devices are equipped with powerful CPUs, touch screens, and wireless communication technologies. The integration of BIM with a smart device provides time and location convenience, ease of way-finding, detailed visualization of building components, improvement with identification of issues, and fast interaction with the model (Kim et al. 2013). This in turn translates into an effective SocioBIM management system. To showcase SocioBIM, we are considering development of applications based on the Building Information Model server (BIMserver.org) platform. We have identified the following user-interface scenarios for our applications:

A. An interface for the administrators to manage users, IFC building models, and comments left by the users. The data will be dynamically exported to other facility management software for processing.

B. An interface for the building occupants to view IFC building models, select assets within the models, leave a comment for a particular asset, and view comments posted by others.

C. A dashboard for facility managers to perform and visualize analytics on the data and comments stored in the database.

7 CONCLUSION

Sustainable building and facility management is knowledge and information intensive and relies heavily on a variety of information provided by the building occupant, inspectors and sensor feeds. SocioBIM can enable the development of a knowledge management system that can effectively be used for problem solving and decision making by incorporating the valuable information provided by the building occupant. The user-interface developed for SocioBIM would facilitate user interaction with the BIM-based knowledge management system. The building or facility asset manager could run queries in SocioBIM to retrieve appropriate information provided by the building occupant and perform analysis on the data. This would lead to not only enhanced and real-time sustainability assessment, service level assessment and post-occupancy evaluation, but also identifying the design lessons and greater community investment in sustainable building solutions. Hence, SocioBIM adds value and promises improved well-being of building inhabitants and competitive advantage to sustainable operation of any building or facility management organization.

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References

Charlesraj, V.P.C., 2014. Knowledge-based Building Information Modeling (K-BIM) for Facilities Management. In *The 31st International Symposium on Automation and Robotics in Construction and Mining (ISARC 2014)*. pp. 1–6.

Exton, P., 2003. Frankfort Airport Now Standardized on Bentley BIM for Operations and Facilities Management. *Business Wire*. Available at: http://www.businesswire.com/news/home/20030513005544/en/Frankfort-Airport-Standardized-Bentley-BIM-Operations-Facilities#.VOBCV_nF98E [Accessed February 15, 2015].

Froese, T.M. 2014 Network for Sustainability Assessment of the Built EnviRonment (SABER), Unpublished.

Froese, T.M. & Vanier, D.J., 2014. Issues in Decision Support Tools for Sustainable Infrastructure Management. In *Computing in Civil and Building Engineering*. pp. 251–258.

Hungu, C.F., 2013. *Utilization of BIM from Early Design Stage to facilitate Efficient FM Operations*. Chalmers University of Technology.

Jensen, P.A., 2008. Integration of Consideration for Facilities Management in Design.

Kim, C. et al., 2013. BIM-Based Mobile System for Facility Management. *Proceedings of the 30th ISARC*, 749.

Liao, C.Y., Tan, D.L. & Li, Y.X., 2012. Research on the Application of BIM in the Operation Stage of Green Building. *Applied Mechanics and Materials*, 174-177, pp.2111–2114.

Teicholz, E., 2013. Technology for Facility Managers : The Impact of Cutting-Edge Technology on Facility Management.

Teicholz, P., 2013. *BIM for Facility Managers*, Hoboken, New Jersey: John Wiley & Sons, Inc.

Vanier, D.J., 2000. Asset Management 101: a Primer. *NRCC/CPWA Seminar Series "Innovations in Urban Infrastructure," APWA International Public Works Congress*, pp.1–15.

Xu, Y.G. & Zhang, Z., 2013. The Application Research for Business Operation Management Based on BIM. *Applied Mechanics and Materials*, 357-360, pp.2316–2319. Available at: http://www.scientific.net/AMM.357-360.2316.