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THE INTERFACE BETWEEN BUILDING INFORMATION MODELS AND THE PUBLIC

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Abstract: Almost all work to date in the field of Building Information Modelling (BIM) tools has developed software for building professionals: designers, constructors, and operators. However, another important group of potential users is the public. Use cases fall into two broad categories. Pre-construction applications span the design phase and all forms of public engagement during design development, from traditional user-feedback/community engagement processes to innovative applications such as crowd-source design. Post-construction applications include a variety of occupant-centric scenarios, including building dashboards, occupancy-assessments, etc. The relevant technology spans both BIM and social media. The Green 2.0 project aims to develop a middle-ware platform to support a range of BIM-to-public applications, with an emphasis on building energy performance and related "Green" applications. By analogy, if Facebook is conceived as a platform for a public-to-public interaction, and Google Maps as a platform for public-to-geospatial interaction, then the Green 2.0 project aims to provide a platform for public-to-building interactions. This paper describes the problem domain and preliminary work to develop the pre-construction and post-construction application areas for the Green 2.0, BIM-to-Public platform.

1 INTRODUCTION

Building Information Modeling (BIM) is a technology which has caused a paradigm shift in the Architecture, Engineering and Construction (AEC) industry, it has transformed the way buildings are designed, constructed and managed. BIM is moving the construction process from being "lonely" to "social", in the sense that BIM is enabling professionals: designers, constructors and building managers to easily share information with each other. Another set of potential users is the general public and the occupants of buildings, who can contribute useful information to the building owners, designers and operators. The current performance gap in buildings is twofold. On one hand, the actual energy saving and resource usage like water usage are not as expected (Turner and Frankel 2008). On the other hand, occupants in green buildings have not been shown to exhibit a higher satisfaction compared to those in conventional buildings (Birt & Newsham, 2009; Altomonte & Schiavon, 2013). A building-to-end user interface can help in reducing the performance gap in buildings and can also create a more satisfying indoor environment for the end-users. In the design phase, end-users preferences and opinions can assist the designers and owners to come up with a user-driven design and innovation. Similar, in the post-occupancy phase, the user interactions with the BIM model can help in capturing occupant feedback about the indoor environment in buildings which can be useful for building operators.

In recent years, end user engagement in the product development industry has been gaining importance. Some social media tools like blogging, online forums, video sharing and social networking are turning out to be useful for facilitating this engagement. Crowdsourced design and rapid prototyping are some of the common methods being used in the product development industry. With recent advances in information technology in the construction industry, 3D modelling and visualization tools like BIM are becoming commonplace. This has created a potential for developing applications that can bridge the gap between the buildings and end-users. In fact, the average North American spends about 87% of his time inside the built environment (Klepeis et al. 2001), hence it is imperative that the building end-users' design preferences and indoor environment quality feedback should be considered.

The Green 2.0 project, being led by the University of Toronto, is aimed at adding user interaction in design and operation of facilities through using Web 2.0 and gaming technologies with BIM software. The objective of our study is to develop web-based or mobile applications built on the Green 2.0 middleware platform to provide end-users with an easy-to-use interaction interface with the building. These applications will then be tested on the existing and to-be-built buildings in the University of British Columbia (UBC) campus using the Living Lab methodology. This paper describes the problem domain and preliminary work to develop the pre-construction and post-construction application areas for the Green 2.0, BIM-to-Public platform. An outline of the Green 2.0 project is provided in the second section. The third section provides a brief overview of developments in the current building-to-end user interfaces. In the fourth section the conceptual use case scenarios in the design and operation phase of the buildings are discussed. The future work related to this study is presented in the final section of the paper.

2 GREEN 2.0

Achieving a sustainable built environment requires socio-technical solutions. Technology and hardware for green buildings have reached unprecedented levels of advancement, yet the decisions to achieve energy and water savings, ultimately, rests on end-users and other stakeholders. Given that modelling and analysis tools have been developed by engineers for use by engineers, the bottleneck over the life cycle of green building management now lies in the human interaction of end users with the facility during design and operation.

We must match the advanced technical tools with socially-savvy tools that engage people in the design stage to make sure that designers understand their needs and attitudes towards energy usage, and that involve larger communities in the visioning and design processes as expected by new net-native generations of home buyers and building occupants. We also need to fully inform users of green opportunities and their possible role in enhancing the energy profile of their facilities in operation phase.

Green 2.0: a middleware platform for enabling socio-technical analytics of green buildings is a collaborative research project led by the University of Toronto. The project aims at developing a web-based middleware platform to empower professionals from diverse background to create analysis applications while engaging users' ideas. The platform brings together several core enabling technologies: open BIM for modeling buildings and related project information, social networks and social network analytics for supporting user interactions and investigating the results of this social interaction, energy analysis to model and provide feedback about the impact of various design alternatives, and business process modelling to model users' activities. The Green 2.0 platform will be open source and free to use, not only open to professional engineers but also available to public users. The Green 2.0 platform provides a base for us to create applications which will give users access to building information and encourage user engagement in both the design and operations phase. The preliminary work on these applications is presented in the fourth section of the paper, Building-to-end user interface.

Research to explore if, when, and how to engage users in building design has been an ongoing subject of research and development. Some researchers have categorized four types of user engagement: unidirectional social research (USR) (information/education), USR (decision support), weak interactive social research (ISR) and strong ISR. Strong ISR, which engage users in all phases of research, is recommended, but studies on ISR projects show that changes are needed in institutional arrangements and organizational settings for ISR (Talwar et al. 2011). Another research project, where novice users were asked to create Business Intelligence information dashboards, found some drawbacks in novice users’ design, such as lack of concepts on categories, lack of consideration in coordinated view, and less consideration on data filtering (Elias and Bezerianos 2011). Therefore, we will collect users’ opinions when developing the interface but not let the users to design any applications in our research. In this paper, the user engagement refers to using the building-to-end user interface.

To better achieve user engagement, an easy-to-understand building-to-end user interface should be useful (functionally), usable (it is easy to do things), and used (attractive and available) (Glawischnig et al. 2011). A number of previous research projects have explored this issue, such as the following two projects:

Robert Zach, et al. developed a Monitoring System Toolkit, MOST, an open-source, vendor and technology independent toolkit for building monitoring, data processing, and visualization (Zach et al. 2012). The toolkit is based on five components: Connectors, Database-Core, Java-Framework, GWT based web interface, Matlab-Framework and thus supports use of building data from various resources. MOST provides a web-based visualization framework to support some use cases such as 3D building browsing. The platform is similar to Green 2.0 platform but the user interaction in MOST focuses on drag and drop and highlighting. One thing that may be valuable is that with the claimed powerful data preprocessing function, the toolkit is allows access to salient and dynamic building information such as zone temperature and energy use, which are the main concerns of building stakeholders including occupants. Although no user applications for presenting such building data were developed, the MOST research team conducted user survey and focus group sessions to investigate the importance of different kinds of information (Chien et al. 2011). The results offer some guidance to the development of our use cases, which will be specifically discussed in Chapter 4.

VIC-MET is a tool developed at Aalborg University in Denmark to involve end-users in the building design process. It offers four different design spaces to enable user-involvement throughout the design process from the mapping of the context to the final solution. Various ICT tools like IHMC CmapTools for conceptual modelling and Ramboll VR Wii for interactive visualization are described in the VIC-MET handbook to support VIC-MET activities in these four different spaces (Christiansson et al. 2011).

The use of social media to present the user with 3D virtual models of the building is another useful method to capture user opinions. In the Finnoo-Kaitaa project, a web portal was used to share project information with end-users and an online forum where registered users can freely propose new ideas and like comment of others. The Nissola Street and railway plan made use of an Internet application that enabled citizens to place comments on different parts of the 3D model while flying through it (Jäväjä et al. 2013). GreenNetwork, developed at UC Berkley, is another social media prototype application integrated in the work environment aimed at promoting a “green work style” amongst the people. It allows people to track their energy use, share this information through social media platforms like Facebook and LinkedIn, and comment on the energy use of their peers (Lehrer et al. 2014). POE 2.0 is a new bottom-up approach towards Post-Occupancy Evaluation (Daltona et al. 2013), it involves analysis of user reviews and comments on social media websites like Yelp, TripAdvisor and ArchDaily. The Smart Campus project being undertaken on four European Universities uses the Living Lab methodology. Their applications are aimed at influencing and transforming the user energy consumption behavior by enabling user interactions with the building. The project expects energy savings of about 20% and 15% of which will be due to user behavior transformation (Nina et al. 2014). These tools and methods have proven to be effective in terms of engaging the users. However, currently there are no applications available that can connect the general public to the BIM model of the facility.

3 CONCEPTUAL FRAMEWORK OF BUILDING-TO-END USER APPLICATIONS

The conceptual framework to develop the building-to-end user applications consists of four steps. First, develop a conceptual process model or algorithm of the application. Use cases will be used to illustrate the requirements and processes that the application will have in this phase. Second, use the use case processes to drive the development of a conceptual data model. This stage will be used to determine how to collect required data and how the application interacts with the data. Flowcharts, process models, and pseudo-code are used to show the processing procedures. Third, programmers will turn the conceptual data model into a detailed implementation-level data models. Fourth, the implementation-level processes will be programmed around the data model. Our research efforts will be focused on the first two steps. The remainder of this chapter will introduce the work done to date in the first stage.

The focus of the "SocioBIM" applications being developed in our research is on the three different targets areas as depicted in Figure 4.1. The social net positive target area is aimed at incorporating sustainable values in occupants which results in green behavior amongst occupants. Green and regenerative buildings often focus on achieving a net zero or net positive energy, for example the CIRS building on UBC campus has a net positive energy performance. However, there is not much emphasis on social net positive performance for buildings where occupant's satisfaction, health and productivity are enhanced by the building environment. The performance gap in buildings often exits due to inappropriate use of the buildings systems by the occupants. These applications will aim at minimizing this performance gap by creating a competing environment amongst the building occupants. In the design and operations phase, these applications will enable occupant feedback and opinions, which will provide useful information for designers, owners and operators.

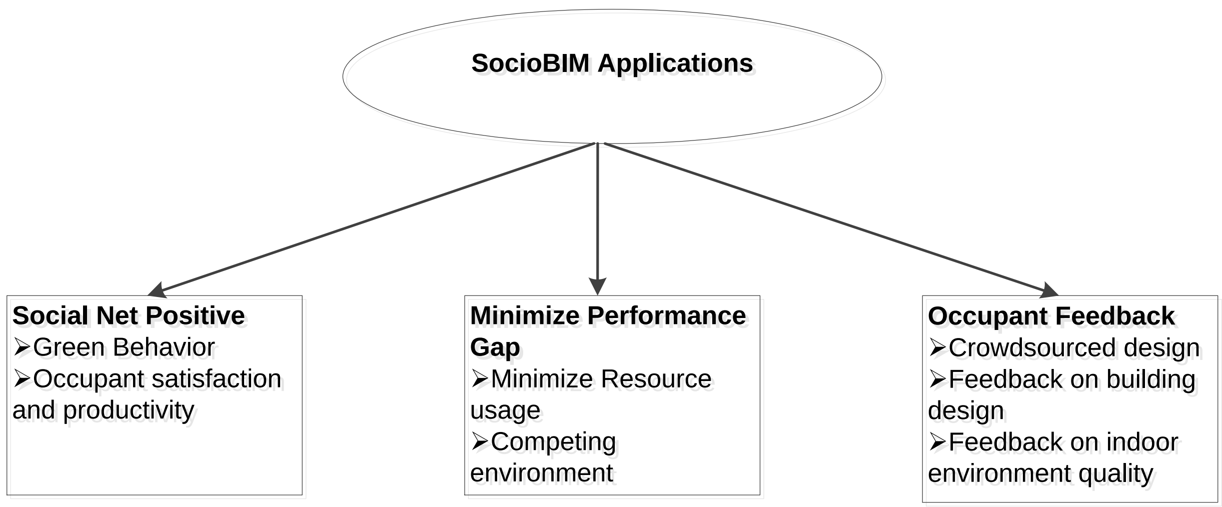

Figure 1 Target areas for SocioBIM applications

The applications will be linked to the middleware interface being developed in the Green 2.0 project. The use of these applications is limited to the design and the operations phase. In the next two subsections the conceptual ideas for two of the SocioBIM applications will be discussed.

3.1 Use Case in the Design Phase

For the design phase, the primary focus of the SocioBIM application is to present the users with a curated BIM model of the facility extracted from the Green 2.0 middleware. The end-users of the facility are able to easily navigate and walk through in this curated BIM model, similar to the Google Maps street view interface. In addition to navigation, the users have the option of commenting, like/dislike certain parts of the model and can propose some design changes as well. As shown in the use case scenario in Figure 2, users create a profile, access the model and they also enter their design requirements. The data collected is then analyzed by the designers and buildings owners to make appropriate changes to building design. These different user entries will ultimately result in a design evolution of the facility.This application can be used in buildings where end-users are known at the time of design of the facility which is possible in case of high-rise residence, office buildings and academic buildings.

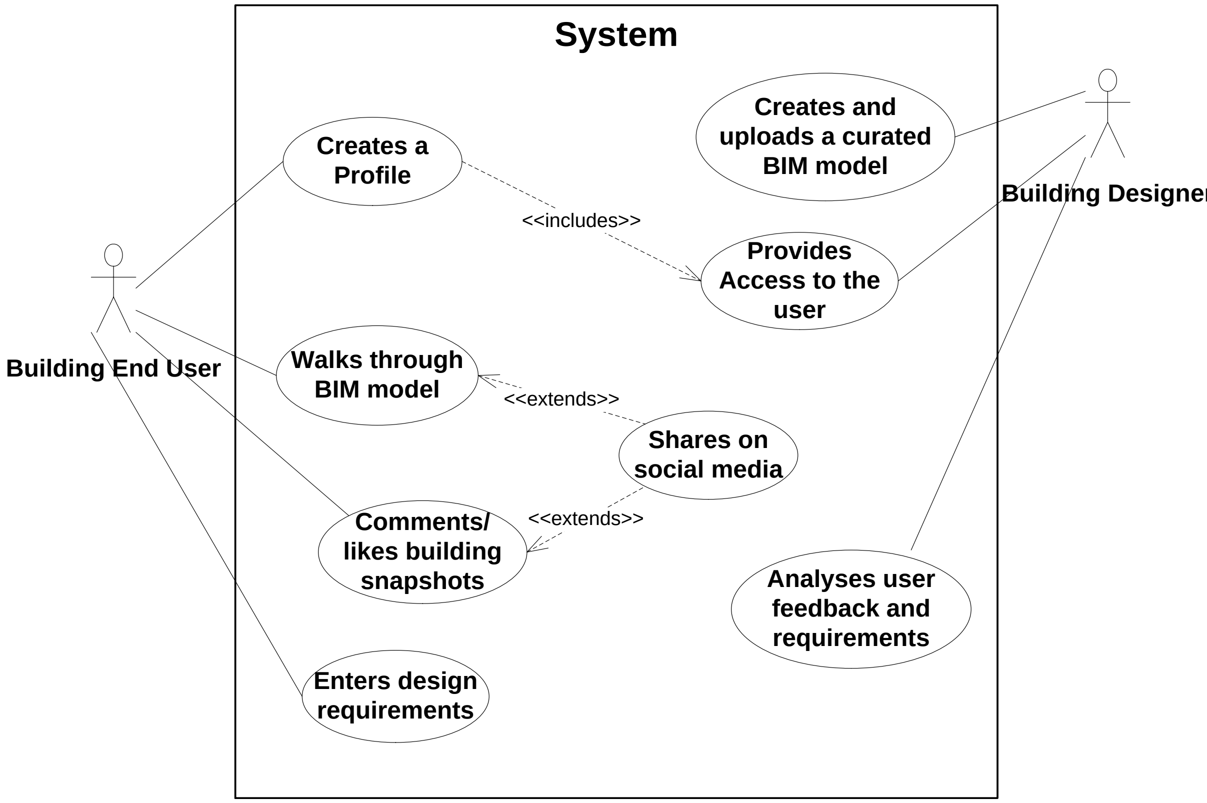

Figure 2. Use case for end-user interaction during building design phase.

3.2 Use Case in the Operations Phase

A typical post-construction application is a building dashboard. Autodesk is conducting a research named Project Dasher, which is aimed at collecting and displaying occupancy information, but it is not for end users' involvement in any phase of construction. Real-time building dashboards will visualize information collected from sensors distributed throughout a building. Specifically, occupancy, power usage, heat sources, airflow, and temperature are presented (Autodeskresearch.com, 2015). We will develop a dashboard to present building data for occupants.

3.2.1 What information to present

The results from the MOST research (survey and focus groups) (Chien et al. 2011) demonstrated that users are more interested in knowing about heating/cooling system, electricity, temperature, humidity, illuminance, the number of occupants, and ambient lighting. Users prefer to use laptop and smart phones to get building information. They wish the user interface be simple and clear, easier to interact with. One feedback mentioned the value of "comparison" function of "Oberlin", which is in accordance with one of our ideas to incorporate a type of "competition pattern" to motivate occupants to reduce energy consumption.

To summarize, our goals are to provide the information that users care most about, illustrate the sustainability of the building and encourage green behaviors. As a protocol to illustrate the ideas above, the dashboards will be presenting these four types of data:

- Electricity usage: This will be divided into Lighting, Devices and Heating/cooling systems;
- Thermal Comport: Temperature and Relative Humidity with votes;
- Health credit: Individual health credit and Average health credit of all the people in the building;

- Energy credit: The energy credit of the working station (room or floor) will be displayed with the average energy credit of all the working stations in the building.

3.2.2 How to collect and present data

The building dashboard will use data from building operating system, and Green 2.0 Middleware. The dashboard is web-based. Occupants can get access to it from their own laptop. Each office, each floor, and the whole building can have a big screen showing the dashboards at every entrance. This use case is applicable mainly to office buildings and academic buildings.

3.2.3 Functions

The dashboard shows the real-time electricity usage with a pie chart and compares each division with the expected levels. When the usage is over expectation, the usage column and number will turn red to alarm the users. In reverse, it assigns energy credits to spaces where energy usage is below expected levels. A vivid 3D building model with energy usage or room credits of all the rooms in the building is accessible from the dashboard. This provides an intuitive sense of competition. Moreover, occupants can vote on their preferred temperature levels through the dashboard website. Therefore, the building manager or the office manager can adjust the temperature according to people's needs. With granted rights to vote on temperature, people are encouraged to interact with the building. In addition, people can enter their mode of commute to building, use of stair v/s elevators, etc., in order to earn individual health credits. This is to encourage green behaviors among occupants.

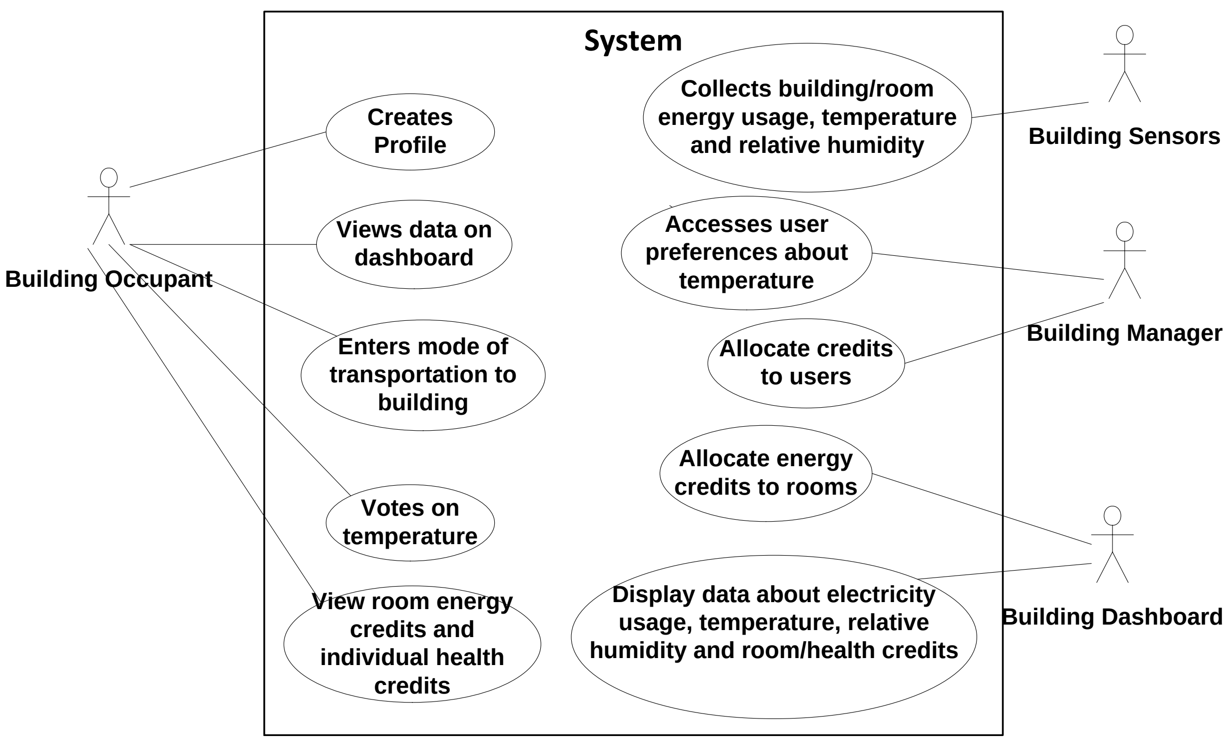

Figure 3. Use case for end-user interaction during building operations.

4 FUTURE WORK

In the following research, the aforementioned conceptual ideas of the SocioBIM applications will be further developed into detailed process maps specifying their requirements and functioning. These process maps will then be used to rapidly prototype these applications in buildings on UBC campus using the Living Lab methodology.

In terms of future work in building-to-end user applications, researches can focus on developing more use cases that are tailored to occupants' need and trying to connect with big data in social media which can make the application not only open to the public but also automatically provide scientific suggestions to designers and building operators.

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