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Digital Twin Approach to Building Information Management

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Currently, verification of building information is based on estimation of historical data. Interaction between the real-world building's indoor environment and a digital yet realistic virtual representation model of building environment is known as digital twin. Where the indoor environment represents by the air temperature, air flow, relative humidity and lighting condition while, digital virtual represent by computational fluid dynamics and luminance level. Digital twin provides the opportunity on real-time monitoring and data acquisition. For instance, employment of digital twin enables gathering, generating and visualizing the indoor environment of building of interest. All gathered data will be stored in the digital twin subsequently, any irregularities will be analyzed. While computational analysis provides visualization of the facility of interest. The integration of this simulation tools to the internet of thing (IoT) represent as a real-time twin. This paper aims to present a conceptual framework design for building information management through the employment of digital twin approach. The proposed framework will be based on the principle conservation of resources and the design for convenient building information management in a large scale. On top of that, the framework design is expected to have appropriate balance between economic, social and environment issues, leading to better utilization of real-time monitoring technology and contribute to optimization of building services

Key Words: *digital twin, indoor environment, performance visualization, building information, energy management*

1. Introduction

Towards the Industrial Revolution 4.0, the extensive applications of internet of things (IoT), cloud computing and digital twin on building industry in general is vital. It is not just allowed early prediction on operation and performance of facility or premises. In addition, executing the digital form condition of both indoor and outdoor environment with high certainty was it implication. Provided it does not involve investing prolonged time consuming along with expensive cost for physical replication. Digital twin for instance, was widely known for its huge contribution in manufacturing and design engineering as it enables replication model of physical product to it digital twin for inspection in term of quality, defect plus the product operation data [2].

Though broad implementation of building information modeling (BIM) which reinforced the idea of conducting full building analysis as early as pre-construction stage and comprising the economical analysis,[3] there is still an industrial prospect to combine IoT and digital twin technology. This approach brings the opportunity to imply the near real-time data via cloud storage to represent updated digital which accessible remotely and perhaps autonomously [4]. While, it is custom for BIM analysis to operate based on existing data that is collected early in the process of creating building profile. This sort of data is not ideally reflecting any changes prior to any event during the building operation timeframe. With that in mind, even though it is seen as ambitious to employed IoT and digital twin in the mean time, with the right strategy and framework it is feasible.

The paper intention was first to define the digital twin approach from the perspective of building industry and subsequently propose a framework for building information management through the employment of digital twin approach. With that goal in mind, this paper will first extend upon on the relationship in which the building information can be manage to coincide with digital twin technology to provide up-to-date digital visualization. In relation to that event, the current trends on technology developed in building industry, specifically related on the employment of IoT and digital twin to manage building information will be discussed. Next, the method corresponding to developing a conceptual framework in the study will then be emphasized. In the end, the conclusion regarding the framework proposed to execute the workflow process was drawn.

2. Building information management

The necessity to manage all the procure data for the sake of building profile configuration has lead to the advancement concerning building automation system (BAS). BAS can be interpreted as centralized, interlinked, networks combination of hardware and software that serve to monitor and control the environment and services in facilities [5]. With regards to BAS implementations, it leaves a trail to cloud computing and IoT platform for storing massive building energy consumption data and enable remote facilities management respectively [7]. To justify the reasons of implementing this technology, it is based on the concerned about the policy involving energy saving. Previous works have claimed that residential and commercial facilities as the largest energy consumer with the consumption of 30-40% compared to transportation sector and other industry [6].

It is estimated that heating, ventilation and air-conditioning (HVAC) system consume about 40–60% of the total commercial building energy consumption followed by lighting approximately about 30%, which both are having a great impact on thermal comfort and visual comfort [1]. These major energy consumers which provide major services for facility thus greatly have effects on building operation cost and the indoor environment.

2.1 Digital twin in building industry

Employment of digital twin in manufacturing industries is very common since it is widely used to represent physical machine tool for the purposes of real-time diagnosis and analysis in case of machines breakdown [8]. Thus, digital twin is generally defined as a virtual representation for their relative physical entity/system. Extensive utilization of real-time monitoring technology is significant in the long run specifically for building industry. As the building is operating throughout its service time, they are vulnerable to malfunction and degrading in performance. Issuing appropriate maintenance scheme such as reactive maintenance, preventive maintenace, predictive maintenance and proactive maintenance to the facilities according to their need is definitely essential.

Deploy continuous actual building services monitoring using a sensor for instance, to track their operation and performance

trends are the example implementation of digital twin in the industry. In relation, it enabled facility manager to outline in advanced the most appropriate and relevant maintenance arrangement. However, there will be an issue in term of cost involving maintenance, labor and parts replacement. In addition, one must not neglect to balance the cost saving and optimization of building services for the sake of energy efficiency [9]. While optimizing the services, it is best not to compromise both the visual and thermal comfort within the facility.

3. Conceptual framework

The employment of digital twin in building information management is simply explained by the conceptual framework portrayed as shown in Figure 1. The figure shows the strategy undertaken for the conversion from a physical room towards its digital twin visual representation. The intention implied is to monitor and provide relevant optimization policy. It is widely known that one way of developing a building profile is by making use of corresponding manufacturer specification. The other approach is by utilizing sensor data that provide the parameter of interest. For instance, the light intensity level used to render indoor environment. The Graphical user interface (GUI) comprises of algorithm and sensor data for the purpose of analysis and provide visual representation is executed to acquire the digital twin. The corresponding GUI can be developed by using Tkinter which is the GUI programming toolkit for python in the mean time which is available as open source.

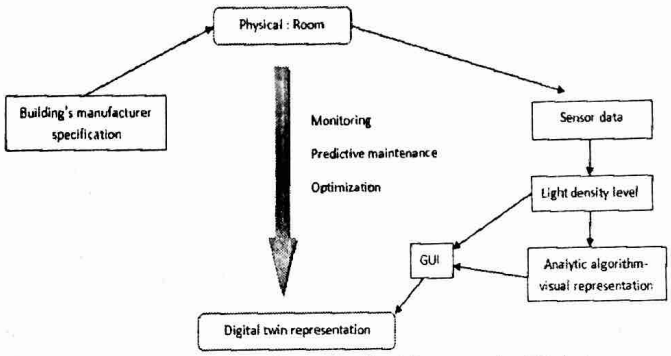

Figure 1: Conversion from Physical Room to its Digital Representation

Figure 2 shows the workflow process to begin by incorporating the Integrated Environment Software <Virtual Environment> (IES<VE>) with IoT. Synchronization between IES software and ERGON however require project URL and token which is available for those who possess a corresponding license.

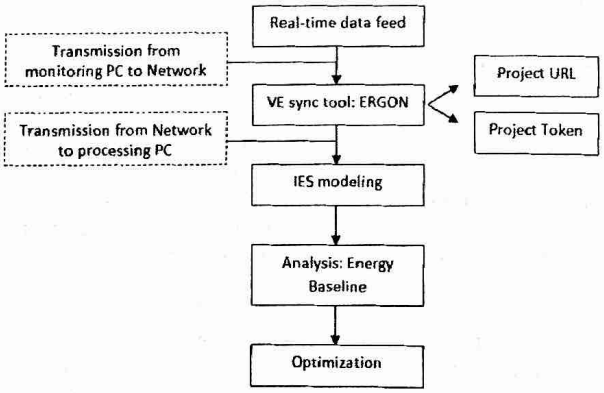

Figure 2: Workflow for IES<VE> cloud based simulation

The process using GUI from the workflow in Figure 2 is shown in Figure 3. Three main steps involve are initially begin from extracting real time data from smart utility meter to ERGON cloud. The data from the cloud was then being synchronized with model developed in IES software. The data implied from the simulation result which is represented in the form of contour of luminance level are known as the rendered form of digital twin for physical lighting condition of the respective room.

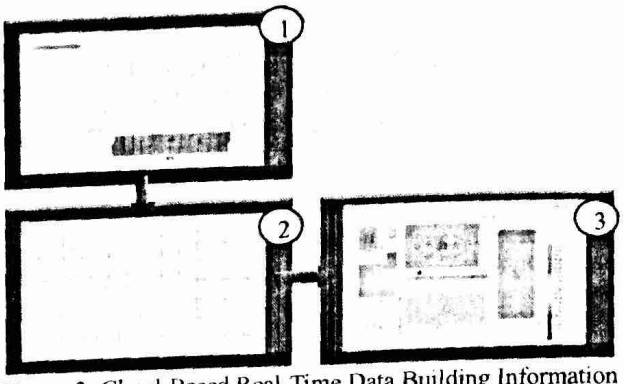

Figure 3: Cloud-Based Real-Time Data Building Information

4. Conclusion

The proposed conceptual framework theoretically enables the researcher to develop digital twin approach for building information management. Eventually, accurate predictive maintenance based on IoT will contribute to the optimization of the process of the building services.

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