Location-based Facility Management System Framework Using 3D-BIM on Commercial Office Buildings

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Abstract –

In order to maintain a reliable facility management (FM) service for a commercial office building, a facility personnel and the building owners make a decision with detailed-level building Operation and Maintenance (O&M) data. By analyzing the data, they can make decisions in terms of whether to and/or where to invest money for maintaining better conditions of the buildings. Conventionally, the facility personnel collect O&M data in a manual manner and organize them in a paper document format. In this format, most of O&M data are intertwined and mingled up so that both FM personnel and building owner fail to capture significant information for reliable O&M performance. More often than not the building owners have difficulty in understanding the building's O&M performance through the bundled data. According to the FM personnel's work process and building owner's decision making process, location data are employed as a starting point to O&M work and O&M performance confirmation respectively. Despite of the significant role of location data, no systematic framework based on the location data has been developed. For the purpose of facilitating both the owner and facility manager's better decision making, the authors develop a system framework for 3D/BIM-based facility information management. The 3D/BIM has an advantage on storing and outputting the location data. Using the system framework, the FM personnel and building owner obtain effective information management platform based on location data. In addition, the research can contribute to the foundation for a development of a BIM-driven facility management system.

Keywords –

Decision Making; Information management; Operation and Maintenance; System Framework; 3D/BIM

1 Introduction

Among the various critical success factors of Facility Management (FM), both facility management (FM) personnel and building owners have common consensus that reliable Operation and Maintenance (O&M) is the most significant success factor in FM (Yoon and Cha 2016). In addition O&M phase, as a longest period in the lifecycle of a building, generates majority of FM expenses (Lee and Akin 2011). It accounts for 85% of total costs spent over lifecycle of a building (Teicholz 2004).

Despite of the practical and fiscal significance of O&M phase, most of the O&M work process is placed upon superficial level. It has limitations on providing proactive work, just providing reactive and impromptu O&M work (Akcamete et al. 2010). Still the paper document is primary medium for O&M information between FM personnel and O&M computational systems, resulting in failure on timely service (Lee and Akin 2011). Even though a compact disk could be employed to store FM information in PDF, these files are easier to lose (William East et al. 2012). Furthermore, it doesn't have proper O&M information repository for assisting them to identify and diagnose O&M problems or increase their awareness of previous problems, maintenance and repairs work (Akacamete et al. 2010). In particular, lack of locational information system results in ostensible analyses on O&M work. According to Becerik-Gerber et al. (2011), FM personnel need locational data which allow topological and accurate analysis on O&M work. They believe the location data are helpful to perform preventive and corrective O&M work. In conclusion, both information reposition and locational data analysis in O&M phase leads to reliable O&M service (Figure. 1). Although several Computer Aided Facility Management (CAFM) programs have been developed to solve these problems, the field of O&M information management system is relatively young and, as such, is still establishing its basic tenets.

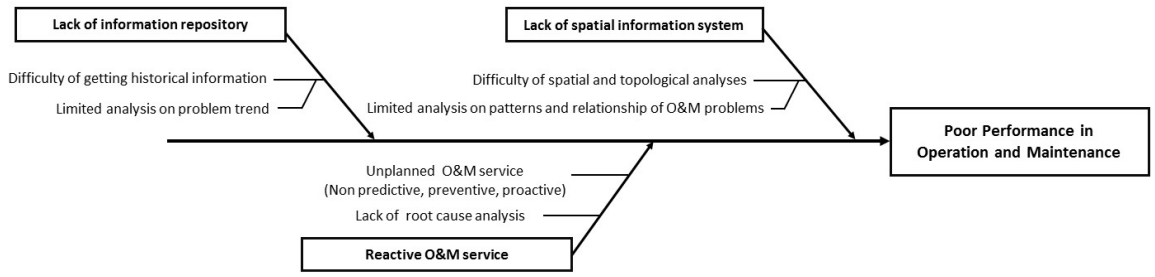

Figure. 1 Root-cause diagram of poor performance in operation and maintenance

In particular, most prevalent CAFM programs such as ARCHIBUS/FM and Maintenance Connection are not appropriate for locational information reposition and analysis. ARCHIBUS/FM provides 2D-based interface. It is difficult to identify problems on three-dimensional equipment such as pipes and conduit, which is main information for HVAC (Heating, Ventilating and Air-Conditioning) among O&M works (Lee and Akin 2011). Maintenance Connection provides web-based FM information management system. However, it doesn't provide locational data visualization. The owners have difficulty in confirming locational data with this program.

The main purpose of this research is establishing a framework for O&M information management system using Building Information Modeling (BIM). BIM can provide FM data repository and become information backbone for FM systems by providing 3D objective-based parametric data (Ghosh et.al 2015). BIM can also improve facilities management by providing accurate FM data and easy accessibility to the data (Kassem et al. 2015; Ismail et al. 2015). The proposed framework will include locational information analysis and computational reposition, based on BIM. The authors hope that both FM personnel and building owner can have an effective FM information management system through this system framework.

2 Literature review

Akcamete et al. (2010) presented BIM-based maintenance planning system. It helps to store maintenance data and understand previous maintenance work trend. Through the stored locational data, it is possible to analyze maintenance information topologically. However, the system's operation is circumscribed in repair work. It doesn't address both HVAC problem and energy management. In addition the proposed spatiotemporal analysis on the information is still in its early stage. The paper simply presents locational relationship between several different repair works. It is necessary to address whole O&M information with locational data and contrive how to utilize the accumulated information with FM personnel and the building owner. Wetzel and Thabet (2015) presents a BIM-based framework to support safe maintenance and repair practices. While it is meaningful that the framework is based on locational data from BIM, so that it can provide more sophisticated information analysis, it just deals with not comprehensive O&M information but only safety issue. Shalabi and Turkan (2016) emphasize FM data collection for corrective maintenance work. They developed BIM-based data repository, improving visualization and interoperability capabilities. The system could receive data from both Building Energy Management Systems (BEMS) and Computerized Maintenance Management Systems (CMMS), conventional FM operation systems. However, the paper mainly addresses linkage between existing FM systems and BIM, but does not present how to utilize the system for providing proactive O&M planning and reliable O&M service.

Previous literatures all agree with the importance of more sophisticated O&M information management system for reliable FM service providing. Furthermore they have consensus that the locational data provide valuable information for it. However, the studies are not only circumscribed in technical issue but also superficial in providing the practical application platform for both FM personnel and building owner. There are limitations on application of the systems to the real FM practice situation. Examining the information flow in practical situation could be the fundamental step for development of an effective and a realistic information system. Satoshi and Ichizou (2013) emphasize the significance of understanding the practical information flow as a fundamental role in establishing an information management system. In this paper, the system framework for O&M information management helpful to analyze the data topologically and comprehensively is proposed based on the case-based analysis on the O&M information flow. It will be helpful to establish more practical system framework as a next step for previous research.

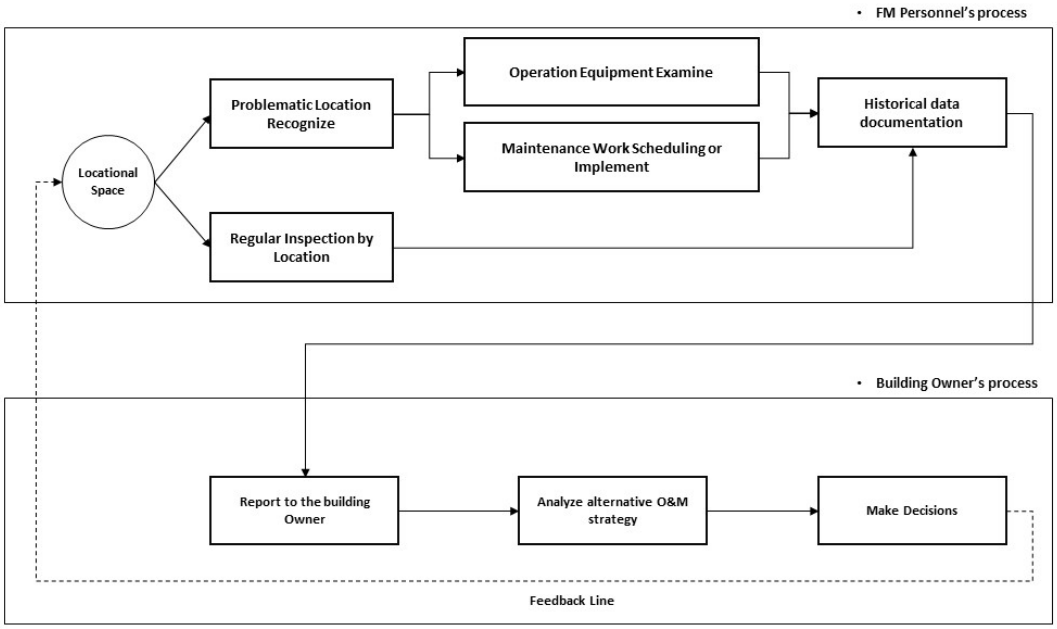

Figure. 2 Current work process of FM Personnel and Building Owner

3 Practical FM Information Flow

As explained above, in order to build an effective information management system, analysis on practical information flow is indispensable. In this paper the monthly FM O&M report documents for a stereotype commercial building in South Korea are examined to understand the information flow in real case. In addition, the building's FM expert interview is carried out in order to identify FM personnel's work process and building owner's decision making process.

3.1 G-building in South Korea

One of the largest commercial office buildings in South Korea was chosen to analyze the FM information flow. The building was constructed in July 2001 with 45 stories above ground and 8 stories below. The building area is approximately 212,000m^2, and the facility maintenance expenses are approximately 20 million dollars per year. In addition, there are 13 facility managers and 48 facility service implementers in FM.

3.2 Analysis on Current FM information flow

According to the G-building's FM experts interview, locational space such as specific floor or space are the starting point for both FM work process and building owner's decision making process (Figure. 2). FM personnel require locational data in establishing O&M schedule or deciding proper solution for O&M problem. Building owners ask for the O&M performance information by location. They consider one space where the certain tenants lease as one unit for managing whole building. In conclusion, both FM personnel and building owner employ the location data as an essence step in order to capture the valuable information. However, in the current FM report document format, it is challenging to extract locational data and this difficulty causes ostensible analysis on the O&M data.

According to the examination on the monthly FM report for G-building, the various O&M data are intertwined and provided in paper document format to both FM personnel and building owner. When they obtain locational data, they should pass through other futile data which are linked to the locational data (Figure. 3). With this current document format, it is almost impossible to sophisticatedly examine the data and obtain valuable information. The difficulty in obtaining locational data leads to failure on proactive work planning. With the locational trend data, the FM personnel can expect which location is vulnerable to specific O&M work and then they can establish proactive solution for it in advance. Furthermore, the current process impedes FM personnel identifying root-cause of O&M problem because all information are intertwined with each other. To be more specific, it is challenging to extract and analyze certain category data. For example, when they need to analyze the whole O&M work orders to find out O&M problem continuity, it is demanding because other data such as O&M equipment or Operations information are given together.

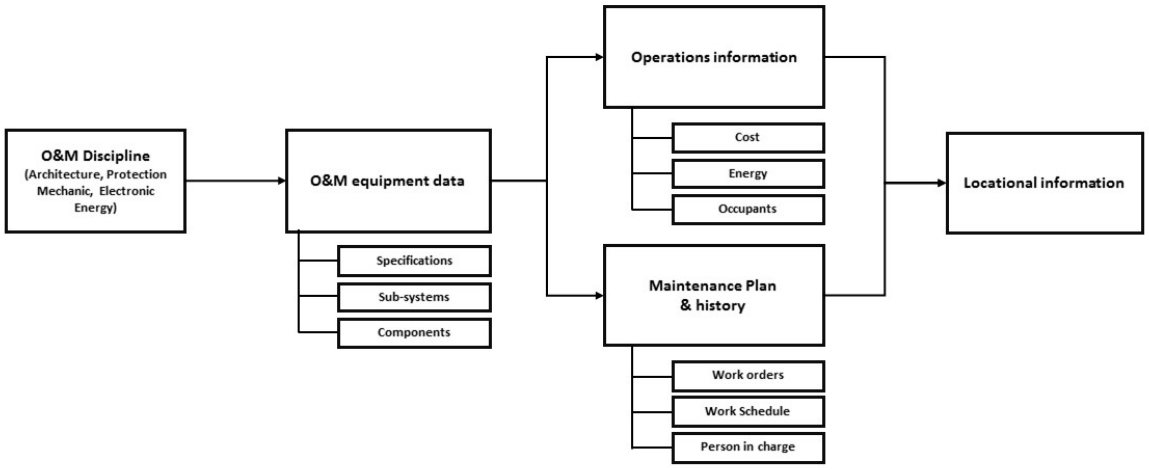

Figure. 3 FM Personnel and Building Owner's O&M information flow in Current FM report

As a result, they manually sieve out the data from the data-mingled document. It is inefficient and time-consuming in FM process. As a result, the FM personnel have had difficulty in obtaining valuable information for providing reliable FM service with this current process.

On top of that, the current information obtaining process reveals that it has a critical disadvantage on information provision to building owner. As every information is bundled up and intertwined in one paper document, it is difficult to extract specific information, which the owner want to confirm. In particular, according to the owner's decision making process, the owner want to confirm O&M performance by the specific location. In the current FM report, the certain information which the owner want to confirm can't be obtained so that they fail to rational decision making for investment on O&M. As a result, the failure leads to unreliable O&M services.

In conclusion, the new FM information process system is necessary in order to provide reliable FM service. It should be possible that both the FM personnel and building owner can obtain desirous information easily and they can analyze the information spatially and comprehensively. The location data will be the key for the system framework.

4 Location-based FM information System framework

Based on the problem analysis on the practical information flow in the current FM report, the effective O&M information system framework is proposed. The framework allows both the FM personnel and building owner to identify patterns and relationship of O&M problems by employing BIM-based locational data. As explained above, locational data such as specific floor or space are the starting point for both FM work process and building owner's decision making process. In other words, the locational data are the hub for the information distribution. Because BIM is proper to provide O&M locational data in 3D model (Ghosh et.al 2015), it is placed upon the center of the system as a repository station. This BIM-based data repository received information from several ways. FM personnel input two different information. One is concerning "Personal data"; assigned department and equipment. By inputting this information to the repository, they can obtain proper information matched with department and equipment. The other one is about "O&M work"; O&M work history or schedule. This inputted data is organized with locational data in the repository and transferred to maintenance schedule data or operation/maintenance solution. As an output, the refined information with 3D locational data can be provided to the building owner when he or she input the data such as location where they want to confirm the performance of O&M. Furthermore, this output is employed for sophisticated analysis on O&M problem. After the O&M team meeting on this output, the updated solution or work schedule is stored again to the BIM-based data repository. The O&M problem information from existing FM programs and problem reception is also inputted to this repository. The received O&M problem is organized with locational data. The BIM-based repository notifies this problem to the FM personnel who are assigned to problematic location. The comprehensive concept of this information system-use process is provided in Figure 4.

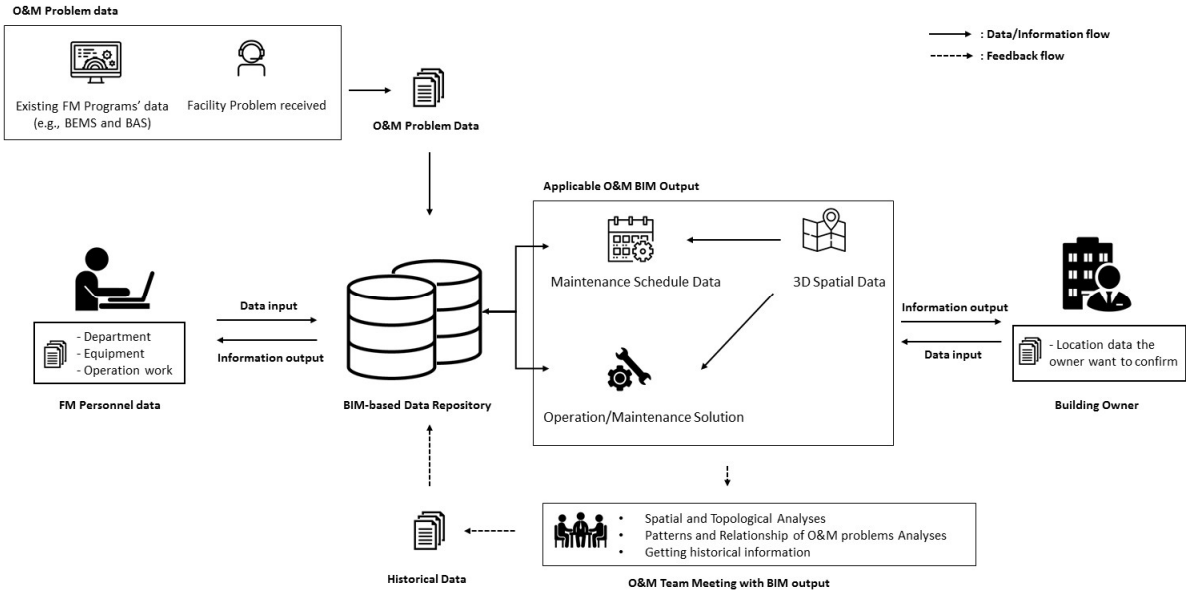

Figure. 4 Locational data-based FM information system framework

5 Conclusion

To provide a reliable FM service, it is indispensable for FM personnel and building owner capture the valuable information in O&M phase. This is because the FM information analysis makes it possible to prepare a preventive O&M work (Oti et al. 2016). In particular, locational data, which is the fundamental component for understanding O&M problem trend or topological reasons, should be presented to FM personnel and building owner for better decision making. Because of this importance of data processing in FM, great attention has been shown to the question of how to establish an effective FM information system. However, fewer studies have attempted to construct fundamental application platform for the system based on locational data. In addition, there were lack of consideration on what the owner's want to know and what the FM personnel want to know for effective FM practice. The previous research mainly had addressed technical issue: how to link BIM to existing FM program. Few have attempted to address BIM in managerial perspective. In this paper, the authors proposed a system framework for practical FM system application. It is established with the empirical analysis on real building's FM report document and FM expert's interview. It is helpful to understand problematic location and provide valuable information for preventive FM. As a next step for previous FM information system research, this research provides an effective application platform.

On top of that, the proposed framework provides sophisticated analysis process on the O&M information. It organizes all O&M data from FM personnel and existing FM system and distributes them with 3D model to FM personnel and building owner. 3D model allows easy and accurate understanding about FM problematic location or object (Lin and Su 2013). The transferred information offer the opportunity to analyze the O&M problem trend temporally and spatially. This will assist FM personnel to plan O&M work schedule more sophisticatedly. Furthermore, the information are provided to the owner when they want to confirm the certain location's O&M information. The owner can understand the overall O&M work performance more effectively and accurately. As a results, by applying the framework, the better decision making of both FM personnel and building owner can be obtained for reliable FM service.

However, this paper is limited to consideration of framework for the O&M information system. It is believed that further practical system development with the proposed framework is worthwhile. The future work will be devoted to establish a practical O&M information system. It is to be hoped that this paper will serve as a platform from which studies of greater depth and specificity may be undertaken.

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References

[1] Akcamete, Asli, Burcu Akinci, and James H. Garrett. Potential utilization of building information models for planning maintenance activities. *Proceedings of the international conference on computing in civil and building engineering. June*, 2010.

[2] Becerik-Gerber, B., Jazizadeh, F., Li, N., & Calis, G. Application areas and data requirements for BIM-enabled facilities management. *Journal of construction engineering and management*, 138(3), 431-442, 2011

[3] Ghosh, A., Chasey, A. D., & Mergenschroer, M. Building Information Modeling for Facilities Management: Current practices and future prospects. *Building Information Modeling,* 223, 2015.

[4] Ismail, Z. A., Mutalib, A. A., Hamzah, N., & Baharom, S. BIM technologies applications in IBS building maintenance. *Jurnal of Teknologi*, 74(3), 69-76. 2015

[5] Kassem, M., Kelly, G., Dawood, N., Serginson, M., & Lockley, S. BIM in facilities management applications: a case study of a large university complex. *Built Environment Project and Asset Management*, 5(3), 261-277. 2015

[6] Kubota, S., & Mikami, I. Data model–centered four-dimensional information management system for road maintenance. *Journal of Computing in Civil Engineering,* 27(5), 497-510, 2011.

[7] Lee, S., & Akin, Ö. Augmented reality-based computational fieldwork support for equipment operations and maintenance. *Automation in Construction*, 20(4), 338-352, 2011

[8] Lin, Y. C., & Su, Y. C. Developing mobile-and BIM-based integrated visual facility maintenance management system. *The Scientific World Journal*, 2013.

[9] Oti, A. H., Kurul, E., Cheung, F., & Tah, J. H. M. A framework for the utilization of Building Management System data in building information models for building design and operation. *Journal of Automation in Construction,* 72, 195-210. 2016

[10] Shalabi, F., & Turkan, Y. IFC BIM-Based Facility Management Approach to Optimize Data Collection for Corrective Maintenance. *Journal of Performance of Constructed Facilities*, 04016081. 2016.

[11] Teicholz, E. Bridging the AEC technology gap. *IFMA Facility Management Journal*, 587, 588. 2004.

[12] Wetzel, E. M., & Thabet, W. Y. The use of a BIM-based framework to support safe facility management processes. *Automation in Construction*, 60, 12-24, 2015.

[13] William East, E., Nisbet, N., & Liebich, T. Facility management handover model view. *Journal of computing in civil engineering*, 27(1), 61-67. 2012

[14] Yoon, J. H., & Cha, H.S. An empirical study of facility management performance on commercial office building in South Korea. *5th International Conference on Civil Engineering and Urban Planning (CEUP).* Xian, China, in press, 2016