BIM-RFID Technology for Facility Management in Power Systems

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Abstract. Currently, there is a lack of a practical and straightforward method to accomplish concealed facility positioning and maintenance work in power systems, such as a substation or power plant. On the one hand, it is hard to find the accurate location of a specific device that is on the ceiling or underground in the Operation and Maintenance (O&M) phase. Another challenge is to provide useful information for facility maintenance workers and to bring a visible location image for them on the site. In this paper, Building Information Modeling (BIM) and Radio Frequency Identification (RFID) technologies are used to solve facility positioning and maintenance issues in power systems. First, the facility position can be determined by comparing the real RFID tag location with the virtual RFID tag location. Moreover, the target-related facility information for the maintenance work can be acquired by BIM models. Lastly, the live view of the specific location of a concealed equipment can be shown on a mobile terminal on the site by using a simple Augmented Reality (AR) technique. This paper, containing a substation case study, demonstrated that the BIM-RFID technology could achieve precise positioning, efficiency improvements, and re-visit times and costs reduction in power systems.

1. Introduction

Facility Management (FM) is a crucial part of project lifecycle management, as the cost of FM constitutes about 70% of the total project cost (see Figure 1) [1]. However, traditionally FM was recognized as a non-core part in the power industry, focusing primarily on support services without real business value [2]. Besides, lots of researchers had finished the FM-related studies, such as creating and using a navigational algorithm for effective real-time indoor visualization to finish utility maintenance in an unfamiliar environment [3]. However, there is a lack of a practical and straightforward method to accomplish concealed facility positioning and maintenance work in power systems, such as a substation or power plant. At present, it is hard to find the accurate location of a specific device that is on the ceiling or underground in the Operation and Maintenance (O&M) phase. Another challenge is to provide useful information for facility maintenance workers and to bring a visible location image for them on the site.
2. **BIM & RFID**

Building Information Modeling (BIM) is an intelligent three-dimensional (3D) model-based process that gives architecture, engineering, and construction professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructures [4]. The core idea of BIM is to achieve dynamic performance and information management. Besides, BIM has powerful 3D display capabilities, which can offer visual aids for facility management.

Radio Frequency Identification (RFID) is a relatively mature technology that has an indoor precise positioning function. RFID tags have the strong anti-pollution ability and can repeatedly be read and wrote. Thus, RFID technology is suitable for power construction projects. Other information acquisition and transmission technologies, such as Barcode, ZigBee, and Wi-Fi [5], are not chosen in this paper since they have apparent shortcomings relative to RFID (see Table 1).

### Table 1. Shortcomings of the related technologies.

| Technology | Disadvantages |
|------------|---------------|
| Barcode    | The tag is easy to wear, and the memory capacity is limited. |
| ZigBee     | It has poor network scalability and poor positioning stability, and the tags are expensive. |
| Wi-Fi      | It is susceptible to external signal interference, and it does not support frequency hopping techniques. Data stability and security cannot be guaranteed. |

3. **Literature Review**

(1) **BIM-based data collection & management**

During the O&M stage, facility managers need to read some unconnected two dimensional (2D) as-built drawings for acquiring the equipment location and dimensional details. This step may take a significant amount of time to perform non-value-added tasks such as retrieving, accessing, and verifying information. This trouble can be solved by using BIM-based means in the O&M phase since BIM can realize quick data collection and management processes in a 3D model. Based on it, Meadati, Irizary, and Akhnoukh [6], and Meadati and Irizary [7] proposed a BIM-RFID framework and a BIM-Quick Response (QR) code environment, respectively, to facilitate component selection and information retrieval. Besides, Adams and Walther [8] adopted an economic analysis method to evaluate the BIM-based data collection system, the results displayed that the connection to a BIM can ensure the availability of up-to-date data and thus achieve an enormous qualitative benefit.

(2) **RFID-based indoor localization & navigation**

Usually, a completed building or plant is managed and maintained by a professional property company that was not involved in the construction process. Therefore, detecting the actual position of a specific device or oneself in an unfamiliar environment based on the 2D as-built drawings is difficult and time-consuming. RFID can solve this problem effectively. Motamedi, Soltani, and Hammad [9] put
forward an RFID-based system for indoor localization, and they found that a manager with an RFID reader can obtain the target asset location quickly. Besides, Costin et al. [10] developed an RFID-based navigational algorithm for effective FM, which provided the shortest route method for FM managers.

(3) BIM-RFID information sharing & exchange

Efficient information sharing and exchange between BIM and RFID is essential for FM. Rely on BIM and RFID characteristics, so that they can work together well. On the one hand, BIM has strong editable functions, and a new object family can be created to display RFID tag with accurate position information in a BIM model [11]. On the other hand, the RFID device has reading and writing functions, and any text information and picture information from the BIM model can be added into RFID tags. When scanning tags, the relevant information can be illustrated on the RFID reader. In the O&M phase, integrating BIM and RFID brings convenience for facility positioning and maintenance [12].

4. Research Framework

In this paper, BIM-RFID is used to not only achieve the information exchange between the virtual environment and the real environment but also fulfill the message passing from facility managers to maintenance workers. Also, an Augmented Reality (AR) tool is used to realize site visualization. A substation case study was implemented to verify the research process and goals. The complete research framework is shown in Figure 2.

5. Case Study

A 35KV substation is located in Liaoning province, in which the floor space is 389.52m², and the total construction area is 769.68m². The main structure is a two-story building, in which the first floor includes 10KV switch rooms, grounding transformer rooms, condenser rooms, and living rooms, and the second floor includes 35KV switch rooms, equipment rooms, reference rooms, and tool rooms. Also, the substation has ancillary buildings, including a pumping station, a firefighting pool, and an accident oil pool.

The first step of the research is to finish the equipment location work. A portable passive RFID system that includes a reader and tags is selected. According to the actual situation, a twelve-digital number constitutes the tags’ Electronic Product Code (EPC) serial number. The standard form is 001234567890, where (1) 00 represents a construction project name, such as the 35KV substation project; (2) 12 represents a single project name, such as the main building construction project; (3) 34 represents a unit project name, such as the installation project; (4) 56 represents a branch project name, such as an electrical project; (5) 78 represents a sub-project name, such as an air-duct system installation project; and (6) 99 represents a specific equipment name, such as an exhaust fan. Besides, all tags can be encrypted. After this, the corresponding tag components are created and placed in BIM models based on the real condition. Now, the equipment virtual location is associated with its real location. Managers can use the RFID reader to gain the tags’ information, such as the EPC number. Then, they can search the same tag in the BIM model based on the existing information to confirm the facility position.

The second step is to supply some useful information for the maintenance workers. In this stage, the most critical work is to add or revise the attribute information of the device in the BIM model. The attribute information may include (1) Equipment operating parameters and spare parts; (2) Mechanical, Electrical, and Plumbing (MEP) information, specifications, and warranty; (3) Electrical panel information; and (4) Work order history information [13]. Managers can transfer the information with the related models (target equipment and surrounding devices and pipelines) to the workers for the preparation of appropriate maintenance instruments.

The third step is to accomplish on-site visualization. Managers can use the BIM platform to isolate useful information for AR applications, such as regional 3D models. Moreover, the extracted information can be added to the AR display application, HP Reveal, to generate the AR effect. Finally, when the workers come, managers can show the 3D image or animation of the corresponding position on the smartphone or iPad, using the target RFID tag as an activator. Based on the BIM model scale and...
the virtual tag position, the location and structure of the whole concealed facility can be confirmed. A simplified process from step one to step three is shown in Figure 3.

Figure 2. Research framework.

Figure 3. A simplified process.

6. Conclusion
This paper proposed a BIM-RFID method for facility positioning and maintenance work. The paper not only described the BIM-RFID detailed application procedures but also verified the method validity.
through a substation case study. The conclusion of the paper is reflected in the following aspects: (1) BIM-RFID can find the accurate location of a concealed device in a short time; (2) BIM can supply some useful maintenance-related information for the workers with other documents; (3) Based on the information, the workers have enough time to prepare the suitable tools for reducing the field re-visit times and labor costs; (4) A simple AR technique can realize ordinary visual maintenance with the help of BIM-RFID technology; (5) The overall efficiency of the maintenance work can be improved.

References
[1] Ž. Rajšter, BIM and DISTO™ tools, Information on https://lasers.leica-geosystems.com/blog/bim-and-disto-tools.
[2] A. K. Nicał and W. Wodyński, Enhancing facility management through BIM 6D, Procedia Engineering. 164 (2016) 299-306.
[3] A. Costin, A. Shaak, and J. Teizer, “Development of a navigational algorithm in BIM for effective utility maintenance management of facilities equipped with passive RFID”, in ASCE International Workshop on Computing in Civil Engineering, Los Angeles, CA, 2013, pp. 653-660.
[4] Autodesk, What is BIM, Information on https://www.autodesk.com/solutions/bim.
[5] K. Chen, W. Chen, C. T. Li, K. Y. Chan, and J. C. Cheng, “Developing a location aware building information modeling system for facility maintenance management”, in Construction Research Congress 2018 (CRC 2018), New Orleans, LA, 2018, pp. 111-120.
[6] P. Meadati, J. Irizarry, and A. K. Akhnoukh, BIM and RFID integration: a pilot study, Advancing and Integrating Construction Education, Research and Practice. 5 (2010) 570-578.
[7] P. Meadati and J. Irizarry, “BIM and QR code for operation and maintenance”, in 2015 International Workshop on Computing in Civil Engineering, Austin, TX, 2015, pp. 556-563.
[8] G. Adams and D. Walther, “An economic analysis of BIM-based data collection systems in facility management”, in International Conference on Construction and Real Estate Management 2017, Guangzhou, China, 2017, pp. 1-10.
[9] A. Motamedi, M. M. Soltani, and A. Hammad, Localization of RFID-equipped assets during the operation phase of facilities, Advanced Engineering Informatics. 27 (2013) 566-579.
[10] A. Costin, N. Pradhananga, and J. Teizer, “Passive RFID and BIM for real-time visualization and location tracking”, in Construction Research Congress 2014 (CRC 2014), Atlanta, GA, 2014, pp. 169-178.
[11] C. Zhang, A. Hammad, J. Chen, and Y. Yang, “Experimental investigation of using RFID integrated BIM model for safety and facility management”, in Proceedings of the 13th International Conference on Construction Applications of Virtual Reality, London, UK, 2013, pp. 150-159.
[12] Y. Fang, Y. K. Cho, S. Zhang, and E. Perez, Case study of BIM and cloud–enabled real-time RFID indoor localization for construction management applications, Journal of Construction Engineering and Management. 142 (2016) 1-12.
[13] R. Liu and R. R. Issa, “Issues in BIM for facility management from industry practitioners’ perspectives”, in ASCE International Workshop on Computing in Civil Engineering, Los Angeles, CA, 2013, pp. 411-418.