Barriers to Benefit from Integration of Building Information with Live Data from IOT Devices during the Facility Management Phase

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Abstract—The building information is invaluable in the facility management industry in order to provide and deliver a timely and professional analysis and consulting support for more effective management services, (e.g. energy management). Nowadays, buildings are equipped with immense number of Internet of Things (IoT) and smart devices. These devices are producing a vast amount of live data about the building. Typically, the captured information from different information sources are stored in heterogeneous repositories. Various information resources together with the live data can be used by the facility management industry to speed up the maintenance processes and improve efficiency of services. To provide more added-value services, they can also benefit from integration of the building information with the live data. There is no doubt that integrating the information can provide value; nonetheless, there are some barriers and considerations when combining the building information with the live data. This prevents many industries like the facility management industry to fully benefit from this integration. In this paper, we introduce the existing barriers to integrate information and live data from the academia and industry perspectives. Subsequently, a potential approach is proposed to make the integration of the building information with the live data possible. The approach is in the form of a three-phase process and its usability is demonstrated by a few use-cases. The output of the process will be beneficial for diverse ranges of users, e.g. the facility management industry.

Keywords — Building Information, Live data, IoT Devices, Sensors, BIM.

I INTRODUCTION

The facility management industry is responsible for providing and delivering a timely and professional analysis and consulting support services for customers (Rondeau et al., 2012). These companies start to play their role in the operation phase of the buildings life cycle. The facility management (FM) companies utilise the building information to speed up the maintenance processes, as well as improving the efficiency of their services. To provide their services, they use various sources of the building information and the live captured data.

The first source of the building information is the handed-over documents from the previous phases of the buildings life cycle, (i.e. through plans in the paper version or the digital drawing format (AutoCAD files, reports, the table, etc.). With the emergence of the BIM technology, the building information has been also available through the developed Building Information Models (BIM).

The second source of providing the building information is the smart and the IoT devices installed in the buildings spaces. These devices produce priceless live data about the status of the spaces and devices. As mentioned earlier, the FM companies can take advantage of the live data along with the buildings space information to provide and deliver more added-value services. However, there are some barriers to fully benefit from combination of the buildings information from the two above-mentioned sources. The main barrier is due to the fact that the building information and live data are scattered across heterogeneous storages. As such, because of the fragmented systems (i.e. separate systems for space planning, the maintenance helpdesk, the building management system, etc.), the FM staff are unable to link the building information. These barriers result in the duplication of efforts, inaccurate data and in some cases where the access to data is restricted, inaccessible data. Indeed, a variety of systems and silos leads to staff’s inefficient work. This is in part caused by non-standardisation of the data input and the lack of standard processes and procedures for capturing and recording the building information. When the data is captured and there are no standard methods or procedures for the data capture and input into a system, the FM staff will develop their own methods and procedures for undertaking these tasks, resulting in the necessity of controlling the data version as well as data duplication issues.

Because of the aforementioned barriers, combinations of the building spaces information and the live data is not available for the FM companies. In this relation, many surveys have been conducted to explore the origins and impacts of these barriers on the efficiency of the services. Lavy and Jawadekar (2014) underscored that the facility management activities depend on the accuracy and accessibility of the data created in the design and construction phases. As such, referring to the GSA (2011), the lack of appropriate and sufficient information can result in cost overruns, inefficient building operations, and untimely resolution of the client requests.

There are many potential benefits involved in eradicating the explored barriers. Improvements can be made to the overall efficiency of the staff activities, minimizing the time spent on the individual tasks. This can also enhance the staff’s performance as less time is spent in an effort to establish the accuracy of the available building information. Indeed, this time can be spent on the task at hand such as monitoring the energy usage. In principle, an overall improvement of the lifecycle management can lead to reductions in the operational costs. The origins of the barriers from both the academic and practice perspectives have been scrutinized and elaborated on through the rest of the current paper. Then, the proposed solution by this study to remove the barriers is presented. Later, the benefits of the proposed solution are described in the form of practical use-cases.

II The Origins of the Barriers

In this section, the origins of the barriers are explained from two various academic and industry perspectives. In the first sub-section, the barriers are related to the heterogeneity of the building information produced during different phases of the buildings life cycle. In the second sub-section, the origins of the barriers associated with the practical and organisational aspects are introduced.

a) The Origins of the Barriers-the Academia Perspective

Consistent with the studied literature, the recognised barriers are associated with either the information produced during the design and construction phase (i.e. specifications of the spaces and devices), or the live captured data during the operations phase. The former is related to the availability of the building information in the digital format. Normally, the building information is handed-over to the operation phase in the form of plans (e.g. architectural/electrical/mechanical plan), tables and reports. This type of information is the only available version of the information for the majority of the existing buildings. In this way, the FM industry as one of the potential users of this information would not be able to combine non-digital buildings information with the digital live captured data from the IoT devices and sensors. During the last decade, the BIM (Building Information Modelling) technology has been introduced to make the digital version of the buildings information available. Notwithstanding the proven capabilities of this technology, still the industry users, (e.g. facility management companies) cannot benefit from the building information through the BIM models. This is due to the fact that the BIM technology confronts a large number of challenges, e.g. updated data for the as-built BIM models (Gu et al., 2008), the pertinent semantic format for the maintenance stage (Shen et al., 2010), the unsystematic use of the building information on the virtual models (Nummelin et al., 2011), and the computerised facility management system integration (Becerik-Gerber et al., 2011). Therefore, both the reliability and accuracy of the BIM models are considered as a principal challenge for the FM industry. Moreover, Pärn et al. (2017) reported a challenge related to the usability of the information from the BIM models for the maintenance stage.

The latter group of the origins of the barriers, i.e.to take advantage from the building information, is associated with the heterogeneity of the live data produced by the IoT devices and sensors. In this regard, Shen et al. (2010) and Winch (2010) identified challenges related to the interoperability, the interfaces with the other systems and the integration of the wired and wireless sensor networks to enhance the live data collection. According to Pärn et al. (2016), these challenges stem from the differences in the data syntax, the schema, or the semantics. With regard to the reviewed literature, the integration of the information and data has been also recognized as a challenge. As Ajam et al. (2010) proclaimed, these issues contribute to some other key challenges in terms of the manual driven process to utilise the building information, the lack of proper quality control procedures, as well as the obsoleteness of the information.

b) The Origins of theBarriers-the Industry Perspective

Facility management staffs encounter several issues in terms of the inability to collect and share the structured building information such as the buildings fabric, the spaces and the mechanical/electrical systems. Some of the reasons for the unavailability of such information are discussed in the succeeding section. One of the reasons behind the emergence of this issue is the incomplete handover of the building information through the building project's life cycle, from the design to the construction and occupancy. As an example, many changes arise during the construction phase which should be incorporated with the 'as design' plans to provide update plans (as-built plans). Nevertheless, for the majority of the buildings only the 'as design' plans are handed over to the further steps. This happens because of the unwillingness to invest time and budget to update the building projects plans.

A further example is related to the need to refurbish or reconfigure the building spaces and the mechanical/electrical systems happening during the occupancy phase. These changes are required to be incorporated with the existing building information as well. All of the above mentioned problems negatively impact the efficiency of the decision making processes for the facility management companies. There are also some further issues related to the fragmented systems due to the facility management staff's tendency to work on their own initiatives. This problem is firstly arising from the lack of proper understanding of the values of the availability of the structured and shareable data. The second group of the reasons for the fragmented systems is related to the lack of standard methods and procedures for the data collection or proper systems to support data sharing. In such a condition, the FM staff relying on their creativity select their own methods which leads to creating more difficulties in effectively managing the building asset.

III The Proposed Process to Integrate Information and Live Data

Data integration was defined by Cruz and Xiao (2009) as "the combination of data from different sources with unified access to the data for its users". Many researchers have proposed methods and models to integrate the building information with the live data to facilitate the buildings maintenance. Yet, inadequate data integration is a current challenge faced by the building information management technologies (e.g. BIM). With the aim of tackling this challenge, this research intends to propose a process model to collect, analyse, and integrate the building information with the live data captured from various IoT and smart devices and sensors. The proposed process includes three phases explained as follows:

a) Phase 1: Structuring an Open Storage

The first phase of the proposed process model is to structure an open storage in which the integrated and qualified building information and live data are stored. The open storages structure should comply with the construction industry standards, i.e. ISO 16739, ISO 12006, ISO 29481. To develop such an open storage, the first step is to explore the above-mentioned standards, (i.e. the European standards for the construction industry). Based on these standards, some structural and semantical requirements are specified. Regarding these requirements, an initial version of the open storage structure can be defined. Structuring the open storage will be completed after accomplishing the second and third phases. This is due to the fact that some additional fields to preserve the information and live data are specified through the next two steps.

b) Phase 2: Capturing the Multi-source Building Information and the Live Data

In this phase, two various sub-processes are proposed to capture the building information and the live data from various sources (e.g. building plans, reports, IOT devices, sensors, etc.). The first sub-process is to digitalise the building information from the architectural/mechanical/electrical plans as well as the project reports. The building plans contain essential information about the buildings spaces and devices' specifications. Likewise, the project reports comprise useful information about the mechanical/electrical/structural systems, the building energy consumption and a lot more. As the first sub-process for this phase, all this information is required to be digitalised. Later, there will be a need to provide a link between the digitalised building information from the plans and from the project reports.

The second sub-process for this phase involves detecting all the IOT devices and sensors installed in the building spaces. This process is to update the information about the new installed devices in the building spaces. To do so, all these devices are detected using laser scans, captured images and video records. The outcome of this phase is a list of detected devices in the form of point cloud data and they need to be converted into the objects. In addition, more additional information like coordination and location is utilised to link this information to the stored building information (through the previous sub-process). During this phase, some new fields are provided to be added to the structure of the data storage explained in phase 1. The iterative phase of feeding the live data into the storage is explained in the next section (Phase 3).

c) Phase 3: Feeding the Live Data into the Open Storage

The last phase of the proposed process model is to transfer the qualified live data to the storage. The captured data from the IoT and smart devices are stored in the databases associated with their software. In this condition, there is a need to define an interface to obtain and transfer this data to the storage. Referring to the second phase, some fields have been defined to store the live data for the installed devices in the building spaces. Therefore, the capture data can be transferred to their corresponding fields in the storage. However, before transferring the data, there is a need to ensure the quality of the captured data. In case of passing the quality control test, the data is ready to be transferred to the open storage.

IV Value Contribution

By implementing the process model proposed by this study, a combination of the building information integrated with the live data will be available for the facility management industry. Using this integrated information and regarding the priorities for the FM industry, useful reports can be provided. For instance, the energy consumption control and energy saving are of high priority for the FM offices. The received alarms/messages, (from data from IoT devices) about the absence of the people in the booked meeting rooms (i.e. building spaces information) is a direct result of the combination of the information about the building space with the live data captured from the IoT devices, cameras and sensors. In this way, the FM office receives warnings to automatically switch off the heating/cooling system, in case of the absence of the people in the booked room. As such, providing real time warning messages about the faulty devices is another merit associated with the integrated building information and live data. With this information, the facility management office can provide an estimation of the costs for the faulty devices for various buildings. Similarly, by having the information about the faulty devices and sensors, the unsecured areas are recognised. Another example for the energy management can be related to the ‘open windows and working radiators’. A message from the facility management team can aware the space users to turn off the heating system. By this, the facility management office can promote the energy saving behaviour as well.

The availability of reliable and accurate building information supports the daily FM tasks such as space planning, space usage and timetabling as well as more complex undertakings such as monitoring and maintenance of the building service, building management systems, energy conservation, building performance/analysis exercises and preventative maintenance, etc. One potentially interesting use for combining the accurate building information with the live data is to break down the traditional data silos. In this way, all the collected data will be available to all the stakeholders and can be used for real-life learning (live lab) environments for the staff and students. By having the capability to access the reliable, accurate and building information integrated with the live data, a better understanding of the built environment can be provided to the potential users. This also leads to the continuously support of improvements in lifecycle management.

V Conclusion

The buildings information integrated with the live data is a valuable asset which can be beneficial to many smart industries. Although diverse technologies like the BIM have been developed to manage the building information, the industry users, e.g. the facility management industry is not still able to take advantage from the combination of this information with the live data. To overcome this challenge, this research presented a process model including three various phases to collect, integrate and store the integrated building information with the live data in an open storage. The expected outcome of the proposed solution by this research is to provide an open access to the integrated building information and the live data for diverse ranges of users, e.g. for the facility management industry. The presented process model by this paper has been prepared to be applied in a real project in collaboration with the facility management industry. By going through the future steps to implement this process model, more details will be provided to the readers.

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