Motivation for the development of an information management framework for Healthcare Facility Management

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ABSTRACT

Facility information is created and continually developed over the lifecycle of a project influencing the current and future conditions of some aspect of the facility. Typically, the information handed over to the owners is in the form of paper-based or digital documents that include the requirements as specified in the contract. Databases such as a Building Information Model (BIM) have enabled the easy accumulation and preservation of data from various phases and sources in the projects lifecycle, which are delivered to the owner, sometimes as a single information model. In an ideal situation, it is expected that the availability of the digital data will enable the Facility Management (FM) team to retrieve any information they require at any moment, increasing their daily productivity. It is now possible to access real-time information from the model and the facilities database on hand-held devices. While the aspect of reducing time to increase efficiency has been addressed in previous research, knowledge about the semantics and structure of the information required during the execution of a work order is also essential and needs to be addressed. In order to understand this information requirement, the authors began the process by studying the information networks of existing healthcare facilities. The literature review and subsequent discussions with healthcare facility owners, operators and managers establish the need and motivation for the development of an information management framework. This paper discusses the preliminary review of literature, the development of a research method based on grounded theory (GT) and the design of a data collection tool.

INTRODUCTION

Owners of all types of facilities share a common thread in their organizational goals; ensuring that the facility is performing to the designed intent and the services are being delivered effectively to the user. The day-to-day management of the facility, including the operations and maintenance, contribute to this goal. The role of the FM team is to operate and maintain the building throughout its lifecycle after it is handed over by the contractors. While the most common objective is to optimize operational costs, the facility manager is also responsible for ensuring people and processes benefit by their efficient management of systems (Lavy & Shohet, 2004). To achieve these objectives, at a minimum, the team requires easy access to up to date and appropriate facility information that includes information from previous phases of the
lifecycle, the changes that have taken place since and knowledge of the current operations to make an informed decision (Lucas et al, 2011). These decisions have a ripple effect on the users, the owner, the strategic development of the organization and the overall delivery of services.

The greatest and most common efficiency hurdle is getting the correct information to a team member at the perfect decision moment (Bryson & Yetmen, 2010). Developments in the field of information management and allied technologies such as global positioning system (GPS), augmented reality (AR), radio frequency identification (RFID), cloud computing, and digital dashboards, have enabled easy access to information by removing the time required to manually search through stockpiles of data. The remaining challenge is the appropriateness of the data. Unavailability of specific task related FM information in a usable format at the workface leads to - uninformed decisions, quick fix Band-Aid solutions, lack of predictability, poor performance of building systems and increased energy consumption. This ultimately affects the environmental and financial health of the facility, the owner organization and the end users.

The problem persists because information flow in the lifecycle of a project is traditionally horizontal and successive and seldom includes the needs of the next phase, rather assumes it. According to Guo et al. (2009), the information flow has both a forward influence and a backward impact. Quantitative values of data are usually dependent on the previous phases. However, the appropriateness of the information or the qualitative aspect of the data must be defined by its usability in the next phase. The information needed for FM comes horizontally across the lifecycle, vertically from within the concurrent operations and from the experience and collective memory i.e. tacit knowledge of the Facility Technicians and Engineers. This study considers the requirements of FM at the time of execution of work and aims to develop a framework based on the qualitative information needs of FM field personnel. The results of this study will be further compared and analyzed with the architecture of current FM software systems. The framework developed can then serve as a management tool for understanding workflows and establishing the requirements for FM systems.

BACKGROUND

All facility organizations are guided by a set of management philosophies that are a reflection of their owners business practices. Healthcare facilities are a unique system, since they have to comply with strict federal and state regulations while ensuring a minimum standard for their ‘environment of care’, which includes the facility and service users, the delivery of care model, the physical environment, and systems design and operational planning.

Management requirements in a hospital facility are centered on four main categories – administrative, medical-surgical and/or clinical, professional support and/or human resources and engineering and maintenance including facilities management (AHA, 1974). The Facilities Guidelines Institute publishes the Guidelines for Design and Construction of Health Care Facilities, which references standards and codes from 40 different agencies. Post occupancy operations and maintenance regulations are guided by local authorities having jurisdiction (AHJ’s)
which adopt all or part of the standards from the Guidelines and the following sources of codes, standards and regulations - Occupational Safety and Health Administration (OSHA), Centre for Disease Control (CDC), National Fire Protection Agency (NFPA), Environmental Protection Agency (EPA), Food and Drug Administration (FDA), Centre for Medicare and Medicaid Services (EMS) and United States Pharmacopeia (USP) (Lucas, 2011). Primary among them is the accreditation standards set by the Joint Commission (JC) for the management of the ‘environment of care’, which covers the following major areas: safety, security, hazardous materials and waste management, emergency preparedness, life safety, medical equipment management and utility management (JCAH, 2004).

Changing federal laws such as the Affordable Care Act (ACA) also have an influence on the management of existing facilities, which may have an influence on how the facility is maintained. Healthcare FM thus becomes critical for the successful delivery of healthcare services and reinforces the need for positioning the FM in a central role in influencing the decisions and processes for the owner organization (Shohet and Lavy, 2004).

Planning ahead for information acquisition is a critical step for ensuring that the data needs for operating, maintaining and managing the facility are delivered to meet the needs of the users of that information. This requires a revision of the data handover standards, contracts and owners project requirements (OPR). Instead of passively ‘receiving’ information, if the owner proactively specifies the information requirements based on their management styles at the front end of the life cycle, a facility information database deliverable such as BIM, can be structured to include those specific requirements. Table 1 captures some of the strategies outlined in studies that formulate guidelines for OPR’s. It is evident from Table 1 that an OPR must align the information needs with the organization goals and structure while also addressing the information exchange standards.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Author</th>
<th>Strategies outlined</th>
<th>Source</th>
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| General Building’s Information Handover Guide | National Institute of Standards and Technology (NIST) in collaboration with Fiatech | - Information Strategy in alignment with the organizations goals and data security policies  
- Information Handover requirements defining form and format and associated metadata  
- Project Information Handover Plan  
- Implementation for establishment of project procedures, contractual responsibilities and training programs | (Fallon & Palmer, 2007) |
Digitization of building information is accompanied with the hope that it is more accessible, accurate and easily communicated (Anderson et al., 2012). Dismissing the traditional view of FM data as a storage full of rolled-up paper drawings, an ideal technological vision is that of a central database, such as BIM, that supports open access to information when and where required across the FM organization. It also offers the opportunity to connect the facility data with other databases and systems related to core-processes such as organizational decisions, business practices, legal procedures, general financial practices and non-core processes such as human resources, health and safety of occupants and in the case of healthcare facilities, concurrent medical and clinical processes. The availability of related information can make the decision process at every level more effective and better informed. Fulfilling the needs of the FM organization, there are several software companies that are now providing ‘software as a service’ packages integrated with BIM, that help capture, collect, analyze and retrieve data. Theoretically, software architecture must be guided by the requirements of the FM organization in order to be effectively used (see Figure 1). However, the user of the information must define the ‘data required’ according to their work-face requirements.
Despite the availability of all types of data and supporting infrastructure, certain bottlenecks created by – organizational policies, technological capabilities and human resources - challenge the efficiency and effectiveness of FM functions. While the accuracy of the data is paramount, it is also important to address the correct type, format, method and roles for collecting that data (Whyte et al, 2010). According to Clayton et al. (1999), the dissatisfaction with ‘as-builts’ arises because of three basic reasons - an inappropriate representation of information (format), a mismatch in the definition of the semantics of the information (structure) and missing or overwhelming information (mismatch in content). The information exchange model specified in Construction Operations Building Information Exchange (COBie) helps capture data at the point of origin and presents them as task based actions – identified by the type of work, preventative maintenance, startup and emergency procedures etc. (East, 2013). A FM system can feed information from a COBie database, enabling an accurate transfer of data. Since the data is captured iteratively and input by its creator, it is assumed to be accurate. Still, the question remains whether the information is appropriate to their needs. The goal of technology is to make workflows easy and efficient, however research shows that it can also be a hurdle to the FM personnel’s primary job, which is assembling, assessing, operating, and repairing physical systems (Anderson et al, 2012).

**METHODOLOGY**

The literature review and round table discussions with facility owners and managers indicates a clear gap between the availability of the data for facilities management, operations and maintenance and its effective use for decision making in the field. Four primary reasons are attributed as causes of this problem: 1) Struggle with using technology in the field (lack of skills); 2) Interoperability between software platforms; 3) The timely accessibility to data in the field; and 4) The content of the data.

These reasons exist because there is almost always a fundamental mismatch in the business management style of the organization and the assumptions built into the FM information needs, data handed over by the design-construction team and the software application design. For the purpose of this research we will study the content of the data by considering the semantics of the information at the time of execution of
a particular work order. The first part of the on-going research evaluates the question – How can the information for Healthcare Facility Management be structured to answer the needs at the work-face planning? Work-face is defined by the authors as the factors that influence any particular task in the field at the time of execution of facility management, operations and maintenance. Work-face planning will ensure that complete information is available for efficient and effective use of labor, equipments and material. The factors include codes and regulations, management philosophy of the organization (established workflows), maintenance type (preventive, reactive, emergency, predictive), people i.e. the engineer/technician (skills and experience), tools and materials (for maintenance activity), and any other factor(s) identified during case studies.

**Research objectives**

The goal of this research is to identify how management practices affect the maintenance workface and then develop a system for structuring information needs of the FM field personnel. The following have been identified as the objectives of this study:

Objective #1: Analyze the current business practices, networks, operations and maintenance procedures and workflows in a healthcare environment.

Identify management workflows: Identify and document the organizational structure, management philosophies and develop an Influence Diagram to understand their role on maintenance planning and procedures for the case-study facility.

Analyze maintenance procedures: Develop an understanding of the maintenance procedures (Reactive, Preventive, Condition Based and Predictive) and their parameters thereof for the case study. Analyze the decisions that lead to this classification (example – Reliability Centered Maintenance logic tree).

Compare information attributes: Develop a matrix comparing the attributes of data collected in FM systems used by the facility with information in BIM (if available) or as-builts and with the actual requirement during fieldwork (collected during observational job shadow).

The analysis of the data collected in the above steps will collectively guide the development of the information requirements at the workface. This step is identified as objective #2: Develop a framework for information needs including collection, storage and workflow mapping. Finally the functionality of the framework will have to be evaluated in the field, which is objective #3. This may be achieved by designing a facilities database to include all the attributes of information identified in the framework which can be then programmatically input into a FM system (Computer Aided Facilities Management, Computerized Maintenance Management System etc.) and tested in a hypothetical maintenance situation. The evaluation and validation method will evolve as the research progresses.

**Research method**

Grounded Theory (GT) is being explored as a research method for this particular study. The emphasis of this methodology is on grounding the theories in data by letting interpretations emerge from observations by constantly ‘comparing, coding and analyzing’ (Fendt & Sachs, 2007). The research thus emphasizes on
building a theory without any pre-conceived notions and hence it is recommended that literature review be done at the very end. However, according to Fendt & Sachs (2007), post-modern writers of GT, including Strauss & Corbin allow for a wide literature review covering several academic disciplines with the intent of forming a solid knowledge base. The main features of grounded theory i.e. ‘using empirical research as its starting point; an iterative process of data collection and analysis; an emergent design and being linked with qualitative research, exploratory investigations, small-scale studies and research focusing on human interaction in specific settings’ are the primary reasons for choosing this methodology (Denscombe, 2003). This method will provide data based on unbiased first-hand observations from the field. Multiple hospitals will be studied to compare and contrast the datasets.

Data collection

At the time of writing this paper, confirmation of participation from three acute care private hospitals and one county hospital was received. The surveys have been sent out, but the case studies are yet to begin. Only one amongst them has an existing BIM. The following iterative steps describe the method of the ongoing research: 1) Survey: Designed to collect general information about the facility, its construction process, FM objectives, human resources and organizational structure. One survey per hospital facility being studied will be collected; 2) Structured Interview: Conducted with a Maintenance Manager (or equivalent) to understand the management and maintenance strategies/philosophies adopted by the organization, the processes in place, the current priorities and problems, future goals of the organization related to O&M; 3) Case study at the Management level: Data is collected via a first hand report through a series of silent observations (i.e. no questions asked) of the everyday workflows. Job Shadowing is a research technique that involves a researcher closely following a member of an organization over an extended period of time to observe what is being done and to reveal purpose. The advantages of shadowing are that the data is more detailed and it solicits opinions and behaviors concurrently (Mcdonald, n.d.); 4) Case study at the Engineering/Technician level: The same procedure as in the previous step is repeated for Facility Technician personnel; and 5) Information Technology case analysis: The software architecture of the FM system (CMMS, CAFM, BAS etc) will be studied to identify data attributes included in the current system(s) used by the facility organization.

To provide a certain limitation or scope to the data, a framework is being used to guide the data collection process during the job shadow while keeping the observations free from any personal bias of the researcher. During the job shadow two tasks will be completed – mapping the workflow as a step-by-step basis and identify specific information needs. The framework (see Table 2) is designed to study the process in three phases after a work order (WO) is requested – the investigation for a WO, execution of the job i.e. the repair and maintenance procedure and documentation at the close-out of the WO.
Table 2. Data Collection Framework for Job Shadow

<table>
<thead>
<tr>
<th>Phases of Maintenance Activities</th>
<th>UNDERLYING GOALS to be IDENTIFIED</th>
<th>Information requirements</th>
<th>Actions taken</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investigation</strong> (For a Work Order)</td>
<td></td>
<td>MT: Maintenance type (Preventive, Reactive, Condition based, Predictive)</td>
<td>Healthcare management system consulted? (Y/N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T: Criticality / timeline</td>
<td>HM: Identification of other hospital zones, occupants etc. that might be affected (if applicable). Information linked to the Healthcare Management system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Co: Code compliance requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Da: Type of facility data required (physical attributes, performance data etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F: Format in which the data is available (and system)</td>
<td></td>
</tr>
<tr>
<td><strong>Execution</strong> (Repair/Maintenance)</td>
<td></td>
<td>Was the problem solved? (Y/N)</td>
<td>What are the actions taken to solve/mitigate the problem? (Included in workflow mapping)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MI: If No, then what information was missing and why?</td>
<td>FD: What are the attributes of the data that is fed-back into the system?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FF: How or in what format is data fed-back?</td>
</tr>
<tr>
<td><strong>Close-out</strong></td>
<td></td>
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CONCLUSION AND FURTHER RESEARCH

This paper outlines the motivation for studying the specific task based information needs at the FM work-face in order to develop a framework for the collection of appropriate and accurate data requirements. This is important for aiding and improving the efficiency of work processes in Facility Management. Healthcare facilities have been specifically considered in this research because of the critical nature of FM in the delivery of healthcare services and the multiple variables involved in the information requirement at the workface. An initial research has established the definition of the ‘maintenance work-face’ and the associated variables. The authors have identified, grounded theory as a methodology for the research and have begun the first phase of the data collection. At the time of writing this paper, the authors have identified the hospital facilities where the case studies will be conducted and are in the process of beginning the field research. Multiple case studies will be conducted to develop an exhaustive database. It is hoped that a pattern or a theory will emerge from the observations and analysis that will formulate the basis for the design of the information management framework. It is envisioned that
the research will contribute towards the development of a management framework that can be used by owners to establish the goals at the maintenance workface and as the architecture for FM software design.

REFERENCES

