



An enterprise architecture framework for electronic requirements information management



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ABSTRACT

Managing information about client requirements effectively can contribute to improve the quality of built facilities, and their related services. However, the process has been challenging to construction project management often resulting in failed projects. This necessitates an overwhelming need for a better approach. This paper presents a novel enterprise architecture framework for managing information about client requirements across all phases of a construction project and through-life of a built facility. The Integrated electronic Requirements Information Management Framework (eRIM) defines an information-centric, and process and service-oriented enterprise architecture approach to requirements management. It also describes how Information and Communication Technology (ICT)/Information Systems (IS) can support this information management. In developing the framework, findings from three case study projects were collated through observations, a questionnaire and interviews of construction practitioners. It is concluded that when implemented and incorporated in the management of construction projects, the eRIM architecture framework can potentially contribute towards improved and more efficient and effective management of client requirements across all stages of a project. Further work is outlined to operationalize the framework.

1. Introduction

This research recognizes that client requirements management begins during the initiation and briefing stage of a project. However, the emphasis of the proposed framework covers the subsequent stages after the brief/program is produced, including design, construction and through-life of a building. The process of managing information about client requirements in construction projects is challenging. In particular managing the information across the various lifecycle phases, and coordination and control of the requirements changes. However, it is a catalyst to successful completion of projects and contributes towards project evaluation and post-project reviews. Client requirements information is a vital construction project resource needed at each project phase and through-life of a facility. Client requirements information is initially produced as a program document (or in UK, the client 'brief') which is generated following programming, a process to establish and record client needs, wishes and expectations for a building leading to statements of architectural problem and the requirements to be met (Duerk, 1993; Pena and Parshall, 2001). Programming is often regarded as a continuous process thus the program document needs to be flexible

and dynamic to incorporate emerging requirements and changes.

Consideration of requirements information is commonly concentrated at the early phases of construction projects and becomes disjoint in later phases. Once the design begins and progresses, these requirements are left aside and the design is used subsequently to interpret client wishes. Similar observations have been made by Kiviniemi et al. (2004). Managing client requirements including communication to all parties to the construction process is not easy because of the large volume of information that comprises the requirements as well as inputs from the many stakeholders involved in the process (Charoengam, Coquinco, & Hadikusumo, 2003). Generally, the voluminous information is paper-based and often difficult to manage requiring the need for electronic information exchange, with ICT gradually replacing paper (Wong and Lam, 2011). The information also needs to be distributed to all project teams who require it for implementation of their individual tasks, and is often shared amongst various applications used at each phase of a construction project. This is emphasized by Aziz, Anumba, and Law, (2006) who state that project teams require on-demand access to information. However, project managers have a greater inclination to communicate information

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verbally than either visually or in writing (Laufer, Shapira, & Telem, 2008). This hinders efficient and effective communication and information management in dynamic project environments. Consequently, it necessitates development and implementation of appropriate project information management systems.

The findings reported in this paper and the associated framework are part of an on-going effort to develop a better approach to managing client requirements information management with a support information system for construction projects taking a lifecycle view (Jallow, Demian, Baldwin, & Anumba, 2008; Jallow, Demian, Baldwin, & Anumba, 2014). The integrated framework (electronic Requirements Information Management – eRIM) is formulated for managing information relating to client requirements *from when these requirements are first elicited in the program document through to the decommissioning and/or disposal of the facility*. This framework specifies a central storage mechanism for collaborative and distributive access by all stakeholders and facilitates the management of changes. The aim of eRIM is to enable construction organizations to improve on the provision of quality facilities through better management of requirements information. The specific objectives of the Framework are: (i) to define a structured approach for a *web-based centralized repository* that can facilitate collaborative and distributed access to the client requirements; (ii) to define a mechanism for *dependency checking between requirements*; crucial for impact analysis, and cost and time assessment; (iii) to improve *information exchange and sharing* between all stakeholders, and interoperability between applications use for requirements management; (iv) to enhance the *process of managing changes to requirements information*. Specifically, the central focus of this paper is on the development of the eRIM framework and its constituent components, with implementation briefly introduced.

2. Related work

eRIM research is at the intersection of three domains: the concept of requirements management, models which operationalize these models and enterprise architecture (EA), which defines the underlying mechanism to implement an enterprise-wide information management system to support requirements management. Therefore, a review of requirements research is presented to understand the current state-of-art of requirements management and efforts for its improvement. Similarly, review of EA was conducted to understand its implications, and explore links between the business and information technology (IT) dimensions for managing information about client requirements. As a result, the research requires describing and representing the enterprise structure of managing the information about the requirements from both a business and IT perspectives. Conceptualizing this will help identify the components necessary to illustrate the interactions and collaborations between them. Because of the need for collaboration and interaction between all the components, the research also needs to comprehend how to formulate rules, and standardize the application, implementation and execution of the EA. A brief description on the development of a software prototype based on the Framework is presented. However, the full detail of the system development is beyond the scope of this paper.

2.1. Basic concept of requirements management

Requirements management as a discipline has its origin traced from the software/systems engineering industry where it has been applied intensively and extended to other industries (Green, Newcombe, Fernie, & Weller, 2004). The discipline is concerned with gathering requirements from clients, organizing and analyzing this information, and managing the processes of reviewing and changing the information as well as the documents in which it is contained (Schmidt and Souza, 2007). In Architecture, Engineering & Construction and Facilities Management (AEC/FM), these processes are spread across the entire

lifecycle of a construction project and the resulting facility.

At each phase of a project, activities are centered on satisfying the client requirements during which changes in requirements may occur. This involves managing the requirement attributes, tracing changes, and analyzing the impact of those changes on time, schedule, value, benefits and other stakeholder requirements. No known system exists that helps to integrate requirements management across all lifecycle phases of a construction project. Very few requirements management approaches define integration into later phases after briefing. Most of those frameworks complement the design process only. Previous research has considered the development of some models that can facilitate the process.

2.2. Requirements management models

The client requirements processing model (CRPM) was developed to help in the definition of client requirements and the incorporation of the different perspectives represented by the client body, and assist in the systematic mapping or translation of the requirements from the business terminology (“voice of the client”) that clients are likely to use into design terms (“voice of the designer”). Its aim is also to ensure requirements are presented in a solution-neutral format (Kamara, Anumba, & Evbuomwan, 2002). Kamara and Anumba (2000) argue that “it is necessary that ‘processing’ be done before conceptual design.” CRPM has three main stages for the processing of requirements: (i) defining client requirements, (ii) analyzing client requirements and (iii) translating client requirements.

During all these stages, managing the elicited requirements is of great importance. However, it is apparent that the CRPM only feeds into the design phase of a construction project but does not apply throughout the lifecycle phases of a project. The CRPM helps capture client requirements and facilitates design development. It serves as a link between project conception and design. In other words, “CRPM serves as the interface between the client’s business needs and design requirements” (Kamara et al., 2002). Design solutions are subsequently used to facilitate the construction of the facility as well as to aid material procurement process. The original requirements documents become redundant in the later phases of a construction project having been substituted by the schematic and detailed design. However, this research argues that the requirements management process should be continued throughout the phases of a construction project and building life, and not just to aid design.

Managing requirements along all phases of a construction project does not only help different teams perform their work efficiently but can contribute to elimination of waste in design and construction. This research argues that construction defects can be reduced immensely with lifecycle management of requirements information. A similar observation was made by Baldwin et al. (2007) that waste can be eliminated in both design and construction process by ensuring the timely delivery of design information and process, and information modeling can facilitate that process.

Kamara, Anumba, and Evbuomwan (2000) note that different media such as drawings, sketches, text and other forms have been used to manage and communicate requirements. This is emphasized by Fiksel and Dunkle (1992) who point out that “there are a variety of forms in which requirements can be represented, including documents and drawings.” Computational tools have emerged that help to manage the different media. In the construction industry, most of these applications are general purpose computer applications such as word processors, spreadsheets and databases in some cases with few specialized applications. There are many disadvantages associated with general purpose applications, and there is a recognized need for more advanced tools. To manipulate changeable requirements for architectural design, computational requirements management and engineering strategies need to evolve with set of procedures (Ozkaya and Akin, 2007). To address this problem, the Computational Hybrid Assistance

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