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MULTIPLE-ACTOR COST CONTROL AND MANAGEMENT SYSTEM: THE UML BLUEPRINT

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Proper cost control and management is pivotal for the success of construction projects and companies alike. However, several of the systems in usage are fragmented, especially in regards to how cost data at the project, department and company levels are portrayed. This is particularly observed when companies carry a sizeable portfolio of projects in diverse and sometimes remote locations. This calls for establishing an integrated cost control and management system capable of addressing these deficiencies while portraying the cost status at various levels of the company's chain of command. Paper introduces an information system (IS) developed for such purpose and which pools multiple actors in the company's hierarchy. It has the potential to streamline the dataflow between the different departments and throughout the company's chain of command. System's functionality is based on the Object-Oriented (O-O) approach and the Unified Modelling Language (UML) known in System Analysis and Design (SAD) of computer-based IS.

Keywords: Information and Communication technology (ICT), Cost management, Information systems (IS), Unified modelling language (UML).

1 INTRODUCTION

It is widely realized that successful project management is contingent upon properly estimating and controlling project costs. But unlike the conception by some, cost control is not only "monitoring" costs and recording data, but also analyzing the data in order to take corrective actions before it is too late (Kerzner 2001). Developing cost control and management information systems (IS) has evolved over the years, especially under the paradigms of Computer Integrated Construction (CIC) and Information and Communication Technology (ICT). CIC and ICT have proved a great contributor to improving construction monitoring, controlling, and decision making (Boddy *et al.* 2007). The importance of having a capable cost control and management IS stems from: (1) its direct relationship with the financial performance of the construction enterprise, and (2) the involvement of various actors in the organizational hierarchy in cost-related decision-making processes.

A research was initiated by the authors in an attempt to develop a cost control and management IS which pools multiple actors in the company's chain of command. Paper reports on one of the first steps of IS development, which is creating the blueprint for the sought system using the Unified Modeling Language (UML) terminology.

2 A GLIMPSE OF THE LITERATURE

The advent of Information technology (IT) has transformed the way construction companies operate. It allowed increasing the automation and integration of IS in construction management processes. Researchers were also active in addressing and promoting the development of IS for various purposes in the construction industry, including cost control and management.

Leung *et al.* (2008), for instance, presented a construction site monitoring system to track the progress and quality of construction works, integrating a long-range wireless network, network cameras, and a web-based collaborative platform. Kobayashi *et al.* (2008) presented a pavement management accounting system (PMAS) to help control the life cycle costs of road pavement projects. The object-oriented concepts were employed in IS for project scheduling and cost optimization (Karim and Adeli 1999). Abudayyeh *et al.* (2001) described the design and implementation of an internet-based cost control IS. Kim and Liu (2007) proposed a cost information model for managing multiple projects, and promoted more information integration amongst multiple projects of the construction enterprise.

3 BASIC CONCEPTS IN DEVELOPING UML-BASED INFORMATION SYSTEMS

The system development life cycle (SDLC) typically proceeds through the phases of: (1) planning, (2) analysis, (3) design, (4) implementation, and (5) maintenance (Whitten and Bentley 2007, Satzinger *et al.* 2009, Shelly and Rosenblatt 2012). Within this SDLC, a number of options exist for developing the sought IS. However, the most popular alternative is to employ O-O principles in a sequential development process. It is worth noting that some recent alternatives have been gaining popularity as well, e.g., agile methods.

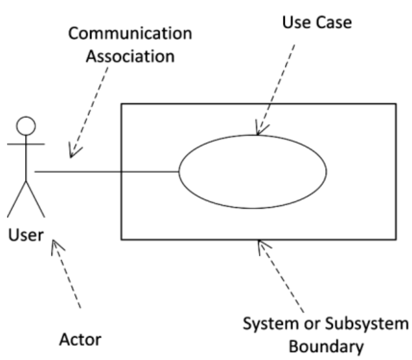
As this research adopts O-O principles, it was important to utilize a universal and flexible platform for system design and representation. The UML was selected. UML is a visual modeling language that enables system builders to create blueprints that capture their visions in a standard easy-to-understand way, and provides a mechanism to effectively share and communicate these visions with others.

4 USE CASE DIAGRAMS

Process was initiated with a fact finding stage that involved interviewing 29 construction professional about the cost control and management requirements, business needs, and existing operational bottlenecks in their respective construction enterprises. The interviewees in reference reflect 6 roles in the construction enterprise; namely, general manager, project manager, project/technical office manager, project/technical office engineer, financial manager, and accountant. Based on the fact finding stage, the system requirements were identified and classified into functional or nonfunctional. The non-functional requirements included aspects related to system security, access and read/write privileges, operating system(s) in usage, interfaces, interconnectivity, remote accessibility, among others.

The functional requirements on the other hand are functions, features or tasks that must be performed by the system in order to fulfill its purpose, satisfy the business needs, and be acceptable to system users (Whitten and Bentley 2007, Satzinger *et al.* 2009, Shelly and Rosenblatt 2012). Research utilizes *Use Case* modeling to depict the functional requirements of the system and incorporate its various actors.

Use Case is a powerful UML tool that specifies the functionality of the system from the end users perspective. Each use case further describes the sequence of interactions between one or more actors (external users) and the system (Whitten and Bentley 2007, Bennett *et al.* 2006). As illustrated in figure 1, a use case diagram shows three aspects of the system: (1) actors, (2) use cases and (3) system boundary. An actor is someone who can initiate a use case. An actor could also possibly be another computer system, or more abstract concept such as time, or a specific date. A use case should satisfy a goal for the actor, and is drawn as a horizontal ellipse on a UML use case diagram. Associations are depicted via lines. The use case model represents the system boundary as a rectangle around the use cases.



Relationship	Symbol	Meaning
Communicates		An actor is connected to a use case using a line with no arrowheads.
Includes	<<include>>	A use case contains a behavior that is common to more than one other use case. The arrow points to the common use case.
Extends	<<extend>>	A different use case handles exceptions from the basic use case. The arrow points from the extended to the basic use case.
Generalizes		One UML "thing" is more general than another "thing". The arrow points to the general thing.

Figure 1. Notations of use case diagram.

The functional requirements were modeled in the form of use case diagrams. Seven subsystems were created; they are: (1) managing login, (2) managing projects, activities and change orders, (3) monitoring, (4) updating, (5) forecasting, (6) financial reporting, and (7) decision aids. Figures 2, 3 and 4 illustrate sample use case diagrams for different functions/subsystems in the enterprise's cost control and management system.

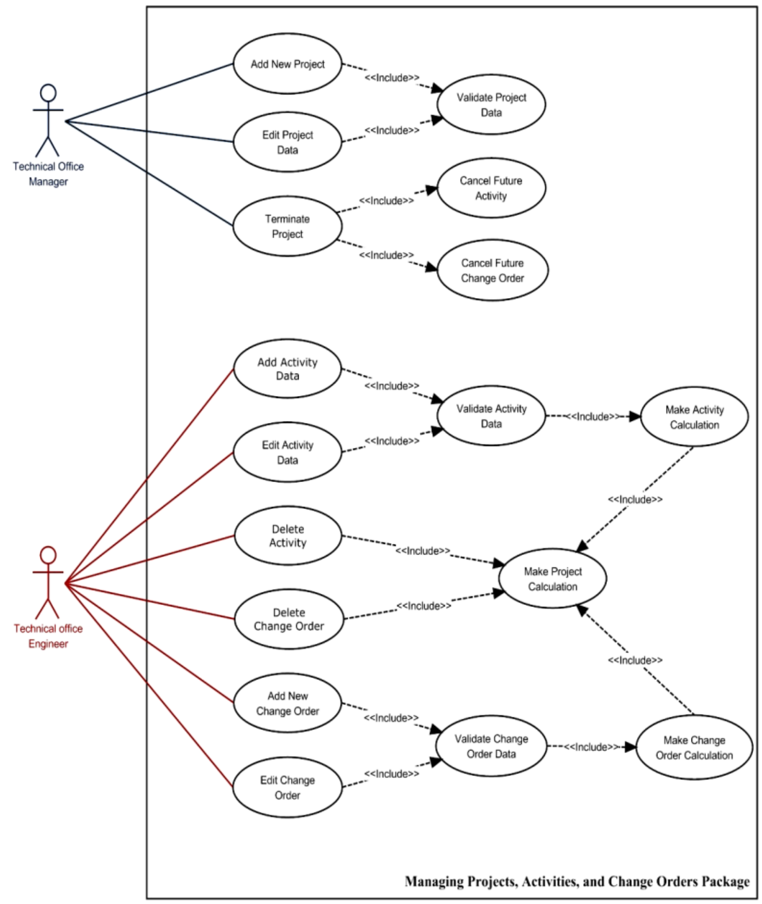


Figure 2. Use case diagram for managing projects, activities and change orders.

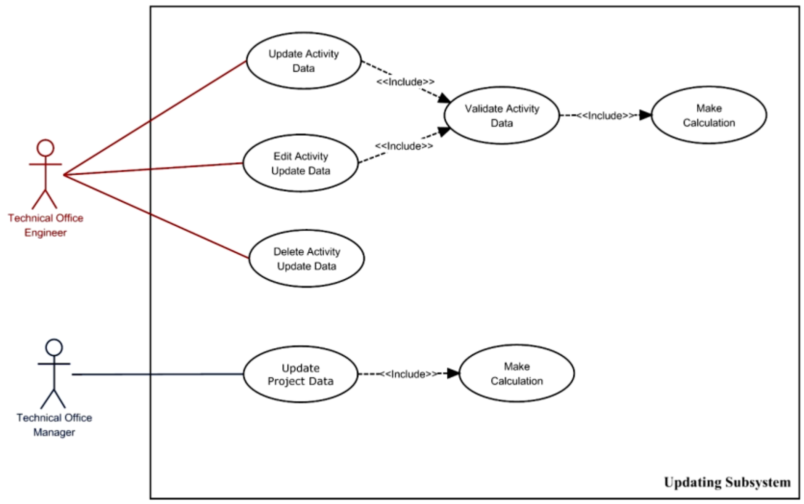


Figure 3. Use case diagram for project updating.

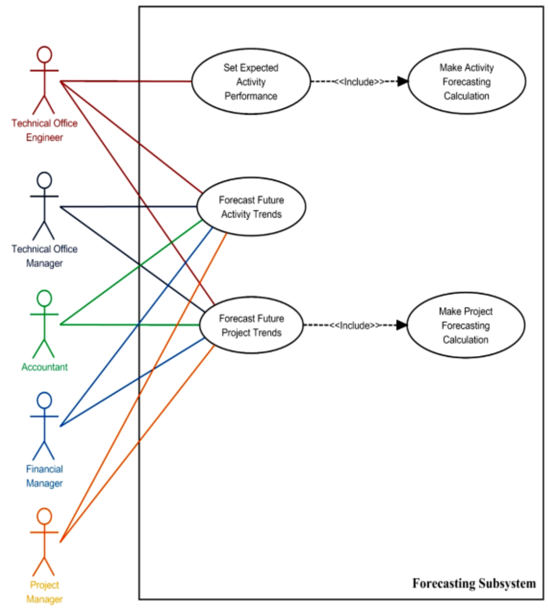


Figure 4. Use case diagram for project forecasting.

As noted, different actors are involved in the processing of the subsystems into consideration. The actors have distinct interests in these subsystems and exhibit various levels of authority and responsibility for data entry and system usage. Generally speaking, each actor interacts with a subsystem in order to achieve a certain desired result. While the technical/project office engineer, for instance, provides support to project in the form of costing data entry and change orders at the activity level, only the technical/project office manager have the authority to change the project-level data or terminate it all together.

Similarly, the updating subsystem manages the process of updating costs for activities and projects. The technical/project office engineer is responsible for managing and updating data at the activity level, while the technical/project office manager have the authority to update the project status. On the other hand, future forecasting requires communication and inputs from different actors including the accountants and financial managers, in addition to the typical actors of project manager, technical/project office manager, and technical/project office engineer. In this context the technical/project office engineer has a responsibility for setting expected performance for project activities based on the performance observed to-date. Future trends require the contribution of more actors at different levels of the enterprise's chain of command. Establishing future trends should account for other kinds of information relevant to project characteristics, market conditions and prior experience in comparable projects. This dictates other actors' contribution as deemed necessary.

5 CONCLUSION

The paper attempted to present the basic blueprint of an integrated cost control and management system using UML. While the technical aspects of developing a software package can be addressed by many, the true challenge is how the management processes and software's systems and subsystems work in unison.

UML has several advantages, one of which is establishing a basis/blueprint upon which the working IS is founded. This has been the focus of this paper. The use case diagrams help to portray the different actors who interact or get involved with the functions of the subsystems. It is understandable that the actors will have different interests in the system components and will exhibit different levels of authority and responsibilities. Through these use case diagrams, one can easily portray such interactions and who in the company's chain of command is involved. Based on the blueprint, the SDLC can move into the software development stage. The fully developed system will not only present some software used in the company but one that aligns with the management processes and the established responsibilities/authorities in place.

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