Design of Integrated Cost and Contract Management Information Systems For Mega Project

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Abstract- **This research designs a concept of integrated cost control, contract management and information collaboration in the Project Management Information System (PMIS), based on the EXPO 2010 Shanghai construction project. In our model, the "Basic Unit of Public Information (BUPI)" and "Contract Control Unit (CCU)" are originally discussed to create the relationship between the cost control and the contract management, and to meet various demands from project managers and owners in mega projects. A static framework in the context of web-based project information platform is introduced later to examine this concept, where different information of project level, contract level, and CCU level can be shared and integrated effectively. This research initially bridges the gaps between the cost control and contract management especially for mega project in the construction industry, and the result can be applied in both academic and practical fields.**

Keywords- cost control; contract management; mega project; project management information system (PMIS)

I. INTRODUCTION

Mega project comes with typical characters such as massive investment budgets, significant amounts of contracts, complex projects relationships and etc. Taking EXPO 2010 Shanghai for instance, the Work Breakdown Structure (WBS) includes the various levels including entitle EXPO construction program, programs owned by different stakeholders, programs classified by different contracts, program located by different areas, different projects, unit projects and etc.

The construction process will deliver the substantial amount of cost and contract information, as well as the complex relationships between them. But in practices, cost control and contract management are independently implemented without information exchange and cooperation, which results in information redundancy and isolation. Therefore the mega project requires the higher integration of cost control and contract management and more effective information management system to ensure the project success.

The aim of this study is to construct a integrated cost control and contract management information system for mega project and organized as the follows. First, we describe the key and related definitions to our study based on abundant literature reviews. Then, to bridge the gaps between cost control and contract management, we choose a proper level for their breakdown structures and relate them by data mapping principles. We finally put forward a framework of integrated cost and contract management and examine it by EXPO 2010 Shanghai construction case study.

II. LITERATURE REVIEW

A. Integrated Information Modelling

Models have existed for a long time and have been used in many different ways. The purpose of a model is to depict something – existing or planned – in a simplified way [1]. There are various researches focusing on integrated models of project management information system, and the ideas differ. The key reason lies in the complexity of the integrated model and multi-attributes of the model's characteristics. Generally, the integrated project management information system covers the four aspects as the follows.

1) The Product Model: Product model plays a central role in integrated project information system since it is a conceptual framework to organize and exchange building product information [2]. The international well-known product model is Industrial Foundation Classes (IFC) data model issued by The BuildingSMART International (formerly known as International Alliance for Interoperability, IAI). The standard IFC architecture divides into four classes including products, processes, resources and contexts. And the IFC product is the base class for all physical objects and is subdivided into spatial elements, physical elements, structural analysis items, and other concepts [3] .The product model covers information such as associated materials, shape representations, placement in space, and etc, and describe more building and construction product information.

2) The Process Model: The process model integrates managerial information and managerial process beyond the product information. According to Thomas Froese, the process model describes the process used to create the facility - the construction process [4], and includes work package, activity, method, work element, etc [5] [6] [7]. Due to characteristics of construction project, the process model could involve various managerial works including managerial objective control, organizational coordination, as well as significant project management information including cost control, schedule control, etc.

3) The Resource Model: The resource model is another key component since consuming resources is necessary in any production cycle and immediately relates to project cost control. The resource model defines the representation of the resources used in the construction process. Resources can be labor, equipment, materials, or less tangible resources such as information, working space, etc [4].

4) The Organization Model: The organization model and contract information are critical to all successful projects since they define the clear organizational structure, appropriate obligations, and contract management. The organization model consists of classes that represent organizational aspects of a construction project. These include such entities as the companies and individuals involved in the project and the contracts that exist among these companies [4].

B. Cost and Schedule Control Information System

1) Work-packaging Model: The work-packaging model was developed by Abudayyeh and Rasdorf 1991 and achieved the desired integration of cost and schedule. This method attempted to create a single information channel while keeping the cost and schedule control viewpoints separate [4]. In 2008, Sangchul Kim et al proposed an integrated model of Work Breakdown Structure (WBS) and Cost Breakdown Structure (CBS) based on the modified work-packaging model, and used Korean construction industry as a example. They considered the "activity" as the basic unit to control the schedule, and this could not only relate the cost control with schedule control but also divide CBS in more detail.

2) Web-based Integrated Project Control System: Ji Li presented an integrated web-based time and cost control system for construction projects [7]. The system mapped project Work Breakdown Structure (WBS) into an object-based model, and generates earned value-based project status reports at project, control object and resource levels including both control object itself and relations among control objects.

C. Summary

In summary, the previous researches have been trying to find a more effective and efficiency approach to the integrated information system by developing different data models. But there are three major issues should be addressed in order to meet the cost control requirements of the successful mega project. First, prior studies paid more attentions to contractors perspective instead of owners and professional project managers points of view. But in reality, owners and project managers are key position and in charge of the entitle cost control process. Second, the objective structures of most information systems were based on the lower level of the whole managerial structure, such as activities. But this type of structure disregarded the integrated information from the demands of higher level of the project managers, and also created amounts of data redundancy. Last but not least, previous literatures mentioned few about integrated cost and contract management in the information system, instead they focused on the cost and schedule control. But actually,

contract management should be considered as a more sophisticated tool to control the cost due to its legally binder relationship and accurate requirements. Therefore, this study is proposing a integrated const and contract management framework to address the above challenges for mega projects.

III. DEFINITIONS

A. Integrated Cost, Contract, and Cooperation Administration (C3A) information system

Current cost control information system lacked the effective integration and information communication with the contract management system, and its structures of objectives, contents, and levels are barely to satisfy the increasing demands of the mega project. Based on both characteristics of cost and contract management, we define the C3A information system as follows.

In light of owner's control approaches and objectives, the C3A integrates of cost control, financial management, and contract management based on the Basic Unit of Public Information (BUPI), provides the reliable storage, transformation, analysis, reporting of the contract and cost information, constructs a web-based information system of cost control, contract management, information share, and interoperability capacity for multiple levels including program-level, project-level, contract-level, and unit-level.

The C3A is not only a symbol of information system, but represents a managerial approach which emphasizes the cost control and contract management.

B. Key Components And Indicators

To bridge the gaps between cost control and contract management, the common information set should be identified and registered in the system. According to Peng [8], the problem of integrated cost and contract management can be transformed into the development of the mapping information relationships between Cost Breakdown Structure (CBS) and Contract Work Breakdown Structure (CWBS), since CBS is a key information objective for cost control, and CWBS for contract management. But prior to relate these two breakdown structures, there are two basic indicators of the information system should be introduced.

The *Basic Unit of Public Information* (BUPI) is defined as the smallest independent unit of information exchange for cost, contract, and financial data. BUPI is the link between cost and contract management and also the basic unit in the entitle information system. For example, in EXPO construction case, one construction contract might include many construction projects, therefore owners or project managers need more detail information units to control and reflect each project's cost and that unit is called BUPI. For construction cost, BUPI is always based on the single project such as Germany pavilion, United States pavilion, etc. According to the Integration Definition for Information Modeling (IDEF1x), the mapping relationships should be deterministic, for this reason the relationship between the BUPI and CBS and CWBS should be either 1:1 or 1:n (n>1).

The *Contract Control Unit* (CCU) is defined as the objective of the BUPI, and so it is the smallest control unit for both CBS and CWBS. Taking EXPO construction for instance again, since one contract includes many projects, CCU should relate to BUPI and base on each project, such as Germany pavilion contract, United States pavilion contract and etc, to improve the accuracy of control.

IV. MAPPING RELATIONSHIPS

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There are three mapping relationships between CBS and CWBS including one to one (1:1), one to more (1:n, n>1), and more to one (n, n>1:1) as follows. To integrate both information sets, we incorporate appropriate information from the CWBS onto the CBS.

A. One To One (1:1)

In this case, one cost item matches with one contract. In Fig. 1, the cost of A100 is $100 Million(MM), and completely relates with the contract B100. Therefore, we add relevant contract information B100 onto the cost information set A100. This situation is expected in construction and installation contracts.
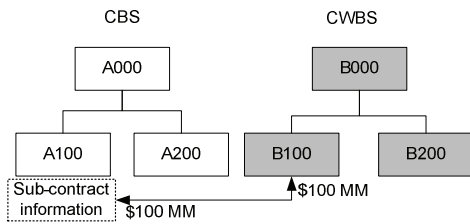

Figure 1 Relationship between CBS & CWBS (1:1)

B. One To More (1:n, n>1)

In this scenario, one cost item relates to multiple contracts. Then this cost item will be divided into sub-cost items, and each of them will be matched with one corresponding contract. In Fig. 2, the cost of A100 is $100 MM, and relates to both contract B100 and contract B200. Then the cost A100 is divided into A110 and A120 and matched to the correlated contracts separately. This scenario is expect in survey contracts, design contracts, construction supervision contracts, consulting contracts and etc, and accounts for 90 percent of the contract numbers and 20 percent of the entitle contract value.

C. More To One (n:1, n>1)

In this situation, multiple cost items relate to a single contract. Then this contract is separated into sub-contracts according to different units, and matched with correlated cost items. In Fig. 3, the contract B100 is $100 MM and consists of

both cost A100 and cost A200. As a result, the contract B100 is broken down into contract B110 and contract B120, both of which are incorporated into the cost items A100 and A200. This situation happens in general construction contracts, material and equipment contracts, infrastructure and municipal contracts, and etc, and accounts for 10 percent of the contract numbers, and 80 percent of the contract values.
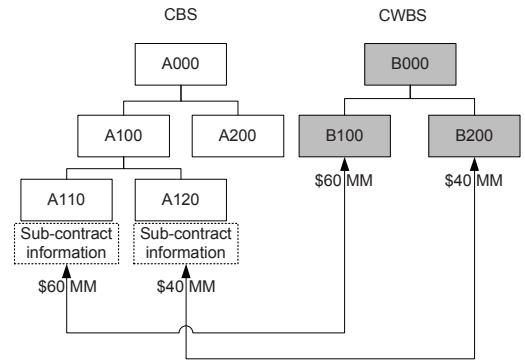

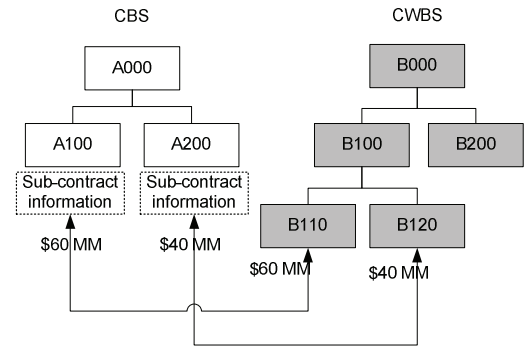Figure 2 Relationship between CBS & CWBS (1:n)

Figure 3 Relationship between CBS & CWBS (n:1)

V. C3A FRAMEWORK

The integration of project management information system is a complex system. One of effective approaches to address this complex problem is the usage of system modeling, which can simplify the complex processes, fasten the modeling establishment, and save time and effort than real application system. We presents the following model in the Fig. 4 based on the Unified Modeling Language (UML), which is a standardized general-purpose modeling language and also easily put into practical application.

The main structure consist of seven compenents as follows:a) Budget plan, including conceptual estimate, planning estimate, engineering estimate, construction estimate and etc. b) Contract price, including three editions of initial price, changing price and final price. c) Cost plan, including the annually, quarterly, and monthly cost required by the schedule. d) Actual performed work, meaning the finished construction work and associated expenses. e) The analysis of integrated cost, including cost variance, schedule variance and actual payment. f) Financial plan, and g) actual payment, both including annually, quarterly, and monthly details.
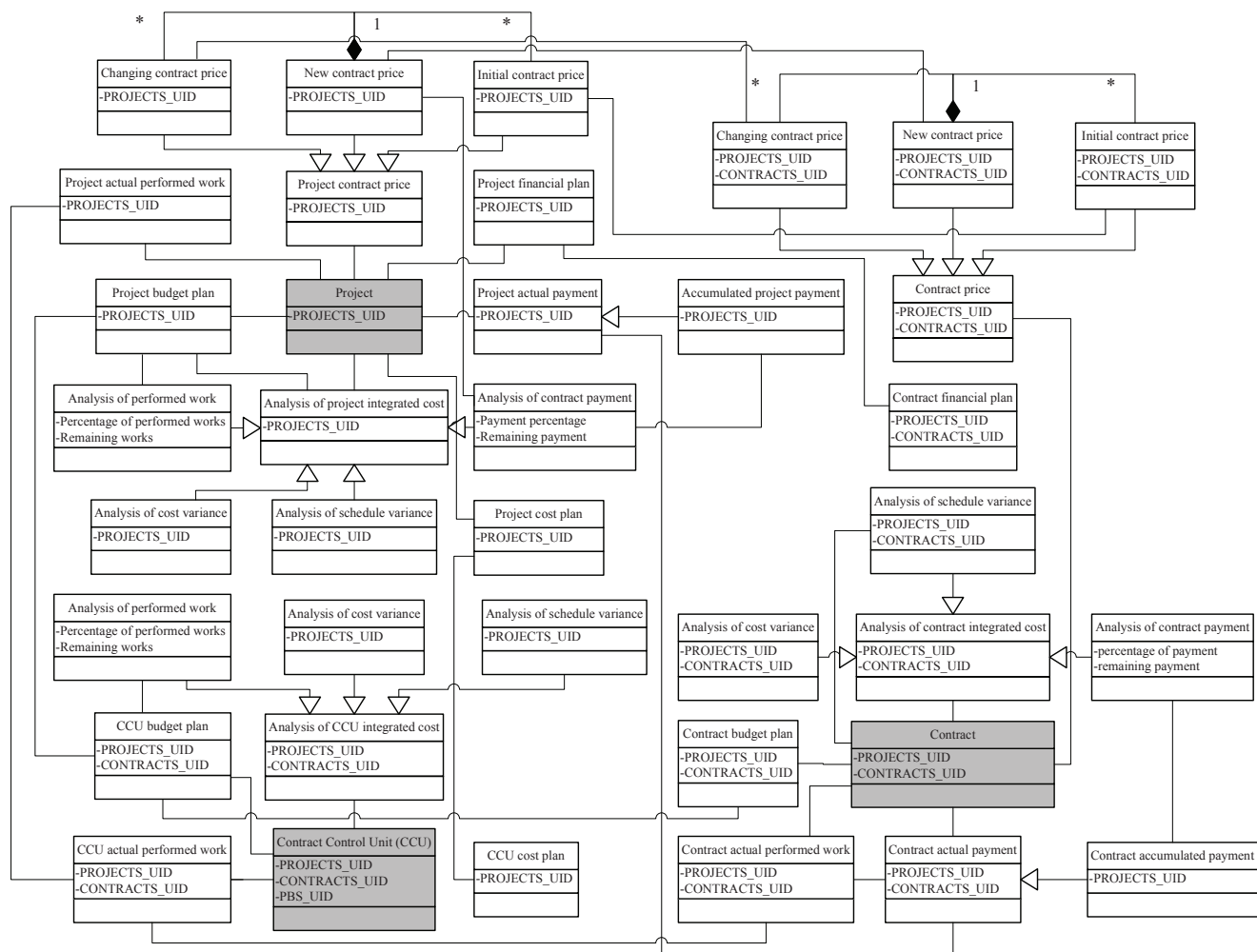
Figure 4 A framework for integrated cost and contract management information system

Integrated C3A information system can meet the requirements from various project levels, from high to low dimensions including project level, contract level and Contract Control Unit (CCU) level. This multiple structure shows its flexibility and controllability especially to owners and project managers due to the CCU level perspective comparing to traditional system of "activity" based model. Also, C3A system manages all project costs through contractual relations, which could also mitigate the potential risks.

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