An Application Strategy for PLM in Construction Industry

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Abstract

There are many interests and researches among an industry as IT develops. It is important to use information effectively and adequately as applying IT to industry because IT provides an innovative strategy for the enterprise. In case of manufacturing industry, many business solutions (e.g. SCM, CRM, ERP, PLM etc) have developed for years. However in case of construction industry, it was hard to develop a business solution due to various differences compared to other industries. This paper presents the need for a customized PLM system implemented in the construction industry for the purpose of its sustainable information storage and transfer. It also investigates the functional factors for such system and the expected effectiveness when fully operated.

Keyword

PLM (Product Lifecycle Management), ILM (Information Lifecycle Management), CPLM (Construction Project Lifecycle Management)

1. Introduction

Constant competitive pressures and market demands require companies to continuously improve the management system and response to their design, planning, development, manufacturing, and operation phases of their product offering whether the product is small or big, simple or complicated. This is just as important to the overall success of the business as the actual product that the industry delivers to the consumers. Managing numerous business elements in a single process presents major challenges that include disparate application systems with multiple data formats, geographical distances between participating parties, and access to various sources and types of expertise.

To remain competitive and agile, organizations must create an innovative information management system throughout the lifecycle of the product, which is named as 'Information lifecycle management' (ILM) and that further develops as 'Product lifecycle management' (PLM) environment.

The same concept could be implemented in the construction industry which is comprised of a exceedingly complicated business process with numerous participants (e.g. client, architect, engineers, contractor, MEP, HVAC, etc) involved in different phases from different geographic area. Accordingly the construction process is affected by many factors, influencing all the parameters.

The construction industry has tried to implement information systems which enable participants to manage data and information throughout the construction lifecycle. The theories on CIC (Computer Integrated Construction) had ruled the research trends in the field for almost twenty years. The approach aims to enhance the data exchange among the computer applications. However this approach has weakness in terms of flexibility: Data that are not pre-defined in the model cannot be touched by practitioners.

The next trend is BIM (Building Information Management). The approach moves the viewpoints from the applications to the construction product and process. The concept has been partly implemented by leading computer applications developers. As results, 3D object-oriented CAD applications have been developed and used for limited purposes.

However, with the necessities for a new approach to manage ever-complex information in the modern construction projects, the construction industry has been encouraged to develop practical methods for handling information of the projects. In other words, in order to determine theoretical values of the parameters as precisely as possible and to reduce errors in the field of construction, the PLM concept is considered which enables a consistent stream of information for the use and reuse of that information.

This paper presents the idea of a customized PLM system implemented in the construction industry for the purpose of its sustainable information storage and transfer. It also investigates the functional factors for such system and the expected effectiveness when fully operated.

2. Trends in Information Lifecycle Management

2.1 Information Lifecycle Management (ILM) System

ILM is a sustainable storage strategy that balances the cost of storing and managing information with its business value. In order to achieve an advanced state of information lifecycle management, the following factors should be embodied into the system. [1]

- Automation of resource management tools and processes, providing management, measurement and dynamic modeling of storage infrastructure, with linkage to business services.
- Integrated policy and metadata management, linking business rules derived from service level agreements to storage management actions.
- Integrated ILM services for security, retention management, data protection and storage infrastructure optimization, working from a common repository of rules and metadata.

An advanced state of information lifecycle management encompasses a storage management world where business information objects are managed automatically, based on their business value. The storage infrastructure is not only business aware, but also is conscious of the content of a business object.

Business decision makers determine the rules for managing their information, and the complex service level requirements of a particular information element are consistently and automatically met. Therefore information technology (IT) and the industry armed with a clear vision of information lifecycle management should be maintained simultaneously to fully benefit from information lifecycle management.

Table 1. The key areas focused in ILM

Key Elements	Execution
Enhancement of IT and business alignment	To enhance service management and manage infrastructure based on the applications and or business services
Integration of information Management and information use efforts	Ensuring the integration of data classification efforts for the purposes of both storage management and access for a significant progress toward the effective use of information as an asset
Implementation of the right ILM-related services	Solutions for continuous data protection, archive/retention management and device visualization that show a clear statement of direction toward integration

Attaining an advanced state of information lifecycle management can result in significant benefits, the most significant of which include improved industrial adaptability and improved service to end-users, suppliers and internal end users. Fully mature ILM may result in performance benefits such as increasing revenue opportunities, reducing costs and driving competitive advantage.

2.2 Project Lifecycle Management (PLM) System

Product Lifecycle Management (PLM) is defined as the activity of managing a company's products across the complete lifecycle, from the early stages of conception to the final disposal or recycling of the product. [2] Since the late eighties of the previous century, PLM received explicit attention. Its manifestation started with Computer Integrated Manufacturing (CIM), which evolved into Engineering Data Management (EDM) in the early nineties and later into Product Data Management (PDM). During this evolution the scope shifted from solely the engineering department to the complete product lifecycle and hence the whole supply chain.

Moreover, the focus shifted from a pure data management problem to a business problem. Companies that apply PLM concepts and systems can be found in different industries. Examples are the automotive and transport sector, aerospace and defense, process industry, life sciences, and heavy machinery. These industries have unique characteristics and therefore different applications of PLM. In addition, the company's supply chain position strongly determines the perception of PLM. [3] Despite these differences, companies invest in PLM for clear common business goals.

Important drivers of PLM are the need for shorter product lifecycles, urge for more complex products in terms of components and functionality, trends of globalization and outsourcing and consequently complex supply chains, the need for customization of products due to more demanding customers, and increasing regulations such as safety, environmental and product reliability regulations. [4] Companies that are successful in dealing with these PLM related issues report benefits such as increased innovative ability, shorter time-to-market, increased profits, less engineering changes late in the lifecycle, less product faults in the field and higher efficiency.

To reap strategic benefits many companies have started to implement the PLM concept more profoundly. At the same time we see that companies struggle with adopting and implementing PLM [5]. A major reason is that PLM affects a wide range of processes within and outside the company. This makes PLM a complex organizational change effort. In practice, the duration of PLM implementations varies from 31 to 45 months. [6]

Also, PLM software implementation itself is complex: it involves not just one system but many systems (i.e., ERP, CAD/CAM, CAE, PDM) that have to be integrated with each other. Figure 1 shows an overview of a PLM system.

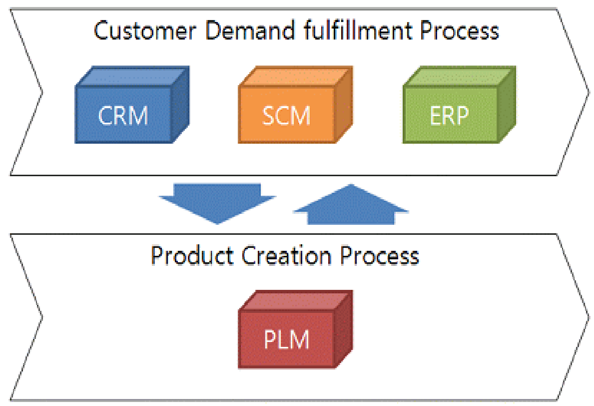

Figure 1. A system overview of a PLM system

One axis unites the customer demand fulfillment process including CRM, SCM, and ERP while the other axis represents the product creation process in which the PLM system functions from the concept, design, development and production of the product.

3. CPLM (Construction Project Lifecycle Management)

3.1 The Characteristics of Construction projects and industry

The ILM and PLM systems mentioned above have originally developed for their implementation in traditional manufacturing industries for higher productivity and consistent stream of information transfer. Construction industry has common aspects compared to other project-base manufacturing industries such as shipbuilding and aerospace. Products are ordered first and then delivered to the client in those industries. The organization structures are complicated in those industries because significant portion of sub-products are manufactured by sub-contractors.

However the construction industry appears somewhat different features as well. The most unique feature of the construction industry is that the procurement paths can vary. The general process of construction project is as follows: pre-design (PD) in which the client think of projects and evaluate the feasibility, schematic design (SD), detailed design (DD), construction documentation (CD), construction and operation/maintenance. Only the client or the client representative can involve in the entire process. The client selects a procurement path by considering interests and constraints. Other participants join in the project according to the contract method that is determined by the procurement path. As a result, the moment and sequence of various practitioners' participation vary according to it. It means that the responsibility to manage project information is also allocated by project-base. For this reason, systems architecture for project information management that has been widely used irrelevant to the project types and regions does not exist in the construction industry.

Another feature is that the construction industry is less sensitive to the development of state-of-art techniques for managing projects compared to other industries [1]. The needs for consistent information management have been continuously mentioned and researched in the academia. A couple of concepts have been implemented in the fields. However, the results have not been widely used in the industry because the main reason is that the deployment of those has rarely provided the incentive to the companies. In general, the market share of construction companies has been affected not by their techniques but by their ability to take new projects. Table 2 lists some key different elements between the two industries.

One axis unites the customer demand fulfillment process including CRM, SCM, and ERP while the other axis represents the product creation process in which the PLM system functions from the concept, design, development and production of the product.

Table 2. A comparison between construction industry and manufacturing industry

Section	Construction Industry	Manufacturing Industry
outcome	Project	Product
process	Unfixed, Various(depend on procurement)	Fixed
product complexity	relatively complicated	relatively uncomplicated
production method	one-time production	quantity production
chances of IT convergence	Relatively hard to organize e-construction	Relatively easy to organize e-manufacturing
Understand client's requirement	several unexpected requirements are originated throughout the process	project planning phase (especially on market research)
design changes	frequent	rare

3.2 IT infrastructure of construction project information management

Traditionally, the construction projects produce enormous amount of information related to cost, schedule, and administration throughout project lifecycle. The formats commonly used in representing information in construction are text documents, 2D/3D drawings, schedule in bar charts and various diagrams [7].

The authors can see that the last twenty years have made drastic improvements in the widespread use of

IT. The trends in IT for construction could be classified into three eras. In the first era, most construction IT has focused on developing stand-alone tools to assist specific tasks. Examples are CAD, structural analysis tools, estimating, scheduling and general business applications. In the second era, the trend in construction IT has focused on computer aided communications. For examples, email, the world-wide web, document management systems etc. have been widely used in the mid 1990s. This is also the stage where theories on CIC (Computer Integrated Construction) were first implemented. Finally, in the third era, there has been a big shift from the past. Much of the research and the development of the IT trend in construction have focused on the actual integration of the overall system whereas it generally was centered on the individual applications of transaction in the past.

Since most decisions should be made in collaborative working of practitioners from different disciplines such as designer, project manager, cost estimator, structural analyst, scheduler, and MEP (mechanical, electrical, and piping) engineer, it is sure that the amount of electronic information from each disciplines has generated increasingly. Given that the size of construction projects has been enlarged and the facilities have been ever complicated, the timely feed of information to the participants becomes important. The management of facilities and cities of the next generation such as super high rise buildings and ubiquitous cities requires more details that represent as-built facilities than before. To this extent, coordinating and integrating information across each discipline became exceedingly important throughout each construction phase.

In an effort to achieve such integration, several attempts have been made. Industry Foundation Classes (IFCs) have been under development since 1995 and they now form a mature data exchange standard supported by many commercial software [5]. In addition, a new line of CAD has been developed. It can create and refer to object-based or object-oriented model. Unlike the entity-based modeling which dominated for somewhat 20 years, these applications generate building model with parametric objects such as walls, columns and windows. The core problem of entity-based CAD was that it was used as a digital drafting board rather than a design tool, in which represents the building model by raw graphic entities or primitives (e.g. lines and arcs) [8].

Object-based CAD software, parametric modeling and model-based design, are now commonly known as Building Information Modeling (BIM). BIM has made a partial success in allowing the model information be extracted for downstream applications in the lifecycle of a project, and connecting the 3D design with the construction documentations.

3.3 A Conceptual Model of CPLM

Recently, the construction industry has introduced various 3D object-oriented CAD applications into pilot projects. However, in the real world situation, 3D building model is not popular. Efforts to create the 3D model have not provided benefits because it has been used for the narrow purposes e.g. validation of construction methods, graphic simulation of construction process etc. [9]. Given that the frame to manage the information throughout the construction project lifecycle, and standard data access interface among various applications has not been implemented, the workloads for processing data have not been decreased. Needs for implementing an environment in which fragmented practitioners can manage the information throughout the construction project lifecycle has been raised. It has prevented participants from using applications based on 3D project model.

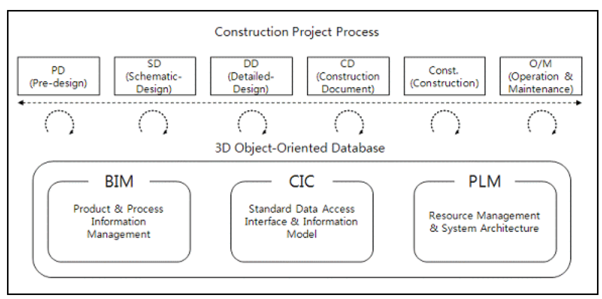

Figure 3. A Conceptual Model of CPLM

A new paradigm to manage the ever-complex projects in the construction industry has emerged. Other industries seem to have increased productivity by introducing PLM and PDM helping designers and engineers to manage the product data and product development process [10]. The approach to manage the resources for manufacturing in PLM can be applied into the construction industry as well. The system architecture to implement PLM is worthwhile for benchmarking. The recommendations from the cases in the field of PLM and PDM will be merged into the methods and techniques that have been developed in the field of construction. Figure 1 shows the evolution of CPLM (construction project lifecycle management). The CPLM is likely to expand the scope of information management from DD (detailed design) and CD (construction documentation) in which 3D object-oriented computer applications are generally well developed into the PD (pre-design), SD (schematic design), construction and operation and maintenance stages.

The CPLM simply does not aim to integrate computer applications or to produce 3D building model. The data should be shared or exchanged among applications. The systems should also feed information to practitioners for decision makings timely and properly. 3D graphic simulations of product and process throughout the project life cycle will enhance the understanding of the project and thus provide sufficient information for decision making. The fundamental techniques to this end have been developed in the field of CIC and BIM. 3D project model will be expanded into further dimensions i.e. 4D in which information on time is merged into 3D, 5D in which information on cost is merged into 4D. The optimization is also called nD [11].

4. Conclusion

There are many interests and researches about design and construction using project model. However, currently, only narrow scope is implemented i.e. visual expression and process control using 3D product model that is created in the detailed design phase. The lack of collaborative design and engineering over project lifecycle causes information loss and thus the benefits of the project model have not been maximized.

CPLM system aims to support decision making over the project lifecycle. The design and engineering process can be conducted virtually in the context. It will improve productivity by eliminating unnecessary waste of time and cost because the design, engineering, construction methods and resource allocations can be optimized. Various graphic and stochastic simulations enabling to predict the potential problems will be conducted. Project model that includes the historical data of design, engineering and construction phases will support facility managers to recognize the situations.

5. Acknowledgment

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