Life Cycle Support for AEC Product/Process through Computerization

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1. Introduction

The rapid development of information technology has made computers indispensable in each major phases of Architecture/Engineering/Construction (AEC), such as in the phases of planning, design and construction. As a result, the integration of existing systems in each phase becomes one of the hottest point of researches nowadays. This is particularly true for the construction phase. Some important concepts such as the product model and the process model have been established (Stumpf et al. 1996, Froese 1996), some critical problems such as the versioning and the authority have been studied (Brown et al. 1996, Rezgui et al. 1998), and the term “computer integrated construction” is well accepted now. However, the previous researches are basically project-centric and focuses mainly on the integration for the design and construction phases in a project.

AEC is an information intensive field, yet it is unique in that all information are specific to each product that is constructed, and that the information is generated and handled by many participants from several diverse organization for every product. For example, planners, designers, general constructors, sub constructors, maintenance staffs, maintenance firms are all the sources of the information.

In China, the government is accelerating the computerization of the state economy and the computerization of the building industry is greatly concerned (Ma 1997, Ma et al. 1998). Some research efforts have been made to computerize the total project information and store it in a CD-COM (Ma et al. 1999).

In Japan, the concept of CALS (Continuous Acquisition and Life cycle Support) that was adopted at first by the military in the United States is been applying to the major industries, including AEC. The key point is the information sharing of product and process through the life cycle by making use of the latest computer technologies, such as Internet in order to increase the productivity, to improve the quality and to reduce the cost. The Japanese Ministry of Construction is planning to carry out CALS in the state-run project from the year of 2004. The prerequisite of this movement is the digitalization of total information by adopting standard format. Several pilot projects have been implemented, but few publication has been made on the research of the systems (Mikami 1999). What the participants are doing in these projects are simply to transfer the files that conform to the standard format by using Internet.

It is time for researchers to consider what framework should be built in the view of life cycle of AEC products, and how to construct it efficiently, effectively and reliably in order to take advantage of new technologies.

2. A Vision

Imagine that you are the owner of a facility, it is important to own the physical facility up to now; and now it becomes very important to own all the product and process data at the same time in the view of the life cycle of the facility; i.e. the data concerning each life cycle phase of the facility, including the general data, the product and process data related to the phases of planning, design, construction, operation and maintenance. By owning these data in a proper way, you can make use of them to response to the ever-increasing social needs more timely and efficiently. For example, by providing the digital data from the planning phase to the designer, you can request reduction of design cost on account of relieving the designer of collecting and inputting the necessary planning data.

If you are the owner of many facilities and you have all the digital data for all product and process, the life cycle data become more useful. You can make use of the data to carry out various analyses. For example, if you are the owner of a road network, you may carry out life cycle environmental impact analysis for existing road to provide insight to the planning of new facilities. You can also optimize the maintenance plan for the existing road and the relative facilities. Otherwise, the difficulty in collecting the data itself may prohibit you from doing the instructive analysis.

A promising way to pursue is to manage the processes of each phase and collect all the product and process data through the life cycle by using Internet. You can agree on the merits by comparing with network shopping which is popular nowadays. In this way, you can obtain all these data and manage the facilities with less time and energy. On the other hand, all the participants can communicate more efficiently. Of course, AEC is much different from the shopping, but the same effect can be expected if we develop the dedicated technology on Internet for AEC.

Based on the above essential considerations, the life cycle support system may have the following characteristics.

First of all, there is a framework to form the system. As the base of the framework, platforms should be selected properly. For example, the platforms for road can be selected as database, CAD (Computer Aided Design) and GIS (Geographic Information System) as well as the Internet. Among them, GIS is selected because it can handle the spatial data such as that of roads very well.

In the second, existing software are integrated and necessary tools (including dedicated groupware) are developed in the framework to form the system. The existing software are integrated in order to avoid the extensive software development task involved in creating such a comprehensive system and to be accepted by all the participants easily, and tools are developed on the platform to achieve good working efficiency.

In the third, standard data format for various data is established and all the data are stored in a central place. All participants follow the format to digitize every necessary information and use the system to send their data to a central place that is managed by the owner or his/her representatives when they carry out the relevant work, and to work with the other participants collaboratively.

In the fourth, the data stored in the central place facilitates various analysis, such as life cycle cost/benefit analysis, life cycle environmental impact analysis and the optimization of maintenance plan. This requires that the data be stored in an efficient way.

3. Key research issues concerning the vision

The merits of the above vision can be realized only through extensive research efforts and relative practices. The key research issues are as follows.

First, to develop the methodology for modeling the life cycle data of various AEC facilities. The concepts of product model and process model have served the purpose of design and construction phases well, but they are not necessarily sufficiently applicable to the life cycle of AEC facilities because wider rang of data have to be involved in the life cycle system. For example, in the planning phase, a lot of social and economic information, such as the statistics of population and social development plan should be considered and it is necessary to incorporate these information properly.

Second, to deal with the methodologies of data storage and update with multiple data format (including multimedia files) within multiple database servers on Internet. The most critical problem under these conditions is to manage the transactions for both the data in databases and the data in files that are involved in the life cycle in order to maintain the consistency of the data. Some middlewares such as MTS (Microsoft Transaction Server) have been developed, but their applicability under the above-mentioned conditions is to be justified.

Third, to deal with the methodologies of scalability of the system; i.e. how the system evolves with the increased number of facilities, which causes new database servers to be introduced and new databases to be established. Some mechanisms need to be established to solve this problem. This problem may have been solved in other industry such as information service industry, but it is not solved in AEC.

Fourth, to deal with the methodologies of integration and the version-up of the component software. The component software may evolve in two ways. In one way, each component software may evolve themselves with time. In the other way, some new component software may be developed based on several existing component software in the coming years so that some new platforms emerge, as if the GIS were developed to solve the problem of the combination of graphic objects and database. The strategies to cope with these situations should be developed.

Fifth, to deal with the methodologies of security management. Since the life cycle of the facilities experiences more participants who are from diverse organization and working on Internet through the life cycle, the access pattern of the participant is much more complex than current systems. So some special models for the security management should be developed to adapt to the requirement of the system and guarantee the security of the data at the same time.

Sixth, to deal with the methodologies of Internet platform for engineering application. Up to now, non-engineering applications have been developed on Internet successfully. The examples include the information publishing and the network shopping. Although some general purpose tools such as email service and file transfer service have been used in engineering field, few engineering applications have been developed on Internet. Engineering application have higher requirements on the platform than the non-engineering application, so existing Internet technologies have to be developed to meet the requirements.

Seventh, to deal with the methodologies of system interaction with the current organization. To apply the life cycle support system means to change the current work style. So it is necessary to coordinate the system with the current organization. It is the prerequisite to the successful application of the new system and deserves to be explored to form some general method that can be applied everywhere. This may require to carry out some pilot experiment by using the developed system.

4. References

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5. Personal background

I completed my undergraduate study in Tsinghua University in 1986 and studied in Nagoya University in Japan from 1987 to 1992, where I obtained my Master Degree and Doctor Degree. The title of my doctoral dissertation is “The Establishment of Replace Criterion of Water Supply Pipes”. I entered into a Japanese company to do practical training for ten months after I received my Doctor Degree. At that time, I turned my research direction to computer application in civil engineering. I went back to Tsinghua University to teach in 1993 and I became an associate professor in 1994.

My research ranged from computer aided design for building structure and road; computer application in construction, especially in project management; and engineering information system for structural design and construction. I am now working in Center for Integrated Research in Science and Engineering of Nagoya University Japan as a visiting scholar. My current research topic is “The Development of Life Cycle Road Management System Based on New Information Technology”.