CITIS AS A COLLABORATIVE VIRTUAL ORGANIZATION FOR CONSTRUCTION PROJECTS

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Abstract: The recent use of information technology (IT) has effectively promoted integration of fragmented information under the distributed construction environment. However, to date, many Internet based system for online project collaboration solutions do not provide standard formats in transmitting contractual documents and project-related information specifically for public projects. This paper provides a concept of virtual organization and then examines a CITIS (Contractor integrated Technical Information Service) system for the public construction projects developed in Korea from the viewpoint of virtual organization concept. The CITIS system suggested here has been applied to local branches of the Korean MOCT (Ministry of Construction and Transportation) and it is current in use. Finally, lesson learned from the field trial is provided to advance the current CITIS toward a fully integrated collaborative virtual organization.

Keywords: CITIS, virtual organization, information technology, fully integrated collaborative system, electronic collaboration, online project collaboration solutions

1. INTRODUCTION

The construction industry has suffered from its fragmented structure along the phases of the construction life cycle. The fragmented nature of construction results in low levels of coordination and integration between the different parties involved. Keeping subcontractors, contractors, designers, clients, and other parties supplied with continuous and enormous information has been challenging problem to construction industry. To overcome this limitation, integrating exchange standards and information processing tools has applied to many collaborative application based on information technology (IT). In an attempt to adopt IT into the construction industry, many Project Management Information System(PMIS) and Web based PMIS provide project collaboration solutions spanning all phases of the construction life cycle. However, to date, they do not provide standard formats for documents and information of project, specifically for transactions between public owners and contractors [1]. As a result, a user needs to rekey or reprocess the data once created so as to reuse them in a local system.

This paper provides a concept of virtual organization and then examines an CITIS (Contractor integrated Technical Information Service)system for the public construction projects developed in Korea from the viewpoint of virtual organization concept. The CITIS system is tested in the public road sites to verify its efficiency. Finally, lesson learned from the field trial is provided to advance the current CITIS toward a fully integrated collaborative virtual organization.

2. VIRTUAL ORGANIZATION AND CITIS

2.1 Literature Review of Virtual Organizations

Today's challenging business environment leads to increasing demand for more flexibility and faster reactivity within enterprises. Toward this end, utilization of resources must be optimized at a highest level so that the geographic and temporal production demands of the market are satisfied. However, it can be inefficient that these different functional groups have to work at the same place and at the same time in order to communicate and collaborate. To overcome these barriers, manufacturing industry proposed virtuality concept, as a virtual corporation, virtual factory, virtual enterprise etc. VO (Virtual Organization) concept

started from the concept of virtual corporation since in 1993[2]. Also, Upton and McAfee (1996) defined as "Virtual Factory is a community of dozens, if not hundred, of factories, each focused on what it does best, all linked by an electronic network that would enable them to operate as one flexible and inexpensively - regardless of their locations"[3].
Today there are several definitions depending on the goals of virtual organizations and the scope of resources combined in a virtual networks. Within the field of these domains, specific researches regarding virtual organization/corporation, virtual company, virtual enterprise and virtual factory can be identified (Markfort et. al. 1999). Despite the differences among them, these concepts have similarity in the sense that they concentrate on the joint collaboration through the network, which makes it easy for companies with dissimilar systems to exchange information electronically.[4] This paper adopts a concept of VO that include the whole similarity of related definitions in order for various information from many different organizations are coordinated and come together based on standardized format and work processes to produce the particular output through a network.

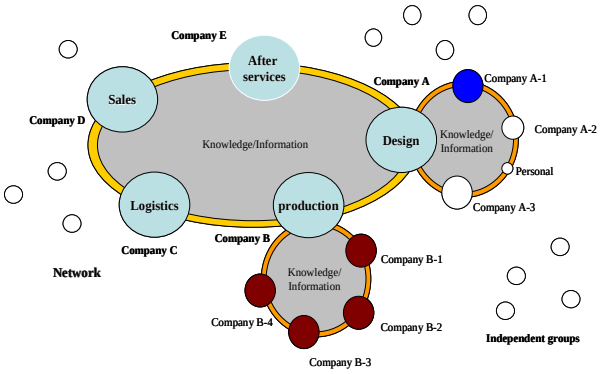

Figure 1. The Organizational Concept of VO in manufacturing industry

(Sources: revised from GNOSIS in Esprit Project)

The primary concept of VO includes the following roles: (1) broker who is selling the services that include marketing activities and information management to the customers; (2) open standards based on the protocols established for the internet which allows members of a community to share information regardless of differences in their individual computer system; (3) a networked manufacturing community that is open and friendly to even the common users; (4) abundant bandwidth that enables the highest-speed links; and (5) security such as firewalls, unbreakable data-encoding scheme, and electronic signature system[3][4][5]. According to Wendy (1999), the basic characters associated with VO concept are summarized as: (1) boundary crossing, (2) complementary core competencies/the pooling of resources, (3) knowledge sharing, (4) geographical dispersion, (5) changing participants, (6) participants equality, and (7) electronic real-time communication[6]. To address these basic characters, Ronald(1999) suggested that VO function should contain the primary services as indicated in Table 1[7].

Table 1. Primary Functions of VO

Function Types	Required Services
Basic Services	Data Service Communication Service Information Technology Service Electronic Certification and Security Service
Business Services	Collaboration Service Knowledge Management Service Coordination Service Process Service Information Service Transaction Service

2.2 CITIS (Contractor Integrated Technical Information Service)

CITIS is a standard used by contractors to deliver contractually specified technical data using a contractor-integrated data management system, instead of having to deliver the information in a printed format. In accordance with a contract, the contractor electronically provides contractual information to the owner through a mutual database server (CITIS server), and the owner then accesses the information in the CITIS server through electronic network, as shown in Figure 1[8].

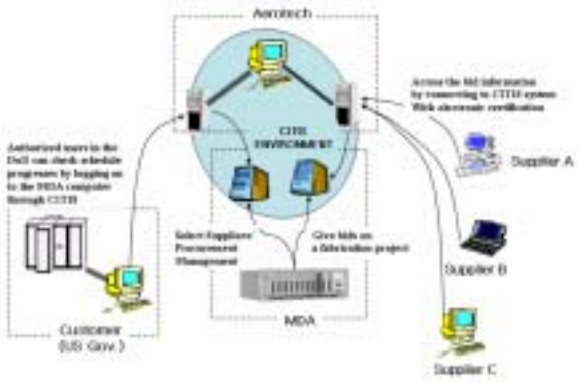

Figure 2. Framework of CITIS gateway in U.S DoD (Source : Andrew McAfee, 1997)

The concept of CITIS has been widely applied for the manufacturing industry as an agile collaborative tool. Especially, McDonnell Douglas Aerospace (MDA) and AeroTech Service Group (ASG) developed commercial CITIS in 1993. This CITIS system facilitated electronic information sharing and

transferring among the companies and their external suppliers, customers, and other partners. Currently, AeroTech Service holds 201 projects, 2,000 suppliers locations, and 234 Web applications and Web sites for CITIS gateway.

2.3 CITIS in Construction

The CITIS concept is a relatively recent introduction in the construction industry. Providentially, several Asian countries such as Japan, Taiwan, and South Korea are extending CITIS concept at the national level toward construction industry. South Korea started from 1998 by MOCT(Minister of Construction and Transportation) on public road construction project. At this present, six local branches of MOCT is applying the CITIS system. The Japanese Ministry of Construction launched their Construction CITIS program in 1996. Japan has been implementing national level IT strategies in construction. As an early exhibition program on CITIS, Japan has conducted various types of field test since 1997 to illustrate how the CITIS concept can be utilized to improve the paper-based construction environment. In the case of Taiwan, starting from 1997, the Ministry of Economy (MOE) introduced the CITIS concept at a national wide level, as an attempt to atomizing construction life-cycle process[9]. The prototype of CITIS system was proposed based on the object oriented techniques so that users can share project information with other applications along the construction life-cycle. Taiwan government presents the conceptual CITIS model and subsequently performs the research to develop the integrated information core model to promote the information sharing with other applicant within the construction industry [9]. In similar case, The OSMOS (Open System for inter-enterprise information Management in dynamic virtual envirOnmentS) is a European project performed by the consortium, which consists of France's CSTB (Centre Scientifique et Technique du Batiment), Information System Institute of University of Salford, and VTT (Technical Research Center of Finland). It aims at providing an infrastructure that underpins the concept of virtual enterprise by promoting co-operation between actors and companies in the construction projects [10].

2.4 Basic Architecture of CITIS system as a construction VO model

On the basis of VO and U.S. DOD CITIS concepts and functions, This paper presents the advanced construction VO model developed for public project in Korea. Originally, U.S. DoD (1993) defined primary functions in CITIS: the core function that the contractor has to provide, and tailorable functions that may be specified according to the contract between owner and contractor. Basically, it consists of information service, data configuration management, CITIS security, data item index, and data exchange standards. However, U.S. DoD only defines the general functions required for CITIS implementation. Subsequently, application functions must be developed with a consideration of adaptation from project management functions. In this context, we established construction CITIS functions in accordance with the primary functions of VO so as to overcome typical limitations being faced in current CITIS systems. Figure 4 presents basic architecture of construction CITIS, which consists of three primary parts - domain part, business part, basic part.

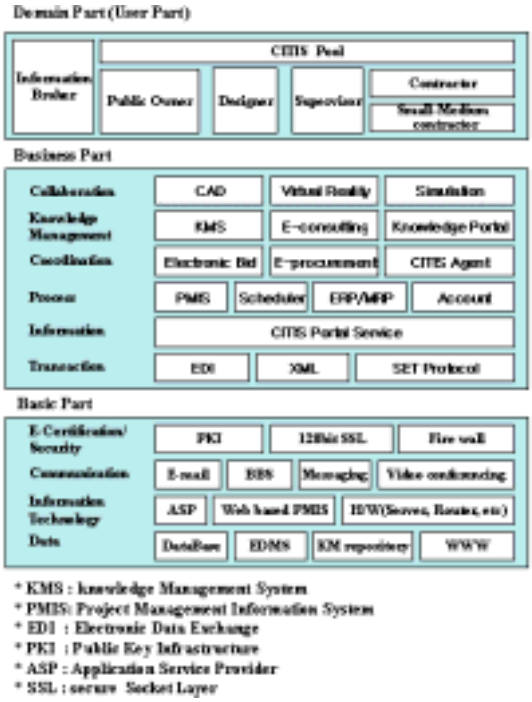

Figure 3. Basic Architecture of Construction VO Model

The domain parts consist of public owners, designers, supervisors and contractors as providers, and a broker as an intermediating function that operates CITIS system. The CITIS structure enables users for boundary crossing, which implies that they are loosely combined in a CITIS pool by dues as an annuity and then rigidly tied to produce the specific products as a project team. In contrast with the domain part, the business part is close to the value adding activity of the participants such as; (1) collaboration service: CAD, real time collaboration and simulation, suppliers chain management; (2) knowledge management service: knowledge provisions for collaboration and project management including know-how and training on setting up a CITIS system and consulting services; (3) coordination service: new application solutions that implement coordination mechanism like procurement actions as well as intermediaries including CITIS agent; (4) process service: whole process or a part of

a process offered by CITIS portal service including internet based project management; (5) information service: specific information required in the process of production including technical specifications, relevant building codes, and construction laws and regulations; and (6) transaction services: a high relevance of compliance to the principle of transaction and timeliness of the services that are back office settlement activity such as EDI, XML, and set protocol. On the other hand, basic service is rather stable and choice of business services should have bases on the basic service; (1) data service: project related data sharable and reusable for the participants characterized by highly standard data and a high stability of the service requirements; (2) communication service: the opinion exchange through the content free communication standards, including the network and required protocols including bulletin, chat rooms or message services for real time communication; (3) information technology service: the hardware and application components like browser and web servers specialized in IT and application hosting; (4) electronic certification and security Service: authorized security standards for authentication, access control, encryption, data integrity, and electronic signatures.

3. THE EVALUATION ON KOREA CONSTRUION CITIS SYSTEM FROM THE VIEWPOINT OF Virtual Organization (VO)

3.1 Korea construction CITIS system Overview

CITIS system of Korea MOCT consists of five sub systems designed for supporting the construction phases such as; (1) owners CITIS server; (2) CITIS agency (broker) server; (3) security and authentication module; (4) CITIS interface with contractor's in-house information system; (5) Electronic Document Management system (EDMS); and (6) Integrated Data Base.

Figure 4. Structure of Construction CITIS

Based on this system, the contractors can transmit the project-related information to the broker CITIS server through the Internet. Subsequently, it is forwarded to the owners CITIS server with the support of socket and SMTP (simple mail transfer protocol) technology. Afterward, the owners make an appropriate decision on the project and then return the document on their decisions to the broker server. Finally, the contractor can retrieve the returned document from the broker server. Particularly, XML formats based on DTD (Data Type Definition) are used in an attempt to communicate electronically among the participants in different computer systems. Figure 5 expressed the role of construction CITIS agent and correlation of participants.

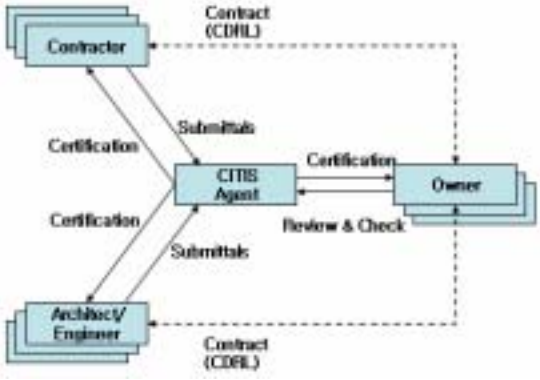

Figure 5. The role of construction CITIS agent

A real system based on the concept of CITIS is shown in Figure 6. The user (owners, designers, inspectors, and contractors) can log into the CITIS server by keying user ID and password and then through approval process, identify connected project name, log time, etc. and execute each accessible menu.

Figure 6. Window for Construction CITIS Menu

The CITIS consists of the following five components: (1) Project Progress Information Management where Project status information can be searched or queried by a project ID and a contractor uploads contractual document for the application of the progress payment by utilizing the project progress management function; (2) Public Notice Management where users can search, modify, and delete public notices regarding the management of

projects; (3) General Information Management that allows the management of general project information such as contract status, user information, submitted information, document registration list and document contents, etc.; (4) Technical Information Management that deals with drawing, specification, construction methods, etc.; and (5) System Management that allows a system manager to control the total system, including code management, bulletin board management, data room management, plug-in management and logging management, and backup of documents and information on projects.

3.2 The result of field test about Korea construction CITIS system

Construction CITIS system is operated for trial application 77 road construction sites from 2003 to 2004. During latest 7 moths, total 2744 contract documents of road projects had used in construction CITIS system. And the result of Multi-users Test(200 user, 100 times) to the CITIS server, CITIS system is not founded error, as performance deterioration and system down, etc.

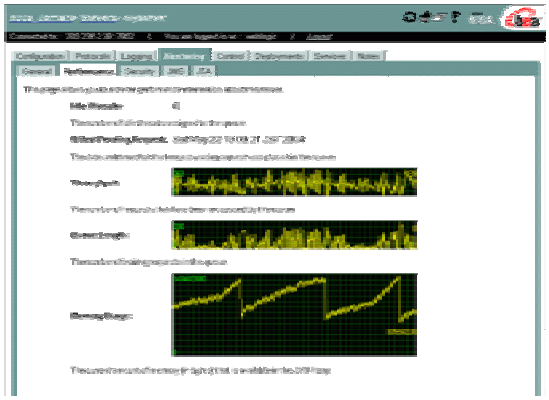

Figure 7. Performance Monitering graph of CITIS web application server (source : CITIS agent interim report)

Table 2 indicates the test results. Subsequently, the CITIS system proved its capacity to transfer the different sizes of documents steadily, showing 14 seconds to 36.5 minutes depending on the size of attached files.

Table 2. Results of Preliminary Multi-user Test

Types of documents	Size of attached files	Processing time
Text	779 Kilo Bytes	14 seconds
	5.16 Mega Bytes	1 min. 5 sec.
	10.6 Mega Bytes	1 min. 48 sec.
	3.24 Mega Bytes	3 min. 22 sec.
Graphics and drawings	50 Mega Bytes	14 min. 15 sec.
	120 Mega Bytes	36 min. 30 sec.

The expected benefits of the system are to reduce not only the current offline delivery time of the construction information but also to minimize the efforts for re-keying and re-processing of the data. The CITIS system handled data and documents electronically which were exchanged between the regional offices, CITIS broker agency, and the contractors on a real-time basis during the project period. Within the context of measuring the benefits, the data coverage was confined to the change order and periodic payment work flow because these works are typically and frequently performed on the construction sites and so considered representative in comparing the cost, speed and data service between as-is and to-be work flow. In a straightforward manner, the application of the system was evaluated to bring the reduction of the time and cost, 35% and 26%, respectively, in the progress payment activity, and 40% and 30% for the design change activity.

3.3 The evaluation on the Korea construction CITIS system from the viewpoint of VO

In spite of good result for field test about Korea construction CITIS system, we considered that the system has characters and functions of VO. Table 3 is results of review for CITIS system from the architectural view of construction VO model

Table 3. Architecture of construction VO model

Characters and Functions of VO		Korea CITIS system
Character	Boundary Crossing	X
	Complementary core competencies / the pooling of resources	X
	Knowledge Sharing	O
	Geographical dispersion	O
	Changing participants	O
	Participants equality	X
	Electronic real time conferencing	X
Function	Collaboration Service	X
	Knowledge Management Service	Δ
	Coordination Service	X
	Process Service	X
	Transaction Service	O
	Information Service	O
	Data Service	O
	Communication Service	X
	Information Technology Service	X
	Electronic Certification and Security Service	O

However, the field management function for contractor and supervisor which the current CITIS system is lacking in, should be established for collaboration to be conducted in the VO as the project is processed in the field. That is, information sharing and monitoring structure is not reflected on it because the contract management functions by ordering public owners has been approached from the exchanging of official contract documents. Therefore, the present CITIS system is concentrated on electronic forward of contract documents, data transmission, and reliability of transmission data.

The CITIS system for mid- and small-companies included in construction CITIS is not equipped with the supply chain management, materials, equipments and managerial functions for field process because of its concentration on providing information with ordering party, These problems have been pointed out through the actual proofs by owners, contracts, supervisors, and it means that construction CITIS should be equipped with the structure and functionalities of virtual company to be established.

4. LESSONS LEARNED AND CONCLUSION

In this research, the authors have put efforts on taking a different view of CITIS (Contractor Integrated Technical Information Service) model in terms of Virtual Organization (VO). As a result, it has been found that CITIS has a limited function on providing collaborative work space. It is more like a electronic document management system only. Often it causes more document work rather than reduces paper-works because many project owners and contractors prefer old-fashioned paper-works to electronic documents. Furthermore, CITIS was not a complete computerized document management system, either. It provided only a fracture of the document management system. In this research, this was proven by applying the CITIS model to 77 construction project for 7 months across the nation.

While CITIS is focused more on the contractual document transmissions, Virtual Organization is a total management of the construction project over virtual (cyber) space. Virtual Organization provides a collaborative work space in which project participants get together and exchange data and information. Given that the construction project is a temporary organization of the project participants (general contractor, A/E, subcontractor etc.), it can expand larger to include extended participants such as project owner and users. Since the information flow is much faster in virtual space, important decision can be made more quickly and efficiently based on more suggestions and ideas of all the participants.

Future research will include the verification of the selected functions of VO by applying them to a real construction projects as many as 300 or more and by survey interviews of the participants.

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