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A Study on the Developing Method of the BIM (Building Information Modeling) Software Based on Cloud Computing Environment

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***Abstract*—**According as the Architecture, Engineering and Construction (AEC) Industry projects have grown more complex and larger, the number of utilization of BIM for 3D design and simulation is increasing significantly. Therefore, typical applications of BIM such as clash detection and alternative measures based on 3-dimenstional planning are expanded to process management, cost and quantity management, structural analysis, check for regulation, and various domains for virtual design and construction. Presently, commercial BIM software is operated on single-user environment, so initial cost is so high and the investment may be wasted frequently. Cloud computing that is a next-generation internet technology enables simple internet devices (such as PC, Tablet, Smart phone etc) to use services and resources of BIM software.

In this paper, we suggested developing method of the BIM software based on cloud computing environment in order to expand utilization of BIM and reduce cost of BIM software. First, for the benchmarking, we surveyed successful case of BIM and cloud computing. And we analyzed needs and opportunities of BIM and cloud computing in AEC Industry. Finally, we suggested main functions of BIM software based on cloud computing environment and developed a simple prototype of cloud computing BIM software for basic BIM model viewing.

***Keywords*—**Construction IT, BIM(Building Information Modeling), Cloud Computing, BIM Service Based Cloud Computing, Viewer Based BIM Server, 3D Design.

I. Introduction

A. Study Background and Aim

IN this study, we aimed to find methods of expanding the BIM(Building Information Modeling, hereafter called BIM) with recent obligations of public ordering body projects to apply the BIM, reinforcement of business competitiveness, complexation, gigantism and modernization of construction projects. This is done by using the acts or technologies of production, exchange and utility of project related information among project participants with the 3D technology and data model during the project lifecycle of planning, designing, construction and maintenance [1].

To expand the BIM, the infra establishment such as various BIM related software, high-performance computer and server that is required for BIM based projects is essential. Thus, effective plans are required to solve problems of reducing the initial expense for large-scale business IT infra establishment, setting an appropriate operating expense based on the business standard, low utility of the established IT infra, etc.

Meanwhile, various cases that procured the efficiency of the IT infra establishment and operation have been reported based on the use of a cloud computing technology that is able to simultaneously provide IT services of data storage, network and contents utility, etc. through the recent internet servers.

Therefore, we investigated the demands of cloud computing-based BIM service to reduce the BIM expansion hindrance such as IT infra expense reduction and collaborative environment improvement. Moreover, this study applied the service development directions and developed a BIM software protocol based on the cloud computing that can be used as a base technology so as to provide future cloud-based BIM service.

B. Study Procedure & Scope

This study focuses on the BIM based technology development by using the cloud computing application technology so as to reduce IT infra expenses and improve collaborative environments. Surveys and questionnaires were conducted on current staff members to derive the scope of the system development. Accordingly, results were utilized to progress the study based on the BIM software prototype system development.

The study proceeded as the following. Firstly, cases of BIM and cloud computing were studied. Secondly, questionnaires and interviews were conducted on current staff members regarding the demand and development directions. Then results of demand and requirements were analyzed so as to select the BIM server based viewer with the base technology of the cloud-based BIM service. Thirdly, a prototype system was developed based on requirements and the future development directions were discussed regarding the cloud based BIM service that is to be expanded.

II. Study of BIM & Cloud Computing Cases

A. BIM Outline

A BIM (Building Information Modeling) refers to the virtual modeling process of facilities. The modeling process includes planning, designing, engineering (structure facilities, electricity, etc.), construction, maintenance and destruction in a virtual space also called VDC (Virtual Design

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Construction)[3]. The BIM is used to virtually create a facility before the construction process and enables a real-life visual verification. The object information of each facility is used for integrated processing of quotation, process management, structural calculation, etc. 3-D designing and construction enables visual collaboration among participants.

B. Outline of Clouding Computing

The cloud computing is a technology that was developed to solve problems such as the inefficiency of large-scale IT investments, low use of IT infra that was established by the optimum point of use and the traditional infra purchase and installation methods that cannot correspond to the fast business environment. It provides highly expandable resources in forms of service to various clients using the internet technology.

Generally, the cloud computing is classified into three main types as shown in Table I[2]. The NIST (NIST, National Institute of Standard and Technology) classified the cloud forms based on the proprietary rights of IT (Information Technology) assets.

TABLE I
CLOUD COMPUTING TYPE

Type	Substance
Private Cloud	Used by creating service with private IT assets in possession
Public Cloud	IT proprietary rights are with business of service provision
Hybrid Cloud	Hybrid between Private and Public Clouds

Recently, the Private Cloud is expanded to an external Private Cloud that manages personal information by using external service. The Public Cloud is also modified to enable its use to specific organizations and it includes the Community Cloud of the common business process. Also, it is distinguished into ① Infrastructure as a Service(IaaS), ② Platform as a Service(PaaS), ③ Software as a Service(SaaS) according to the service form. This study focuses on the development plan of the Software as a Service(SaaS) from the cloud computing environment.

III. DEMAND SURVEY ON CLOUD BASED BIM SERVICE

In this study, a survey was conducted to deduct system development requirements and Cloud based BIM service provision technologies to solve problems relating to the software and hardware establishment expense that is a hindrance element to BIM expansion, and the BIM data management efficiency.

A. Demand Survey Outline

i. Demand Survey Method

The survey was conducted on BIM marketability to understand the recognition of current BIM technologies, the preference of cloud service, existing BIM software satisfactory level to set cloud based BIM service directions and development possibilities of the cloud based BIM software.

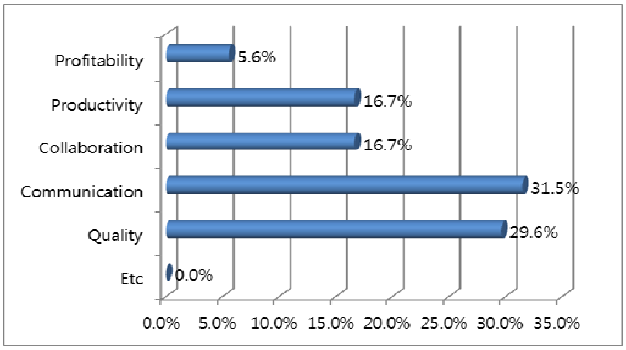
Moreover, a workshop was conducted with a total of 7 participants including researchers and experts in the academic and business fields so as to deduct cloud BIM service directions and select base technologies for prototype development.

ii. Characteristics of Survey Subject Group

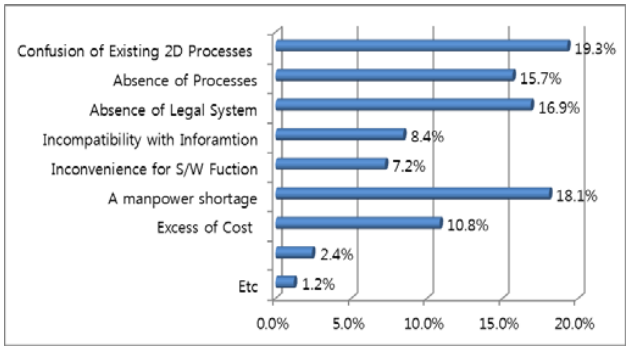
A total of 32 subjects participated in the survey (10 Constructors, 20 Designers & Engineers and 2 Professional Construction Business Staff & Others). The subjects have an average experience of 12 years including hands-on-experience, and have conducted an average of 2.09(1.48years) BIM based projects mainly based on 3D modeling (designing, structure, etc.) and interference check.

Negative results showed for the BIM application effects with an average score of 3 Points (Satisfactory Level of 50%) but positive results showed for the possibility of future use with an average score of 3.65 Points, which showed to be higher than the satisfactory level. The activation period of the BIM is forecasted as about 3.7 years.

As shown in Fig. 1, enhancement of communication and design were highly considered as BIM application effects, and problems of confusion with existing 2D processes and insufficient manpower were considered to negatively hinder the BIM.



[BIM Application Effects]



[BIM Expansion Hindrance Factors]

Fig. 1 Survey Trend on BIM Application Effects and Hindrance Factors

B. Preference and Development Direction on Cloud based BIM Service

The preference of the Cloud based BIM service showed an average of 3.56 Points (About 71.2%) out of a total preference scale of 5 Points and in particular, the preference (3.86) of subjects who (11 subjects) have used the cloud service was higher than the preference (3.4) of subjects who have not used (21 subjects) the cloud service in the past. Thus, it was investigated that the use of services will increase as the cloud service generalizes.

Furthermore, as displayed in Fig. 2, the survey on the development directions of the Cloud based BIM service showed that subjects preferred inexpensive software that features core functions and provides BIM data service such as library.

In the Cloud based BIM Service development area, there were high demands on quantity estimation & quotation (12%), service provision (10.8%) and interference check(10.8%).

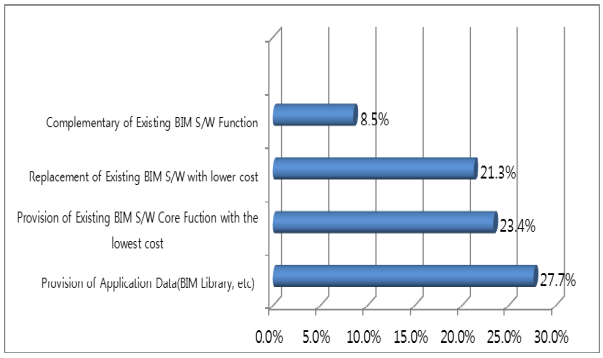


Fig. 2 Development Directions of the Cloud based BIM Service

C. Cloud based BIM Service Core Function Workshop Results

Based on the survey explained beforehand, analyses were conducted on the requirements for the selection and the development of the core functions to derive development directions and future services of the Cloud based BIM Service.

The following explains the workshop effects based on survey results.

○ The BIM based Cloud Service requires to be developed with a competitive price (inexpensive) based on the basic functions of the existing commercial system.

○ The development functions require to be enhanced based on the SaaS (Software as a Service) that provides software service and the IaaS(Infrastructure as a Service) that provides data storage and management service.

○ In case the Cloud based BIM service aims to achieve core functions and a competitive price, it must focus on specializing in specific projects(Eg. Public Organizations, hospitals, small buildings, etc.) and specific subjects(Eg. Public ordering body, small design office, etc.) for better marketing, instead of developing for all project types and subjects.

○ Serviceable Area: Planning service (Provision of site analysis, floor-area ration, ratio of floor area to site, regulations review, module analysis, gross quotation), server for BIM model management(IFC support, revision management), server based viewer for BIM model review(For collaboration purposes, provision of commenting function), interference and constructability review service, process review standard 4D simulator, estimated quotation service, BIM based collaborative system(PMIS substitute), eco-friendly service, etc.

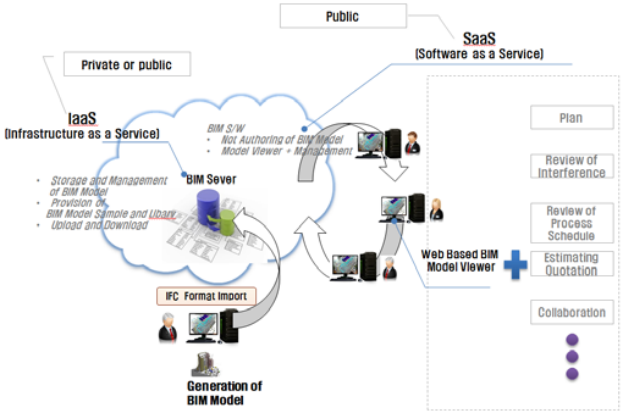


Fig. 3 Directions and Core Functions of Cloud based BIM Service

IV. Prototype System Development based on Cloud based BIM Service Demands

Prototype System Design for Cloud based BIM Service

On the basis of survey and workshop results as shown in the below figure, this study developed a prototype system after selecting the source of BIM service, the BIM server-based viewer, by reviewing the IFC-supporting BIM server and the BID models and connecting various future data with base modules of cloud based BIM service.

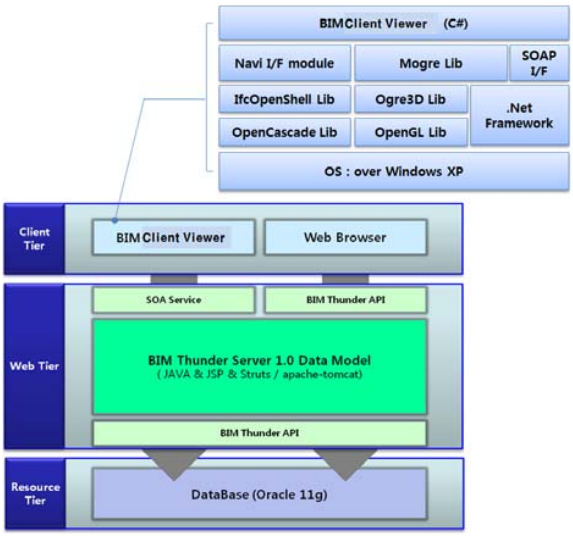


Fig. 4 Architecture of the BIM Server and Viewer

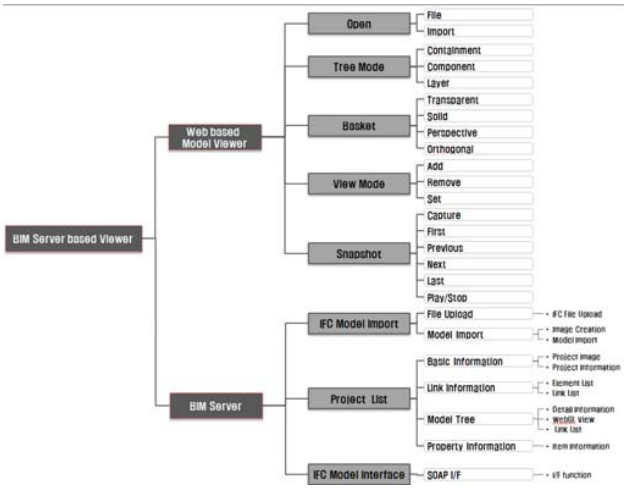


Fig. 5 Functional Diagram of the BIM Server based Viewer

The architecture of the BIM server was developed by classifying the Resource tier for BIM data storage, the web tier for BIM model up/download support and the Client tier for interface provision that is able to up/download the BIM model. Also, the data base used a widely-utilized RDB, Oracle 11g, and established an RDB structure that is able to hold all BIM data which is formatted into IFC based on the IFC 2X3 analysis so as to establish the database. Furthermore, the BIM server based Viewer was developed by using the C# Program based on the .Net Framework.

Fig. 4 and Fig. 5 display the architecture and functional diagram of each BIM server based viewer development.

A. Prototype System Development for Cloud based BIM Service

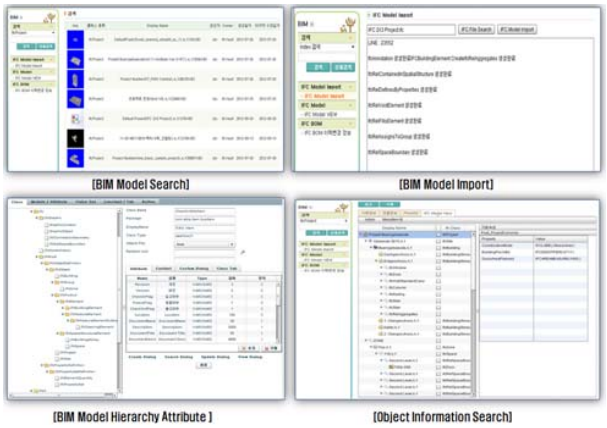


Fig. 6 Main Functions of the BIM Server Management

Fig. 6 displays the BIM server management screen that is applied from the BIM server based viewer. When providing Cloud based BIM service in the future, various functions including the registration, search, history management of various BIM models of IFC will be possible for effective BIM model management, and other functions will be also provided such as detailed search of IFC import history data, IFC property hierarchy applied data search and search & management of detailed data by object.

A prototype system was developed with the viewer based on basic functions that can be used for developing Cloud based BIM service as defined in Fig. 5(Refer to Fig. 7). The BIM model that may be reviewed with the viewer is a prototype that connects to developed BIM servers or opens model files. In addition, the system was developed to enable IFC hierarchy applied property search, model review, model transparency adjustment, snapshot for review, time tracing(first, previous, next) of models based on the captured screen and auto-view function(play/stop).

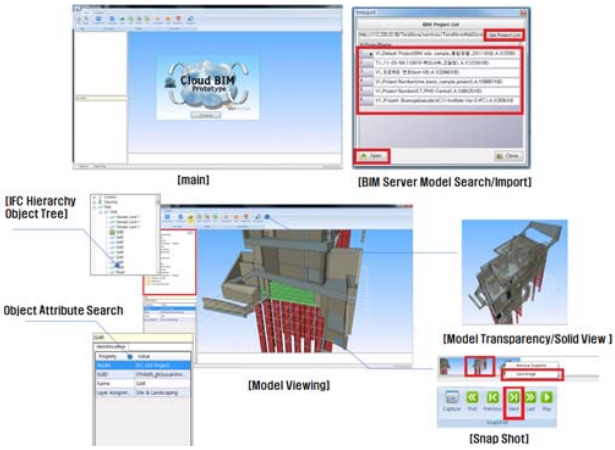


Fig. 7 Main Screen by Functions of the BIM Server Based Viewer

V. Conclusion

This study proposed solutions to problems of initial BIM investment and collaborative environments by grafting the BIM onto the cloud computing technology that was recently introduced in other industries. Also, a prototype system was developed with the basic technologies of future cloud based BIM service.

The server was developed to provide functions of registration, search and history management of various IFC based BIM models and other functions such as detailed search of IFC import history, IFC property hierarchy applied data search and management of detailed data by subject. The viewer was developed to enable model search and review in link with the BIM server.

Acknowledgment

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