

# Resource Allocation Methodology of Virtual Desktop Infrastructure in Cloud Computing BIM: Focusing Korean Small and Medium Sized Architectural Design Firm

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## Abstract

**BIM (Building Information Modelling) technology has been expanded for using in construction project during the past 20 years. However, recently its spread has been delayed than the initial expectations, due to the high-cost of BIM infrastructure development, the lack of regulations and process.**

**In design phase, especially, collaboration based on BIM system has being a key factor for successful next generation building project. In the many analysis of current research about virtualization and BIM service, convergence of cloud computing and virtual server system can be proposed as a most successful solution for data exchange such as drawing, 3D model, object data, properties,.**

**Therefore, this study has a purpose DaaS(desktop as a service) for BIM user design phase by phase. By analysis user's desktop resource data from Pre-design phase to Schematic design, Design develop and Construction design phase, we defined criteria to resource distribution on virtual desktop environment.**

**The goal of the study is to enable the BIM customized cloud computing server. It will bring cost saving, high-performance quality of working environment and cooperation's convenience and high security when doing BIM work in small and medium sized architectural design firm.**

## Keywords –

**VDI (Virtual Desktop Infrastructure); Cloud Computing; BIM; Design Collaboration; Virtualization**

## 1 Introduction

The introduction of building information modelling (BIM) in construction has changed many existing processes in the industry. Communication tools are now available that allow designers and constructors to discuss and interact in the construction environment. This process can reduce the errors and changes associated with construction. Meanwhile, it supports the construction process and reduces costs while minimizing legal conflicts. Ultimately, it facilitates the successful implementation of entire projects.

However, the introduction of BIM at construction sites also causes many problems due to the diversity of environments. Table 1 illustrates the types of problems resulting from the BIM introduction process.

Of these problems, this study aims to focus on the systematic shortcomings of BIM-based cooperation. Previous studies related to BIM cooperation include “The Difficulty of Utilizing BIM in a Large-Scale Project (Chi Joo Lee 2009), “The Inadequate Configuration of BIM-Based Cooperation Systems (Jung Wook Park 2009), and “The Cost of Software/Hardware Burdens for the Use of BIM (Smart Market Report 2008), to name a few. Summarizing the aforementioned problems, the current BIM-based cooperation system has important problems resulting from the adequate sharing configuration system. Thus, recent studies have emphasized the importance of research into relevant areas.

Table 1 Diagram of Research Methodology

Problems when Introducing BIM
Lack of standards and guidelines 3.5cm
Compatibility issues with BIM software
BIM process fixation problems 2.5cm
BIM tools utilizing professional shortage
The initial cost of risk when introducing BIM

This paper aims to conduct a study on the design of a virtual desktop infrastructure (VDI) system model for a cloud computing BIM service. This research seeks to make improvements in the aforementioned problems associated with the cooperation system.

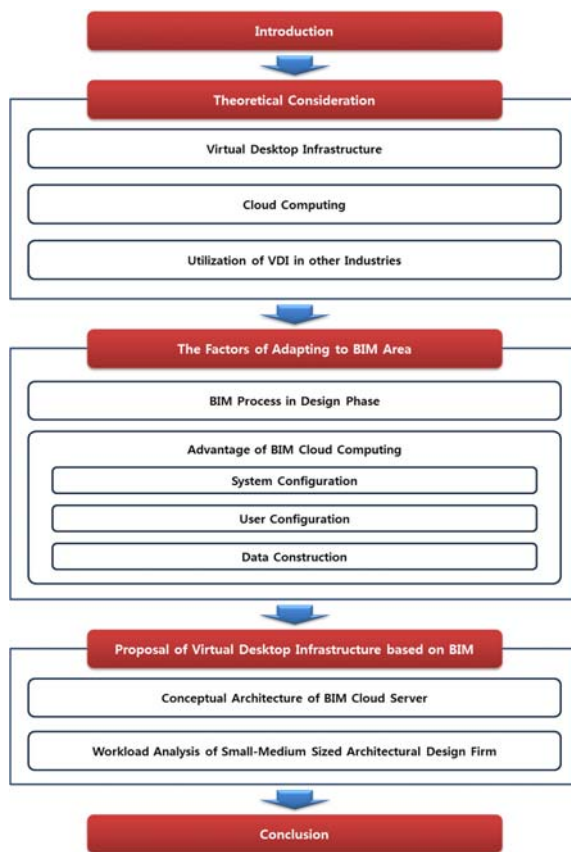


Figure 1 Diagram of Research Methodology

Figure 1 illustrates the procedures performed in this study. First, we investigated small- and medium-sized design firms in the Republic of Korea to perform a theoretical analysis of BIM processes. Then, we prepared a checklist for applying BIM to the context of this study.

Third, this study proposes a virtual desktop infrastructure based on BIM while giving appropriate authoring usage/authorization allowances to users.

## 2 Theoretical Considerations

### 2.1 Virtual Desktop Infrastructure (VDI)

VDI services generate virtual machines (virtual PCs) to be operated in a server’s cloud data. Moreover, these services allow users to utilize desktop environments anytime and anywhere through a device connected to a network. In the field of VDI, this process is known as “virtualization.”

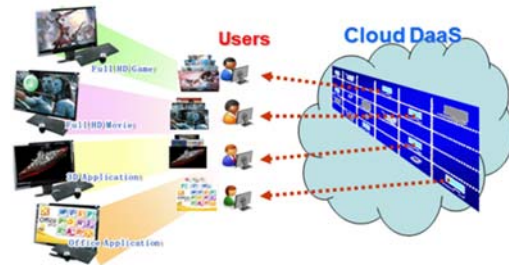


Figure 2 Desktop as a Service Solution

First introduced in 2008, VDI technology has been growing rapidly with virtualization technology, cloud computing, and increased use of mobile devices in the corporate, financial, telecommunication, and public institute computer markets. Currently, the most prominent VDI companies are Citrix and VMware. Approximately 20 VDI companies have released relevant products, including Microsoft, which owns Windows OS, Quest, and Virtual Bridges.

### 2.2 Cloud Computing

To utilize VDI effectively, one needs a cloud computing service model suited to a given usage. Such services allow users to use a service by accessing the shared pool of computer resources that control an environment. DaaS- (Desktop as a Service) based cloud computing services can be provided as shown in Figure 3 below.



Figure 3 Cloud Service

SaaS (Software as a Service) provides an environment that can develop, distribute, and manage PaaS (Platform as a Service) applications or cloud applications. Prominent companies in this category include Salesforce.com, Google, and Facebook.

IaaS (Infrastructure as a Service) offers an infrastructure environment, such as servers and storage. The most prominent giant in the IaaS field is Amazon, the first company that embarked on the cloud business journey in earnest. Based on this early entry, Amazon has the highest degree of infrastructure reputation and competitiveness in the industry.

### 2.3 Utilization of VDI in other Industries

Table 2 Application and Utilization in other Industries

Company	Characteristic
1. The Catholic University of Korea, Yeouido ST. Mary's Hospital	Provides easy solution for building a cloud computing system Improves care spaces
2. Seoul National University Hospital	Seeks to minimize power consumption in the 24-hour hospital Uses health information systems while moving toward a virtual solution
3. GangNam Severance Hospital	Allows full PC availability, regardless of the device type. Provides real-time, delivered health information
4. Kindred Healthcare	Improves stability of the desktop in the data Employs a low-cost strategy, implemented using a thin client
5. Bell	Manages virtual desktops easily, more than 4000 VM Includes a built-in disaster recovery solution
6. IRMC (Intell Risk Management Corporation)	Saves time and operates hardware Provides the additional time-saving of a new PC
7. Samsung Advanced Institute of Technology	Prevents important data leakage (CAD design drawings, etc.) Supports tablet devices, such as mobile work
8. Hyundai Heavy Industries	Allows faster speeds (text, Internet, etc.) Provides comfortable office space
9. LG CNS	Includes anytime, anywhere high-level security Provides integrated services to the storage network
10. SK Telecom	Gives stable resource management Provides an all-in-one thin client
11. Korea Workers' Compensation & Welfare Service	Prevents information leaks and protects against cyber terrorism Improves speed and usability
12. Court of Korea	Provides the same working environment at all locations Offers smart work by VDI
13. Woong-Jin	Enhances eco-friendly corporate image Improves the work environment (dust, heat, reduced occurrence of noise)
14. Allianz	Increases convenience for IT management staff Switches the old PC into VDI
15. MPC Marketing Technology & Services	Provides WAN, LAN environment support for outsourcing services Supports mobile environments
16. University of Incheon	Complements disadvantages of PC (fan noise and heat generated by the PC, complex PC Accessories) Provides smart classrooms throughout the VDI
17. National Health Insurance Service	Reduces costs by 83% through zero client installations
18. Korea Institute for Curriculum and Evaluation	Reflects success through the national 2012 proficiency test in English
19. Korean Intellectual Property Office	Secures unpublished patent data
20. Multifunctional Administrative City Construction Agency	Allows data sharing and interactive communication between teachers and students
21. MIRAE Asset	Applies virtualized resources as differential user's tasks and acts

Table 2 illustrates how other industries have used and applied VDI. A total of 21 businesses were surveyed regarding how they introduced and utilized virtual computing. There were 85 application items that

we classified into 16 larger units. Classifying VDI into 16 larger units, it became that security was most frequently utilized in other industries, followed by maintenance, efficiency, and mobility. According to previous analyses, other industries actively use security, maintenance, VDI efficiency, and mobile items, verifying its applicability.

The architectural field also takes seriously security, maintenance, efficiency, and mobile items. If such items could properly align with features of the architectural industry, the possibility of success would increase. Therefore, further research into utilization cases in other industries is necessary.

### 3 The Factors of Adapting to the BIM Area

The introduction of BIM in the field of construction has significantly changed many areas of construction. CAD (computer-aided design) work, which implemented BIM, has resulted in work-time reductions, reutilization of extensive design data, efficient workforce placement, improved design quality, and greater economic profits. It has also brought about significant changes across the construction industry.

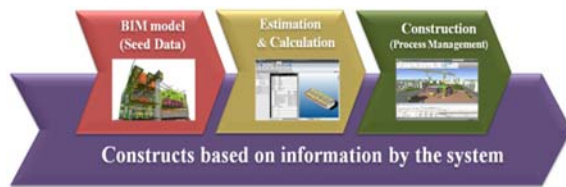


Figure 4 Processing Time for Standard PC

As for small-sized buildings, a variety of variables influence them, leading to many difficulties in managing construction sites. However, the introduction of BIM in the remodelling sites of small-sized buildings has resulted in improved quality for buildings. BIM also makes construction more economical by eliminating factors of construction delay, such as design changes and reconstruction.

In particular, designing atypical structures with conventional 2D design methods has caused several floor plan errors because such structures contain many areas that cannot be represented with 2D drawing. However, 3D-based BIM locates inconsistencies between structural members; thus, it allows a smaller number of design errors requiring additional review compared to 2D drawing. As a result, 3D-based BIM is superior in terms of construction costs, responsibility issues, and maintenance and management concerns, all of which are important in the construction process of an

atypical structure.

### 3.1 The BIM Process in the Design Phase

This study limits its scope to the utilization of BIM in the design phase. Therefore, it aims to present clear criterion regarding the design area for construction projects prior to the main text.

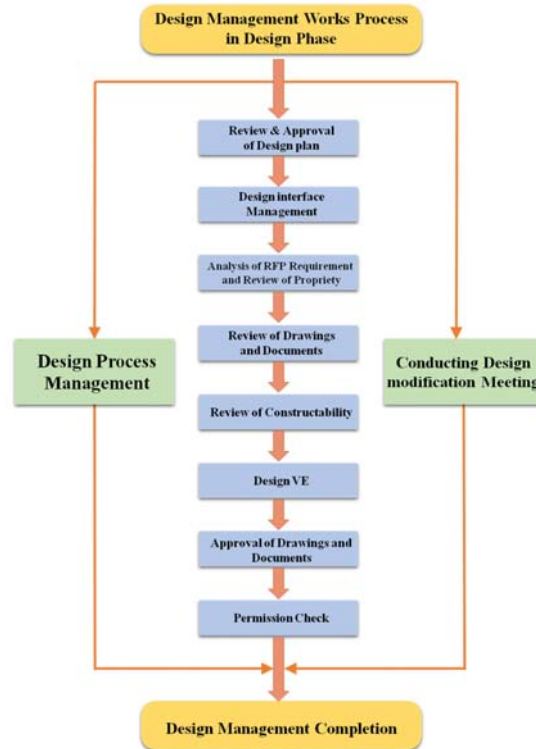


Figure 5 Activity of Design Management

Figure 5 illustrates the specific activity of design management. In general, the design area for construction projects is classified into preliminary or implementation design. The preliminary design phase involves deciding whether to reflect the client's requirements in the project direction. This phase also includes conducting a broad review as to the implementation schedule for design projects and construction productivity (costs, constructability, quality, etc.). The implementation design phase specifies actual work and involves conducting a review on design outcomes. Ultimately, this phase decides whether actual construction can commence. Along with a contractor, this phase provides various support for the design VE task, construction schedule management, and licensing procedures.

### 3.2 Advantages of BIM Cloud Computing

In general, the reason for introducing VDI is its ability to build an environment allowing one to process tasks anywhere as though using one's own PC.

Users are able to process tasks by accessing personal virtual desktop environments at other departments or sites. They are able to work flexibly by conducting VDI with their PC.

The system considerations for configuring VDI can be classified into the following three factors: system, user, and data configuration.

#### 3.2.1 System Configuration

A construction project typically uses a great deal of software. When utilizing a variety of software, VDI is capable of conducting a batch management function through central management. It can proceed with batch upgrades by using the software distribution function when conducting a security patch in the user's window. This function is based on the software installed in VM (virtual machine), collecting hardware and software inventories. It can be applied equally to the upgrade of office software installed in VM. Even users who do not use high-end programs are able to manage computing resources and conduct efficient application installation and distribution.

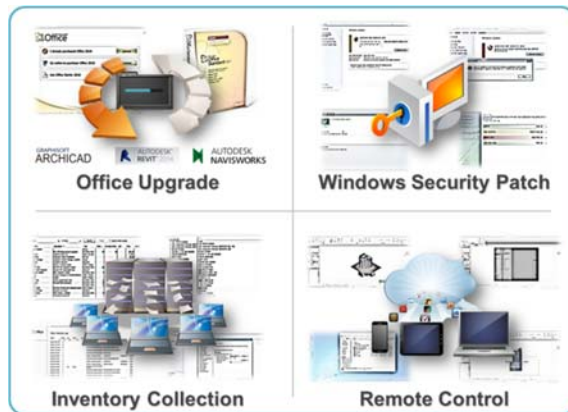


Figure 6 VDI-Based Integrated Management Systems

#### 3.2.2 User Configuration

A variety of users exist in a VDI-based BIM project suitable for construction sites. They can be subdivided into three broad user types. The first type involves a practitioner who performs high-performing modelling tasks. The second type is a cloud access user who

performs relatively less-demanding tasks, such as presentation and mark-up. The third type is a user who accesses the private cloud in order to upload simple work journals.

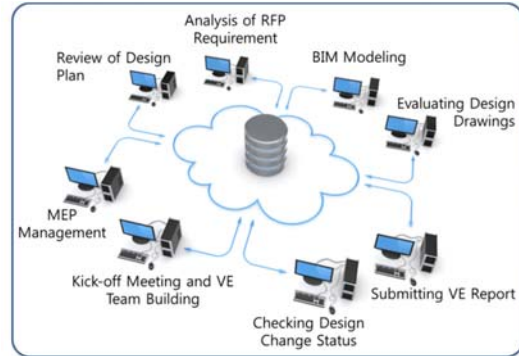


Figure 7 Configuration of VDI User

It is possible to improve work processing capability based upon these three types of practitioners. To do so, one must identify their work environment patterns and distinguish their authorities in each construction environment. In this way, one may also distribute resources more efficiently and design virtual models in advance.

#### 3.2.3 Data Construction

Given the nature of construction projects, there are many occasions to work jointly with partners, involving two data types: data that needs to be shared together and data that requires security management.

It is possible to configure in such a way that an external user can access a corresponding project server only via virtual desktop after accessing the VPN and desktop when an external user accesses a corresponding project server. In this case, an external user can conduct a task only after accessing a corresponding server via the network, whereas cannot retrieve data from outside via virtual desktop.

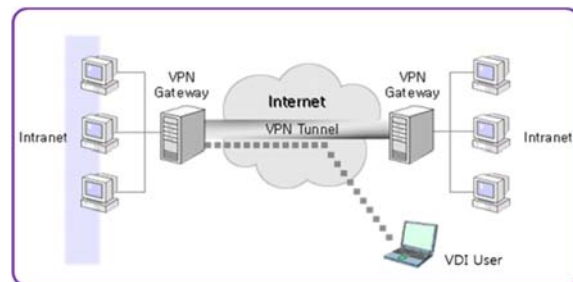


Figure 8 VDI-Based Data Security Design

### 3.3 Efficient Scale Computation for BIM Cloud Computing

Table 3 Optimal Scale of Server Estimation

Methodology		Characteristic
Calculating Method	Concept	A method of calculating numerical scale and applying correction values based on elements for calculating scale, including number of users.
	Advantage	Ground of scale estimation that can be clearly presented and it can be estimated more simply than other methods.
	Disadvantage	If the correction value is wrong, the big difference with the desired value has taken place and it is hard to present accurate back-up data for the correction value.
Referencing Method	Concept	See similar scale by comparing rough system scale based on basic data depending on business volume (number of users, DB size).
	Advantage	Relatively safe scale that can be estimated as a comparison with existing established systems.
	Disadvantage	Presented ground (back-up data) is not clear as scale is estimated by comparison, not by calculation.
Simulation Technique	Concept	Scale is estimated by modelling work load for target business and simulating it.
	Advantage	Relatively accurate values can be obtained.
	Disadvantage	Great deals of time money are required.

There are three methods for sizing the cloud server. First, one can calculate the numerical scale and apply the correction value based on elements for calculating scale including a number of users.

Second, the referencing method involves referring to similar scales by depending on business volume (number of users, DB size). Third, in the simulation technique, scale is estimated by modelling and simulating the work load of the target business. In this study, we focused on the referencing method and calculating method in order to build up the BIM cloud system.

## 4 Proposed VDI System Based on

The BIM-based information exchange framework proposed in this study is built on the basis of a system model ideal for a VDI supporting both the cloud system and virtual environment simultaneously. Therefore, the proposed BIM service resource allocation methodology for the virtual desktop environment can be described as follows.

The resource allocation methodology for the virtual desktop infrastructure should integrate BIM with the conventional cloud. In so doing, one is able to minimize excessive network construction costs by reflecting the latest cloud technologies and construction tasks while also improving speed and work efficiency through information exchange.

### 4.1 Conceptual Architecture of BIM Cloud Server

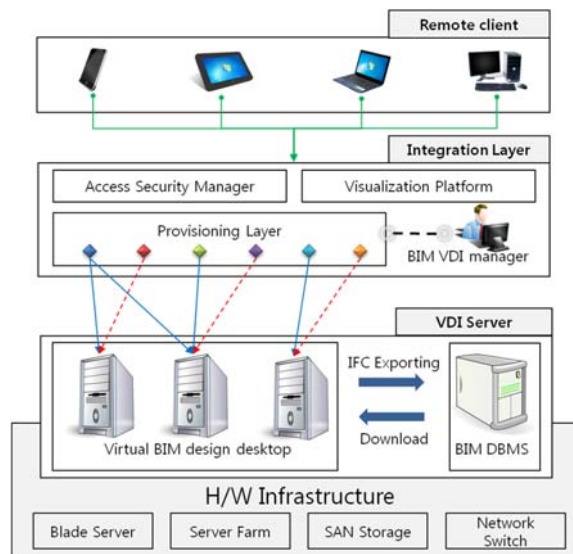





Figure 9 Integrated Management Systems Based on VDI

Figure 9 illustrates the operation method of the VDI-based BIM server. Each user of the design team remotely accesses the virtual BIM work environment through their own IP based on their access permission received through the Xen Hypervisor and Active Directory. The BIM VDI manager is deployed to play the role of resource allocation to each user, network protocol selection, and user grouping through the Xen Studio of Master OS. The BIM model management module or 3D viewer can be connected through the BIM DBMS in the VDI workstation or on an external cloud network. The optimized environment for users can be constructed by installing additional APIs in the Master besides the basic tools. The setup software in the Master instantly provides updated software applications to individual server users through the Virtual Machine distribution settings. Furthermore, the work environment can be integrated through the Snapshot setting (server environment can be restored to a certain point in time).

#### 4.2 Workload Analysis of Small-Medium Sized Architectural Design Firm




A VM performance test must be conducted to prevent any dissatisfaction of VDI users due to delay, and the resource that is inputted to the BIM design organization must be determined through this test.

Table 4 Processing Time by Standard PC

	Revit	IFC viewer	A BIM viewer
Connection Image			
Access Time	00 :00 :24.72	00 :00 :19.84	00 :00 :22.48
Loading Time	00 :02 :46.30	00 :00 :07.46	00 :00 :38.72
Control Speed	00 :00 :04.37	-	-
Rendering Time	00 :02 :23.30	-	-

The standards of the server environment must be defined to calculate the size of resources. The existing user server environment and VDI server environment were set as in the Value (balanced price and performance) stage to satisfy the general requirements of the BIM tool environment (the recommended system specifications of Autodesk Revit).

Table 5 Processing Time by Virtual Machine

	Revit	IFC viewer	A BIM viewer
Connection Image			
Access Time	00 :00 :15.72	00 :00 :13.59	00 :00 :18.67
Loading Time	00 :02 :54.48	00 :00 :08.04	00 :00 :42.45
Control Speed	00 :00 :04.48	-	-
Rendering Time	00 :02 :18.30	-	-

The access, loading, and operation speed of Revit and the software applications of two BIM viewer producers were measured based on the test scenario with existing users and VDI users. The measured time values are shown in Table 5 the VDI performance was more stable than the performance of existing users.

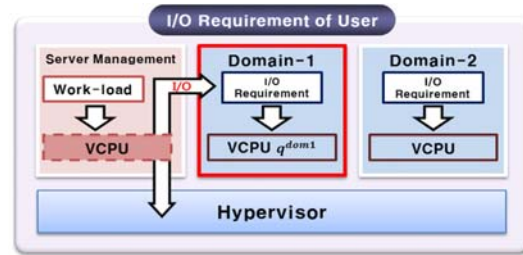


Figure 10 Data Processor of Input-Output Control System

Table 6 Resource Allocation Design Based on VDI

Variable Name	Explain	Variable Name	Explain
$i$	Request Time	$q$	Server request Value
$j$	Request Desktop No.	$\bar{q}$	Average Duration
$\emptyset$	Desktop Performance	$C$	Total Resource
$\rho$	Performance Ratio of Desktop	$\alpha$	Premium Resource

$$q_i = \emptyset_1 \rho_i 1 + \emptyset_2 \rho_i 2 + \emptyset_3 \rho_i 3 + \dots \quad (1)$$

$$\bar{q} = \frac{1}{n} \sum_{i=0}^n q_i$$

$$C = \bar{q} + \alpha \quad (2)$$

$$\alpha = 20 \sim 30\% \quad (3)$$

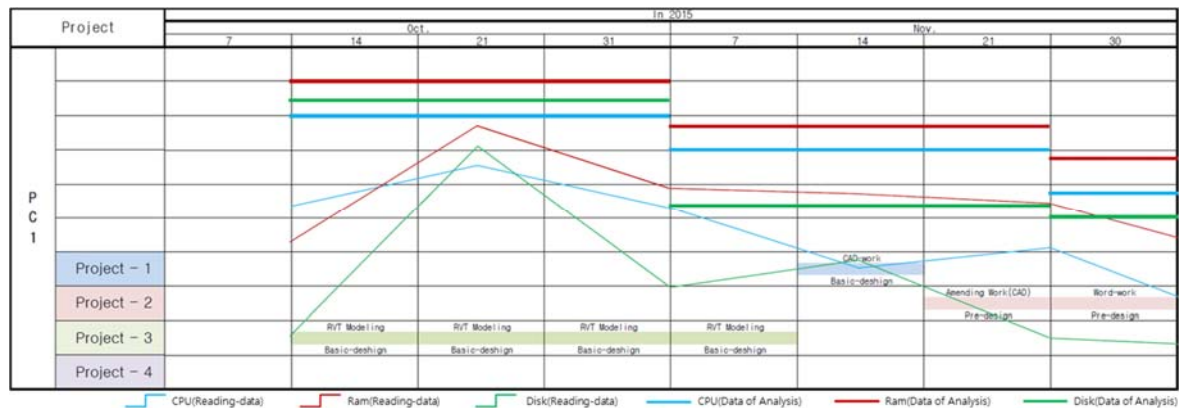


Figure 11 Resource Data in the BIM Environment

Figure 10 shows the work-load request of users in the cloud computing environment according to their resource usage. The average work-load was determined by referring to these work-load data (1), and the total resource was calculated by adding the alpha value to the average value (2). For the alpha value, the allowance rate was determined (3) through an existing server size calculation study (Na 2010). Figure 11 shows the sample data calculated through the calculation method (2). In the next study, we will present the optimum resource data for BIM workers and suggest a method of introducing the data to a VDI system.

## 5 Conclusion

This paper proposed a BIM cloud system methodology for BIM users. The system proposed in this study would improve many areas of BIM by leveraging VDI in the BIM construction environment process.

However, there may be many adverse effects of this framework if leveraging is performed recklessly in the conventional IT environment and in the general work environment. To address these adverse effects, a thorough investigation must be conducted in advance to ensure the systems are suitable for the construction environment. Moreover, it will be imperative to identify the tasks and environment of the system's users, to consider the characteristics of each construction project, and to conduct a follow-up study in the mid and long term.

As for the results of this study, it is still necessary to regularly conduct development and research regarding BIM data lightening, shape/attribute data parsing technology, and resource allocation for the implementation of the framework, as shown in Figure 11.

## Acknowledgement

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## References

- [1] Jung, T.H., Kim, S.W., "The construction management of BIM-based small building remodelling." *Architectural Institute of Korea*, volume 12(1): 191-192, 2012
- [2] Lee, S.Y., Ham N.H., "A Study of BIM-based Construction Management Work Process Development in Design Phase." *Korean journal of construction engineering and management*, volume 14(6): 90-101, 2013
- [3] David Linthicum "Complex clouds must be managed with automation." *Infoworld Article*, March 2013.
- [4] Yoo, S.Y., "Implementation Issues of Virtual Desktop Infrastructure and Its Case Study for a Physician's Round at Seoul National University Bundang Hospital" *The Korean Society of Medical Informatics*, volume 18(4): 259-265, 2012
- [5] Tien, D.N., "Energy Management for Mobile Virtual Desktop Infrastructure in Mobile Cloud Environment" *KIISE Transactions on Computing Practices*, volume 20(8): 477-481, 2014
- [6] Dillon, T., Wu, C., Chang, E., "Cloud Computing: Issues and Challenges" *International Conference on Advanced Information Networking and Applications*, 27-33, 2010