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## **BIM-BASED FILE SYNCHRONISATION AND PERMISSION MANAGEMENT SYSTEM FOR ARCHITECTURAL DESIGN COLLABORATION**

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**Abstract.** In building information modelling (BIM), the amount of information increased and architectural design processes became more complex as projects expand. This is because while a collaboration environment is important for smooth communication among experts, this has not been realised because of unclassified file synchronisation and permission settings among team members. Therefore, this study aims to support cooperation in BIM modelling projects by synchronising BIM data from different computers and rendering BIM project management easier by providing a BIM model viewer and data through the Web. The proposed technology, which is a construction project-type, purpose-tailored browsing technology, provides BIM information related to construction environments and planning processes only to the relevant experts.

**Keywords.** Building information modelling (BIM); architectural design collaboration; process; file synchronisation; permission management system.

### **1. Introduction**

#### **1.1. BACKGROUND AND PURPOSE**

Recent advancements in computing technology have expanded from construction to the application of building information modelling (BIM) technology. In BIM technology, due to the expansion of projects, architectural design processes became more complex and the amount of relevant information increases. Such changes create the need for several experts to be

simultaneously involved in the project, thus increasing the need for collaborative design. For a successful design in a distributed environment, effective communication among experts is important, and various digital media support this interaction. In particular, due to developments in the Web environment, a method to support collaborative design in a dispersed environment is currently being developed. File exchange and communication through the Web support the effective exchange of BIM information among team members. However, in the collaborative design process, information regarding file synchronisation and permission settings for team members are created at each stage, and such information is not presented in a form useful to experts from different fields, thus causing strained communication. In light of this, the purpose of this study is to help collaborative design in BIM by synchronising BIM data from different computers, and rendering BIM project management easier by providing a BIM model viewer and data through the Web.

## 1.2. METHOD AND SCOPE

This study focuses on the development of a technology related to file synchronisation and permission management in a cloud environment for BIM-based collaboration. The scope of this study encompasses multi-residential houses. We used Autodesk Revit<sup>®</sup> as a BIM file, the Web Graphics Library (WebGL) to generate a cloud environment, and developed a permission viewer as an application program in Microsoft Visual C# .NET. By way of a file converter to model a file viewer in the Web environment, we enabled conversion from a Revit file (.rvt) to a JSON file in Visual C# .NET, such that it could be provided as a plugin to Revit<sup>®</sup>.

The outline of this paper is as follows:

In this section, we have examined the background, purpose, scope, and method of this study.

In Section 2, we classify relativity among collaborative concepts in architectural design, participants in the design process, and cases involving collaboration systems in past studies, and examine the components of collaboration in these.

In Section 3, we develop a prototype collaboration system in a cloud environment based on the components required for collaboration determined in Section 2, and create an environment by classifying file synchronisation and permission types according to the subject of design.

Having identified problems by analysing the application of this system to multi-residential houses, we suggest in Section 4 a direction for the development of such systems in the future.

Section 5 contains our conclusions and research plans for the future.

## 2. Theoretical consideration

### 2.1. CONCEPT OF COLLABORATION

Unlike in the past, the scope of construction nowadays has expanded to the application and proliferation of BIM with the advancements in computing technology. To address complex and diverse projects, BIM-applied design processes subdivide relevant tasks that are addressed by experts from various fields. However, compared to diverse expertise in the relevant fields, the working hours allocated to architectural design are insufficient, due to which the subjects of design have to carry out group work in multiple design offices, or in a dispersed environment. Accordingly, for a successful project, it is necessary to create a working environment where the participants in the design process belonging to various fields can coherently contribute to the project. BIM-based construction is a result of the opinions and efforts of participants of design from various fields, and this process is called collaboration. Collaboration is the most important factor in BIM-based construction, and involves integrating the opinions and effort of the participants of the design process. For successful collaboration during a BIM-based construction process, effective communication and exchange of reliable design information are necessary. Collaboration can be defined as teamwork, or a method of cooperation to maintain consistency and productivity. In a collaborative environment, error in work during construction can be prevented and work efficiency can be improved through the effective management of correlations among various subjects.

### 2.2. DOMESTIC AND OVERSEAS COLLABORATION SYSTEMS

Archispace, developed by Virtual Builders, the ArchiBIM by Solideo Systems, and GTeam by Gehry Technologies are some local and international instances of collaboration systems. Archispace is a component-based integrated structure modelling tool that is easy to use and systematic, such that even non-experts can easily design a construction space and simulate changes in the design in three dimensions (3D). ArchiBIM is a BIM viewer that can be managed by combining it with the administrative system of local governments. GTeam is a web-based system that uses general sharing systems (N Drive, Dropbox), making it difficult use among experts.

These collaboration system technologies are listed in Table 1. Collaborative systems are developed and used in various areas, such as governance, research, construction, and manufacturing for systematic and efficient management, and to minimize technological limitations. However, these systems

cannot be shared because they are combinations of basic templates, and information is not classified in a manner useful for experts from various fields.

Table 1. Collaboration System Technologies.

Division	Archispace LT	ArchiBIM	GTeam
Development Agency	Virtual Builders	Solideo Systems	Gehry Technologies
Development Year	2010	2012	2002
Coverage	Architectural Design, Interior	IFC Browser	Project Management
Web-based operation	X (Stand-alone)	O	O
Web standards	X (Stand-alone)	O	O
Cloud Environments	X	O	O
Collaborative management techniques applied	X	X	X
Guide	X	X	X

### 2.3. COMPONENTS OF COLLABORATIVE SYSTEMS

Having examined collaborative systems, we can classify them as follows according to the scope of work and characteristics: a system to create design drawings using a BIM authoring tool, a conversion system that converts BIM files so that they can be read on the Internet, and a management system the information stored by which is classified and shared in a form useful to experts. The components of such collaborative systems suggest the considerations listed in Table 2.

Table 2. Considerations of Components of collaborative Systems.

Division	Considerations
Work System	whether it is easy to work on, amend, and supplement design drawings according to the experts' working environments
Conversion System	whether files created at each BIM working stage need to be converted for synchronisation among experts from various fields
Viewer System	whether multiple designers can freely conduct simulations regardless of their working environments
Management System	whether it is easy to synchronise the created design information or library, classify it by field, and share the relevant information

## 3. Cloud computing-based file synchronisation and permission management system

### 3.1. OVERVIEW OF CLOUD-BASED COLLABORATIVE SYSTEM

The system proposed here enables multiple participants to check BIM data in real time, exchange opinions on design and, most importantly, manage files

by field because permission management settings are classified according to user type. The system also enables interested participants from various fields to freely collaborate in real time, or review or amend designs in regionally dispersed environments. For this, we used a cloud environment, which enables visible and real-time access to BIM data.

### 3.2. COMPOSITION OF CLOUD-BASED COLLABORATIVE SYSTEM

Our system is composed of three modules, as shown in Figure 1, and the functions of each module are as follows:

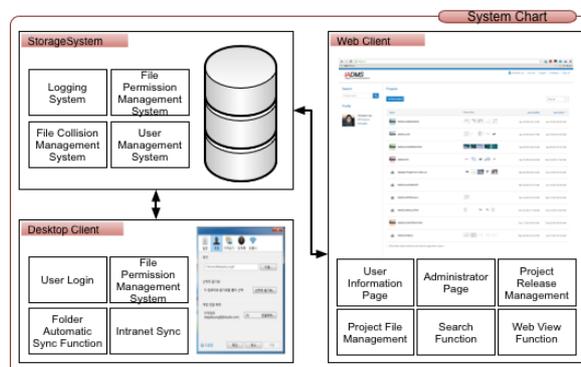


Figure 1. Service Diagram.

#### 1) Storage system

The storage system manages the entire project. The system, located in the centre of the service, supports user permission management and opinion exchange among users, and manages the overall collaboration process. It contains and manages information regarding operation models and design file servers. Considering that it needs to manage users, we developed an application program using Microsoft Visual C# .NET. We also used Autodesk Revit as a commercial BIM authoring tool. To convert BIM model files into JSON files, we used Visual C# .NET, which is provided as a plugin for Revit.

The storage system is composed of a logging system, a file permission management system, a file collision management system, and a user management system. The logging system manages all work updates by converting them into logs, and can thus recover any point in time in a project. The file permission management system creates projects and sets permission by user account, file, and folder. The file collision management system sends alarm messages to clients, and changes file names to avoid collisions when users amend a file simultaneously. The user management system adds users and sets access permission them. These systems are embodied in a class and,

by setting users of the inner class and containing an operation module for the BIM authoring tool, are closely related to each other.

### 2) Desktop Client

The desktop client grants permissions to users to access the server. It is composed of a user login, a file permission management system, a folder automatic sync function, and an intranet sync. The user login logs into a user account and encrypts at 128 bits. The file permission management system enables the logged-in user to amend files in folders for which he/she has permissions, and to read or link to ones for which he/she does not have permissions. The folder automatic sync function automatically syncs work updates. As for the intranet sync, in case the system is connected to an intranet, it enables performance improvement as it is linked without going through a server.

### 3) Web Client

The Web client allows users to access a server, download BIM files for review, exchange opinions on design with other experts, and make amendments. The Web client is composed of a user information page, an administrator page, project release management, project file management, a search function, and a Web view function. The user information page identifies how users manage, amend, and change information related to a project, and manages user history. The administrator page manages the registration and permissions of project participants, monitors the current status of the project, manages errors, and updates logs. The project release management manages releases according to the progression of the project and the submission lists. The project file management enables file and folder permission management via the Internet. The search function is a function to search through work files, work information, and the library. The Web viewer function visualises release images through Web browsers.

## 3.3. CLOUD-BASED COLLABORATIVE SYSTEM SCENARIO

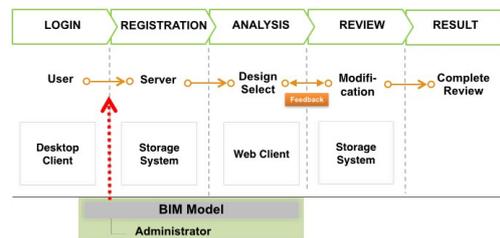


Figure 2. Collaborative system scenario.

The design collaboration order when using this collaborative system is as follows:

- 1) Users participate in collaboration as desktop clients.
- 2) When collaborating users decide on a BIM model to review, each user requests server registration and is granted permissions through the storage system.
- 3) When registration is completed, participants select what they need to review from the Web client, and determine the amendments to be made by examining the design.
- 4) If modifications need to be made, the user makes changes to the relevant item in the storage system.
- 5) The modified BIM model is sent to each user for review.

#### 4. Cloud computing-based file synchronisation and permission management system utilisation

##### 4.1. THE SUBJECT OF COLLABORATION

We selected a multi-residential house as the subject of collaboration for our experimental scenario, as shown in Table 3. Designers as well as people/companies related to the design of the structure, facilities, and materials could participate in discussion on design in this system.

Table 3. Multi-residential house outline

Modelling	Division	Contents
	Address	Hwagok-dong, Gangseo-gu, Seoul, Korea
	Building area	441.1 m <sup>2</sup>
	Structure	Reinforced concrete construction,
	life	60 years

##### 4.2. HOW TO CONDUCT DISCUSSIONS

To apply a cloud-based collaborative system, users needed to enter their names and Internet Protocol (IP) addresses on a collaborative server for access. For project management, the administrator grants users permissions to access the relevant folders. Therefore, users request the administrator for server registration in order to register their folders on the project server. If “My folder” is synchronised with the project server, the cloud environment provides a viewer for users to review BIM files. The administrator can designate files for review and grant access permissions to each user, and assist all participants simultaneously review a BIM file. Participants can select information in the BIM file that they want to review by using the viewer, and

access permission is classified according to user expertise. The users can search files they need to review from the file server and download them.

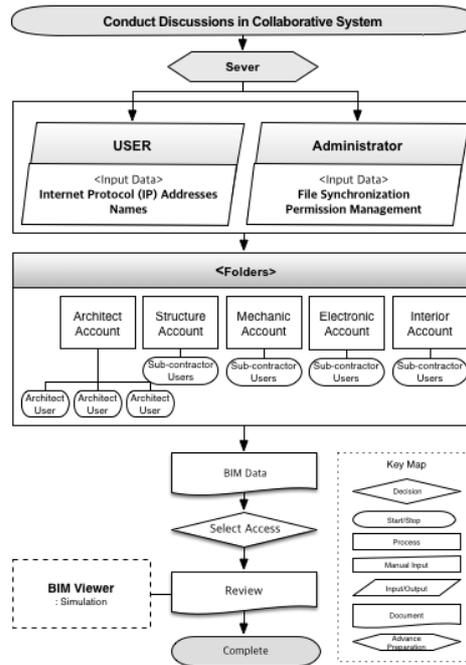


Figure 3. Conduct discussions in a collaborative system.

### 4.3. FILE SYNCHRONISATION AND PERMISSIONS

As shown in Figure 4 (left), users convert rvt files to json to review them in the cloud environment. To this end, files are provided in Revit plugin form. Each user reads files, for which access permissions have been granted, as JSON files. Users can review files in a mobile environment, as shown in Figure 4 (right).

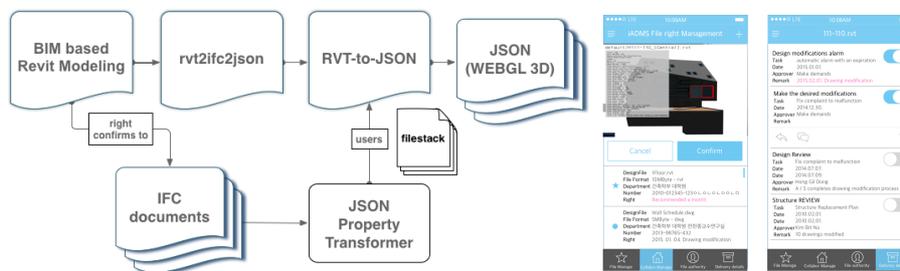


Figure 4. Files convert process (left) and mobile environment (right).

With the simultaneous review function, which allows administrators to make all users observe a model through the same view, users can exchange opinions more interactively. Furthermore, because folder access permission is granted to users according to expertise, they can immediately check the content they need to review for discussion on the design, and can request amendment. As shown in Figure 5, users check the model, provided following classification by the administrator, through the viewer.

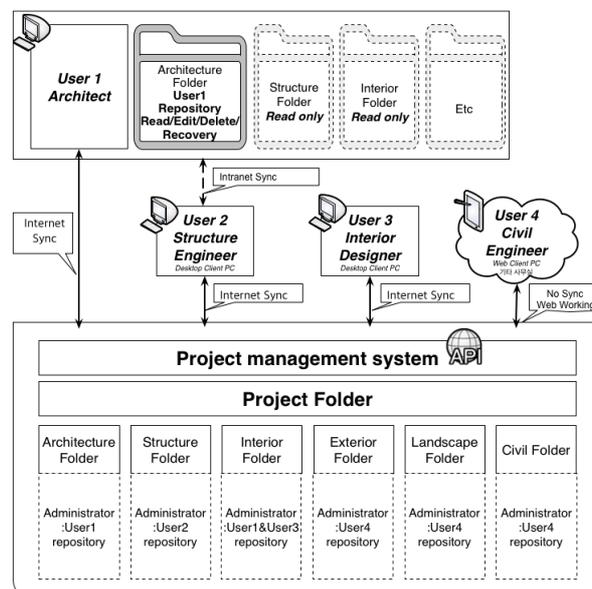


Figure 5. Files classified by the user.

This system is not identical to those proposed in past studies, which involve confirming and changing shape values using a BIM authoring tool. On the contrary, since the shape and attribute values of BIM files are provided as they are with the viewer through the Web, users can quickly make various amendments. Users can also review the model in real time. When there a request for amendment is made, the amended model file is re-sent to users. As shown in Figure 5, participants can again discuss the amended model, and this process is repeated if an additional amendment is necessary. If amendment is not needed, participants can move on to discuss the next model.

## 5. Conclusion

When a model classified by experts from various fields is provided to project participants, they can immediately check and amend files, thus enabling effi-

cient discussion on design and a reduction in the time spent on the design. Accordingly, in this study, we proposed a file synchronisation and permissions system in a cloud environment for efficient, real-time discussion on design. Unlike past methods in the area, which allowed users to change parameters in a limited design environment, the proposed real-time collaboration function is interactive, and enables users to examine models classified according to fields of expertise, in a visible cloud environment with a viewer. Based on our study, we can claim the following:

First, remote collaboration among various architectural design fields is possible through this system due to file synchronisation and Web-based file sharing using cloud computing.

Second, our system makes possible a dispersed version for data management, such as a 3D structure-modelling file, which is easy to manage.

Third, because work folders, which are classified according to permissions granted to each user, are built in storage form, which includes the entire history as well as information required to trace each item of the history, users do not need to depend on a central server; this increases efficiency.

In future, we plan to implement technology to reflect amendments made through discussion in real time, and implement architectural design in a Web-based environment.

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