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Paper:

Research on Deep Integration of Construction Management and Computer BIM Technology

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As information development has progressed in the field of architecture in China, owing to the lack of unified information exchange standards and information integration mechanisms, it is difficult to exchange and share information between different stages and application systems during the construction lifecycle. The formation of information islands and faults hinders the application of information technology in the field of construction, thus affecting the production efficiency of the industry. In this study, construction engineering management and computer building information modeling (BIM) are deeply integrated, and an international standard for the construction industry is introduced. Moreover, a BIM information integrated building management platform is developed that combines BIM technology with the construction engineering management to realize the exchange of engineering information and shared and integrated management, in addition to providing theories, methods, technologies, and platforms.

Keywords: building lifecycle management, BIM, IFC standard, information sharing, management platform

1. Introduction

Based on the information technology of other industries, building information modeling (BIM) technology provides a new technique for the development of information technology in the construction industry. It provides accurate and detailed knowledge resources along with shared information for the whole life cycle of the architecture [1–3]. BIM expresses the physical and functional characteristics of architecture via digitization and records data from the beginning of the emergence of the building. Integrating and sharing information on different specialties and stages in a construction project and storing it in a database such that it covers the entire life cycle of the project is the main purpose of implementing BIM technology [4–6]. The application of digital information technology in construction projects is the concept of BIM. In this way, we may solve the problems exemplified in the software at different stages of construction projects. BIM further includes considerable information, geometric data, spatial location, geological conditions, and attributes of certain building elements. On this basis, engineering designers and construction technicians can coordinate and work together efficiently to make accurate technical judgments regarding current building situations by studying varied data on the buildings [7–9].

2. Relevant Research Based on BIM Engineering Management

2.1. Characteristics of BIM Information

This paper presents a method of creating BIM information oriented towards different stages and applications using the BIM sub-information model at its core. The basic concept is to create BIM information at different stages of the development of engineering projects. In other words, from project planning to design, construction, and operation, corresponding sub-model data for different applications are established. Each sub-information model can evolve automatically. It can form the information model of the present stage by extracting, extending, and integrating data from the previous stage model, and can generate the application sub-model for a certain application integration model data as well. As the project progresses, it finally forms a complete information model of the building's life cycle. BIM information is built through the entire life span of the construction project. It is the process of accumulation, expansion, integration, and application of the construction life span engineering data, and serves towards construction life period information management, as shown in **Fig. 1**. The characteristics of the BIM model are shown in **Table 1**.

2.2. BIM Project Management Framework

The first technical problem to be solved to realize engineering information management based on BIM is that of the storage of BIM data and the sharing of distributed heterogeneous data. To solve the above problems, the integration mechanism of BIM is proposed based on the BIM architecture. The basic concept is to create BIM data in stages as per the progress and requirements of engineering projects, i.e., from project planning to design,

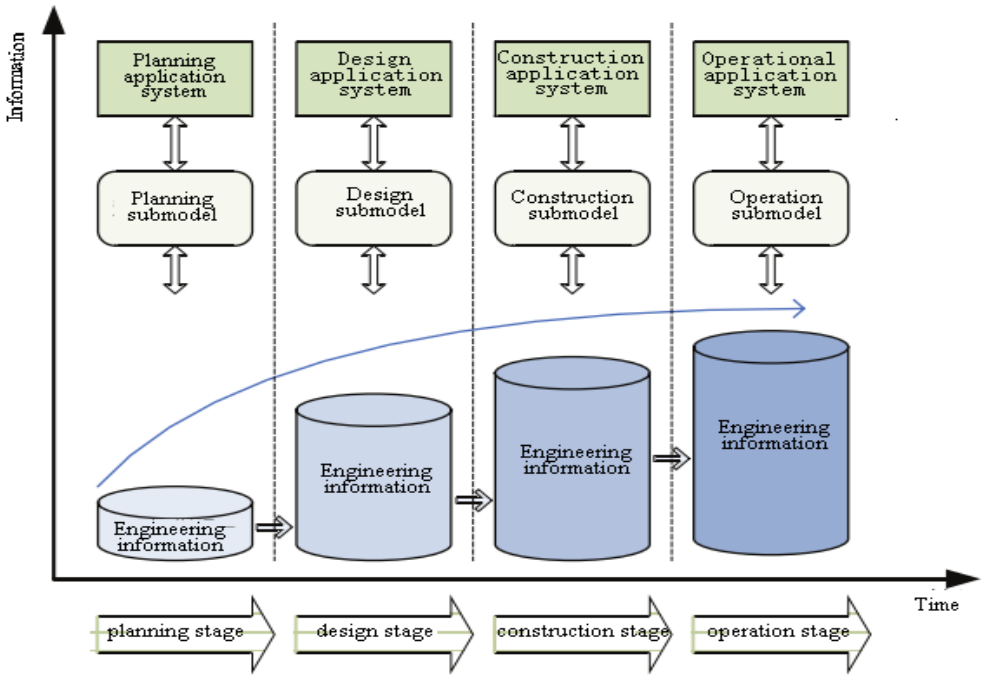

Fig. 1. Construction process diagram of BIM.

Table 1. Characteristics of BIM Model.

Characteristic	Specific content
Parameterization	The basic component attributes in the model can be expressed in the form of parameters that can receive, process, convey, and feedback the data.
Visualization	3D display of the component image, interaction with components, and feedback visually
Simulation	Building model simulation, construction schedule simulation, and emergency management simulation
Coordinability	Conflict coordination among professions
Output property	Advantages of parameterization are derived from 2D drawings, bills of quantities, and various electronic documents.

construction, and utilization, and the corresponding sub-information models are established for different applications. Each sub-information model can evolve automatically and form an information model in the present stage by extracting, extending, and integrating the data of the previous stage models. The application sub-information model may be generated for certain application integration model data as well. Along with the development of the project, a complete information model of the architectural life cycle is formed. The integrated framework of the BIM includes the data layer, model layer, network layer, and application layer, as shown in **Fig. 2**.

3. Deep Fusion of Building Engineering and Computer Thchnology

Through the development of the BIM information engineering management platform, this study combines building engineering and BIM technology intensely. The whole platform design includes function design, architecture design, and database design.

3.1. Framework Design of BIM Information Engineering Management Platform

(1) Server

The data storage module comprises a system database, BIM metadata database, sub-model view database, IFC database, file meta-database, and file storage system. Data access is divided into several sub-modules, using ADO.NET technology to access the database. Business logic is encapsulated through Web Services and an interface for remote invocation is provided.

(2) Client

For BIMIIP toolbox, the client comprises a user interface module, and the function is realized by calling Web Services remotely. For the BIMIIP BIM information integration manager, the client consists of a user interface module, business logic module, data access module, and 3D graphics engine module. Depending on the functionality, the user interface can call Web Services remotely or via local client modules. The physical structure is shown in **Fig. 3**.

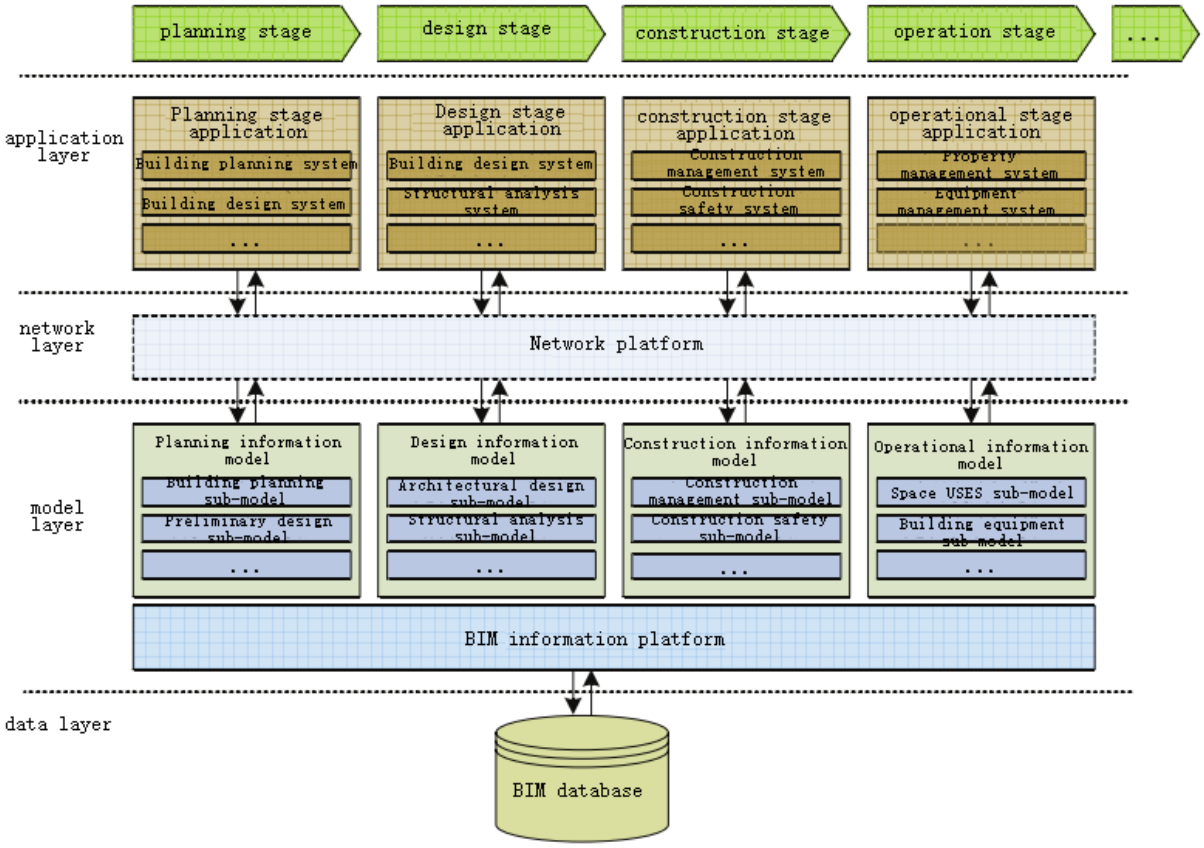

Fig. 2. Basic structure of BIM engineering management.

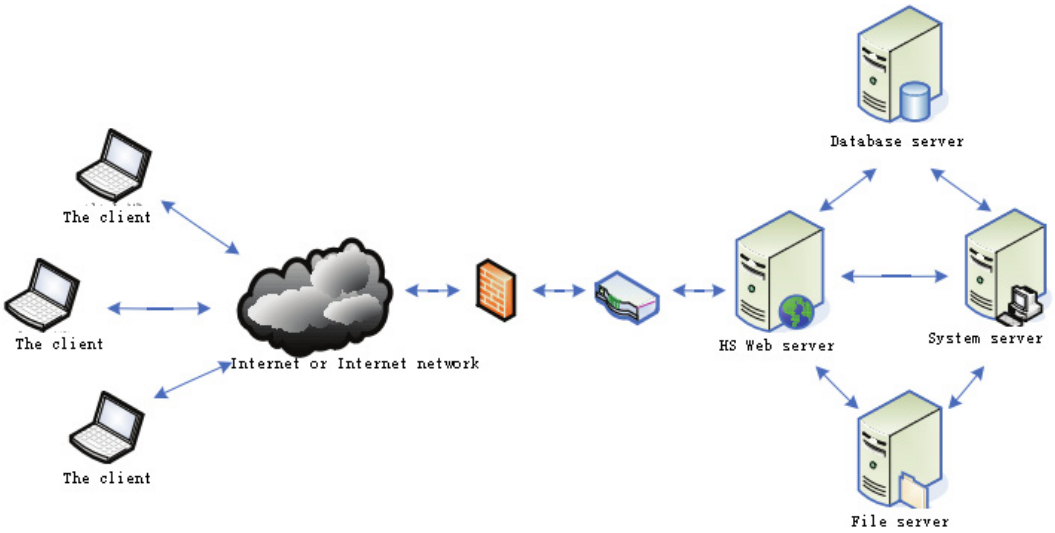

Fig. 3. Physical structure diagram.

3.2. Database Design

The system database is used to store user information and operation information, including user name, user rights, user groups, and user operations. To facilitate management and usage, these objects are organized using a tree hierarchical conceptual model, as shown in **Fig. 4**. The system log is used to record the various actions that the user performs on the database. Users store their basic information using the platform, including user identifiers, user names, user passwords, and communication mode emails. Users belong to specific user groups, which have different data access and operation rights.

The user definition table is shown in **Table 2**.

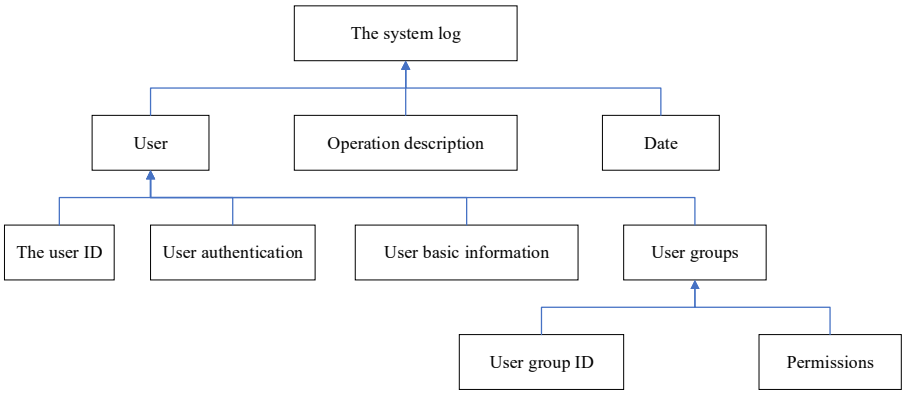

Fig. 4. Model of the system database.

Table 2. User definition table.

Field name	Data type	Description
User GUID	int	Primary key for user tables
Name	nvarchar	Username
User ID	uniqueidentifier	User ID
User PWD	nvarchar	User password
Address	nvarchar	User address
Company	nvarchar	User unit
Email	nvarchar	User email
User Group GUID	uniqueidentifier	The foreign key of the user group table

3.3. Web Services Interface Design

Web Services technology provides a bridge for client-side invocation server applications. Web Services runs on the IIS server and its interface definition is described by the Web Service description language (WSDL). The main methods provided by BIMIIP Web Services are as follows:

1) Register User: register new user;
2) Approve User: approve user;
3) User Logon: user login;
4) User Logoff: user logout;
5) Assign User Group: specify user groups;
6) Assign Rights to Group: specifies user group permissions;
7) Find Property Set: find attribute sets;
8) Add Property Set: add attribute sets;
9) Delete Property Set: delete property sets;
10) Add Property to Property Set: add attributes to the property set;
11) Delete Property from Property Set: delete attributes from the property set;
12) Add Description to Terminology: add term description;
13) Delete Description from Terminology: delete term description;
14) Search Description of Terminology: query term description;
15) New Partial Model View: create a new sub-model view;
16) Delete Partial Model View: delete the child model view;
17) Upload Partial Model: submit the sub model;
18) Download Partial Model: extract the sub model;
19) Upload File: upload files.

3.4. Experimental Results and Analysis

In this study, taking a stadium project in a certain area as an example, the developed BIMIIP is tested. The plane of the stadium is elliptical, with a length of 333 m from north to south and a width of 294 m from east to west. Its concrete structure consists of one layer under the ground and seven layers above the ground, forming three-level bowl-shaped stands. The steel structure is supported by 24 truss columns and braided to form a hyperbolic saddle shape.

(1) User login management platform

The administrator login interface is shown in **Fig. 5**, and the user authorization interface is shown in **Fig. 6**. Through this interface, the administrator can authorize the user's permission and the authorized user can access the data in the permission range.

(2) Running instance

The integrated platform supports multiple participants to exchange and share information over the internet. This process is tested by two participants in the design phase. The first participant provides a 3D model of a part of the concrete stand, which was provided by a research institute through an IFC file, as shown in **Fig. 7**. To share this part of the model, first, the model file on the platform is opened, as shown in **Fig. 8**, and then it is submitted to the BIM database, as shown in **Fig. 9**.

Fig. 5. Administrator login interface.

Fig. 6. User authorization interface.

(3) Experimental analysis

The application shows that the BIMIIP fusion platform provides a unified data exchange and integration platform for building engineering information management, and the centralized storage and management of construction engineering information makes the data exchange process change from many-to-many to many-to-one and improves the efficiency of the data exchange. By using IFC standard as the data exchange format, unnecessary format conversion is avoided and data reuse is improved.

4. Conclusion

The system and framework of technology fusion based on construction engineering management and BIM are established, and the corresponding information management flow and management mechanism are established as well, which provides the application mode of BIM for engineering information management oriented to the construction life period. The research results of this study have high research value for solving the problem of information fault and information loss at every stage of the project construction, realizing the information exchange, sharing, and integrated management for the entire life span of the construction project. The information integration platform based on BIM deeply integrates building engineering management and computer BIM technology,

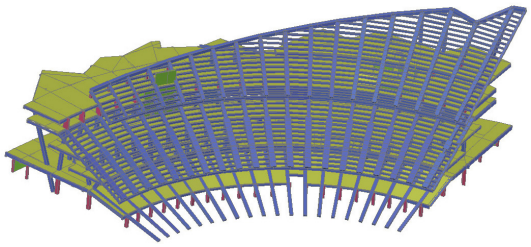

Fig. 7. BIM model.

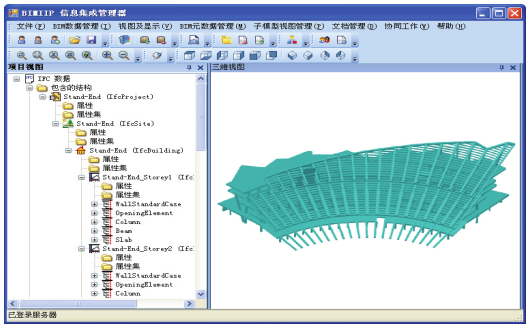

Fig. 8. Main interface of the platform.

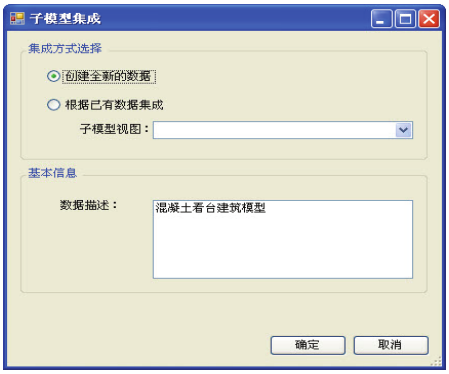

Fig. 9. Sub model integration interface.

which not only verifies the theory, method, and technology of the integration and management of building engineering information, but further has high practical value and broad application prospects for improving the efficiency of the construction industry and the level of information management, and can produce greater social and economic benefits.

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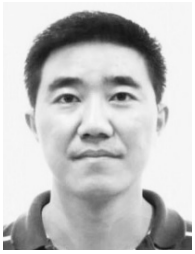

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