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Research Article

Study on Building Lifecycle Information Management Platform Based on BIM

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Abstract: Building Information Modeling (BIM) and building lifecycle management (BLM), proposed for the realization of building lifecycle information exchange and sharing, play a crucial role in the research and development fields of construction information integration and interoperability. This study, from an information technology point of view, based on BLM and BIM technology and Industry Foundation Classes (IFC) standard, proposes the concept, frame and realization method of Building Lifecycle Management Platform (BLMP). This BLMP presents a practical and effective way to realize information creating, exchange, sharing and integration management of all participants of the construction project.

Keywords: Building Information Modeling (BIM), Building Lifecycle Management (BLM), Building Lifecycle Management Platform (BLMP), Industry Foundation Classes (IFC)

INTRODUCTION

With the domestic and international construction scale expanding and the building technological content increased, the characteristics of project management, informatization, integration and virtualization, are more and more obvious. The lifecycle integrated management has become one of the most important developments of project management. To realize the lifecycle management, the most fundamental and important work is to solve how to create and manage the data and information correctly and preferably, after that we could know the accurate information storage location and share them with other participants of the project.

The development of BIM/BLM, with the rich digital information created, managed and shared in the construction process, provides a powerful technical and ideological support: BIM can implement project information modeling, digitization and reducing the information loss in design, build and management process; BLM will improve the level of information sharing with all stakeholders at different process of the construction project lifecycle and reduce the building information exchange barrier.

In this study, our objective is to propose an information management method and tools which make it possible to collect and share information of the various kinds in the building lifecycle among architects, engineers, and builders. Thus, we wish to store the information in the BIM database so that it becomes exploitable, organized and to enrich the knowledge throughout the lifecycle of the building. We base our approach on the standard IFC, using BIM/BLM technology and Web services, propose the Building Lifecycle Management Platform (BLMP) with Data storage layer, Collaboration service management layer, Collaborative work application layer and Project information portal layer , four layers of the structure from the bottom up. This BLMP presents a practical and effective way to realize information creating, exchange, sharing and integration management of all participants of the construction project.

This study is organized as follows. Firstly it reviews the related research about BIM, BLM and IFC etc. key technologies used in this study. Then it presents the concept and design principle of building lifecycle management platform, which is used to definite the chief information integration function and design principle of BLMP. Base on the above, it presents the frame and realization method of BLMP platform with the functional structure and network architecture of the integrated system based on BIM database. Finally the study ends with conclusions.

LITRATURE REVIEW

Recently, Most of the discussions associated with BIM have focused on the construction phase (Azhar, 2011). Some of the hot research issues are related to "the ownership of the model", the trends, benefits, risks and challenges of BIM for AEC industry (Eastman and Rafael, 2008b). Some are how 3D, 4D and nD BIM model would benefit the AEC area (Lee *et al*., 2003; University of Salford, 2009; Zhang *et al*., 2011).

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Researchers believe that BIM is a realistic potential to improve the construction industry, and many of them have begun to discuss how to use BIM technology in information building, management and sharing during the life cycle in construction industry. Renaud *et al*. (2008) have developed a collaborative platform called Active3D which is used as a support for data exchange and data repository. However, their indexation method is limited to the static aspect of the building lifecycle. It allows to model and to merge heterogeneous information but it is not well adapted for the management and the evolution of data.

This study proposes an approach to build an integrated collaborative construction Management Platform (BLMP) based on BIM. Various information such as time, cost, safety and quality are integrated on the BIM database in this approach. Different stakeholders can extract and update information via the BLMP by accessing the system through internet.

KEY TECHNOLOGIES

Building Information Modeling (BIM): BIM is the abbreviation of Building Information Modeling and the initial concept was proposed by Professor Chuck Eastman of Georgia Institute of Technology 30 years ago. However, BIM technology exactly drew attention in 2002; the Autodesk Inc. released BLM/BIM white papers, which officially proposed the two wheels of solutions for construction information technology are-BLM and BIM (Eastman *et al*., 2008a)

The National Building Information Modeling Standard (NBIMS, 2007) vision for BIM is "an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information, created or gathered about that facility in a format useable by all throughout its lifecycle." (National Institute of Building Sciences, 2007).

Building information modeling solutions create and operate on digital databases for collaboration, manage change throughout those databases so that a change to any part of the database is coordinated in all other parts, and capture and preserve information for reuse by additional industry-specific applications.

The following section presents the main features of BIMs that we found in the technical literature. (Lin *et al*, 2005; Eastman and Rafael, 2008b)

- **Digital databases:** Building information modeling solutions create and operate on digital databases for collaboration. The building industry has traditionally illustrated building projects through drawings and added information over those illustrations via notes and specifications. The principles of building information modeling turn this relationship around. In a building information modeler, the building information is stored in a database instead of in a format (such as a drawing file or spreadsheet) predicated on a presentation format.
- **Change management:** Building information modeling solutions manage iterative change through a building's design, construction, and operation. A change to any part of the database is coordinated in all other parts.
- **Reuse of information:** Building information modeling solutions capture and preserve information for reuse by additional industry-specific applications. Successful information technology solutions outside the building industry are based on one primary principle: Data is captured once, as close to its point of origin as possible, and stored in a way that it is always easily available and can be presented in context whenever required.

Building Lifecycle Management (BLM): In 2002, the Autodesk Inc. put forward the concept of BLM (Building Lifecycle Management), which ranges from the planning, design, construction, operation and maintain phases of the building life cycle, emphasizes the key of the Building lifecycle management is how to Manage and use the digital data and it is a big change and innovation in the building information management field.

BLM, which runs through the whole processes of construction (from concept design to dismantle or reuse), using the digital way to create, manage and share the capital asset Information and based on the integrated virtual building information model and collaboration, is aim to achieve design-construction-management process integration. According to Counsel House Research report, BLM, combining BIM and online collaboration, have been considered as the important driving force to improve Building Design, construction, management process in the future (Fang *et al*., 2005; Renaud *et al*., 2008).

The construction information management has been researched for many years, but due to the lack of the realization and feasible technology support, most research just stay in theory and concept level without breakthrough in practice. BIM provides the technical support to achieve both the idea and the practice of the BLM.

BIM standardization-Industry Foundation Class (IFC): Data integration of the Construction is the basic of BIM, is also the foundation of realization BLM information integration. Although BIM technology solves how to build information models, a unified

standard is also needed to connect the work of information exchange and sharing etc. Therefore, developing general data models or interoperability standards is become to one of the important tasks to realize information integration.

At present, IFC (Industry Foundation Class) standard, enacted by IAI (International Alliance for Interoperability), as a standard BIM specification has been adopted as a central information repository in order to deliver the integrated building information. In 1995, IAI enacted data standard of Industry Foundation Class, which directly face the building object. IFC standard is object-oriented three-dimensional architectural product data standard, to share information database by different major or different software in same major, thus achieve the data sharing and interaction. Whether to support IFC standards and the extent of support is one of the methods to figure out the Level of BIM model (Dunn, 2007).

Autodesk Inc., Graph is oft Inc., and other international enterprises vigorously support and use BIM concept in their software products. Meanwhile, the IFC standard won great progress, and IFC2x formal version was launched. In 2004, U.S. compiled "the National BIM IFC Standard" based on IFC, and put the establishment of application standards and regulations based on IFC on the agenda. IAI and TC184/SC4-Industry Automation Systems and Integration/Industrial Data of ISO have close contact and further cooperation. Therefore, the IFC standards also were recognized by ISO. In 2005, IFC2x Platform of ISO system was approved and published.

As data model standards applied in various fields of AEC/FM, IFC model not only includes those almost tangible architectural elements (such as beam, slab, column, etc), but also includes the abstract concept (planning, spatial, organization, cost, etc.). The latest IFC standard contains the following nine architecture field: building, structural analysis, structural components, electrical, construction management, property management, HVAC, building control, pipes and fire control. In addition, the next-generation standard of IFC is expanding to construction drawing examination system, GIS system, etc. (Buildingsmart, 2009).

PRINCIPLE OF BUILDING LIFECYCLE MANAGEMENT PLATFORM DESIGN

The building activity generates a great number of data and information of various kinds. The management and the communication of these data by the various participants is complex (Renaud *et al*, 2008). Our design and management methods use IFC, BIM, BLM and related computer and communication technology to create information management platform and facilitate the sharing process for a better qualification and validation of data.

In this study, we proposed the concept of BLMP, Building Lifecycle Management Platform for short. Through creating information management platform based on BIM central database, we provide a single access for all the participants of projects to obtain personalized information on the Internet, in order to realize different function module information integration in different phases, including construction project planning, design, construction, operation and maintenance etc., data consistency and accuracy. Meanwhile, the BLMP could assist the participants' decision-making, control and implementation of construction projects.

Information integration of BLMP:

- **Life cycle information integration:** Each stage of the Construction life-cycle information is integrated through full exchange and control, which makes construction project management information in different process of the project transmit accurately and adequately and participates in every stage obtain effective communication and cooperation. The BLMP, established to realize the BLM idea, should include the building lifecycle information sharing, exchange, reuse, knowledge management, communication and cooperation, and support to the business decision-making and the strategic target-realized as well.
- **Management functions information integration:** Construction projects have multi-management goals which mutual influence and restriction, such as cost, time, quality, safety, environmental protection, contract, communication etc. These goals and management functions should be overall planned and considered in the project life cycle, In order to achieve global optimization of project.
- **Participants information integration:** With the foundation of advanced information technology and the idea of cooperation to win-win, the participants of projects build a project management information integration platform which provides a way of coordination and communication for each participant, eventually achieving the purpose of reducing cost, Speeding Schedule, quality guarantee, control risk to multi-win-win situation.

The life cycle information, different management functions information and different parties information are integrated together to constitute a complete, integrated management system, the building life cycle information management platform is shown as Fig. 1.

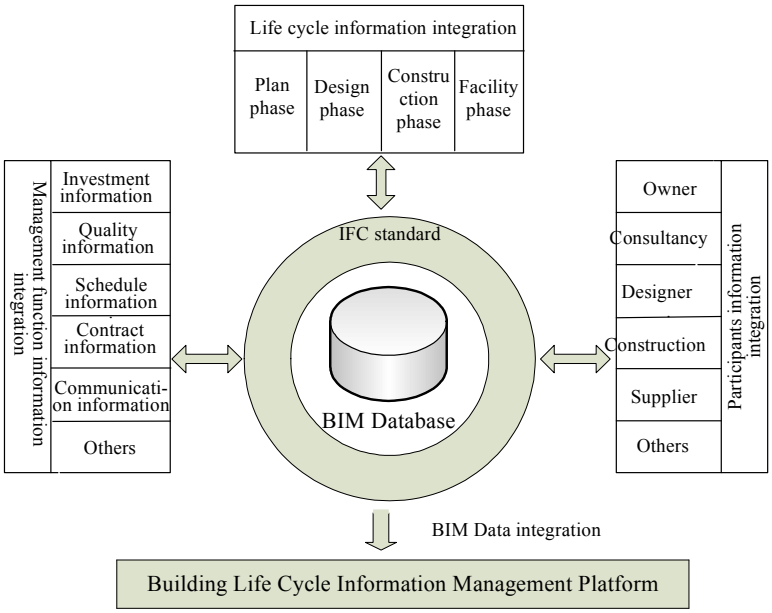

Fig. 1: BLMP based on BIM

Design principles of BLMP:

- **Dynamic and expansibility:** Construction projects have various types, a lot of stakeholders, and in different places and different objective condition, the project management modes are also different. The system must be able to adapt to the highly flexible, dynamic and distribution environment and should be expanded flexible, including openness, modularization, distributivity, dynamic updates and expand etc. For instance, network protocol, the operating system and application software all follow the common international standards, such as IFCs standard, etc. On the other hand, according to the needs of different users' to customize and select the appropriate function module, the system is extensible and dynamic, such as the workflow customization, business management module split and free combination, etc. (Khanzode *et al*., 2007).
- **Ease of use:** The friendly design fully considers that the construction projects users are diverse and multifaceted, even if not professionals can also quickly master the system. With B/S mode, after connecting to the Internet, the user can access and operating system according to the respective spheres of competence, not subject to the limitations of space and time.
- **Data security:** Because BLMP users are from different project parties, rigorous security management and access control are designed in integration system, the rational allocation of user privileges and with encryption software and hardware to improve system security to prevent illegal invasion and operation; system data can be automatically or manually backup, import and export, to ensure the security of system data.
- **Maintainability:** As we all know, software maintenance costs account for a large part of the software life-cycle costs, therefore we must be fully aware of the importance and urgency of the system maintenance and improve the soft maintainability, including understandability, modifiability and testability.

BUILD STRUCTURE OF BUILDING LIFECYCLE MANAGEMENT PLATFORM

General framework of BLMP: According to modern information network technology and the application experience of project information platform, taking BIM database as the project data loader with the information integration platform, and using middleware technology as handling a large number of heterogeneous data object-oriented and distributed applications integration, in order to provide a basis technical support for collaborative design and project life cycle information management. Adopting four-layer logical structure software system (Yang and Eastman, 2009), BLMP includes the data storage layer, collaboration service management layer, collaborative work application layer and project information portal layer, four relatively independent logical schema, shown in Fig. 2.

- **Data storage layer:** The main function of the data storage layer are data storage, data

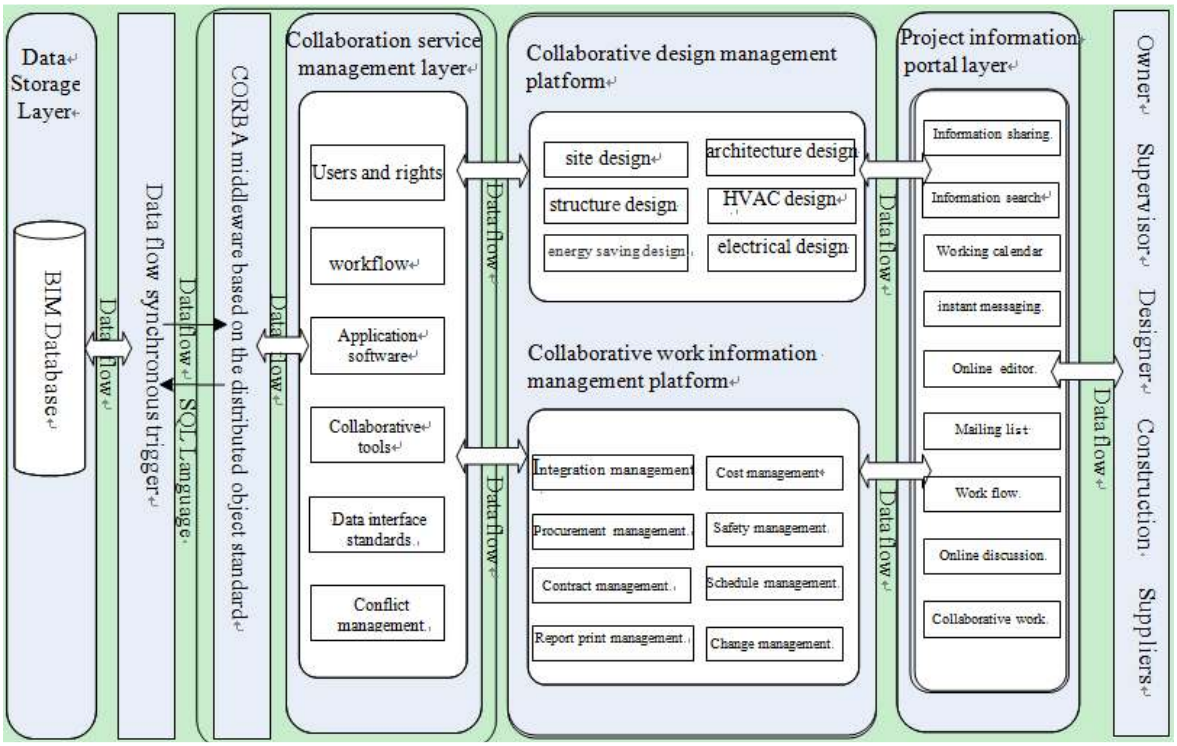

Fig. 2: Mode of General Architecture of BLMP based on BIM

synchronization, data security control and data record transactions, including structured and unstructured information base, knowledge base and ability library. BIM database based on IFC standard stores information and needs of the construction project life cycle process. This layer stores the original information of the project, providing data support for the other layers.

- **Collaboration service management layer:** As an intermediary between data storage layer and work application layer, collaborative service management layer is the key for data integration turning to the application integration, providing collaborative interactive tools and workflow management, etc. Meanwhile, in order to solve some of the data formats and application program without correspondence, adding the middleware CORBA distributed object-based to connect the data storage layer and collaborative work application layer, responsible for instruction translation and processing will involve data processing, for example, read, query, delete, add, and other operations (Halfawy *et al*., 2006).

- **Collaborative work application layer:** This layer is providing services for the integrated management, including construction projects at all stages and aspects of the subsystem, for example, BIM design software, contract management, investment management, procurement management system, document management system. This layer can be an existing software system; the effective integration of the design should take full account of scalability.

- **Project information portal layer:** This layer provides a single interface to meet individual needs and interests of the project member units through the information portal, as a simple and uniform access point of Web application for the construction project information management and application.

BLMP functional structure model: According to BLMP framework model, the Collaboration Workspace is divided into three functions subsystem, cooperative service management platform, cooperative design work platform; collaborative work information management platform is shown as Fig. 3.

Collaborative services management platform is the information management platform for maintenance and setting up the system background operation subsystems, which is mainly to the above three information platform of the database, the foundation components, application software integration, system function expansion, user

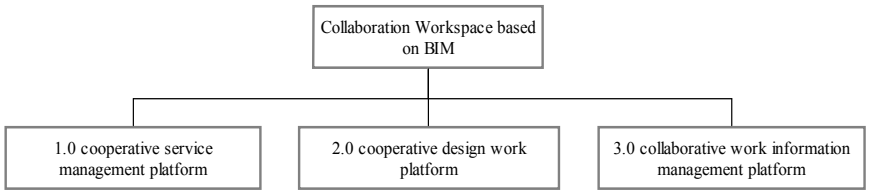

Fig.3: Mode of general function structure of BLMP

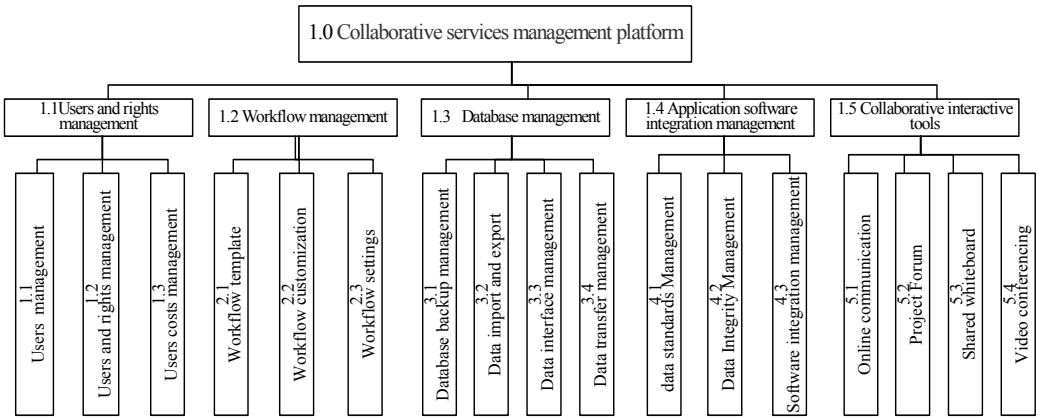

Fig.4: Functional structure of collaborative services management layer

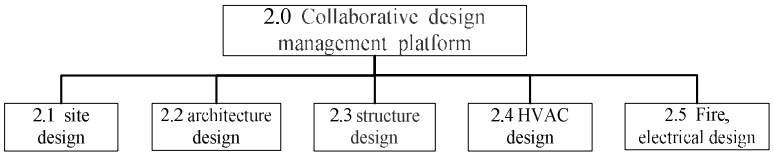

Fig. 5: Functional structure of Collaborative design work platform

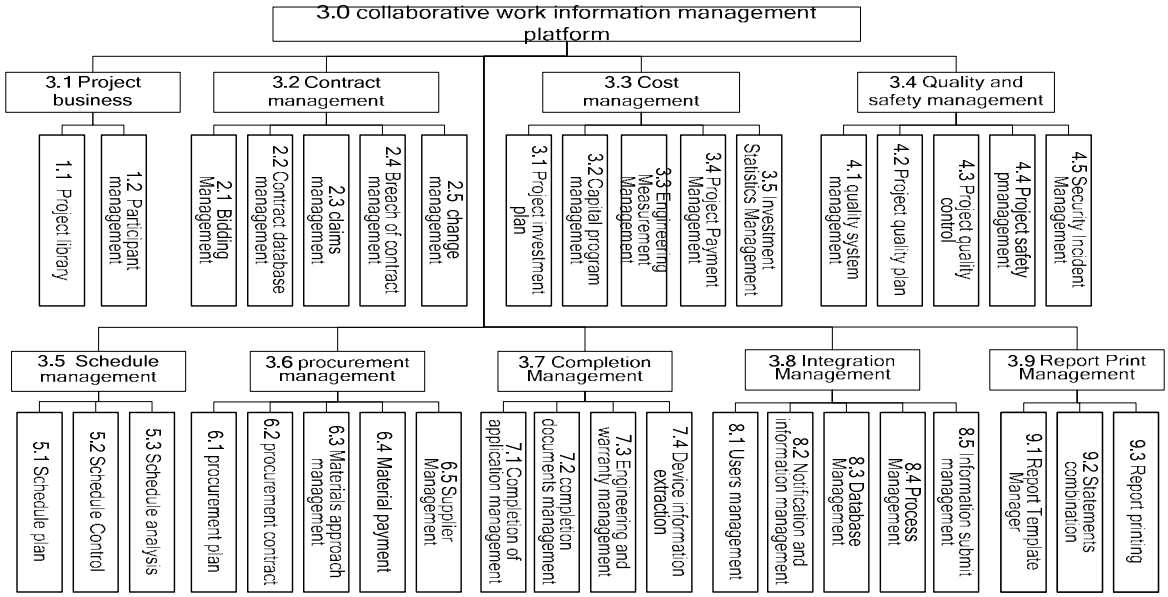

Fig. 6: The Functional Structure of collaborative work information management platform

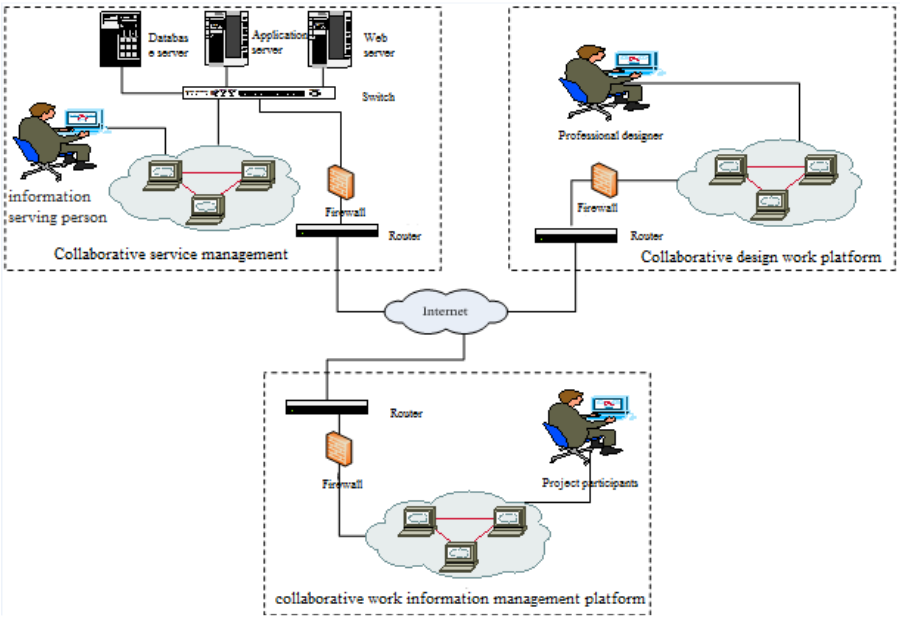

Fig. 7: The network topology of BLMP

management, system configuration and initialization and so on the subsystem of the operation, shown as Fig. 4.

Collaborative design work platform is the platform for unit each professional to collaborative design, including site design, architecture design, structure design, HVAC design subsystem, shown as Fig. 5.

The collaborative work information management platform is the platform for project stakeholders, including project owner, designer, construction, supervisor, material suppliers to work collaboratively. The Functional Structure of collaborative work information management platform is shown as Fig. 6.

The network architecture model of BLMP: The network architecture model of BLMP, designed in accordance with the principles of advanced and reasonable, the cabling system in place, separated by a reasonable and reliable internal and external network resource sharing, and facilitate management (Yang, 2007). The network topology of BLMP is Internet-based WAN, therefore, system and network requirements for information serving person relatively higher than for the application user's. Participating in the construction project only with a computer and network equipment to connect to the Internet can have permission to access and operating system platforms shown as Fig. 7.

CONCLUSION

In this study, based on BIM technology and BLM thought, we have established BLMP information platform, illustrated details of the platform design and implementation process, including design principles, the general structure, functional structure model and Network system structure model, using Data flow synchronous trigger, middleware technology and PIP (project information portal) to solve data exchange and software integration and collaborative work of BLMP. BLMP aimed at the construction project life cycle information integration, storage and management, is the information and technical support platform for building lifecycle information management.

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