Construction of BIM collaborative management platform for the owner in China

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Abstract. With the rapid development of information technology, BIM application of all parties in engineering construction is becoming more and more mature. The construction of BIM collaborative platform is the key to information sharing and collaborative work of all parties. Based on the decomposition of the owner's life cycle project management tasks of China, this paper carries out detailed functional requirements and information needs analysis, and proposes the functional design, basic architecture and information flow of the owner's BIM collaborative platform, which can provide reference for the construction, selection and application of the owner's BIM collaborative management platform.

1. Introduction

In recent years, BIM technology has developed rapidly in the field of engineering construction and achieved remarkable results in the field of design and construction [1]. However, the construction of BIM platform which guarantees the cooperation of all parties still needs to be improved [2]. On March 20, 2019, the Ministry of Housing and Construction of China issued the Technical Standards for Business Coordination Platform of Construction Projects, which clearly pointed out the important role of BIM application in project collaboration platform. As the biggest stakeholder of the whole construction project, as well as the main organizer and coordinator of the construction participants, the owner has become the most powerful promoter of the construction of BIM collaborative management platform. Therefore, based on the actual needs of the owner, the framework of BIM collaborative management platform is an important guarantee to achieve real collaboration, information sharing and full play of BIM benefits.

In 2003, the U.S. government implemented the national 3D-4D-BIM plan. The British government explicitly required enterprises to achieve full coordination of 3D-BIM by 2016. Strong policy support promoted the development of BIM collaboration platform. Many scholars also put forward many BIM platforms based on big data, cloud computing, internet of things, GIS and other technical support [4-8] and BIM platforms based on sensor data input [9-12].

The application of BIM technology in China is relatively late, and the research of BIM collaboration platform is relatively lagging behind. On the basis of project participants, Yuehe put forward the framework structure of project supervision information management system based on...
BIM collaboration platform [13]; Wei Chenkang and others put forward the collaboration information management platform based on construction general contracting management mode [14]; Jiming proposed the construction scheme of BIM-based comprehensive management platform in cloud environment [15]; Xu Yan and others proposed the operation and maintenance of pipeline corridor based on BIM multi-source data query[16]. Duan Yujuan put forward the dynamic control response mechanism and control process of total contracting cost under BIM information integration platform[17]. In addition, many scholars have conducted in-depth research on BIM platform based on cloud technology and big data, Li Tiejun has developed BIM-based construction equipment operation and maintenance management platform [18]; Guan Yue, Kang Lihua and others have proposed BIM integrated cloud platform based on BIM technology and cloud technology [19]; Wei Shiqiao has proposed project management platform based on cloud technology and heterogeneous technology [20]; Chen song et al. proposed an information platform to manage the full life cycle management of prefabricated components[21].

In summary, the current research in other countries mainly focuses on the integrated application of BIM with cloud computing, big data, internet of things, sensors and other technologies; the research of BIM platform in China is mainly aimed at the construction and supervision parties, and for a certain stage or functional requirements of the project construction, and for the whole life cycle of the project based on the BIM collaborative management of the owner's project management tasks and management process requirements. Platform research needs to be improved urgently. On the basis of WBS task decomposition and process sorting out of real estate company's life cycle, this paper puts forward the functional requirements and information requirements of BIM collaborative management platform for owner, and constructs the framework of owner's BIM collaborative management platform, which can provide reference for the construction of BIM collaborative platform.

2. Requirements analysis of BIM collaborative platform from the perspective of owner project management

2.1. Task decomposition and process sorting of owner's project management

As the responsible party of Engineering construction, the owner is responsible for organizing, coordinating, supervising and managing. It is the general integrator of project management. It carries out management work around project objectives such as progress, cost, quality and safety, in order to maximize the benefits of the project. Owner's management involves not only the process management of the whole life cycle of the project, but also the organization management of the participants. The overall application process of BIM in the whole life cycle of the project is shown in Figure 1, and the specific task decomposition and process are shown in Figure 2.

Figure 1. The overall BIM application process of the owner
Whether to take the land
Prepare the preliminary feasibility report of land acquisition
Determine the highest price
Organizing bidding for survey and design
Whether to take the land
Project planning
Project investigation
Project design
Supervision and construction bidding
Project construction
Construction acceptance
Project operation and maintenance

Figure 2. The work flow of task decomposition of the owner’s work
2.2. Analysis of platform user roles and rights requirements

Based on the above task decomposition of the owner, the user roles of BIM platform are divided into three categories: owner users (management and execution) and other participants, as well as system administrators. Owner users are divided into ordinary employees, project managers and company decision makers according to their respective authority. Other participants are divided into construction participants, survey and design participants, supervision participants, consultation participants and property participants according to their respective participation stages and work contents. Based on the needs of different participants around the owner's life cycle project management, the operational authority and corresponding user roles of BIM collaborative management platform are divided as shown in Figure 3.

![Figure 3. The Platform user rights division diagram](image)

2.3. Analysis of platform function and information requirements

Based on the above work task decomposition of the owner, the functional requirements analysis and information requirements of the owner's BIM collaborative management platform are carried out according to the four stages of pre-planning, survey and design, project construction and project operation. Among them, the information used to upload the BIM platform to achieve information sharing among participants and the platform's functional reality is called input information, and the information obtained through the corresponding functions of the BIM platform is called output information. The specific contents are shown in figs. 4 to 7.

3. Construction of BIM collaborative platform from the perspective of owner project management

3.1. Function design of owner BIM collaborative management platform

Based on the functional requirements analysis of the above platform, BIM collaboration platform are divided into 11 functional modules, including model management, cost management, progress management, change management, authority management, bidding management, maintenance management, information document management, project contact information system, task tracking list system and third-party software interface. The functional framework of the platform is shown in Figure 8.

3.2. Basic framework of BIM cooperative management platform for owners

Considering the actual operation mode of the platform, the following platform architecture is proposed: the owner BIM collaborative management platform makes full use of the data storage service and data computing service of the cloud service side, stores all kinds of structured and unstructured data of the whole project cycle in the cloud side, and calculates in the cloud side. The overall architecture of the
platform is divided into four parts: data collection layer, data storage layer, data extraction and utilization layer, and realization of data function layer. The realization of data function layer and data extraction utilization layer interoperate through REST API service interface. Its logic framework is shown in Figure 9.

Data function implementation layer serves users in the form of menu list. After receiving user's operation instructions, the system connects with data extraction utilization layer by REST API interface. Project Liaison Personnel Information System is suitable for project BIM team formation and responsibility and authority division. Task tracking list system is used for docking designated users to remind to-do items, and the system that does not feedback the processing results within a specified time will warn to remind.

Data extraction and utilization layer includes third-party software interface and function deepening interface. Data are extracted from data storage layer and processed and utilized according to needs. The processed data can be directly used by users through function layer. At the same time, programmers can develop software platform in this layer according to the special needs of users.

The data storage layer takes IFC as the standard to ensure the accuracy and interoperability of all kinds of information. At the same time, it can support the storage, transmission, retrieval and encryption of various formats such as pictures, documents, tables, videos, BIM model files, and collect different files in time. The engineering data in the application system is synchronized and updated by the database-driven mode, which ensures the owner's real-time control of the engineering management related data. The data acquisition layer mainly collects data through manual input, file import, automatic collection of monitoring system and automatic generation of system.

![Figure 4](image.png)

Figure 4. Platform functions, information requirements and output in the early planning stage.
### Figure 5. Platform functions, information requirements and output in the early planning stage

| Task decomposition | Functional requirements | Information requirements | Information output |
|--------------------|-------------------------|--------------------------|--------------------|
| **Bidding for survey and design** | Bidding entry inquiry, Bid evaluation management, contract management | Tender documents, Bidding documents of all parties, Investigation and design task book, Recontracting and designing contract | Multi-party quotation contrast table, Tender price, Answer content document, Bid evaluation opinions |
| **Project investigation** | Regional map, Site Location of survey points, GIS Software Interface | Engineering hydrological survey report, Topographic map, Engineering geological survey report, Geological and meteorological data, Seismic Intensity Data | Scene model of survey points, Three-dimensional site model |
| **Project design** | BIM Project budget query, Contrastive analysis of multiple schemes, Material supplier management interface, Virtual roaming 3D-BIM, Real-time browsing, Real-time association of design changes | Professional design drawings, General project plan, Construction drawings of all specialties, Bill of quantities | Budget table of project cost, Multi-scheme and multi-view Model, Project funding plan, Design scheme display, Technical instructions |

### Figure 6. Platform function, information requirement and output in the construction stage

| Task decomposition | Functional requirements | Information requirements | Information output |
|--------------------|-------------------------|--------------------------|--------------------|
| **Bidding for construction and supervision** | Bid registration query, Bid evaluation management, contract management, Multi subcontract summary | Tender documents, Bill of quantities, Construction task sheet, Bidding documents of all parties, Supervisory task sheet, Information of bid evaluation committee, Construction contract, contract for construction inspection and control | Multi-party quotation contrast table, Tender price, Documents for answer contents, Bid evaluation opinions, Bid winning notice, Summary of subcontracting |
| **Project construction** | Material use record, 4D-BIM virtual construction, Construction scheme simulation, On-site transport simulation, 3D construction site layout, Complex Node 3D-BIM, Construction progress inquiry, Real-time monitoring, Change audit tracking, Material system docking | Construction submission documents, Patrol records of safety production, Machinery entry schedule, Working material information sheet, Construction progress plan, Material purchase contract, Contact form for labor personnel, Construction/Supervisor weekly report, Records of regular meetings | Construction schedule simulation plan, Model of construction scheme, Field transportation scheme model, 3D Site layout model, Construction details of complex joints, Real-time construction schedule, Construction video monitoring, Real-time flow chart of change audit |
| **Construction acceptance** | Contrastive analysis of rework, Contrastive of budget and settlement, Acceptance records for each stage, Paper classification | Notice of rework, Engineering acceptance list, Rework acceptance report, Engineering warranty, Change of visa settlement form, Change of visa receipt, Project payment statement, Engineering guarantee paper | Comparison pictures of rework, Budget settlement deviation contrast, Acceptance records and information |

### Figure 7. Platform function, information requirement and output in project operation stage

| Task decomposition | Functional requirements | Information requirements | Information output |
|--------------------|-------------------------|--------------------------|--------------------|
| **Project operation and maintenance** | Multi-view video surveillance, Project revenue analysis interface, Equipment maintenance tracking, Acceptance data retrieval, Approval of maintenance costs, Emergency plan management, Fault handling feedback tracking, Item attribute query, Project profit analysis, Operation permission settings | Contact form for property Personnel, Equipment maintenance records, Project revenue and expenditure, Safety inspection report, Housing lease/sale records, Household acceptance records, Material purchase records | Maintenance monitoring video, Project income analysis report, Equipment maintenance record, Acceptance data, Approval and tracking of maintenance costs, Emergency plan implementation plan, Real-time flow chart for fault handling, Item attribute table, Project profit analysis report |
3.3. Process design of BIM cooperative management platform for owner

BPMN (Business Process Modeling Notation) Business Process diagrams can create Business analysis of Process profiles and describe the implementation of those processes. For each function section of the above platform, take progress management as an example to elaborate the application process in this platform environment. The progress management of the owner is divided into three sub-modules: planning, progress inquiry and deviation analysis. In the planning preparation module, the construction unit shall, according to the requirements of the contract and its actual situation, work out a feasible progress plan through manual compilation or automatic data import, and submit it to the supervisor for review and approval before handing it to the owner. Meanwhile, the construction unit will link the completed progress plan with the BIM model output by the design unit, and the BIM model will be preliminarily established at the construction stage. In the progress query module, it can be divided into 4D BIM plan progress query and actual progress query. Finally, after the actual progress is obtained, the progress management deepening interface of the BIM collaborative management platform will automatically generate the deviation analysis report between the planned progress and the actual progress. According to the analysis report, the owner will judge whether progress correction is needed according to the progress of the milestone node within the enterprise.

According to the above process, the BPMN business flow chart of the progress management function plate of BIM collaborative management platform is drawn as shown in figure 10.

![BIM collaborative management platform based on owner](image_url)

Figure 8. Platform functional framework
### Fig. 9. The platform logic framework

| The owner | Construction participants | Supervisory participants |
|-----------|---------------------------|--------------------------|
| **Owner’s Progress Management** | **Construction Progress Plan** | **Construction Schedule After Approval** |
| Preliminary preparation | Prepare progress plan | Audit the actual progress |
| Enter the progress management interface | Connect the planning progress with BIM model | |
| Model reading | Connect the actual progress with the BIM model | |
| 4D BIM plan progress inquiry | Generate analysis report between plan and actual progress | |
| 4D BIM actual progress inquiry | Whether to correct progress | |
| Generate analysis report between plan and actual progress | Yes | |
| Real-time construction | Corrective progress confirmation | |
| 4D BIM model | Recommended construction scheme | |
| Issue a notice of progress | Speed up construction | |
| The end of owner's progress management | | |

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Table: The platform logic framework

- **Cost management**
- **Model management**
- **Bidding management**
- **Progress management**
- **Change management**
- **Rights management**
- **Maintenance management**
- **Third-party software**
- **Project contact information system**
- **Third-party software interface**
- **Information file management**
- **Mission tracking list system**
- **Functional secondary development**
- **Architecture model deepening interface**
- **Cloud data standardisation**
- **User instruction programming**
- **Data processing deepening interface**
- **Picture video edit interface**
- **Contact information settings**
- **Cost model deepening interface**
- **Permission information settings**
- **Data storage**
- **Data collection**
- **Data extraction and utilization**
- **Artificial upload**
- **Software import**
- **Monitoring collection**
- **System automatically generates log information**
- **Market research report**
- **Investment plan**
- **...**
- **Word**
- **Drawings**
- **Excel**
- **BIM model**
- **Video**
- **Regional figure**
- **Topographic survey map**
- **Construction simulation BIM model**
- **Calculation audit BIM model**
- **Others**

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### Fig. 10. Process management module BPMN flowchart
4. conclusion
Based on the WBS task decomposition of owner's management in the whole life cycle of the project, the functional and information requirements of BIM collaborative management platform are analyzed. On this basis, the framework of owner's BIM collaborative management platform is proposed, which can provide reference for the construction, selection of owner's BIM collaborative management platform and the promotion and use of BIM technology. With the further development of BIM collaboration platform in the future, the owner-oriented collaboration platform will become an effective tool for the owner's project management and realize the owner's lean management of the whole life cycle of the project.

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References
[1] Wang G B,Zhang Y,Jiang Z J,et al.(2009) Benefits situation to stakeholders using BIM In preconstruction stage of projects. Journal of Shandong Jianzhu University, 24(5): 438-442.
[2] Tang B.(2014) A Componentization tactics under the bim platform for parametric design(Master Thesis). Tianjin University, Tianjin, China.
[3] Li K.(2017) Research on BIM application maturity of owner project(Master Thesis). Northern University of Technology, Beijing, China.
[4] Eissa A, Monjur M, Yacine R.,(2016) Cloud-based bim governance platform requirements and specifications: software engineering approach using BPMN and UML. Comput. Civ. Eng, 30(4):1-22
[5] Bouska, Robert. (2017) Evaluation of maturity of BIM tools across different software platforms. In: Creative construction conference 2016. Sopron. 481-486.
[6] Seung H P, Chang H H.(2017) A study for extension of bim/gis interoperability platform linked external open data. Journal of the Korea academy-industrial, 18(3): 78-84
[7] Pei H D, Naai J S.(2019) BIM-based AR maintenance system (BARMS) as an intelligent instruction platform for complex plumbing facilities. Applied sciences, 9(1592):1-12
[8] Mehmet Y, Vishal S. (2019) A BIM integrated, visual search and information management platform for COBie extension. Facilities, 37(7/8): 502-524
[9] Szu C C, Tzu C C, Huei S Y, et al. (2017) Implementation of cloud BIM-based platform towards high performance building services. In: International conference on sustainable synergies from buildings to the urban scale, Seoul, 436-444.
[10] Kai M C , Ren J D, Yi J W . (2018) An automated IoT visualization BIM platform for decision support in facilities management. Applied sciences, 8(7):1086-1090.
[11] Li C Z, Xue F, Li X., et al. (2018) An internet of things-enabled BIM platform for on-site assembly services in prefabricated construction. Automation in construction, 2018, 89:146-161.
[12] Davtalab O, Kazemian A, Khoshnevis B. (2018) Perspectives on a BIM-integrated software platform for robotic construction through contour crafting. Automation in construction, 2018, 89:13-23.
[13] Yue H. (2015) Research on information management of supervision based on BIM collaboration platform. Journal of Lanzhou Jiaotong university, 34(01):180-184.
[14] Wei C K, Xu H T, Zheng C H., et al. (2017) Development and exploration of BIM collaborative information management platform based on construction general contract management. Construction technology, 46(22):1-4.
[15] Ji M.(2016) The design and implementation of integrated construction management BIM-based platform in cloud environment (Master Thesis). Chongqing University, Chongqing, China.
[16] Xu Y, Cheng J Z, Li M F. (2016) Research on the management platform architecture of pipe gallery operation and maintenance based on BIM. Modern surveying and mapping, 9(06):35-38.
[17] Duan Y J.(2013) Dynamic Control of construction general contracting cost based on the BIM information integration platform (Master Thesis). Chang’an University, Xi’an, China.

[18] Li T C, Wang J, Zhou X P. (2017) Operation and maintenance management platform of construction equipment based on BIM. HV&AC, 7(06): 29-32+127.

[19] Guan Y, Li W X, Qiu Y. (2016) Study on application of BIM integrated cloud platform in whole process quality management. Building management, 44(24): 50-52.

[20] Wei S Q, He Y. (2018) Research and application of project management platform based on BIM technology. Port & Waterway Engineering, 08: 113-117.

[21] Chen S, Gao X W. (2017) Research and application for the production and construction information management platform of Shanghai Metro line 17 PC members. Construction technology, 46(09): 103-106.