Chapter 10
Management of Construction Schedules Based on Building Information Modeling Technology

Lianying Zhang, Xiang Zhang and Teng Ma

Abstract As construction projects becoming increasingly large and complex, the traditional methods of schedule management largely undermine the improvement of management level. However, the integration of Building Information Modeling (BIM) and scheduling information can help maintain control of scheduling goals and enhance project performance. This paper proposes a BIM-based construction schedule management framework and establishes a model to integrate scheduling information in life cycle. Moreover, information retrieval and integration and core supports for realizing the model are also examined. The study extends the existing research of construction schedule management, and can be used as guidance for BIM-based schedule management practice.

Keywords BIM · Construction management · Schedule management · Scheduling information management model

10.1 Introduction

The traditional methods of construction schedule management have several problems that hamper the collaboration between project participants and the maintenance of project schedules. These problems include dispersed and inaccurate project information, inefficiency of rearranging the schedules and low-level visualization of the schedule management system [1]. Moreover, as construction projects becoming increasingly large and complex, the industry demands for more efficient schedule management system that facilitates successful accomplishment of projects at a minimum waste of resources. Many previous studies recommend

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that Building Information Modeling (BIM) technology can be used as an efficient tool of providing visual information such as design parameters, project data and 3D model [2]. Yet, the studies regarding integration of project schedule to BIM model fail to view the system in the perspective of project life cycle. Therefore, this paper aims to propose a BIM-based schedule management system that considers life cycle of project. In addition, information retrieval and integration in BIM-based schedule planning and the core supports for BIM-based schedule management are also discussed in the paper.

10.2 BIM and BIM-Based Scheduling

According to Eastman et al. (2008), BIM is a process that define objects parametrically, and when related object changes the parameters also changes in accordance with the rules embedded in them [2]. And Kymmell (2008) defines BIM as a project and process simulation that allows making adaptations of the simulation parameters in a virtual environment that contains all the information required [3].

A number of studies indicate that BIM can considerably boost construction performance. Suermann (2009)'s research indicates that the implementation of BIM can substantially improve management of project schedule and quality [4]. Zuppa et al. (2009) also suggest the positive impact of BIM on project's schedule, quality, and cost [5]. Aslani and Chiarelli (2009) describe the advantages and beneficial of BIM, and they emphasize that for contractors, BIM facilitate tracking and managing changes, preparing for schedules and estimates [6]. Korman et al. (2008) conduct case studies to show that effectively using BIM requires integrating extra knowledge rather than resolving physical problems [7].

Regarding the integration of construction scheduling to BIM, many different approaches are found in previous academic studies and industry practices [8–12]. Ospina-Alvarado and Castro-Lacouture (2010) find that the existing literature with respect to the use BIM for scheduling purposes can be classified into "use of the model to generate the schedule as part of BIM" and "Link of the model to an external schedule for visualization" [13]. Other researches explore how to realize BIM-based 4D management model, especially integrate schedule information to BIM. Tse et al. (2005) propose a method to model objects and interfaces in BIM [14]. Fu et al. (2006) research on integrating information such schedule, cost, project, risk and energy saving, and provide a blueprint of the development of nD models in the future [15]. Zhang and Wang (2003) develop a 4D-MCPRU project management system, and realize the link between AutoCAD and Microsoft Project scheduling in both directions [16]. Nepal et al. (2009) propose several approaches for querying information from IFC-based BIM model [17]. Weise et al. (2009) develop a 4D simulation package called "scheduling assistant" which allows to import complete IFC models regarding 4D information, and apply it to Microsoft Project as a plug-in using IFC-interface [18].

10.3 BIM-Based Schedule Management System

10.3.1 The Establishment of BIM-Based Schedule Management System Framework

The management and control of schedule is one of the essential works of entire construction project management. The traditional schedule management system mainly relies on manual operation. The main problems exist in this system are: the overall system design concept is vague; the scheduling information is poor in visualization, availability, timeliness and accuracy; and unfavorable to system self-organization and self-running. This paper propose using Autodesk Revit to acquire available data to establish the BIM-based schedule management system in a pattern of 'Model-View-Controller' [19], as shown in Fig. 10.1.

Realization of Model layer: using Autodesk Revit to build 3D BIM, and export the graphics data in the model to DWG format graphics files. Then, Autodesk Revit and API are used to assist secondary development to export property data of the 3D model to a SQL Server database, and connect the graphic data and the property data one-on-one through producing distinctive building components ID. Meanwhile, independent construction schedule setting modules are developed to store construction scheduling data stored in the SQL Server database.

Realization of View layer: Displaying construction schedules based on Autodesk DWG Design Review, and display specific information of building

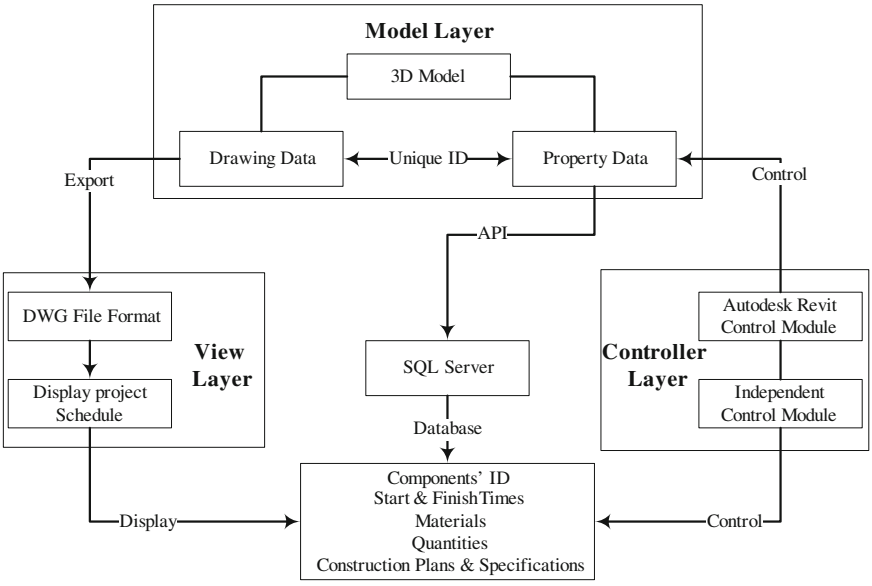

Fig. 10.1 BIM-based project schedule management system

component through property sheet control, for example, components' ID, start and finish times, materials, quantities and construction plans and specifications.

Realization of Controller layer: Development of independent construction schedule control modules and control current duration. Then compare start and finish times of every building component, and judge whether the setting component should be displayed. To control display or hidden state of every components and send messages to the View layer.

When construction scheduling information has been input into the 3D BIM, property information of a building component in the graphic module of Autodesk Revit will be obtained such as duration, labor, and resources. If one building component is selected in the View window, the graph of the component will be highlighted, and corresponding property bar in building component properties toolbar will also be highlighted, therefore construction procedure of the component are easy to be controlled. And if construction schedules are found to be different with the expectations, we can adjust the durations of related objects and current construction state, the system will automatically update the database, and refresh the 4D model, and it is convenient to check the current duration and schedule, and facilitate construction management.

10.3.2 BIM-Based Scheduling Information Management System

The establishment of basic framework provides architectural support for BIM-based schedule management system, yet in order to effectively implement it into construction schedule plan and daily activities, a powerful scheduling information management system is required.

The management of construction project information involves many participants, such as owner, designer, contractor, supplier, operator, government, and financial institution. There are huge amount of information, and the exchange of information are complicated, and the traditional way of information management is low efficient and arrange in disorder. To transfer construction scheduling information between all participants smoothly, and to be available for management departments, a project integrated control system must be built. This system is BIM-based platform, and it views project activities as basic objects based on computer network, and construct scheduling information processing platform that is under collaboratively management and control. Thus, the scheduling information can be shared and collaboratively managed across different departments, corporations and areas. So the key to construct BIM-based schedule management system model is to change the traditional way of information transformation and sharing, and integrate scheduling information of different project phases and participants effectively in the purpose of realizing the project information management in full life cycle.

To establish the BIM-based schedule management system, the difficulties are the creation, management, and sharing of BIM information. Currently, the main method to store BIM information to build data storage center based on IFC standards, and allow visit and revise of distributed, heterogeneous application systems to realize information integration.

This paper proposes creating BIM-based information management model in all project phrases by using information sub-models as kernels. The basic principle of the idea is to create information sub-models in all project phase, i.e. project planning phase, project design phase, construction phase, operation phase, in according to the need of the project management. Every information sub-model evolves automatically, and can retrieve, extend, and integrate data from the sub-model of previous phrase, and then create the sub-model of the present phrase. As the project continues, scheduling information model in full life cycle is created, as shown in Fig. 10.2.

From the project planning phase to the project design phase, then to the construction phase and operation phase, the project schedule is integrated step-by-step, and in the end, the complete project schedule is formed. In every project phase, the system will define information exchange model of the specific

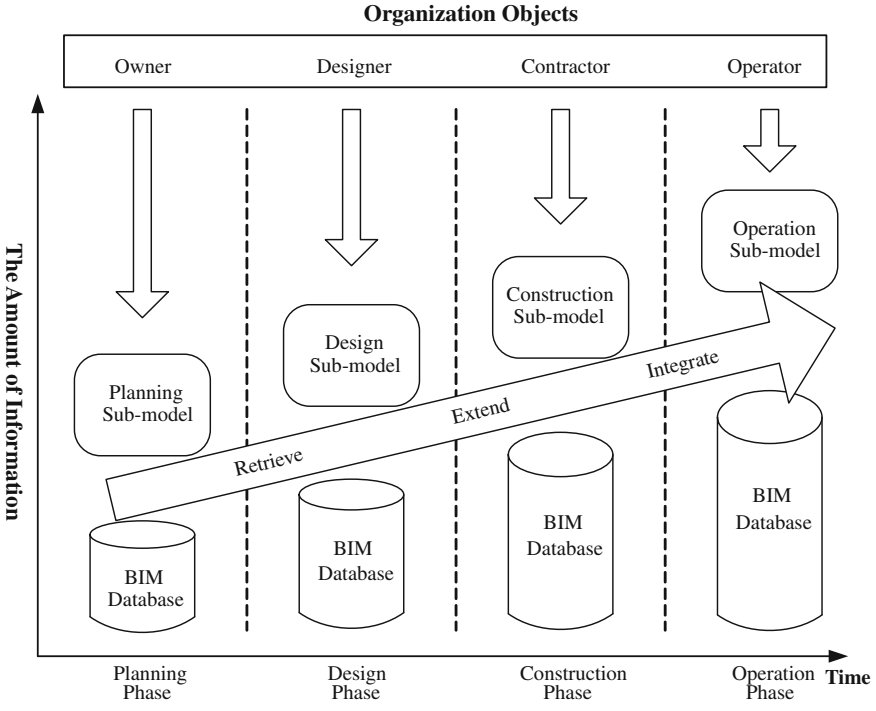

Fig. 10.2 The evolvement of BIM-based schedule management sub-models

application in that phase, and realize data integration and sharing by retrieving and integrating information sub-models.

10.3.3 Information Retrieval and Integration in BIM-Based Schedule Planning

The data in construction project schedule reflects durations of building objects and their overlapping relationships, and describe the state of the 3D model. For project schedule management, that data is the base of the 4D construction information model. Therefore, the organization and management of construction schedule data is one of the important steps of BIM information management system.

Construction site management is a complex and dynamic process with many unexpected changes, which contains huge amount of data of different kinds. And as the progress of the project, the amount of data is continuously accumulated, so high demand is required to manage those data in BIM information management system. Moreover, construction project is a complex system of high integration, and it involves different departments, types of work, resources, labor. Although the sources of data are complicated, every participant needs to obtain and share these data. After considering the above factors, we propose using SQL Server to store and retrieve schedule management information in database.

Data transfer and function calls between schedule and SQL Server database are programming by C language. In the process of project implementation, schedule data are collected, they are entered into Microsoft Project that automatically track the progress of project, and obtain usage information about schedule, resources and cost. The follow-up task duration, material, and labor are adjusted according to the situation at that time, and the updated schedule will feedback to the database of SQL Server.

10.3.4 Core Supports for BIM-Based Schedule Management

Software and basic technology that are used to load scheduling information in BIM model include: Autodesk Revit (3D Architecture, Structure and MEP modeling tool), Microsoft Project (project schedule planning tool), SQL Server (key development technologies for realizing schedule management system), IFC standard (realizing BIM data exchange and sharing).

In this paper, we propose using Microsoft Project to create project schedule management file. Project scheduling information are stored in database of SQL Server by using C language programming and API of Microsoft Project, and at the same time, scheduling information of standard file format in SQL Server are imported to Autodesk Revit by using API of Autodesk Revit. Moreover, BIM sub-

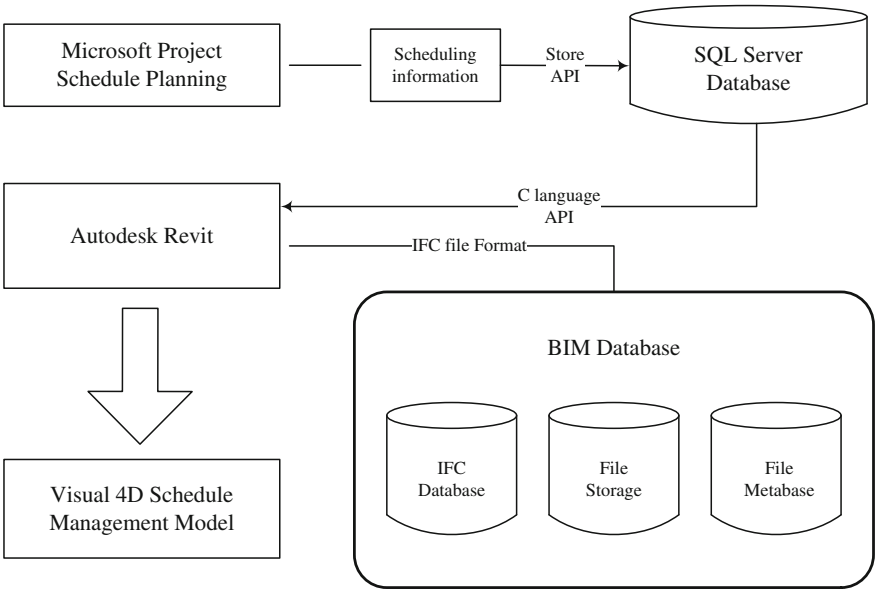

Fig. 10.3 Core supports and realization of 4D model

models data are imported to Autodesk Revit in IFC file format, and their property information are loaded to the schedule response nodes, so that BIM-based 4D project schedule model is established, as shown in Fig. 10.3.

10.4 Conclusion

Previous researches about project schedule and BIM model integration are unable to view the system in the perspective of project life cycle. This paper proposes using a BIM-based schedule management model that considers life cycle of project. Researchers try to establish BIM-based schedule management system framework by using a 'Model-View-Controller' pattern. It is the extension of the current research of using BIM for scheduling purposes. However, the real application of the model still needs to be further studied.

The application of BIM-based schedule management demonstrates its unique advantages and benefits, and it can substantially improve traditional schedule management methods. Although the application of BIM technologies in China has just started, its application is bound to have a profound impact on the construction industry.

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