Research on IDM-based BIM process information exchange technology

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Abstract

IFC (Industry Foundation Classes) laid the foundation for interoperability with different applications. However, the IFC lacked the specifications for the process, such as where and when the information was created, edited, and exchanged. Determining what and when to share is difficult. Thus, IDM (Information Delivery Manual) was introduced to capture the business process while providing detailed user-defined specifications on the information that need to be exchanged at particular points within a project. However, the development of IDM needs the widespread support of participants who have high professionalism. Thus, the development of IDM lasts long, and the model view of the exchange requirement is difficult to modify, which obstructs BIM (Building Information Modeling) information sharing. In this paper, the technical framework of the BIM process information exchange was proposed based on the relationships among IDM, IFC, and IFD (International Framework for Dictionaries). According to the framework, the basic method for BIM process information exchange, which is composed of process modelling and exchange requirement extraction based on IDM, model view auto-generation depending on natural specification of exchange requirement, exchanging data by the requirement view in a linear sequence, was established. The exchange requirement model view auto-generation application was also developed. Actual practice in the 4D (4-Dimensional) construction management system of the information specified by the exchange requirement view was presented. Application results illustrate that the framework and the method for BIM process information exchange is effective, and helps in the safe, accurate, and highly efficient exchange, sharing, and integration of data.

Keywords: IDM, IFC, BIM, process information exchange, MVD (Model View Definition)

1 Introduction

During the past decades, interest in information technology in the A/E/C (Architectural/ Engineering/ Construction) industry was stirred. As information technology advances, the usage of parametric design applications, project management software, and so on, which, to some extent, assisted the development of the A/E/C industry in different aspects, has become increasingly popular. Meanwhile, information related to the A/E/C industry software is more complicated than before. With the proposition of BIM, we hope to integrate all the information concerned, and keep its consistency and integrity.

The A/E/C industry has its own characteristics—highly complicated, long period, and with different participants. It is very common for the different application processes of a project to use

different software, which have different data structures that result in extreme complications in the safe, efficient, and accurate exchange and sharing of information among different application processes. To facilitate interoperability with different applications, the IFC standard was introduced. IFC is a computer-readable, neutral expression of building data, which make the data about the lifecycle of the A/E/C project independent of a specific system. However, different software merely adopts IFC to particular business processes, and the information these processes operate on should be extracted accurately. Furthermore, the information the process produced should be integrated accurately, thereby assuring the consistency, integrity, and conformity of the information created, exchanged, and merged in the process. The lack of recognition and specification of business process results in difficulty for the IFC to describe the creation, modification, and exchange of information in the process. Therefore, the information needed and produced by this process cannot be determined based on practical application process.

To discover and control the business process and determine and specify the information exchange requirement, the international alliance for interoperability put forward the IDM. IDM proposes a methodology that captures (and progressively integrates) the business process while providing detailed user-defined specifications of information that need to be exchanged at particular points within a project (Wix and Karlshoj, 2010). IDM first states the individual tasks of the business process and the information on which the tasks operate. With the dependencies among the tasks, the information required to be exchanged (information exchange requirement, exchange requirement) can be identified. The exchange requirement, of which the part specified by natural language is more readable for those without background knowledge about IFC, can be broken down into functional parts related to IFC entities, with which developers are familiar. Thus, the exchange requirement serves both the software developers and the participants altogether. The US general services administration put forward the MVD, which helps define the information exchange requirement, was also adopted as part of the IDM. The IDM for architectural precast was developed for the specification of the business process and the exchange requirement between different participants associated with the process (Eastman et al., 2007). A new methodology for the development of IDM was also developed. Different representations of IFC entities in different applications, which should be considered in developing model views, were discussed in detail. A case study of IDM was also presented (Panushev et al., 2010; Venugopal et al., 2010; Aram et al., 2010). To help the information exchange, the IDM was converted into UML (Unified Modelling Language) concept models, based on which the database was developed for the editing and browsing of IDM through the web (Kim et al., 2010).

However, problems still exist, as follows:

- The development of IDM should be supported by both the participants and the modeling experts of the process. IDM development also needs a long period.
- MVD needs the participation of modeling experts and high specialism.
- Revising or autonomously defining the model view is difficult for the users.

The current paper first studied the basic method of IDM. Based on the relationships among IDM, IFC, and IFD, the technical framework of BIM process information exchange was then proposed. According to the presented framework, the basic method for BIM process information exchange, which is composed of process modelling and exchange requirement extraction based on IDM, model view auto-generation depending on natural specification of exchange requirement, exchanging data by the requirement view in a linear sequence, was developed. Actual practice in the 4D system of information exchange according to the requirement view generated by our model view auto-generation application was presented.

2 Basic method of IDM

Process discovery and data mining are the conventional processes used in IDM development and IFC development and extension. The development approach is composed of discovering process, mining data, extracting exchange requirement, creating functional parts, and defining business rules as a linear sequence. In this paper, based on the method of process discovery and data mining, we changed and detailed the process of process modelling and exchange requirement extraction as follows.

2.1 Process modelling

Process modelling is the process of model development for business organizations and their operations. The development of process model for information exchange process is necessary for the recognition, control, assessment, and improvement of the process. The main procedure includes:

- Process recognition: This involves the discovery of the key business process in the domain concerned, such as the task, participant, and the most important aspect in IDM, the information exchange between different participants.
- Data mining: Based on questionnaires, interviews, documents, and so on, data mining is the collection of more information for detailing the process.
- Analysis and process map: Data analysis runs through the whole process modeling, with the assistance of step 2; the process can be modeled as a process map by Business Process Model and Notation.
- Process statement: This entails the compilation of process maps and the natural language specification into a document, which help others get acquainted with the business process. The format of the process statement is already specified in the IDM methodology (Wix and Karlshoj, 2010).

2.2 Extraction of information exchange requirement

Information exchange requirement is the foundation for the collaboration and communication between different participants. Capturing the detailed content of information exchanged between different task owners and stakeholders is necessary. The steps are as follows.

- Identification: Based on the information exchange between different participants and the dependencies between tasks of the business process, the exchange requirement from the message flow is distinguished.
- Detailing: With the help of information collection, including interviewing the actors of the task and document retrieval, the specific contents of the exchange requirement are worked out.
- Partition: The exchange requirement is divided into logically related parts (functional parts) based on the operations of the participants on the exchange requirement.
- Documentation: The objective and the contents are described in a natural language.

3 BIM process information exchange

3.1 Technical framework

For a real free flow of information to occur, three factors need to be in place: the format for the information exchange (IFC), a specification of which information to exchange and when to exchange the information (IDM), and a standardized understanding of what the exchanged information actually is (IFD) (BuildingSMART, 2008).

IDM establishes a collaboration mechanism between the project participants. Participants of the various business processes share and exchange information based on information exchange

requirements that come from the business process. The exchange requirement model, whose functional parts and MVD support the software development, represents the exchange requirement in a technical way. IFC specifies the format of the information exchanged and lays the foundation for the interoperability of information among applications. As both functional parts and MVD are related to the concepts in IFD, the relationship between the functional parts and the IFC information unit can be established by IFD, thus forming the basic unit of the model view. IFD can be considered as the bridge that coordinates user-level collaboration and machine-level interoperability together (as shown in Figure 1).

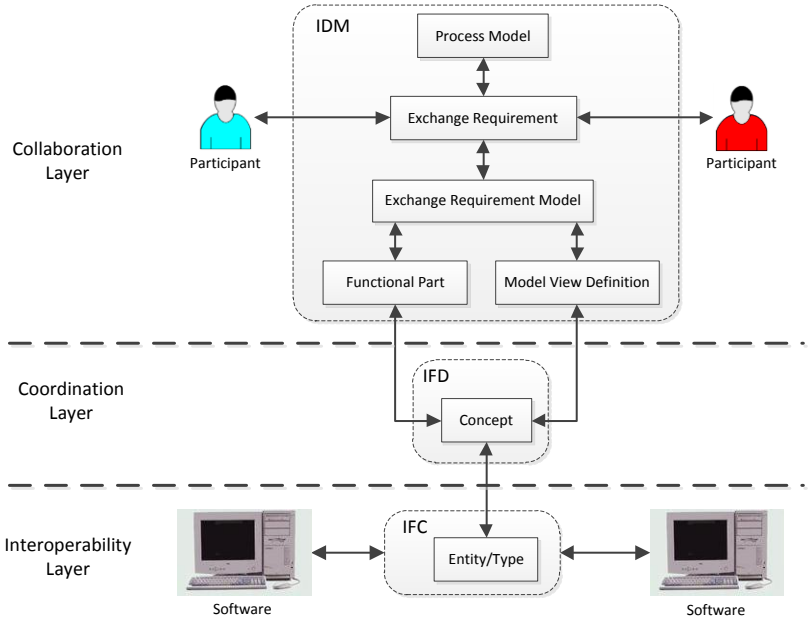

Figure 1. BIM process information exchange technical framework.

3.2 Model view auto-generation based on natural language

Exchange requirement is composed of functional parts, each of which has a corresponding concept. IFD can be considered as a set of concepts with different attributes; thus, the concept corresponding to a functional part is contained in IFD. Therefore, the concept binding of MVD can be achieved with the mapping from the concept in IFD to the IFC information unit. The model view can then be defined easily (as shown in Figure 2). At this point, the functional part of the exchange requirement is equal to the information unit in MVD. Hence, as long as the user inputs the concepts comprising the exchange requirement in a natural language, the MVD can be easily generated.

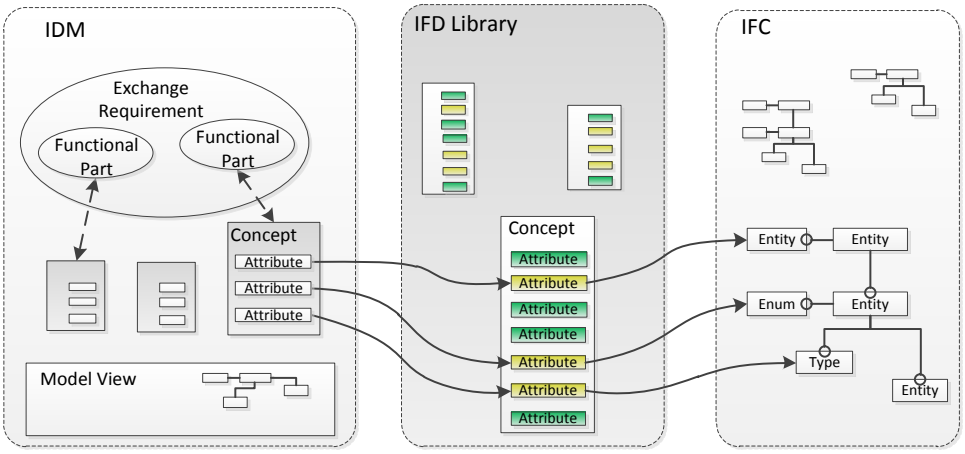

Figure 2. Mapping relationship between exchange requirement and IFC.

The routine for developing the exchange requirement model view is similar to MVD, as earlier mentioned (Hietanen, 2008). Based on the mapping relationship, if the process modelling and exchange requirement extraction are completed, the exchange requirement model view is ready as well. Thus, the establishment of the IFD Library is important. The present paper built a prototype of the IFD based on IFC2x3 and the terminology system of the Chinese AEC industry.

To easily guide the user, the library was divided into nine domains, including structural analysis and construction management. The user can select different domains for different applications. The user should decide which concept in the domain is needed for the exchange requirement, and then choose the attributes of the concept. Finally, the model view is generated automatically.

4 Implementation

4.1 Process modelling for schedule management

By analyzing the documents (Zhang, 2008; Zhu, 2002), the common process for schedule management was established. Furthermore, the "Schedule Plan" part was detailed by the owners, contractors, and subcontractors, and the establishment of the "Schedule Control" (as shown in Figure 3) part was supported by the owners, contractors, subcontractors, and supervising engineers. (The classification of the participants was based on actual Chinese conditions.) The process model presented by the process map and the specification document can be used for information requirement extraction. Business process reengineering can be taken advantage of to release the benefits of information sharing.

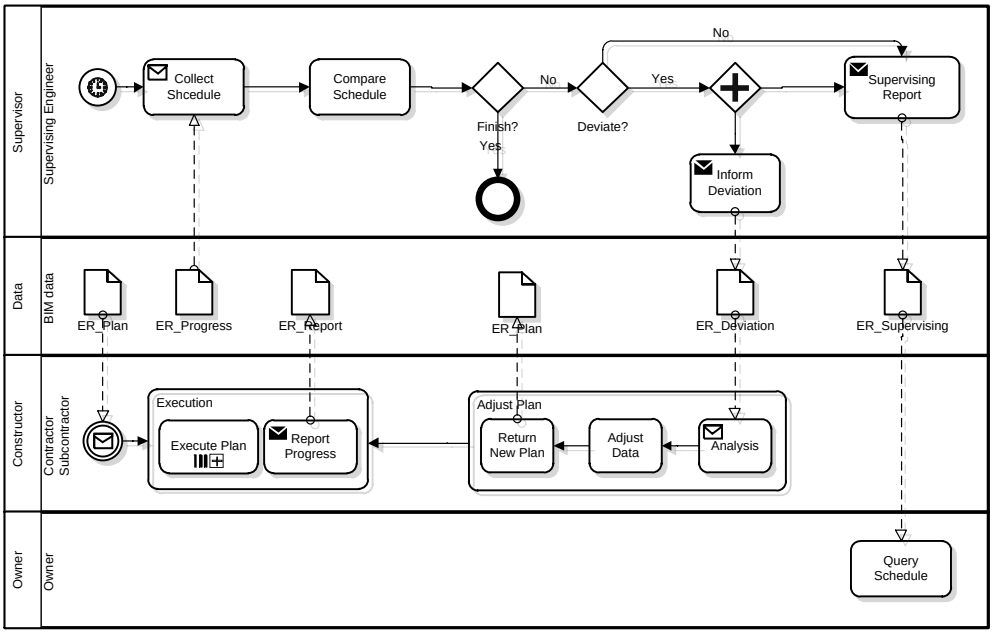

Figure 3. Process map of schedule control.

4.2 Extraction of exchange requirement in schedule management

According to the method in Section 2 and the process model of schedule management, the exchange requirements shown in Table 1 were captured.

Table 1. Exchange requirements of schedule management

Exchange requirement	Main content
er_building_model	Building model provides information for downstream analyses (thermal, lighting, schedule, and so on) to be undertaken; the model provides information about the building, layout of spaces, building elements, and construction resources.
er_schedule_plan	The schedule plan model contains information for schedule management and cost control. The model provides information about the construction schedule with construction resources, segments, activities, and their relations to building elements.
…	…

4.3 Model view auto-generation

The software requirement view auto-generation wizard was developed based on 3.2. Users can input basic information of the view, choose the domain to which the exchange requirement belongs, select concepts, set the attributes step-by-step according to the wizard, and finally export the model view in express or xml language.

Figure 4. Steps in model view generation.

4.4 Practice of the information shared

Based on the schedule plan model view generated before, the information for schedule management is extracted, and the data are put into practice in the 4D-GCPSU system (Zhang and Li, 2010; Hu and Zhang., 2011; Zhang et al., 2008). The schedule management model contains information of the construction plan, the construction resources of each task, and the relationship between tasks and building elements. Figure 5 shows the 4D construction simulation of a commercial house in Xi'an. The user can stop the simulation at any time to query resource usage, as shown in Figure 6. Hence, the method presented in the current paper that specifies exchange requirement, auto-generating model view, and extracting the data in a linear sequence really works.

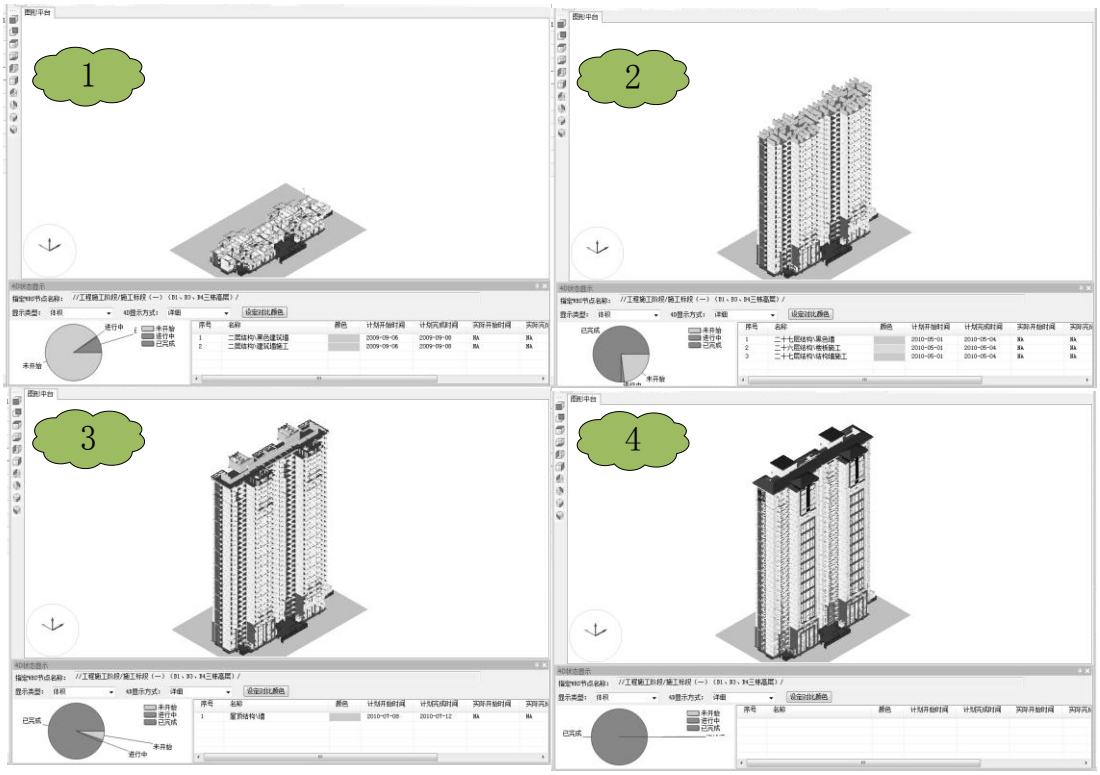

Figure 5. 4D construction simulation in the 4D-GCPSU system.

Figure 6. Resource query in the 4D-GCPSU system.

5 Conclusion

By synthesizing IFC, IDM, and IFD, the technical framework for BIM process information exchange was proposed. According to the framework, the method composed of process modeling and exchange requirement extraction based on IDM, model view auto-generation depending on natural specification of exchange requirement, exchanging data by the requirement view in a linear sequence, was established. The requirement model view auto-generation application was also developed. By putting the method into practice on schedule management and application results are shown in the 4D-GCPSU system, illustrating that the framework and the method for BIM process information exchange is effective, and helps in the safe, accurate, and highly efficient exchange, sharing, and integration of data.

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