A NEW APPROACH TO REUSING CONSTRUCTION FIRM'S LEGACY MANAGEMENT INFORMATION

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ABSTRACT

Nowadays most construction firms have begun to use information management systems in their business to work more efficiently. At the same time, a lot of management information is being accumulated and some of the legacy information can be reused to support decision-making. Up to now, the legacy information has not been reused so effectively in construction firms as expected. This paper introduces in an integrated way a new approach to reusing construction firm's legacy management information, which is based on BIM (Building Information Modeling) technology. In the paper, the current approaches are reviewed first, and then the framework of the new approach is described. Next, the key issues and the corresponding techniques of the new approach are clarified. Finally, a prototype system developed for the new approach and its application are demonstrated. It is concluded that the new approach can be used in construction firms to better reuse the legacy management information.

Key words: Construction firms, Legacy management information, Information reuse, BIM.

1. INTRODUCTION

Nowadays most construction firms are using information management systems as management tools and more and more information is being accumulated in the systems over time, related to productive information on elements such as labor, machine, and material and so on, and covering aspects such as schedule, cost, quality, etc. (Rujirayyanyong 2006) The legacy information of reuse value is referred to as information resources in the context of this study and it is expected that by making full use of information resources, the ability of decision-making could be improved, which thus enhances the competitiveness of construction firms.

There exist two approaches to reusing information resources. One approach is to manage the major information (e.g., engineering documents) and make it easy to query. For example, Tserng (2004) analyzed five phases of knowledge management, i.e. collection, extraction, storage, sharing and update, and developed a system to support information reuse. The other approach is to extract useful information to build data warehouse and excavate potential knowledge by using data mining techniques. For example, Soibelman (2004) conducted schedule delay analysis using decision tree method and artificial neural network method to analyze the information accumulated in enterprise databases. Some construction firms hire management consulting firms to implement Business Intelligence (BI here after for short) tools for them. However, the existing approaches are still not convenient and efficient for construction firms to use.

BIM (Building Information Modeling) technology makes it possible to share information in the lifecycle of construction projects efficiently. In this study, a new approach based on BIM technology was formulated in order to reuse information resources more efficiently and effectively, and a prototype system was developed to verify it. This paper is intended to present the approach in an integrated way.

2. A NEW CONCEPTUAL FRAMEWORK FOR REUSING CONSTRUCTION FIRM'S INFORMATION RESOURCES

Though investigations against high-level managers in construction firms, it is estimated that only about 10 percent of the legacy information in construction firms' information management systems can be regarded as information recourses in the sense that they can be reused in future. So it is necessary to extract information resources firstly from the information management systems of construction firms in order to make efficient use of them. Based on the consideration, a conceptual framework is established for reusing construction firm's information resources, as shown in Figure 1 (Ma Z.L. 2009).

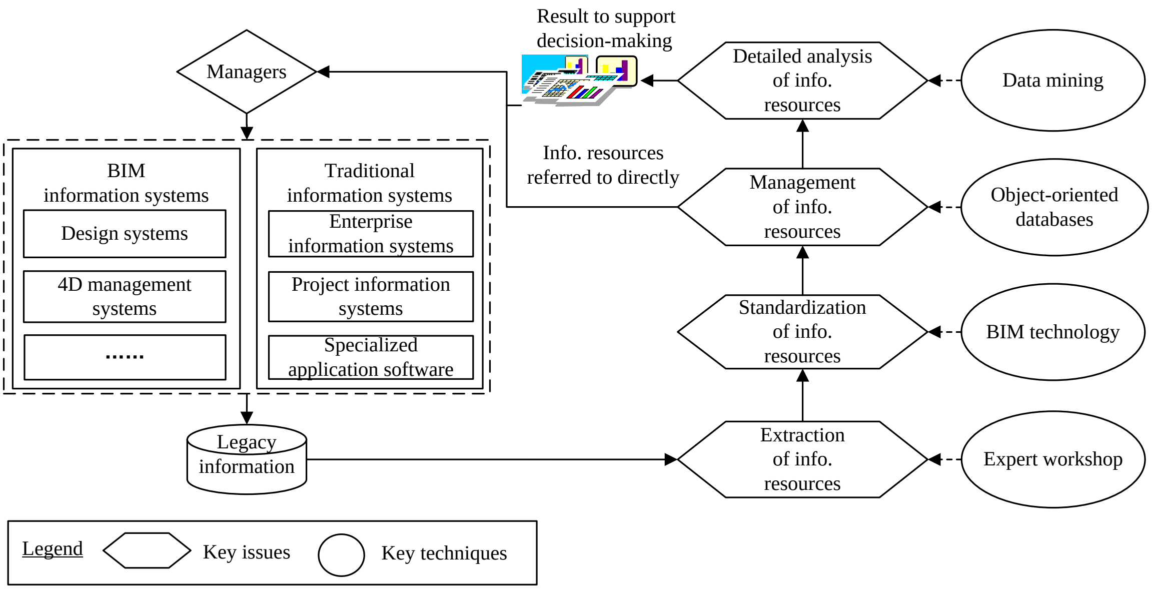

Figure 1: Conceptual framework for reusing construction firm's information resources (Ma Z.L. 2009)

According to the framework, information resources need to be extracted from the information management systems after a project is completed. The information resources then should be standardized and added to a dedicated system; just like reusable spare parts that are removed from used cars and stored in the warehouse. Whenever the support for decision-making is needed, the managers then can analyze the information resources by using a dedicated system. This framework reduces the quantity of legacy information stored in the database of the dedicated system so that the information resources could be reused efficiently.

In order to implement the framework, several key techniques need to be used to clarify the key issues; for example, expert workshop is used for identifying the information resource items, BIM technology is used for the standardization of information resources, an object-oriented database management system is used for managing them, and data mining technology is used for extracting knowledge to support the manager's decision-making.

3. RESEARCH ON THE KEY ISSUES

3.1 Identification of information resources using an expert workshop

While the identification of information resources is the basis of the new approach, it is very difficult to carry out the work because it not only involves many aspects of the management of construction firms, but also depends on the experience of the managers. An experienced manager knows what kind of information can be reused in his decision-making, while an inexperienced manager does not know it well. In addition, the identification has to be systematic, so that the information resource could be extracted from information management systems without losing the valuable one.

Hence, the procedure for the identification of information resources is formulated and implemented in the study as shown in Figure 2. In Step 1, the major decision-making activities in construction firms were summarized based on extensive literature review. As a result, the decision-making activities are divided into two parts, project level activities and enterprise level activities; the former includes 5 project stages such as bidding and contract-signing, and the latter includes 8 functional management categories such as planning and production. In Step 2 and Step 3, the information resource items that are required in the activities and their usage were summarized. Thus totally 63 information resource items were proposed, among which, 37 items are related to project-level management and the rest are related to the firm-level management. Then a questionnaire form was formulated for use in next step. In Step 4, a workshop was held and 5 experts from top construction firms in China were invited to discuss and fill in the questionnaire form to evaluate the reusability of the information resource items. The reusability of the information resource items was divided into three levels, i.e. Level A, Level B and Level C, where Level A corresponds to large reusability, Level B to medium one and Level C to the small one. As an example, Table 1 shows the information resource items of Level A and Level B reusability.

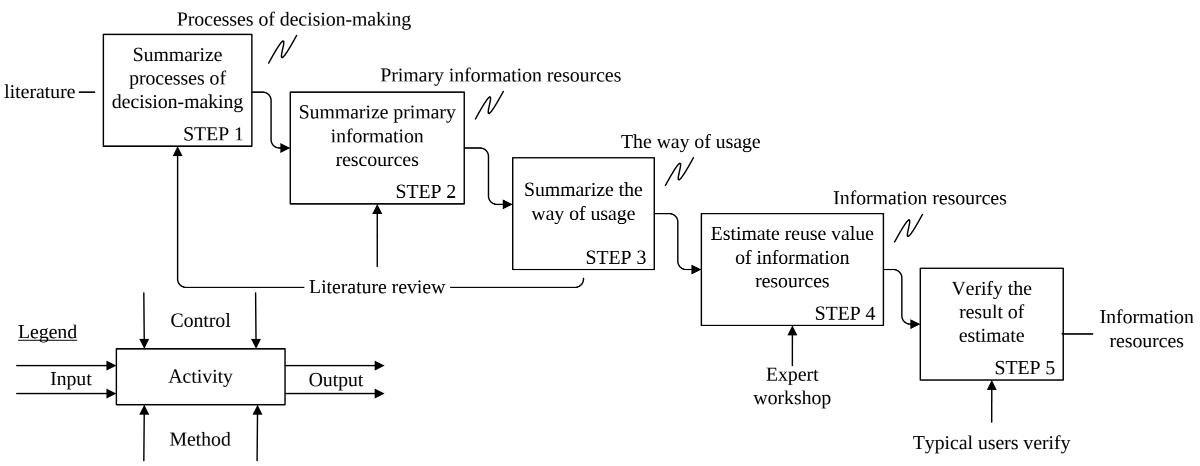

Figure 2: Procedure for the identification of information resources (Lu N. 2011)

The evaluation results on the reusability of information resource items were verified by holding a meeting in a construction firm which had implemented information management system successfully for several years. Ten high-level managers including the general manager attended the meeting and were asked to evaluate the reusability of the information resource items independently. As a result of comparison, the evaluation was in agreement with that given by the experts. Thus it is concluded that the result of identification of information resource items is applicable for extracting the information resources from construction firms (Ma Z.L. 2010b).

Table 1: Partial information resource items (Ma Z.L. 2010b)

Code	Information resource items	Reusability level	Code	Information resource items	Reusability level
1	Project bidding detail	A	15	Cost accounting record	A
2	Certificate info.	A	16	Design documents	B
3	Cooperation record	A	17	General info. of bidding	B
4	Cost plan detail	A	18	General info. of contract	B
5	Actual schedule detail	A	19	Contract documents	B
6	Material procurement record	A	20	General info. of constr. plan	B
7	Direct cost record	A	21	Material plan detail	B
8	Indirect cost record	A	22	Equipment plan detail	B
9	Annual plan	A	23	Labor plan detail	B
10	Project contract record	A	24	Labor work record	B
11	Project cost record	A	25	Equipment procurement/rent record	B
12	Construction method	A	26	Quality inspection record	B
13	Cash flows record	A	27	Employee performance record	B
14	Income and expenditure records	A	28	Deployment of staffs record	B

3.2 Representation of information resources based on BIM technology

In order to manage information resources that have been extracted from existing information management systems, it is better to define a neural format for storing the information resources. In recent years, with the development of BIM technology, the IFC standard (BuildingSMART International, 2008) has been recognized as a mainstream data standard. The study adopts the IFC standard as the storing format of information resources. There are three reasons for doing this. First, because of the direct or indirect relationship between the construction firms' management information and the products, it facilitates future integration of the information resources with the design information. Second, the IFC standard, which is object-oriented, contributes to storing information resources efficiently and can make it convenient for the construction firms to query information resources that they want. Finally, the IFC standard contributes to better sharing and exchange of information resources since it does not change with information management systems.

However, the IFC standard has not been used except for a few aspects such as scheduling and cost estimating in the field of construction management up to now. Hence, in order to use the IFC standard in this approach, it has to be expanded.

In the study, the extension of the IFC standard was carried out first on the information resource items of Level A reusability. Object-oriented analysis method was used and eleven classes including labor and organizations were identified. By examining the IFC standard, it was found that only three categories of information related to “data records”, “drawings” and “the relationship with drawings” need to be defined as extensions. Thus, the hierarchical structure of existing and extended entities about the abovementioned categories is shown in Figure 3. In the structure, two entities related to drawing are in the resource layer, so they do not inherit from IfcRoot (Ma Z.L. 2010a).

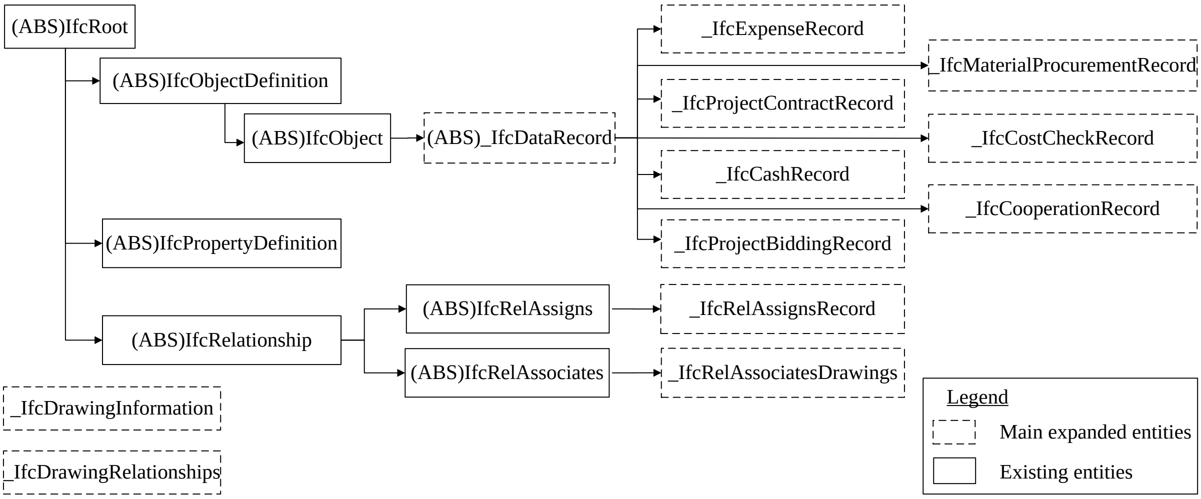

Figure 3: The hierarchical structure of existing and expanded IFC entities related to "data records", "drawings" and "the relationship with drawings" (Ma Z.L. 2010a)

The IFC-based model of information resources is formulated as shown in Figure. 4. Based on the model, the information resources are supposed to be extracted and transformed into ifcXML files before they are imported into the prototype system developed in this study. In order to do so, the mapping between the information resource items and the IFC entities was established and used.

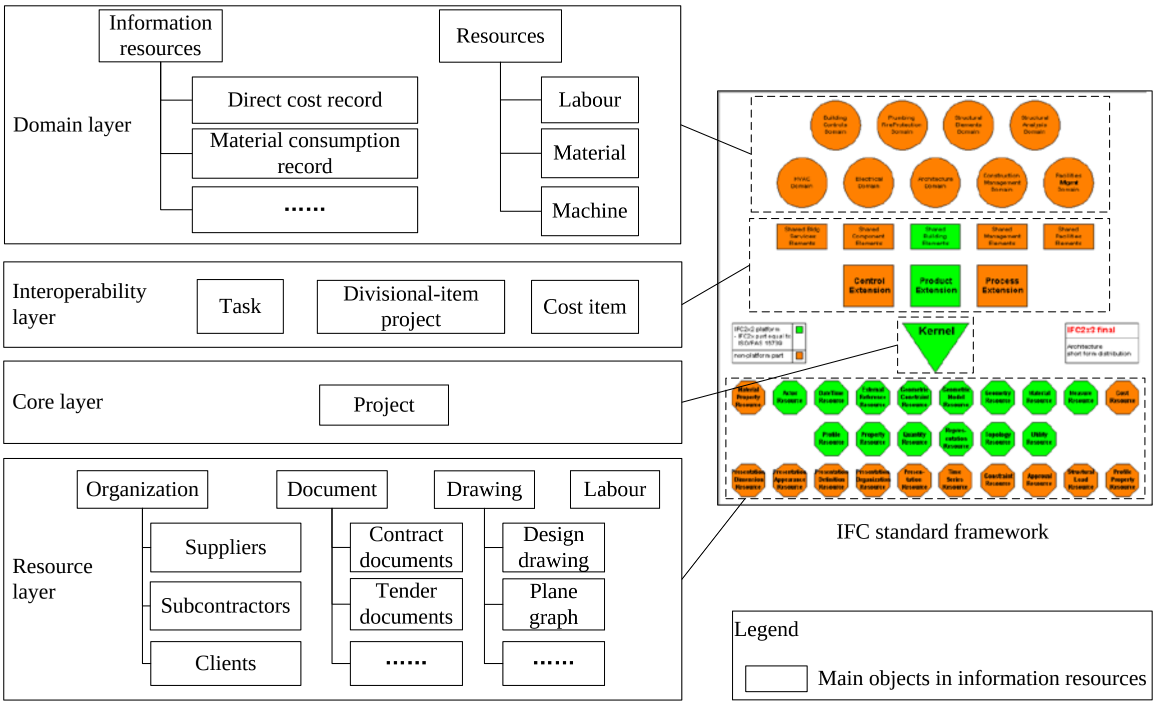

Figure 4: Information resources model based on the IFC standard (Lu N. 2011)

When analyzing the information resources stored in the system, an inverse process needs to be carried out. Since the combination of information resources may be needed in many cases of decision-making, the mapping between the data member of IFC entities and the decision-making activity need to be established in advance before the data are used for the analysis to support decision-making. The process of obtaining the data of information resource for decision-making is shown in Figure 5, where the main IFC entity represents IFC entity whose attributive data can be use directly, while the basic IFC entity represents that whose attributive data have to be obtained through relation entities before being used.

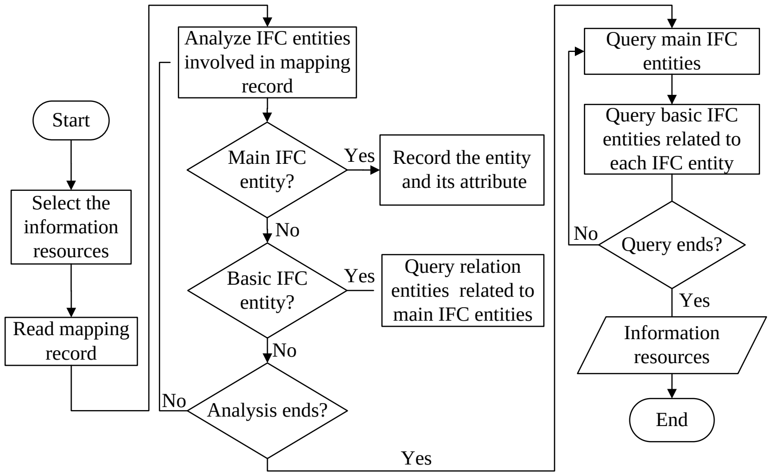

Figure 5: The process of obtaining the data of information resources (Lu N. 2011)

3.3 Management of information resources using object-oriented database

Since large amount of legacy management information are anticipated to be in such a system in order to make use of information resources in construction firms, it is necessary to adopt an efficient database management system. Traditionally, relational databases (RDB) management systems are used to manage data in information systems (Demian 2006). Considering that the IFC data are object-oriented, it was expected that object-oriented database (OODB) management system are more efficient than the traditional RDB management system. To verify it, comparisons were carried out by using an OODB management system, Versant (Versant 2011), and a relational database, SQL Server, respectively.

The comparison was carried out in the following way, i.e., establishing databases for simple data (e.g. a single IFC entity), combined data (a relational entity is used for combining two IFC entities) and complex data (more relational entities are used for linking more IFC entities), and then manipulating the databases by inserting information and querying information up to 100000 times. The results are shown in Figure 6. It is clear that in most cases, the OODB management system showed much higher performance than the RDB management system (Ma Z.L. 2011). Hence, the Versant system was used in the development of the prototype system.

3.4 Reuse of information resources

Through investigations, it was concluded that the statistic analysis method can satisfy construction firms’ daily needs for supporting decision-making in most cases. So the prototype system that is developed in the study provides only the basic analysis functions, i.e. graphical representation of the retrieved data and multiple linear regression analysis. Besides, to satisfy users’ need for complicated analysis, the prototype system facilitates outputting information resources in the form of XLS, CSV and ARFF files so that users can make in-depth analysis with specialized software such as BI tools.

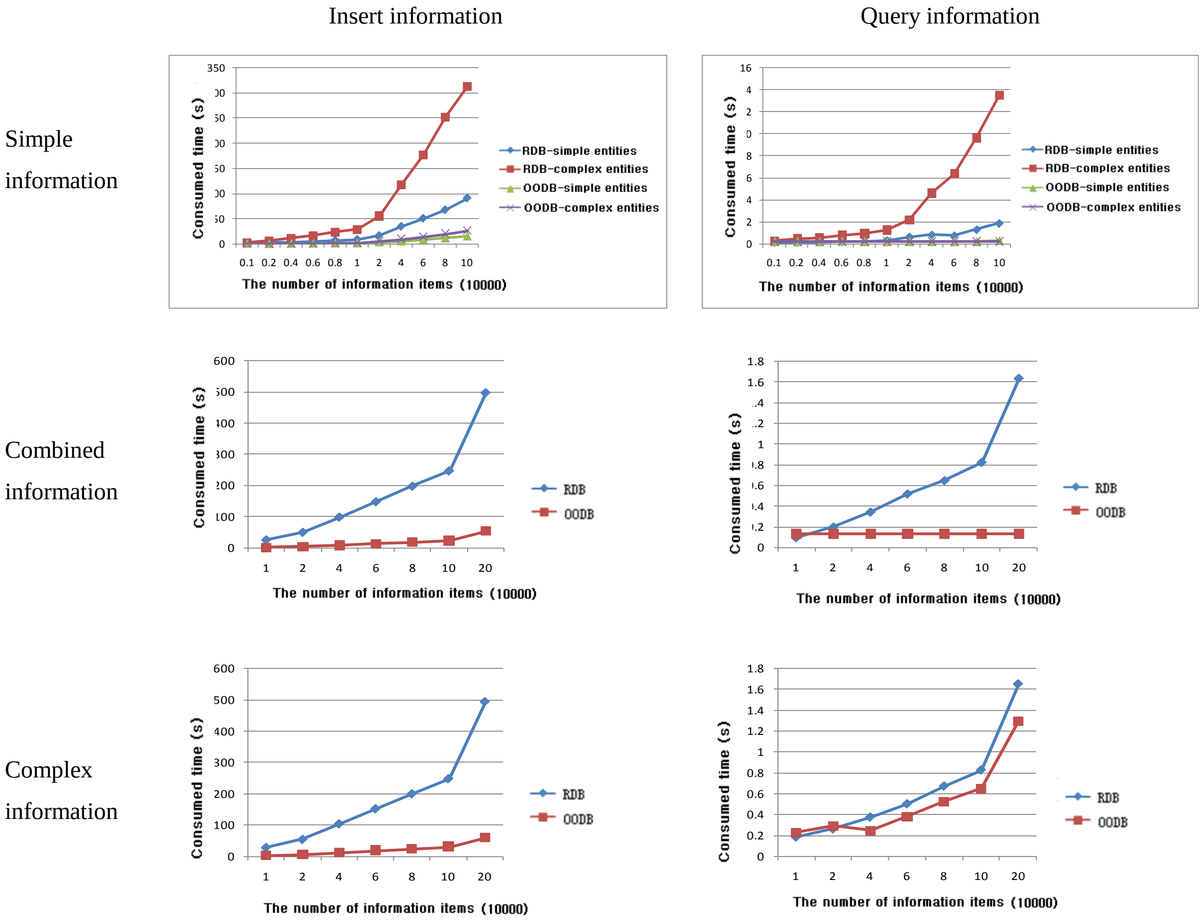

Figure 6: Comparison of OODB and RDB for the efficiency of manipulating IFC data (Ma Z.L. 2011)

4. PROTOTYPE SYSTEM

4.1 Introduction to the system

Based on the abovementioned research, the author et al. developed a prototype system called the Information Resources Reuse System for Construction Firms (InfoReuse) for the new approach by using C# language and Versant database management system. Figure 7 shows the system model and Figure 8 shows the user interface of the systems.

The system has two types of users, i.e. information managers and information analysts. The former are responsible for importing information resources from existing information management systems. In addition, they are responsible for managing such settings as departments, users and user rights; maintaining information resources, decision-making activities and analytical models; and setting the mapping of IFC entities, etc. The latter can search, analyze and output information resources that they want.

4.2 Using the system for case studies

In the study, a construction firm that has used an ERP system for about 8 years was selected to test the prototype system and to verify the approach. The extracted information resources covered project information, suppliers, material, WBS, material purchase records, cost records and enterprise cost records etc. There were about 5000 information resource instances from 21 projects. The size of the corresponding ifcXML files was about 10MB involving 30,000 IFC entities. The imported information resources were then used it to predict project cost, to assist in material purchase and so on. For example, the information resources of wood-based panel factory projects were used to predict the cost of a planned project. It was found that the construction cost of a wood-based panel factory project mainly depends on the output of the factory and duration of the project. Based on this feature, the cost of the planned project was predicted by using multiple linear regression analysis method and it proved to give satisfying results.

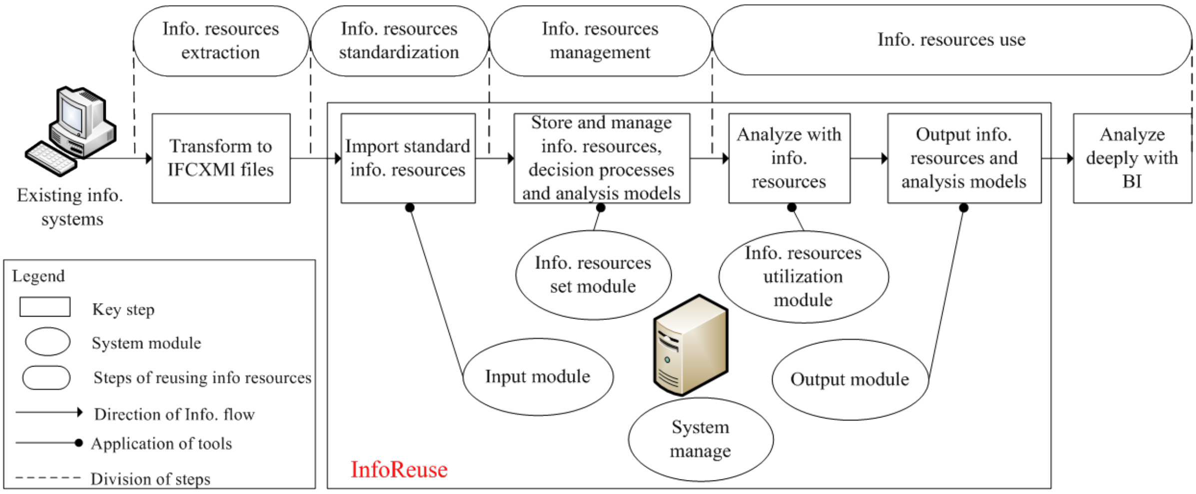

Figure 7: System model of InfoReuse (Lu N. 2011)

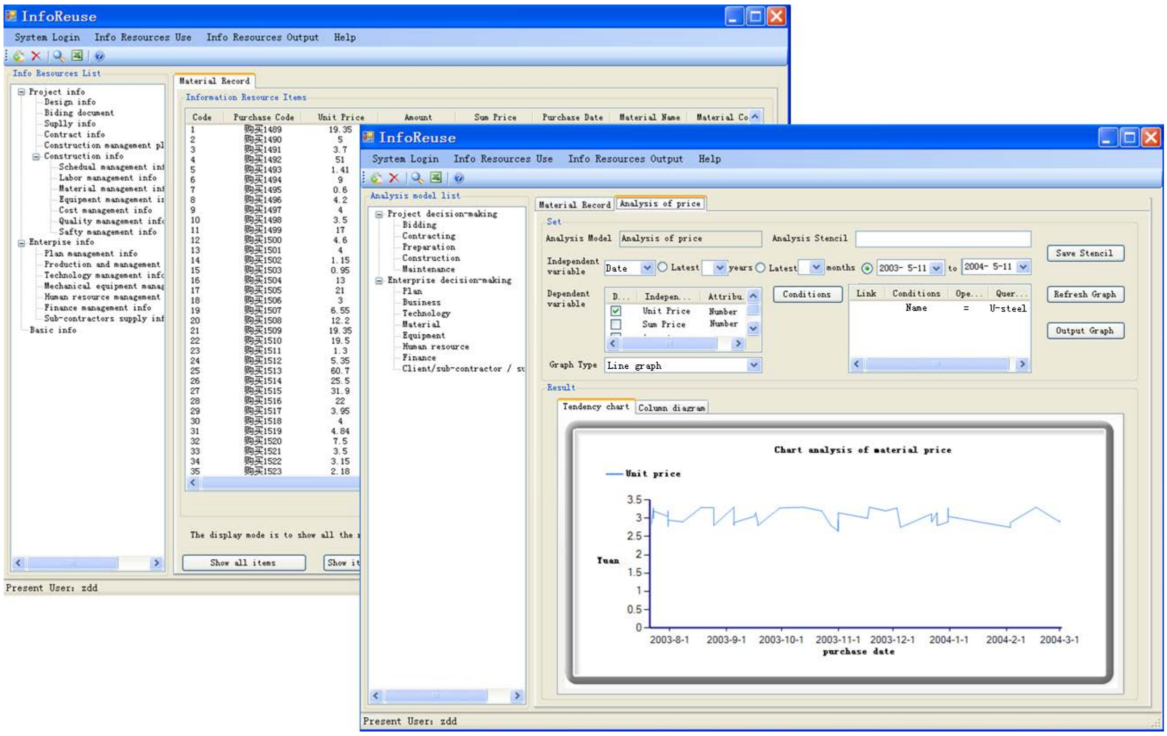

Figure 8: InfoReuse's user interface (Lu N. 2011)

5. CONCLUSIONS

A new approach for reusing legacy management information in construction firms was established based on BIM technology in the study. This paper introduces the related key issues and the corresponding techniques, a prototype system developed for the new approach and its application. It is concluded that the new approach can help construction firms to better reuse legacy management information to support the decision-making in their management.

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