A Product Model Centered Integration Methodology for Design and Construction Information

프로덕트 모델 중심의 설계, 시공 정보 통합 방법론

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Abstract

Researches on integration of design and construction information from earlier era focused on the conceptual data models. Development and prevalent use of commercial database management system led many researchers to design database schemas for enlightening of relationship between non-graphic data items. Although these researches became the foundation for the proceeding researches, they did not utilize the graphic data providable from CAD system which is already widely used .

4D CAD concept suggests a way of integrating graphic data with schedule data. Although this integration provided a new possibility for integration, there exists a limitation in data dependency on a specific application.

This research suggests a new approach on integration for design and construction information, 'Product Model Centered Integration Methodology'. This methodology achieves integration by preliminary research on existing methodology using 4D CAD concept, and by development and application of new integration methodology, 'Product Model Centered Integration Methodology'.

'Design Component' can be converted into digital format by object based CAD system. 'Unified Object-based Graphic Modeling' shows how to model graphic product model using CAD system. Possibility of reusing design information in latter stage depends on the ways of creating CAD model, so modeling guidelines and specifications are suggested. Then prototype system for integration, management, and exchange are presented, using 'Product Frameworker', and 'Product Database' which also supports multiple-viewpoints.

'Product Data Model' is designed, and main data workflows are represented using 'Activity Diagram', one of UML diagrams. These can be used for writing programming codes and developing prototype in order to automatically create activity items in actual schedule management system. Through validation processes, 'Product Model Centered Integration Methodology' is suggested as the new approach for integration of design and construction information.

Keywords: Product Model, Integration, Design, Construction, Information, Methodology

1 INTRODUCTION

1.1 BACKGROUND

Additionally design for manufacturing (DFM) is required in order to reduce loss generated when initial information of design is transferred to the following stage, and to increase productivity and ability of reusing and sharing information. Detailed understanding of producing processes and principles of product helps perform DFM. In the construction industry, architects who have various knowledge on construction processes and building materials' properties, can also produce documents of high quality, such as drawings and specifications. Recently object based CAD programs have helped architects make DFM enable. As object based CAD system adopting object-oriented concepts and applying it to the design process provide various functions in producing building components in object style individually and in managing their data, it became possible to manage various data of building using three-dimensional graphic objects and to integrate these with related information consequently.

In addition to the growth of object based CAD system, as concept of product model appears, researches on data exchanges with different computer systems became more active. Research outputs are also being applied to the construction industry, and International Standardization Organization (ISO) and International Alliance for Interoperability (IAI) are performing related studies.

1.2 PROBLEM STATEMENT

As three-dimensional CAD systems become common modeling tools and since their graphic models can provide various data based on object-oriented technology, three-dimensional graphic product model become the center of integration. Graphic objects provide a good visibility that help users access the information they want to get. In such case, integration can be performed when other information are prepared and graphic objects have a specific properties to include data on other objects, such as identification, reference, or pointers.

Although wide use of three-dimensional CAD system and much research on product model have been conducted, there still exist problems in practical application of product model.

1.3 RESEARCH OBJECTIVES

Although quantity of construction information composed of

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product model-related data continues to cumulate as time goes by, percentage of utilized information decreases. This phenomenon loads project participant with burdens of information operations.

However digitalization of construction documents and efficient management using information technologies can overcome these problems successfully. Using a good project information management system helps to improve ways and method for management of data.

The objectives of this research are to suggest new integration methodology in order to give a solution to some questions occurred in integration on construction information, such as 'What is integration in the construction?', 'What to integrate?', 'How to compose graphic model?', and 'How to apply and utilize?'.

1.4 Research Scope

This research is available and discuss the aspects of construction project process from detailed design to construction planning phases. Unified object-based integration methodology effects on detailed design and drafting tasks during the design phase, and data model and prototype system generate activity items which are automatically used in the construction planning phase. Logical sequencing activity items are excluded from these research scope.

Some supplementary business operations, such as integrating, maintaining, and utilizing tasks are added to the traditional processes. These operations are included in the scope of this research. 'Product database' and 'Product Framerworker' help store and utilize product model data efficiently using visualized multiple management.

Often some of the actual data from activities are used for verification, which is about middle level activities, such as 'Installation of Main Steel Column', 'Installation of Girder', 'Installation of Deckplate', 'Placing and Curing of Concrete', 'Placing and Curing of Core Concrete', and 'Installation of Curtainwall'.

2 LITERATURE REVIEW

2.1 Product Model in AEC Industry

As researches on product model and international efforts on standardization continue, there are some trials where building elements are viewed from the point of views of product model in construction industry. Product model in AEC field is considered as building itself, as a final output, and data model representing and storing data related to each component of building.

It is expected that continuous research on construction product model will enable sharing and exchange of data among heterogeneous application related to AEC industry. For example, it is possible that CAD system stores design data into a file in standardized product model format, and a schedule management programs used to open and utilize it.

As product model concept was initiated in the manufacturing industry, it is necessary to undergo some adaptation in order to fit with the features of construction industry. Construction industry resembles project in non-repetitive, resource constrained works must be completed in scheduled time. But producing outputs such as building, bridge, highway, harbor, airport, and others is alike with the manufacture's. For this reason, studies on practical application of these two types of features are conducted and some domestic studies on design information management using IFCs (이근형, 2000).

2.2 Integrated Information Model

Schedule, cost, and design information integration is a core theme of the various integration related researches conducted recently. As stated by Jung (Jung, 1988), these information contribute a greatly and from the perspective of Computer Integrated Construction (CIC) have closer interrelations with each other.

There are various integration models on construction industry, such as Teicholz's (Teicholz, 1987), Hendrickson's (Hendrickson, 1989), BOD model (Kim, 1989); (안병주, 1995), Workpackaging Model (Rasdorf, 1991), CIBS Model (송혁, 1989), Matrix Model (이규진, 1997), Composed Matrix Model (신진우, 1998), Assembly Model (Kim, 1999), and others.

2.3 4D CAD

After Kim (Kim, 1989) presented a conceptual model for integration of design elements and schedule items, Collier (Collier, 1996) and Mckinney (Mckinney, 1996) later conducted researches on integration of CAD model as practical design information and schedule information. After these researches, CAD not only contained information drawing but also on individual entities representing each component composing a building.

Researches on 4D CAD utilizing the features of individual CAD entity enable representation of to represent each building components are conducted in Center for Integrated Facility Engineering (CIFE) mainly. There are various computer applications, such as CIFE 4D CAD, PlantSpace Series provided by Jacobus Technology (Jacobus, 1997). As 4D CAD concept enables simulation of visual construction in scheduled order, researches on finding logical errors in construction schedule have been conducted (Koo, 2000).

3 ANALYSIS OF THE EXISTING INTEGRATION METHODOLOGY

3.1 Application Oriented Integration

Efficient project management requires integrated management tools and techniques in order to administrate and control the tasks and operations that occurred in projects. EVMS(Earned Value Management System) is one of these techniques, and helps analyze the status and forecast the outcome of project using cost and schedule. Although EVMS is a general and an efficient tool for project management, it does not include design elements of design which are also important in construction project.

After BOD model including design objects into integrated data model was presented, 4D CAD concepts expanded widely, and applications enabled 4D CAD concepts integrating CAD data with scheduling data. These applications visualize the construction schedules with graphic engine and display selected graphic elements' schedule data. These also enable finding of logical error in schedule and for generalist to understand the sequences of construction with no professional notations or diagrams.

These applications need some requirements to be followed sequentially to integrate CAD and schedule data automatically using specific integrating engines. Source data such as CAD and schedule data, along with others have to be produced according to the structures provided by the vendors. After source data are prepared, required data objects can be instantiated and linked to one another by following the fixed integration processes and using specified programs.

Although this 'Application Oriented Integration Methodology' is convenient, it also has some shortcomings. This chapter deals with some issues of existing integration methodology using specific applications. Advantages and disadvantages are analysed and revealed through this preliminary research.

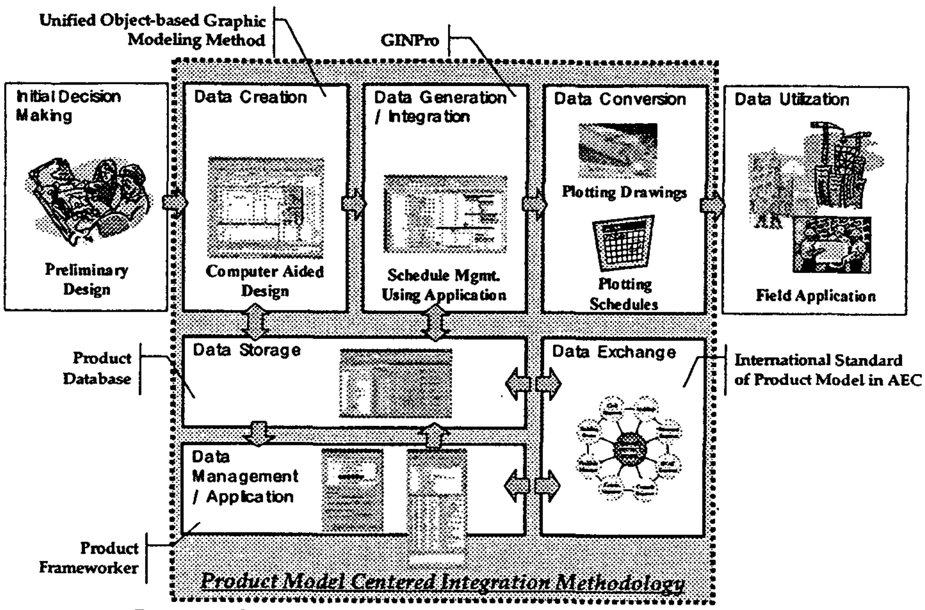

Figure 4.1. Concept of 'Product Model Centered Integration Methodology'

3.2 EVALUATION OF THE EXISTING INTEGRATION METHODOLOGY

This preliminary research is conducted in order to investigate the features of application oriented integration methodology. For this purpose, JSpace series were selected as the integration tools and prototype was developed. Various levels of integration on CAD elements, schedule information, and others were considered and some processes, such as 'Analysis of JSpace Class Library', 'Constructing Hierarchy of Project Class', 'Connection with Individual Applications', 'Definitions of Project Class', and 'Instancing Objects for Integration' were accomplished sequentially and finally integrated database were constructed, and visual simulation was demonstrated.

Some advantages are enlightened by closer study of application oriented integration methodology using commercial integration tools and despite of the advantages, there are some limitation in this integration way.

Some features in a positive point of views are summarized as follows;

- Application uses the existing data so that it is possible to minimize additional work.
- There are pre-defined integration processes.
- There are well-formed data structures that can be used by applications.
- Users or organization can utilize the most recent information technologies developed in integrated management.

There are some limits such as these:

- All data have to conform to the standards provided when they were produced.
- Users or organizations must follow the processes predefined by the vendor.
- Users or organizations' databases will be dependant on specific vendor.
- Applications' prices may become burdening to users or organizations.

4 DEVELOPMENT OF A NEW INTEGRATION METHODOLOGY

4.1 PRODUCT MODEL CENTERED INTEGRATION METHODOLOGY

4.1.1 Conventional Process

Preliminary design is one of the operations at the initial decision-making phase. Preliminary design stresses the architectural concepts, evaluation of technological process alternatives, size and capacity decisions and comparative economic studies. Detailed design follows the preliminary design, and CAD tools are used by architects or drafters, and this operations is corresponded to data creation phase. During this phase, 'Unified Object Graphic Modeling Method' can be adopted in order to produce structured data files, and increase reusability of design information and collaboration between designers, estimators, and schedulers.

In next phase, 'GinPro' can be used in order to generate and integrate design and activity data. 'GINPro' generates activity items automatically using design product model and cumulated basic unit works database.

CAD data created in 'Data Creation' phase and activity items for schedule management in 'Data Generation/Integration' are conversed into drawings and schedule diagrams in paper documents format which are acceptable to the engineers at construction fields. Use of these drawings and schedule network diagrams are the generalized features of recent construction projects. So 'Initial Decision Making', 'Data Creation', 'Data Generation / Integration', 'Data Conversion', and 'Data Utilization' forms a conventional data usage process.

4.1.2 Supplementary Process

As to how of storing data into a particular database is a critical aspect of data management, 'Product Model Centered Integration Methodology' suggests some principles of integration to expand application scope with keeping original data structure and recommend object-oriented database because international standards are developed based on object oriented concepts. To

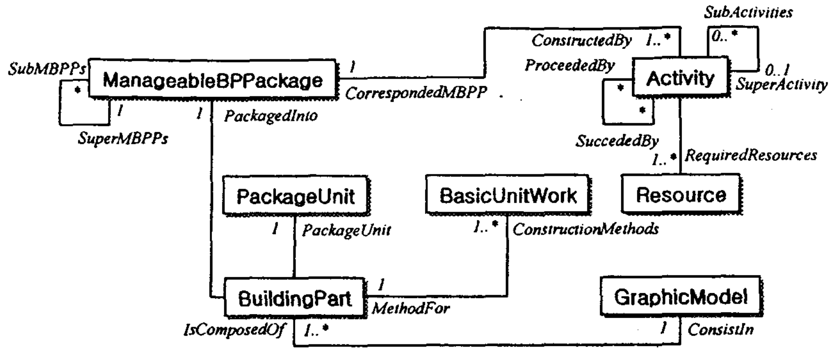

Figure 4.2. Product Data Model for Schedule Management

verify the suggestions product database is actually developed in this research.

'Product Frameworker' supports multiple viewpoints encouraging structural management and use of the product models. As it is quite common for a component of a constructed facility to perform several functions, and to be shared among several assemblies, multiple viewpoints are adopted to 'Product Model Centered Integration Methodology'. As the method and systems are designed and implemented based on STEP standards, data are exchanged among heterogeneous systems through neutral file format.

4.2 UNIFIED OBJECT-BASED GRAPHIC MODELING

Today, important roles of three-dimensional model are to display building models realistically using visual effects and to find potential problems in advance through walk-through and simulation tests. As the models created to fulfill this purposes are not objects containing any information of construction projects by this time, but just graphical model having only visual information, because whose purposes are just to maximize visual impact. As it is costly to make visual models, it is ineffective to use them for the purpose of visualization and simulation. Workers have to create models under careful plans in order to reuse this model information that becomes the basis for the latter construction stage (박은정, 2002).

The purpose of the 'Unified Object-based Graphic Modeling Method' is to provide guidelines of modeling ways and composing objects to not only present building product models effectively but to also deliver design information to next participants without data loss, and to enable architects to collaborate with others using unified process, modeling rules, and code systems.

The purpose of second dimensional CAD systems is to rapidly produce drawings. On the other hand, three-dimensional object-based CAD systems focus on reusability and application of building model rather than the quality of printed blueprints. So it is required to prepare guidelines for object-based three-dimensional graphic modeling. The guidelines should contain classes' usage of building elements, such as which class is to be used, which properties are to be specified, how the additional classes are to be customized, and others. In addition to these items, code systems should be included.

4.3 HETEROGENEOUS PRODUCT DATA STORAGE

It is impossible to develop a perfect product data model which can contain all related data and be usable through out all stages of processes. Although IFC tries to deal with various domains of construction project,. it is still an incomplete data model. IFC 1.51 just covers the architecture and facility management domains, and IFC 2.0 adds construction management, and HVAC domains to IFC 1.51's scope.

Because the IFC v 1.51 doesn't support structural engineering, the information generated from a specific engineering application is not be represented by the IFCs. Some classes are defined by the EXPRESS language. The objects instantiated from these classes, which define the 'ENTITY' keyword in the EXPRESS language, are stored in the product model database.

Heterogeneous product data storage can be developed by following the process 'Schema Compile', 'Class Compile', 'Creation of Database Schema', 'Creation of Product Model Database', 'Product Frameworker Development'.

4.4 GENERATION AND INTEGRATION USING PRODUCT MODEL

Data model have to represent graphic objects according to the which methods which are adopted into graphic elements in CAD systems. For this reason, this research suggests that all graphic objects are divided into building parts, lowest level, and managed by them or their groups. If a graphic model includes various data of building components, several building parts' instances are created, and if a graphic model is a building component itself, only one building part's instance is created (이근형, 2002).

Until now, 4D CAD concept could only be used only to simulate construction schedule visually according to relationship of CAD graphic elements and schedule data. Schedule data have played a role of source for 4D simulation because graphic object in 4D CAD system can find related schedule objects but schedule objects cannot find any objects. Efficient management requires a bi-directional relationship between graphic objects and schedule objects.

Figure 4.2 describes product data model with consideration of product model centered integration in order to integrate graphic elements in CAD system and activity items. Data model is designed using UML (Unified Modeling Language) notation, and consists of six classes of graphic model, building component, building component package where administration is available, smallest unit work, activity, position etc., and each class has peculiar attributes relationship with other classes.

In this research, some major data workflows are described which is modeled in order to develop application for integration design and construction information. These workflows are as following.

- Instancing Graphic Models
- Instancing Building Parts
- Allocating Basic Unit Works
- Instancing Manageable Building Parts Packages
- Grouping Manageable Building Parts Packages
- Instancing Activities

Figure 4.3 is an example of workflows which presents 'Instancing Activities'.

4.5 Extended Product Model Management

The information on the construction is passed through the design phase, the structural engineering phase, the estimation phase, the construction phase, and the maintenance phase. As previous phases' information is used recurrently, design information management is very important for construction project. The product information undergoes three different stages, creation, rearrangement, and application, in the figure during the project's life cycle.

The design and structural information is created by the CAD system and the structural engineering system, respectively, then they are stored in the database and rearranged according to the manageable breakdown structures. Depending on the users' allocation into the various structures, the objects representing the data will have new relationship with one another. The last stage of the product information is the application step. During this step, estimation, scheduling, construction management, and other systems use the database through distribution technologies.

For extended product model management, 'Product Frameworker' is needed. The purpose of 'Product Frameworker' is not only to integrate heterogeneous data, such as architectural and structural engineering information, to calculate quantities of building product model but also to support multiple viewpoints and visualization using an existing CAD system.

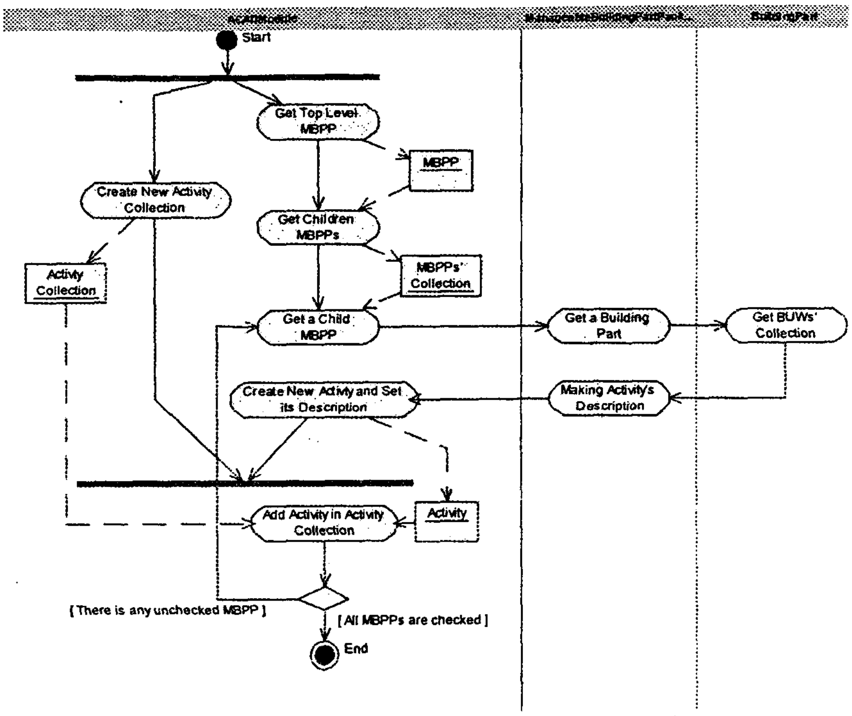

Figure 4.3. An Example of Workflows (Instancing Activities)

5 EVALUATION OF NEW INTEGRATION METHODOLOGY

5.1 Data Creation

Integration tools need various data to be integrated. Design and construction data integration can be achieved under the condition that there are two kinds of data to be integrated and application tools for integrating. Applications utilized to integrate uses conventional data included in computer files. Usage of the existing files lessens burdens additional tasks to make data repeatedly in order to change data format.

Although they use the existing files, it is not that any task is not needed. Workers having responsibility of making data files using related computer programs have intents to satisfy data requirements not by their own electric file, but by printed documents or drawings. Consequently the files have more various data elements and more complex its relationships with them.

5.1.1 Design Data

Though object-based CAD system can offer useful functions in order to produce qualified electric design data, modeling ways and reusability of design data depends on existence of any unified modeling methods. Unified graphic modeling method suggested in this PMCIM offers a means to reuse and utilize the existing electric design data efficiently. This modeling method is a set of rule and guideline made under the considerations for reusability. Table 5.2 shows features compared with other methods of modeling.

PMCIM offer different design data creation method like Table 5.2. Building object models created according to suggested method represent various architectural properties of actual building. Every model have their own behavioral rules and unique properties, for example, where they are, where they are attached in, what object they have, what material they are composed of. These objects are well structured and stored in electric files and can be utilized by other applications such as database.

5.1.2 Construction Schedule Data

Traditionally, construction schedules are made by hand and once at initiation time of project. As scales of projects are larger, schedule items' logical sequences are more complex, so computers aids are inevitable. Schedule management softwares help define complex relationships of activity items and calculate various values, such as durations, floats, and others. They have modules for exporting and importing data from commercial database, such as Microsoft Access, Dbase, Oracle. Even if they use external database, source data have to be created by hand.

Generally, project's construction schedule items are over two or three hundreds and larger projects are more. There are many errors in many activity items typed manually, so these errors induce linked latter errors. GINPro (***G***eneration and ***In***tegration using ***Pro***duct Model) was developed in order to lessen burdens of manual inputs and can produce activities for constructing related building objects successfully. Construction participants can select and delete schedule items according to their necessity.

Table 5.2. Comparisons of Modeling Methods

	Without Unified Method (Conventional CAD System)	Without Unified Method (Object based CAD System)	Using Unified Object-based Graphic Modeling Method
Recognizable Objects	Nothing	Basic Objects (Wall, Window, Stair, Column)	Basic Objects, Finishing Objects
Recognition Factor	Layer	Object Name, Layer	Object Name, Description, Layer
Number of Objects	Nothing	High	Medium (One object can include various material layers.)
File Types	Unstructured	Structured	Structured
Reusability	Low	Medium	High

Through GINPro, PMCIM shows well-modeled design information being reused to generate and propagate latter data seamlessly (see Figure 5.1).

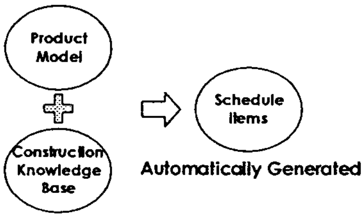

Figure 5.1. Schedule Item Creation Concept

5.2 INTEGRATION FEATURES

In the preliminary research, design data created by traditional CAD system are instantiated by elements' group including many lines, arcs, box, and blocks. As each element of CAD system cannot represent individual building element's property, they have to be grouped and groups' scope is decided according to construction activities' level. For example, deckplates are grouped in each floor and structural steel columns are in each section. Then grouped objects are integrated with activities having name such as 'Deckplate Installation in 3rd Floor', 'Structural Steel Columns Erection in 4th Section' and others

But PMCIM instantiates CAD objects by each building element and integrates these objects to activities. One design item (structural steel column) is integrated with four activity items. When GINPro use MBPP to package some design items, relationship of design and activity items become many-to-many relation.

The traditional integration methodology adopts separate graphic engine display individual graphic elements visually, so separate object converter is needed in order to instantiate design data. As source file including design data is not well structured, it is impossible to back trace what elements are their source data from design objects in integration tools. Activity objects instantiated by object converters have any pointer or reference to source data, therefore traditional methodology's navigable direction is one way.

Table 5.1. Comparisons of Integrating Features

		Traditional Methodology	PMCIM
Design	Instantiation Unit	By Elements' Group	By Each Building Element
	Navigable Direction	One Way	Two Way
	Needs for Tools	Separate Object Converter	Not Necessary
Activity	Instantiation Unit	Lowest Level	Lowest Level
	Navigable Direction	One Way	Two Way
	Data Source	Database	Product Model
Design and Schedule Relationship		One-to-One	Many-to-Many

As object based CAD data are mapped into object as it is in PMCIM and design source file is well-structured, bi-directional navigation among objects is possible. Therefore it is possible to operate CAD elements visually from outer program without separate graphic engine. This way of visual operation lessens development cost for integration tools. For this reason, PMCIM becomes practical alternative. Table 5.1 is comparisons of integration features of traditional methodology and PMCIM suggested by this research.

5.3 FLEXIBILITY OF BREAKDOWN STRUCTURE

Information structure and relationships on construction projects are so complex and inter-influential. So flexibility of information breakdown structure is an important point in construction information management. Although IFC, an international standard of product model, has some features in order to be adopted in construction fields, its structure is not dynamic but static.

Actual construction information has multiple and dynamic relationships, so new computerized method for integration is needed. As original structure of classes of IFC is static and have to be kept as it is, additional classes are needed to integrate with them. Additional classes cannot be included into neutral file format used in order to exchange product model and they are stored into object database.

PMCIM suggests that object oriented databases are used for flexible product data management such as product database developed in this research. Object database can store not only IFC objects but also newly added classes with simple programming codes.

5.4 BUSINESS PATTERNS

Information technology invites changes of business strategies and patterns. PMCIM also bring some changes of business patterns of construction projects as shown in Table 5.1. Architect, drafter, estimator, scheduler, integrate manager become to use different tools and work in unusual ways. Architect and drafter's tools cause, however, cost increase, time and cost save in latter stages' operation and tools. Integrate manager have used specialized integration applications, such as CIFE 4D CAD or Jacobus PlantSpace Series requiring high cost, but changed business can be satisfied with ordinary applications, such as object-based CAD system already used architects worldwide, and commercial DBMS.

Table 5.1. Business Patterns

		Conventional	Changed	Effects
Architect	Tools	Paper, Pencil	Object-based CAD	Cost Increasing
	Op.*	Conceptual Design	Conceptual Design, Modifying	-
Drafter	Tools	Traditional CAD	Object-based CAD	Cost Increasing
	Op.	Drafting	Modeling	Time Saving
Estimator	Tools	Drawings, Spreadsheet	Drawings, Spreadsheet, Object-based Product Model	-
	Op.	Measuring, Quantifying, Modifying	Modifying	Time Saving
Scheduler	Tools	Schedule Mgmt. Apps.	Schedule Mgmt. Apps., Object-based Product Model	-
	Op.	Creating Items, Sequencing, Modifying	Sequencing, Modifying	Time Saving
Integration Manager	Tools	Specialized Integration Applications	Ordinary Application, DBMS	Cost Saving
	Op.	Interrelation Check, Integrating Operation, Data Management	Interrelation Check, Integrating Operation, Data Management	-

Op.*: Operation

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

This research suggests a new approach on integration for design and construction information, 'Product Model Centered Integration Methodology'. This methodology achieves integration by preliminary research on existing methodology using 4D CAD concept, and by development and application of new integration methodology.

This methodology is composed of 'Unified Object-based Graphic Modeling', 'Heterogeneous Product Data Storage', 'Generation and Integration using Product Model', 'Extended Product Model Management'.

Possibility of reusing design information in latter stage depends on the ways of creating CAD model, so modeling guidelines and specifications are suggested. Then prototype system for integration, management, and exchange are presented, using 'Product Frameworker', and 'Product Database' which also supports multiple-viewpoints.

'Product Data Model' is designed, and main data workflows are represented. These can be used for writing programming codes and developing prototype in order to automatically create activity items in actual schedule management system. Through validation processes, 'Product Model Centered Integration Methodology' is suggested as the new approach for integration of design and construction information.

6.2 FURTHER RESEARCH ISSUES

This research mainly focused on practical method for making qualified design information and utilizing it. Research results show that well modeled design information helps to utilize them following phases by managing integrated information, exchanging data using international standards, and creating activity items automatically.

It is recommended that researches on application and utilization of well-modeled design be conducted. Various application of design information can lessen burden of participants in construction projects. Especially, information items created automatically are easy to be integrated, therefore it is necessary that automation of data creation be attempted. After this, if necessary, some items are added and removed manually in order to increase reusing productivity.

6.3 RECOMMENDATIONS

6.3.1 Needs for the Additional Classes

Some standards, such as DXF and IGES have been developed to share the data of the commercial CAD applications. As many classes in IFC have been created to present graphic properties, IFC still contains the characteristics of a graphic standard, too. IFC has the goal to be practical standard not only of the CAD applications but also of all applications in AEC domain. Additional classes about estimation, scheduling, contracts, and CM (Construction Management) have to be developed to keep the balance with the classes about design. Until now, most of the applications having modules for the IFC are the programs on architectural design. More various commercial applications supporting data sharing with IFC in the AEC domain would make IFC a worldwide standard.

6.3.2 File Sharing among the Other Domain Applications

In the process of development, we designed the additional classes to represent the structural engineering information. DIMS can handle not only IFCs but also these additional classes and integrate two kinds of information. This system can store the objects, which do not belong to the IFC, only into the database. However, if IFC were to expand their domain and a system is developed based upon this, it could store all the objects into a neutral file format, thus significantly increasing data sharing. For example, three-dimensional building graphic model created in a CAD system could be exported to the neutral file format based on IFC, then a scheduling program could import the information on the building, create the activities, set the logical sequences and export these data to the same file.

A database could be used efficiently if it used in one organization. In the inter-organization, a database is not adequate as it is difficult to migrate a database from one organization to the other. But a file is easy to move and copy. If various applications would have the functions to import and export files based on IFC, the neutral file format would give the most powerful way.

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요 약

최근 건설 정보 통합 모델에 설계 요소를 반영하는 개념이 발표되고, 4D CAD 시스템을 이용한 정보 통합에 대한 연구들이 수행되었으며, 현재까지 그 활용분야를 넓히고 있다. 하지만, 이러한 형태의 정보통합은 특정 응용 프로그램을 중심으로 이루어지기 때문에 각 조직만의 독특한 내용적 특성을 반영할 수 없으며, 기존의 프로그램과 다른 새로운 프로그램의 도입 및 개발에 따른 유지, 보수 비용을 요구하는 등의 단점이 있다.

본 연구에서는 이러한 문제들을 해결하기 위하여 정보통합을 위한 새로운 접근 방법으로써 '프로덕트 모델 중심의 설계, 시공 정보 통합 방법론'을 제시하고 이에 대한 비교 평가를 위하여 기존의 방법론에 대한 선행 연구를 수행하였다. 이를 위하여 현재 설계, 공정 정보의 통합을 위하여 널리 사용되고 있는 4D CAD 개념을 조사, 분석하였다. 연구 분석 결과 기존의 통합 방법론은 여러가지 장점이 있었지만, 전체 건설사업의 생애주기 중 후반부에 통합이 이루어지기 때문에 정보 활용의 기회가 적으며, 후속단계에서 원시정보의 활용이 미흡하고, 통합 정보의 활용 범위가 상용프로그램이 제공하는 기능으로 제한되고, 3차원 프로덕트 모델에 대한 관리가 곤란하였다.

이러한 단점을 해결하기 위한 설계, 시공 정보의 통합을 위한 새로운 방법론을 제시하였다. 제안된 방법론은 '일관된 객체 기반의 그래픽 모델링', '이질적인 프로덕트 정보들의 저장', '프로덕트 모델을 활용한 정보의 생성, 통합', '확장된 프로덕트 모델의 관리' 등의 4 부분으로 나누어서 제안하였으며, 마지막으로 이들에 대한 활용 개념을 기존의 업무에서의 활용과 새롭게 보충되는 업무에서의 활용으로 나누어서 제안하였다.

6장에서는 본 논문의 전체적인 요약과 후속 연구 주제들과 이를 위한 제안을 하였다. 본 연구를 통해서 특정 응용프로그램 중심의 통합이 아닌 프로덕트 모델 중심의 설계, 시공정보 통합을 위한 새로운 통합 방법론을 제시하였으며, 본 방법론을 통해서 실제로 사용하고 있는 프로그램들을 활용하면서, 각 조직의 환경에 적합한 정보 통합을 통해 건설 생산성 향상을 기대할 수 있게 되었다.

키워드: 프로덕트 모델, 통합, 설계, 시공, 정보, 방법론