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The Research of Integrated Enterprise Modeling Method Based on Workflow Model

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Abstract - *In the research field of enterprise modeling and CIM implementation, many results are achieved in last 20 years, such as CIMOSA, GRAI-GIM, PERA, ARIS and DEM. But difficulties were still encountered when these methods are applied to guide the CIM system design and implementation. In this paper, a new integrated enterprise modeling methodology based on workflow model is proposed. The corresponding system architecture is presented. The integrated modeling environment is described. The and the relationship between the workflow model and views are discussed.*

1. INTRODUCTION

CIM(Computer Integrated Manufacturing), which can improve the competitive ability of the enterprise using information technology, advanced manufacturing technology and modern management method, has become a widely acceptable concept in both academic and industry. The implementation of CIM system is a very complex process, which need the powerful guidance and support of enterprise modeling methodology. With the development of CIM System theory and methodology, many results were achieved in the field of system modeling, analysis and design. Some of them have world-wide reputation, such as CIM-OSA (CIM Open System Architecture), GRAI-GIM (GRAI Integrated Methodology), PERA (Purdue Enterprise Reference Architecture), ARIS (Architecture of Integrated Information System) and DEM (Dynamic Enterprise Modeling).

CIM-OSA provides an open and life-cycle-oriented reference architecture, which is represented as a cube with three axes: Generation of Views, Instantiation of Building Blocks and Derivation of Models. It proposes not only the common structure and modeling language available industry-wide, but also an Integrating Infrastructure that provides a set of generic services aimed at model execution[1]. GRAI (Graph with Results and Activities Interrelated) was proposed by the University of Bordeaux I, France[2]. It is a useful tool for facilitating systematic decision making procedures in manufacturing systems. The main constitution of GRAI model is GRAI grid and GRAI net. GIM is the integrated methodology based on GRAI model, which has established a well structured approach for the modeling analysis and CIM implementation. PERA was proposed by Purdue University, 1992[3]. It considers the entire CIM system as two streams—manufacturing stream and information stream at the conceptual definition stage. And then, it describes the manufacturing, information and human tasks of the system. The main contribution made by PERA is that it describes the human aspect of the integrated system. ARIS was proposed by Prof. A. W. Scheer, 1992[4]. The architecture strives to describe an information system which can support business process from all views and across all phased of development. It includes the Organization, Data, Function and Control view. The control view, which is an essential ARIS component that distinguishes it from other modeling architectures, retains the relationships between different views. DEM provides an architecture for enterprise management. It provides structured modeling tools as well as a set of enterprise reference model. By pre-allocating the existing model block, DEM can significantly reduce the complexity of the system.

The existing major CIM architectures and modeling

methods have different characteristics and advantages. But difficulties were still encountered when they are applied to guide the CIM system design and implementation. The problems can be summarized as follows:

(1) It is difficult to maintain the consistency of the enterprise model. The consistency problems exist not only between different views but also in one view itself.

(2) It is difficult to make the model evolution. One enterprise model normally has several views. The modification in one view is difficult to be transferred consistently to the other views in time.

(3) It is difficult to analysis and optimize the enterprise model. Being short of the tools to support the model's simulation, it is difficult to find the deadlock or bottleneck in the model. On the other hand, it can not support the enterprise BPR (Business Process Re-engineering) and optimization.

(4) There lacks an integrated modeling method and relevant supporting tools. The existing CIM architectures and methodologies are difficult to integrate the different views of the model. The modeling process is seldom well controlled.

Because of these problems, the enterprise model can not meet the demand of the CIM System application.

In this paper, an integrated enterprise modeling method based on workflow model is proposed. By setting up an integrated modeling environment with the support of CORBA and it's ORB service, an integrated modeling and simulation method and associated tools are developed. In our approach, the workflow model is the core model, the organization view, resource view, function view and information view are the company views. Model mapping tools accomplish the transformation between the workflow model and the other views. The whole modeling process is led and controlled by the view navigation module based on Internet/Web technology. Thus, the integration and unification of the workflow model with other views can be achieved. Moreover, it is easier to test the performance of the enterprise business, design and manufacturing process through the simulation of the workflow model, which is supported by a Petri net model run on the backstage.

2. SYSTEM ARCHITECTURE

Based on the requirements we collected from the application enterprise and a review of the current CIM architectures, a new CIM System architecture is proposed as shown in Fig.1. It is also a cube-like architecture with three axes: views, implementation life cycle, and instantiation of building block. The explanation of the features are as follows.

2.1 System views

One model and four views are presented in the new architecture. It is the workflow model—which is the core in the architecture, and organization, resource, function, and information views—which are served as assistant ones. The workflow model is used to describe all the business process in the enterprise, i.e. management processes, product design and developing processes, and manufacturing processes. The workflow model includes the basic activities, the logic relationship between them, the flows in the process (such as material flow, information flow, and capital flow), and functions of the process. Organization view describes the organization units and their relationship. Resource view describes the resources that are needed by the process, such as equipment, material, software, hardware, and so on. Function view describes the functions that are accomplished in the process. And information view includes all the information related to the process, and the characters of the information.

The reason that takes the workflow model as the core model is described as follows. First, it makes the whole modeling process concentrate to the process modeling. As we know, the simulation of the process model could give the valuable information for enterprise BPR. Second, workflow model covers most of the information that are included in the other views. This makes it possible that we can test the consistency of the whole

model by running the workflow model. Third, with the rapid development of the workflow technique, more workflow products are available in the market. It will be great help to implement the enterprise model.

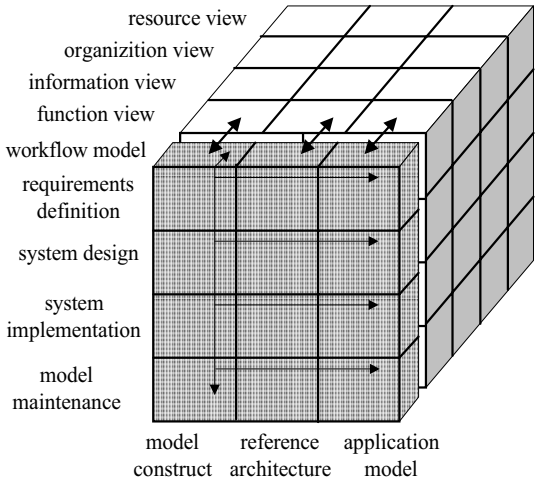

Fig.1 CIM System Architecture

2.2 Implementation life cycle

Different from the architecture of CIM-OSA, we divided the whole implementation life cycle into four stages: requirements definition, system design, system implementation, and model maintenance. Each stage has its own emphasis.

(1) Requirements Definition

During this period, requirements definition model will be built up on the basis of business process survey. It begins with the organization view, simplified resource view, and the workflow model, which consider the organization structure and the main process in the enterprise. Then, the major information needed by function view and information view is retrieved from workflow model through model mapping mechanism. After revise and formalization by associated tools, the function view and information view will be generated.

(2) System Design

In system design period, concepts related to the requirements definition are transferred to information technology interface, for example, enterprise data model, the module and transaction definition, and network topologies. The emphasis is put on the adaptation of the information and resource view. It will also optimize the model from the view point of information technique. The requirements definition and system design are loosely linked. That means the system design can be changed without modifying the requirements definition model. But it does not mean these two stages can be developed in isolation. The content determined in system design period should not conflict with that of the requirements definition period.

(3) System Implementation

In system implementation, the workflow model is transferred to the one that can be understand and operated by the computer. That is to say, the physical link between the original model and the information system is established. Material flow, information flow and capital flow are used to initialize the workflow model. And a backstage Petri net model is introduced to support the operation and simulation of the workflow model.

(4) Model maintenance

We use a series of well formed model document modification files to help the model maintenance. The main work of this stage is to record and maintain the model document.

2.3 Instantiation of Building Block

General model block is suitable to all the enterprise. Enterprise reference architectures contains a set of templates required to describe the model for one kind of manufacturing enterprise. Application model is the specific model to a particular enterprise, which is formed by the general building block and other components according to the relevant reference model.

3. INTEGRATED MODELING AND SIMULATING ENVIRONMENT

In our approach, several views and model exist at the same time in one level. Furthermore, different level has different model. These views and model are so tightly related that one change in one view or model will cause the modification of the others. The use of the traditional series modeling method could not meet the demand for efficient modeling, nor could it make the maintenance of the model easy. So we set up a soft-bus based on

CORBA aimed at providing an integrated modeling and simulating environment. With its ORB service, we can set up the dynamic link between different distributed object. Usually, the link between the application objects is a Client/Server pattern.

With the support of CORBA technique, modeling tool and simulation tool can be integrated into one environment. The output of the modeling tool—enterprise model, will be sent to the simulation tool as the input, as shown in Fig.2. The key technique in accomplishing the integrated modeling and simulating are as follows.

(1) The mapping from the organization view and resource view to the workflow model, and that from the workflow model to the function view and information view. This will be discussed briefly later.

(2) The mapping from the workflow model to Petri net model. Petri net is well suited describing and simulating the dynamic process. We will use the backstage Petri net model to simulate the operation of the workflow model. The Petri net model is not shown to the user. This is why we call it backstage Petri net model. The mapping from the process model to Petri net is already a mature technique. The mapping from the organization and resource part of the workflow to the Petri net still remains open.

(3) Heterogeneous model data transformation based on CORBA. As stated before, different enterprise views, workflow model and Petri net model exist in the modeling process at the same time. This makes the data transformation more complex and difficult. Coincident data formalism is considered as one solution.

4. INTEGRATED MODELING AND SIMULATING PROCESS

Under the supporting of integrated modeling environment, view navigation based on Internet/Web technology is introduced to lead and control the whole modeling process. The modeling process is stated in detail.

First, build up the organization view and simplified resource view. Organization view describes the organization object and the relationship between them. It will provide the role for the process definition and allocate the human resource for the process operation. Resource view describes all the resources relevant to the process. It will provide the manufacturing resource material to process definition and operation. On this basis, the workflow model is built up. The process of building up the workflow model is a process of abstracting the main activities from the business process and organizing them according to their executing logic. At last, based on the obtained workflow model, organization view and resource view, the function view and information view are built up through mapping mechanism. And supplementary statement can be added to the resource view if it is necessary.

View navigation not only guides the modeling process but also controls it. In order to make the model be more flexible as well as be easy to be modified, in our modeling method, it is prescribed that one kind of the

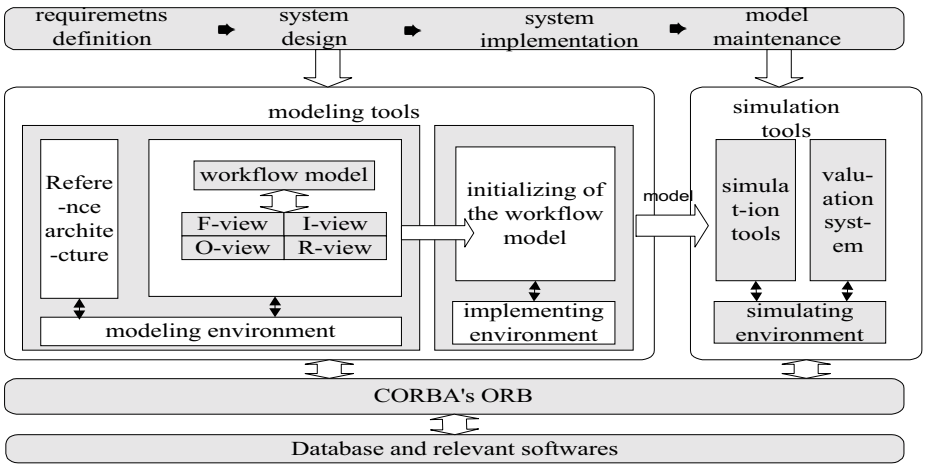

Fig.2 The structure of integrated modeling environment

information can enter the model from only one definite entrance, and can be spread to the whole model by model mapping. That is to say, in the whole modeling process, the information relevant to organization or resource can only enter the model from the organization/resource view; while the information about the process, function and information can only enter the model from the workflow model. For example, during the operating of the workflow model, if a new machine is needed, the workflow modeling tool can not add the machine itself. The only thing it can do is to send a request to the server and wait for the reply. When the request is responded with right information, such as, the machine has been added to the resource view by the resource view modeling tool, then the workflow model can use it now. The modeling process is shown in Fig.3.

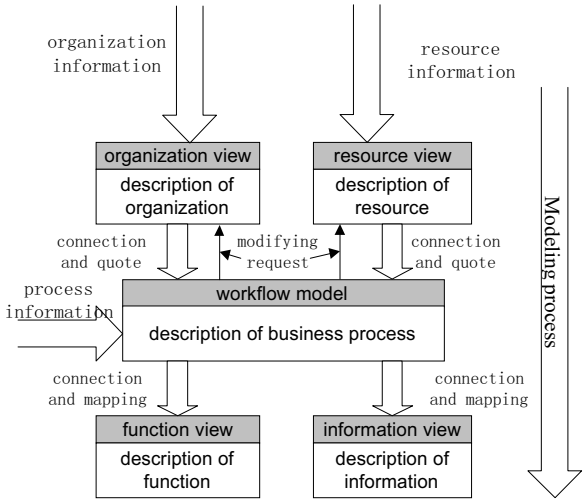

Fig. 3 Modeling process

The output of the modeling tools—enterprise model , will serves as the input to the simulation tools. First, the workflow model is transformed to the Petri net model, including the transformation of the process, role, and resource. Then, Petri net simulation tool will start the running of the Petri net model on the background. The simulating process will be mapped to the workflow interface with animated results. The result of the simulation can be exported directly also. The structure of the simulation tools is shown as Fig. 4.

5. THE RELATIONSHIP BETWEEN THE WORKFLOW MODEL AND THE OTHER VIEWS

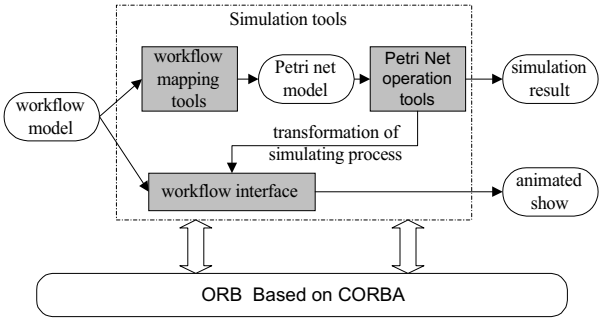

Fig.4 structure of simulation tool

In this part, we discuss the relationship between the workflow model and the organization, resource, function and information view briefly.

The organization view describes the organization object and structure. The organization object includes the organization unit, human and team. The arrangement and relationship between the organization units form the organization structure tree, which describes the structure of the enterprise organization. Team, which is formed temporarily in order for some project and goal, describes the dynamic characteristic of the enterprise organization.

The organization view is tightly connected with the role defined in the workflow model. The role refers to the human or organization unit who carries out the activity. Two kinds of roles are introduced in the model: operator and manager.

The organization view will provide the role for the process definition and allocate the human when the workflow model is operated. All the information about the role comes from the organization view. Once the workflow model occupies some unit from the organization view, it will modify the data (but not the structure) dynamically, and release it after the operation. An organization-activity matrix is produced during the workflow model operating process. The connection and quotation form the mapping between the organization view and the workflow model. In some extent, we can think that the organization view provides the human resource that is needed by the workflow model. Workflow model can not use the units that does not exist in the organization view.

The mapping between the resource view and the

workflow model can be also formed just as the same. The resource view provides the necessary resources for the workflow model definition and operation. Part of the information about the "input" and "output" of the activity comes from the resource view. Once the resource is introduced into the workflow model, resource-activity matrix is built up and is reflected back as the dynamic part to the resource view, for example, the material flow, and the capital flow. The change to some process may cause the important change to the resource view, i.e. the product researching process may cause a new manufacturing equipment be added to the resource view.

All the information for building the function view and information view is included in the workflow model. The processes of building up the function view and information view are the processes of abstracting the relevant information from the workflow model. The goal of abstracting is first to set up the structure of the function and information, then to detach the function and information from the process in order to make the enterprise model be more flexible. As it is known, one function is accomplished by one or several activities. Function view can be treated as the structured combination of the subset of the workflow model. The function view can be built up based on the function-activity matrix and the function part in the workflow model. The information view is closely connected with the information included in input and output of the activity. The information property, such as data name, data structure and control data, forms the static part of the information view. The movement of the information that processed and produced in the executing of the activity forms the dynamic part of the view.

With the clear relationship between the different views and workflow model, we can build up them easily.

6. CONCLUSIONS

As we all know, process modeling is the basis for the process integration, which is considered as the higher level of enterprise integration. In this paper, an integrated enterprise modeling method based on workflow model is proposed. The workflow model is considered as the core model. Model mapping functions fulfil the transformation between the different views and the workflow model. By setting up an integrated modeling environment we can carry out the integrated modeling and simulation process. The whole modeling process is led and controlled by the view navigation which is the mechanism that guides and controls the modeling step. In fact, the concept of cooperating modeling is shown in the methodology.

The advantage of the approach is obvious. First, it integrates the different views of the model and the workflow model. As we know, workflow model can serve as the executable model. The integration connects the modeling process and running process more tightly. And it is easier to modify the model with the help of model mapping mechanism. Second, the modeling tool and simulation tool is integrated. The simulation tool gives the consistency inspection and performance test of the model. Third, with the help of the CORBA technique, the efficiency of the modeling process could be improved.

As a result, the whole model would be more flexible. And flexibility is the key characteristic of the future enterprise models that can meet the demand of the rapid changing market. Moreover, the integrated modeling process with views navigation presents a new modeling concept, which changes the traditional series modeling process to a more centralized, well controlled and cooperated modeling process.

Although our approach is challenge, some key problems still need further research. For example, how to use the CORBA technique to form the integrated modeling environment; how to make the efficient and full use of the view navigation based on Internet/Web; and how to transfer the organization and resource part of the workflow model to Petri net model. We will continue our research to find the satisfying solutions to these problems.

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