

# Research of a Virtual Information System Supporting Dynamic Collaboration

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**Abstract** - *In the rapidly changing global competitive environment, dynamic collaborating among companies is required to bring a complementary set of competencies to address new market opportunity. To support this new relationship, an Agile Manufacturing Information System (AMIS) assisting the virtual enterprise to manage and control information flow among collaborating partners is described in this paper. Based on the analysis of the virtual information system requirements, the architecture of AMIS is presented by using distributed workflow and agent technology. And the functions, features and execution scheme of this system are discussed in detail.*

## INTRODUCTION

In the rapidly changing global competitive environment, dynamic collaborating among companies is required to enable people and processes of the partners be combined timely and cost-effectively in order to bring a complementary set of competencies to address new market opportunity. This relationship maximizes the combined competencies to achieve each company's strategic goals and provide solutions to meet their customers' needs [1]. In this circumstance, the traditional information management system will not suit to because the relationship among partners is not only cooperative but also competitive thus the requirements of the new information management system are different from the old one. To address this problem, we propose a virtual information system for dynamic collaboration. In our system, there is no preset relationship between partners. When a market opportunity is found, a virtual enterprise may emerge through dynamic collaboration. The partners of the enterprise may change even after the enterprise has been created.

The remainder of the paper is organized as follows. In section 1, we analysis the important AMIS requirements. Section 2 is devoted to the key technology of designing

AMIS. An organization structure and a system model are presented in section 3. The features and the execution scheme of this model are detailed in section 4. Finally, we conclude with directions for future work in section 5.

## 1. ANALYSIS OF AN VIRTUAL INFORMATION SYSTEM REQUIREMENTS

Dynamic collaboration is product-oriented which is created with the beginning of the product's life-cycle and dissolved while the market opportunity disappeared by the organizer. Different from traditional enterprise where organization structure is strictly hierarchical, a dynamic collaborative enterprise is not only hierarchical, but also plat. The organizer of the virtual enterprise has the responsibility and obligation to manage the collaborative enterprise and all of the other partners must be controlled by the organizer. On the other hand, each partner has sufficient independence and autonomy that can manage its own company with individual business goals and can have different management mode and organization method. In a virtual enterprise, it is needed to exchange product data and knowledge frequently and dynamically which are segmented and distributed across the distributed sites of partners. Information sharing between distributed databases and providing consistent information to distributed partners

- Responsiveness: agents should perceive their environment and respond in a timely fashion to changes that occur in it.
- Proactiveness: as well as responding to their environment, agents should exhibit goal-directed behavior by taking the initiative.

According to these properties, software agents do not only empower individuals but also being used to help whole organizations work more effectively. A virtual enterprise is collaborated by some individual companies which are autonomy and cooperated. Therefore, it is a solution to represent each partner by a software agent.

### 2.3 Workflow Technology

There are various business processes in an enterprise. As defined by WFMC, workflow is “the computerized facilitation or automation of a business process, in whole or part”[4]. A workflow consists of a set of activities, their execution sequences, the startup and stop conditions of the process, and the description of each activity such as the executor, associated application and data, and etc. The workflow management system “completely defines, manages and executes “workflows” through the execution of software whose order of execution is driven by a computer representation of the workflow logic”[4]. In a virtual enterprise, it is necessary and useful to use workflow management system to manage each partner’s individual task and cooperate with others in specific protocols to complete the collaborative project.

## 3. ARCHITECTURE OF AMIS

### 3.1 AVE Organization Structure

The organization structure of a virtual enterprise has been separated into two level: the top one is collaborative enterprise management level and the bottom one is partner level, as depicted in Fig 1. The management level is in charge of organizing, sustaining and dissolving the AVE and the partner level completes the product developing task. The enterprise which the organizer is located can span two level that acts as a organizer and a partner.

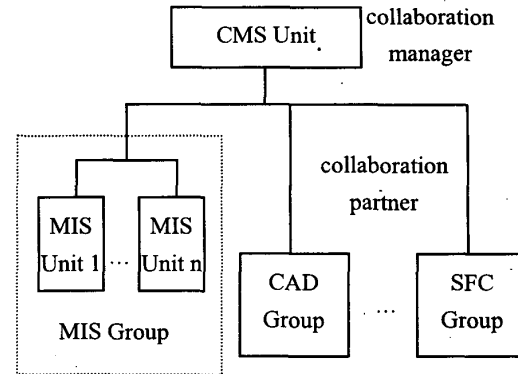


Fig. 1 AVE architecture

### 3.2 AMIS Architecture

As shown in Fig 2, AMIS is composed of several autonomous AMIS units which cooperate over network. While the core applications are different, AMIS units have different functions. For example, unit A has the responsibility to assist partner A to create, sustain and dissolve the collaboration because the Collaboration Management System (CMS) is running in it. And unit B is devoted to design products with Computer Aided Design (CAD) application.

### 3.3 AMIS Unit Characteristics

AMIS unit is designed to be an intelligent software agent which is the basic element of AMIS. As shown in Figure 2, each AMIS unit consists of seven modules: an server, an client, a workflow management system, a core application, a database manage system, a local database and a knowledge base. The core application could be CMS, MIS, CAD, SFC, etc. The unit communicates with others through the server and the client. With the server, the unit makes the local data accessible to the other units. And with the client, the unit can access the other units' data. The workflow management system is responsible for converting a unit query to a unit workflow. The structure information about the system and the disassemble rules of query are all stored in the knowledge base. The data created by the local application is stored in the local database.

To enhance the autonomous, AMIS units should satisfy

are essential to support agile product development. However, each company can compete with and/or partner with other organizations within and without the virtual enterprise, so that it is necessary to provide procedures to ensure individual partner information securities. In summary, AMIS must possess the following functionality [2].

- 1) Use open and adaptive architecture to support rapidly and dynamically reconfiguration of the partners: agile enterprise is virtual and product oriented; they are formed dynamically and may not exist after the product's development life-time. AMIS must provide a flexible and open architecture to host partners dynamically.
- 2) Provide a tool to manage the virtual enterprise for the organizer: agile enterprise is dynamic, thus creation, sustaining and dissolution operations must be provided in AMIS.
- 3) Reflect partner individual policies and retain partner autonomy: agile enterprise consists of multiple partner policy sets; collaboration should not penalize the partner's individual policies.
- 4) Accommodate partner heterogeneity: agile enterprise is usually composed of variant computer hardware, software platforms and applications. To achieve partner information sharing, AMIS must accommodate partner's heterogeneity.
- 5) Support the information inter-operation across partners: product data and knowledge are segmented and distributed across the distributed sites of partners. AMIS should support partners to access these distributed databases frequently and dynamically.
- 6) Provide consistent information to distributed partners: inconsistent data at different partner will lead to manufacturing faults. It is up to the AMIS to make sure that every data partner accessed has the same version.
- 7) Insure the necessary security of partners' data: partners will collaborate to address a market

opportunity and compete to get another opportunity. To Insure the inter data not to be accessed by the other enterprise, some necessary procedures must be provided in AMIS.

## 2. BASIC TECHNOLOGIES

Modern information technologies have been used to form virtual enterprises which rapidly respond to the changing market demands. This section is devoted to introduce three key technologies which are used to manage and control the information flow among autonomic partners.

### 2.1 Internet Technology and its Relative Services

Cooperating over network will become the main working method in a virtual enterprise. Heterogeneity in computer hardware, software platform and application is shielded by the Internet with its TCP/IP protocol sets. And based on the Internet, some new WEB technologies, such as CGI, WEB Request Broker (WRB), ActiveX Controls and JAVA Applet, have been developed which can support real-time data exchange over the Internet. Accordingly, a lot of enterprises are using Intranet as a major information and communication tool for their employees which is the physical foundation of dynamic collaboration.

### 2.2 Agent Technology

An agent is "a self-contained program capable of controlling its own decision making and acting, based on its perception of its environment, in pursuit of one or more objectives"[3]. By an agent, a system has the following attributes:

- **Autonomy:** agents should be able to perform most of their tasks without the direct intervention of humans or other agents, and they should have a degree of control over their own actions and their own internal state.
- **Social ability:** agents should be able to interact, when they deem appropriate, with other software agents and humans to complete their tasks, and to help others with their activities where appropriate.

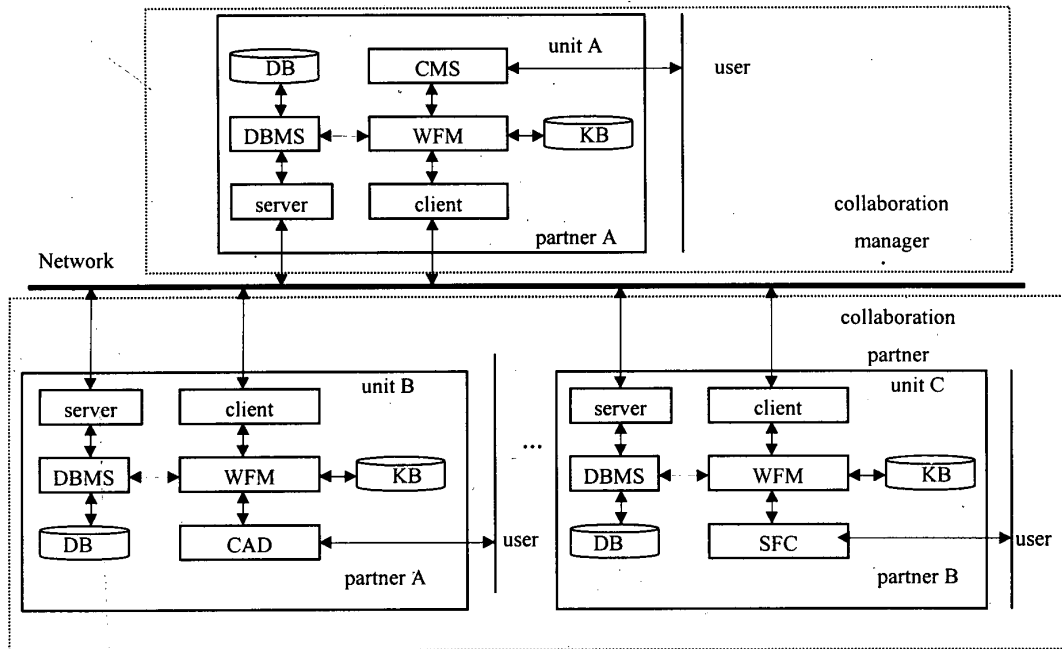


Fig. 2 AMIS Architecture

the following demands:

- the operations of connecting and disconnecting with AMIS are completed by themselves;
- the couple between two AMIS units is loosest;
- according to the knowledge in the knowledge base, the workflow management system can transfer a query into a workflow and combine the results of the sub-queries automatically;
- the data is refreshed by the unit which the data belongs to.

#### 4. FUNCTIONS, FEATURES AND EXECUTION SCHEMES OF AMIS

AMIS assists organizer to create, sustain and dissolve a virtual enterprise. It has the following features:

- One and only one CMS unit could be contained in AMIS.
- With one or more units, a partner can play one or more roles in the collaboration. For example, the company with the CMS unit may run the CAD unit at the same time.

- The similar function can be processed in several partners at the same time. For example, two CAD units are processed individually in partner A and partner B. With the cooperating of these two units, the CAD function is perfectly performed.
- With the support of the CMS, it is available to create, sustain and dissolve a virtual enterprise in AMIS.

At the various period of the collaboration's life-cycle, the architecture and the execution scheme of AMIS are different.

##### 4.1 the Creation of the Collaboration

When a market opportunity is found by a company, AMIS is established with only CMS unit performed in it. At that time, the AMIS is devoted to the following tasks: analyses and evaluation of the market opportunity, analyses and evaluation of the difference between the capacity the collaboration already has and the capacity needed to address the market opportunity, and the confirmation of the aim. The message of creating a collaboration is broadcast in the Internet by the CMS unit. According to the feedback, the CMS unit selects

partners. When a company is invited to join the collaboration, the CMS unit creates a temporal AMIS structure information and sends it to the new unit. Before connecting to the AMIS, the new unit has been established by the new partner. This autonomous unit configures its local information and connects to the Internet. When the new unit received the AMIS structure information and the "join" command from the CMS unit, it refreshes its system structure database and returns a confirmation. Then CMS unit refreshes its system structure database and sends the data to the other units of AMIS to refresh their database. After all of these operations have been finished, one new unit is added into the AMIS.

#### 4.2 the Maintenance of the Collaboration

When a virtual enterprise has been established, there are two tasks needed to be completed by AMIS. The first is to control and manage the design and manufacturing information. The second is to support the dynamic refreshment of system structure.

By the cooperation of the function units in the AMIS, the first work has been implemented. However, the production data and knowledge are stored in the local database of the partner companies. It is needed to exchange the production information among the partners frequently. So the distributed work-flow execution scheme and data exchange scheme should be specified to insure the consistency and the security of the data. The "dynamic two-phase-commit protocol" and "partner data ownership protocol" described in [2] is one of the solutions.

During the execution of the AMIS, CMS is in charge of monitoring the status of the other units and controlling the adding, removing and modifying of the function units. The process of adding a unit is similar to the process of creating collaboration. When an unit wants to be removed from AMIS, CMS sends the "dissolve" command to the unit. After the unit received the command, it sends the confirmation back to the CMS. Then the unit modifies the system structure in its local database to prevent the data to be access illegally. When the CMS received the confirmation, it modifies its

system structure database and sends the message to the other units to refresh their databases. Sometimes, the function of a unit is changed. For example, product computer aided design is originally completed by one CAD unit. Now, it is changed to be completed by two CAD units. In this case, CMS sends the "refresh" command and the new system structure to all units Each unit reconfigures itself to adapt the change of the AMIS.

#### 4.3 the Dissolution of the Collaboration

When the collaboration is dissolved, CMS sends the "dissolve" command to all of the units. After received the confirmation from the other units, CMS unit ends its work. When the other unit received the "dissolve" command and sent the confirmation back, the unit modifies the system structure in its local database to prevent the data to be access illegally.

### 5. CONCLUSIONS

Based on the analysis of the virtual information system requirements, an Agile Manufacturing Information System (AMIS) is presented to support creating, sustaining and dissolving of a virtual enterprise. In our system, partners can join in, stay, or leave the collaboration. The organization structure, system model, system features and execution scheme are detailed in this paper. Further work should be accomplished in system development such as implementing a prototype system.

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