An Integrated Activity Driven Control System in CIMS

Zhu yunlong  Xue jingsong  Li hongxin Wang Zhi
Shenyang Institute of Automation,
Chinese Academy of Sciences, China, 110015

Abstract: CIMS is a high sophisticated system that involves all of activities including engineering design and production and integrates them together. In the course of implementing CIMS, only when the integration of information and function or organization has been completed can the optimal goal of the system be achieved. This paper analyses CIMS project in Shenyang Blower Works, present a new approach to Integrated Activity Driven Control System (IACOs) that is responsible for managing and controlling all of activities throughout CIMS. The framework of IACOs is proposed and its function is introduced. Meanwhile, relative database, rule sets and control strategies are designed.

Keywords: CIMS, Workflow, Activity Integration, Blackboard

1. Introduction

With the advanced manufacturing technological popularizing in manufacturing industries, worldwide competition is becoming increasingly serious and traditional manufacturing enterprises are facing new challenges and opportunities. In order to share the market, the significant strategy to obtain competitive predominance is to improve product quality, to reduce lead-time while continuously to be innovative to adapt to changing demands in the market. Under this situation, CIMS emerges and develops rapidly as a new technology. It is very useful to meet these requirements. At the present, CIM technologies permeate though industries and have branched out in many directions.

Although the evidence is largely noticeable, it appears that CIMS is not generally performed well in manufacturing industries in that CIMS design is carried out only emphasizing on the information integration without considering process integration fully. In the implementation of CIMS, information integration is a fundamental stone, which have each sub-system share information. Although during the process operation of CIMS, various occasions may happen at any time. How to effectively manage all of activities within/among sub-systems and to have them executed smoothly is an essential problem and must be solved immediately. Only when the integration of information and process or organization is completed, can the optimal goal be achieved.

This paper presents a new approach to Integrated Activity Driven Control system (IACOs) that is designed to control and trigger all of activities in CIMS so as to make them operated successfully and to implement process integration. In the meanwhile, IACOs monitors production activities, provides its accurate status information and decision results for enterprise policymakers as well as CIMS system administrators. The structure of this paper is as follows: First, to overview SB-CIMS project and simply introduce IACOs function. Then, to give IACOs architecture and the relationship between components of it. Third, to explain the mechanism and control strategy. Finally, give a conclusion.

2. Overview SB-CIMS project and introduce IACOs function

CIMS project in Shenyang Blower Works (SB-CIMS) consists of three applications sub-systems and a Network & Database sub-system. The application sub-systems include PADIS (Production and Decision Information System), EDS (Engineering Design System, i.e. CAD/CAPP/CAM) and SAs (Shop Automation System). SB-CIMS involves in all of processes throughout the enterprise, including engineering design, inventory control, cost control, production planning, product cost, sales order management, performance measurement, material requirement planning, capacity planning, purchasing planning and shop floor control etc. These processes consist of various activities. Since 1989, SBW has become to carry out CIMS project. In the end of 1995, an

---

1 This project is supported by 863 high-tech program (S11-944-007) and NSFC(69884005, 59990470)
integrated computer information system was fundamentally established and all of sub-systems can share information fully. The configuration of the whole system consists of a mainframe (IBM4381), ninety terminals, AS/400, RS/6000 and PS/2. The operation system includes MVS, Win NT, OS/2, Win 95 etc., and the DBMS embraces DB2, DB22 etc.. In order to improve the ability of sharing information, SB-CIMS builds up three local databases relating to three application sub-systems and a global database. The successful implementation of SB-CIMS project has raised production efficiency enormously and improved the level of management.

In the preliminary stage of implementing CIMS project, the federal design group focuses on information integration, overlooks the process integration. Three application sub-systems are designed and developed by function, not by process.

In 1991, the federal design group comes to realize that there are various sorts of activities in CIMS, which weave together, proceeding in series or in parallel. Once a task, which must be completed in special time, is delayed, relevant activities involved in the task will not be operated and completed by scheduled time. In that case, actors who participate in these activities will be eager to know where the crucial problem is, when and how to do the task. If the task involves in three application sub-systems, more serious the problem is.

From process perspective, a task consists of all of activities. The completion of a task means its relative process starts and ends, i.e. all of activities in the process are accomplished. Only when these activities are managed effectively can the ability of process integration be enhanced. However, there is no such function in SB-CIMS, i.e., each sub-system only shares information and operates independently. In that case, an integrated activity driven control system that navigates and controls all of activities in CIMS is required. The role of IACOs in SB-CIMS is displayed in fig.1.

Generally, IACOs monitors and tracks all of activities existed among or within sub-systems, collects its status information, then manages and triggers these activities. From function perspective, IACOs should consist of two parts:

The first is to collect real-time state information of each activity. It includes three types of information, namely:

- Activity current state: recording whether the activity is early, delayed, processing, suspend or completed in time, and when these activities will be operated.
- Report of each complete activity: to record the actual starting and ending time of each activity
- Progress of activity: to record the progress of each activity such as when the activity is operated, when it will be finished, and how many tasks is waiting for processing, etc.

The second is to make decision and steer these activities. The function is as follows:

- To classify activities into four types, namely:
  - complete activities on schedule
  - early/tardy activities
  - executable activities
  - unexecutable activities
- To analyze which activity will be affected if some activities are delayed or ahead of schedule and make a decision

First, IACOs analyses whether the precondition that each activity to be operated is met or not, how many activities are delayed or ahead of schedule and whose activities will be affected. Then, to reschedule these activities and generate a result. The result includes control information and alarming message.

- To send some message to associated system and steer them

IACOs will send corresponding sub-systems the reasoning results. These instructions will navigate all of activities executed in order. Thus, IACOs can guide each sub-system to operate smoothly in time.

Additionally, IACOs also offers historical and real-time views of information and trend charts.

3. The Architecture of IACOs

The architecture of IACOs is composed of several components as follows (see fig. 2):

1) Task Decomposer: it consists of description of rule set and activity definition model. In description of rule set, the precondition of each type of activity is defined. Activity definition model defines each task class is composed of what types of activities. Thus, when an instantiated task is submitted to Task Decomposer, decomposer will easily divide it into concrete and dependent activities according to rule
2) Communicator: It delivers reasoning results generated by Reasoning Machines to relevant nodes to steer all of activities. In the meanwhile, it also receives activity progress and task requisition from each node.

3) Activity State of Administrator: It mainly manages activity states, such as whether these activities have completed or are in progress, how many requested tasks there are. In the meanwhile, the administrator also collects production index and production progress from three LDBs (Local Database) and a GDB (Global Database). The four databases store a mass of comprehensive and accurate information that includes product design progress on the engineering side and production progress on the manufacturing side as well as task planning generated by each sub-system respectively.

4) Acquisition of Knowledge: It extracts main information from three LDBs and a GDB. The information includes schedule each activity and role/organization who will process it.

5) Data Structure of Blackboard: It creates a dynamical database and provides Reasoning Machine with associated data.

6) Reasoning Machine: It is the core of IACOs. In IACOs, each node will transfer activity states to Activity State of Administrator through Communicator. Reasoning Machine will reschedule these activities according to activity states, resources and relevant knowledge provided by Acquisition of Knowledge and Data Structure of Blackboard. In Reasoning Machine, there are two lists of table, namely a schedulable queue and an executable queue. Because of enormous tasks or activities in schedulable queue, the conflict of resource requirement emerges, these tasks/activities need to be rescheduled and optimized, and activities favorable for execution are selected out and put into executable queues waiting for assignment.

7) Display and Interface: It explains what operators inquire about and display relevant results.

4 The Mechanism of IACOs
4.1 Database designing of IACOs
4.1.1 Build activity classes

For effective management and control system running, the necessary division and recombination of activities in accordance with business rules of the enterprise is needed. There are various sorts of activities in sub-systems. Some only exist in one sub-system, others are involved in several sub-systems. We classify types of activities into local activity class and global activity class.

- to create local activity classes

If the activity exists only in a sub-system, it will be treated as a local activity class. For instance, engineering design is composed of three activities, i.e. CAD, CAPP and CAM. Because these activities don’t involve in other sub-systems, we define the three activities as local activity classes.

In fact, an activity can be divided into many sub-activities according to practical requirement. For instance, we consider CAD as an activity, but we also can divide it into three activities, such as designing solution, drawing and document generating.

- to create global activity class

If an activity in local activity classes has information interchanged with other sub-systems, this kind of activities should be selected out and considered as a global activity class.

When a concrete task is requested or a user decides to inquire about the progress of it, the task will be automatically divided into several activities according to the activity classes. The finer the granularity of an activity is, the more accurate and comprehensive its information is and the more difficult to manage it.
The object of activity class is as follows:
<meta_activity>:: = <task_id, task_type, activity, role>;
<Activity> ::= = <activity_id, name, type>;
<Role> ::= = <role_id, name, org_entity>;

4.1.2 Set up rule set of each activity class

IACOs create a comprehensive and accurate database of activity states that describe, instruct, verify and record what will happen at every step of activities, including before, during and after events for each activity. From logical perspective, it needs to describe the precondition of each activity class.

As activity classes are hierarchical, process rules are also hierarchical accordingly. In other words, local rule sets are created for respective local activity classes, and global rule sets are created for global activity classes. The principle for creating process rules shows that the fine extent of dividing task classes of will directly affect the description granularity of process rules. It will also affect control level of the operation of system because each process rule is actually related to each activity class.

The representation of rules is described as follows:
<rule_activity>:: = <activity_id, pre_condition, produced_data>;
<pre_condition>:: = <activity_idx, data_name, data_path, data_type>;
<produced_data>:: = <activity_id, data_table>;
The object model of activity is referred to figure 3.

According to the object model of activity, the operation chain of each task class is easily formed and the operation logical graph of the entire CIMS is emerged. It manipulates the production and business activities of the enterprise and manipulates the operation of the system.

4.1.3 Set up activity progress of database

The basis and the precondition of IACOs are to monitor and to master each activity status. The complete extent of activity states in progress library will directly affect the reliability and efficiency of IACOs. Therefore, progress library of activities must be created, and each activity progress at every stage must be truly and effectively stored in it.

The structure of activity progress is as follows:
Activity_progress_table {
    Activity_class_id, /* class identifier */
    activity_id, /* identifier */
    start_time, /* when it will start */
    end_time, /* when it will end */
    message, /* what information will be produced */
}

p_stime, /* the actual starting time of processing */
p_etime, /* the actual ending time */
a_status /* activity status: 0-completed; 1-processing;
2-unprocessing; -1—suspend .... */

Fig.3 The Object Model of Activity

In fact, there are many tables to record main information about activity progress of activity; we do not illustrate it here.

4.2 Control Strategy

In IACOs, two types of trigger are defined and established, they are event trigger and time trigger. They exist in CIMS and affect the operation of activities together. Here, an event is defined as an independent activity such as designing a product or assigning a contract, etc. In Shenyang Blower Works, production pattern is small batches, so we consider a contract or a type of product as a parent event. IACOs will track and control the parent event progress throughout SB-CIMS and guide all of child events(activities) involved in the parent event. Simultaneously, in the process of guiding activities, each activity in SB-CIMS will be timely and is not on executive at any time. It means there are time trigger in CIMS. Time trigger will also conduct these activities by each activity of planning time. If the activity falls below the threshold of processing time, IACOs will prompt it. Thus, the whole operation of CIMS will be managed and controlled throughout the two types of trigger.

4.3 The Mechanism of IACOs

The core of the IACOs is Reasoning Machine. It activates Task Decomposer, Communicator, Activity State Administration, Acquisition of Knowledge and Data Structure of Blackboard, of which the Communicator monitors activity states at any time. When a node issues an
activity request, Communicator will transfer it to Reasoning Machine. Then, it judges which task class the requested task belongs to and starts Activity State of Administrator. In the meanwhile, it also activates Task Decomposer to divide the task into activities and put it in activity progress of database. The Reasoning Machine produces schedulable queues using rules. After that, Reasoning Machine optimizes the schedulable queues and ultimately generates executable queues according to activity progress and relevant knowledge. In the course of processing it, new knowledge resource is produced by which the rule sets are modified and used as dynamic rules to schedule the activities again. The Communicator monitors activity requisition and operation situation of correspondent nodes at any instant and feedback to Activity Progress of Administrator for unified maintenance. The whole operating process of the control system progresses accordingly, so the effective management and control of the entire system can be achieved.

5. Conclusion
IACOs has been developed under Windows NT. It has the ability to collect real-time data and steer all of activities operated smoothly. It also offers historical and realtime views of information and creates trend charts. Implementing IACOs not only information integration has been achieved, but also has process integration achieved. It strongly supports the overall implementation of CIMS in next stage.

【References】