# Research of Modeling in Complex Manufacturing-process-oriented Visual Production

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**Abstract.** The text, aiming at equipment status data and processing craft data, puts forward a visual modeling method, SOA architecture, to provide an integrated management method for real-time collecting, monitoring and warning. Consequently, it helps production personnel freed of large quantity of handwork, such as collecting and statistics analysis etc., and effectively avoid misreading or misjudgment arising from individual subjective judgment, which is beneficial to product efficiency and cost reduction. Finally, the text states reasonability and expansion capability of application case and method of proof.

## Introduction

With higher and higher requirement on product quality, the customer puts forward higher requirement on management of equipment state parameter and machining parameter. Due to lack of effective ability of automatic collecting and integrating, many enterprises adopt method of manual collecting relevant data in machining segment and inputting it in relevant operation system. However, enormous data volume will cause high labor intensity, low efficiency and wrong data or incomplete dirty data. Moreover, long-time manual statistic will result in misjudgment or not timely detection in the process of identifying equipment failure and product quality. Therefore, it is hard to ensure product quality under the course of abnormal equipment operation.

In case of lacking in a valid and integrated unified platform for data collecting, statistics monitoring and abstract warning, the company may have no effective countermeasure on mass data collecting and monitoring, which will result in lag in every segment. Therefore, it is hard to discover and solve the problem timely in early stage of equipment failure or when there is anomaly trend in product quality. Consequently, the enterprise's intangible production cost is greatly increased.

## Visual Plant Model

As shown in figure 1, visual modeling is mainly to realize configurability of MES system. The part will describe production factors, like production distribution, technological process and materials restraint etc.; system supporting service mainly relies on tasks of monitoring layer for modeling information completing process, such as data collecting, production event handling, event releasing and subscribing, resource coordination and data base access etc., which supports the top-layer application (including dispatching function); application packages are models concentrating on customized development of process management application, which, generally aiming at the enterprises' practical demands, can finish particular management functions with comprehensive utilization of modeling configurability and basic service supporting.

 

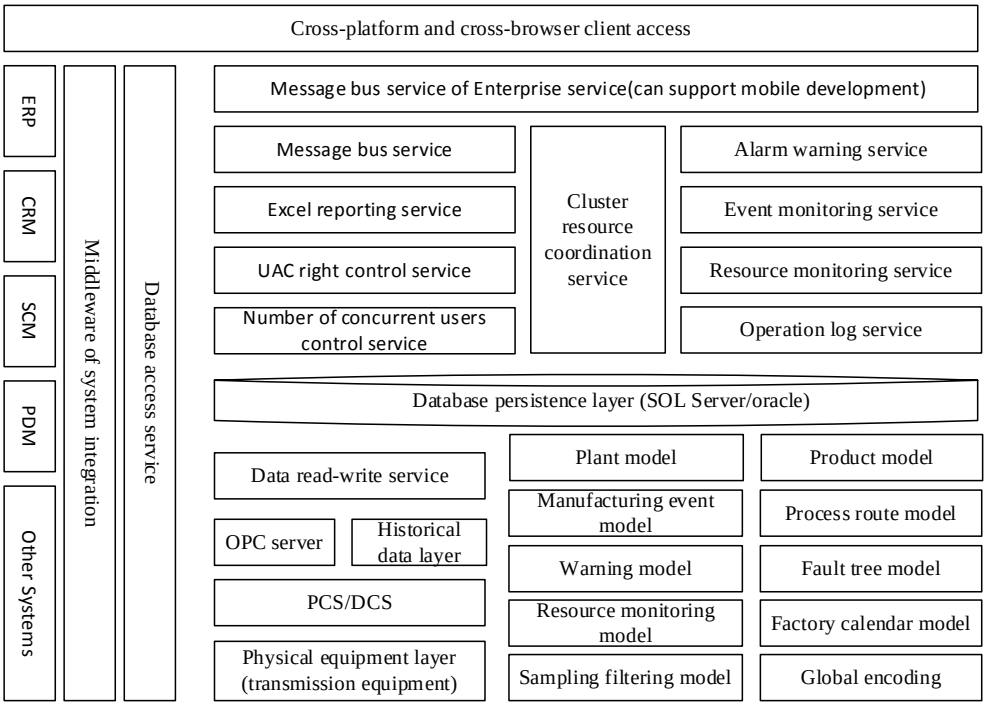


Fig. 1. Overall architecture

For visual plant model, the way of visual graphics is used to develop group's organization chart and departments' physic layout via association and incidence relation between dynamic configuration pixels, visual plant model, so as to build a visual and configurable digitalized plant model. This model will abstract three basic semantic meta from manufacturing-related organization framework, namely group, branch and department, and establish an organization structure model for group-branch structure through basic connected relations between configurations; abstract three basic semantic meta from physical layout related to plant's practical production, namely manufacturing area, manufacturing location and processing equipment, and establish physical layout model and their physical connected relations through configuring and-or-invert ternary relation; abstract collecting variable element from bottom-layer data collecting and controlling, and realize both-way communication between bottom-layer physical equipment and equipment collecting monitoring model through data source and OPC communication protocol.

Organization structure model: describing essential information of group, branch and department, as well as logical relationship between them; there is one and only one group; branch is subset element of group, which can be one or multiple; department is subset element of branch, which can be one or multiples. It includes any one or more of manufacturing workshop, energy supplying workshop and quality inspection department.

Physical layout model: It describes physical connected relations and materials flow direction of equipment in manufacturing workshop; every workshop is divided into many manufacturing areas in accordance with their own craft process. There must be distinct boundary between each area, without overlapping; every manufacturing area is divided into many manufacturing locations in accordance with craft process. There must be distinct boundary between each location, without overlapping; different kinds of manufacturing equipment will be located in each manufacturing location. Different manufacturing areas will be connected via connection of manufacturing equipment.

Equipment model: describing monomer information of manufacturing equipment, including name, coding and variables of collecting monitoring.

Data collecting model: describing every manufacturing equipment's collected data source, collecting method and server information of data source; therein, collected data source including manual input and automatic collecting; collecting method including collecting based on event, collecting based on cycle and collecting based on count; under mode of automatic collecting, server information of data source including IP address, port, user name and access password of data

source;

Equipment name: Equipment one
Equipment coding: GD0102
Equipment type: GDBZJ
Equipment capacity: JGCD01

Equipment state


Whether the production event is collocated? Yes
Whether the warning is collocated? Yes
Whether the resource monitoring is collocated? No
Whether the change is collocated? Yes

| Variable name | Collecting method | Collecting protocol | Server |
|---|---|---|---|
| Cabinet temperature | Based on time | OPC | 192.168.1.10 |
| Electrical machine current | Based on event | SEMI | 192.168.1.20 |
| Gas pressure | Based on count | OPC | 192.168.1.30 |

Fig. 2. Equipment model figure

Warning model: describing warning rule and notification method corresponding to each manufacturing equipment.

Releasing model: it is used to notify the user in case of warning model triggered.

**Event Model and Backstage Service**

Event model is used to describe specific equipment's manufacturing activity incurred, processing mode, conditions for triggering event involved and method to handle it.

It is to set up essential attributes of event detection variable, including data source, communication protocol, collecting method and collecting amendment rule etc. Including, data source mainly includes OPC server, SEMI server and manual input; communication protocol mainly includes OPC protocol and SEMI protocol; collecting method mainly includes periodical collecting based on time and collecting based on event; collecting amending rule mainly includes stored procedure and dynamic chained library, which is used to amend physical deviation arising from sensor. For variables collected automatically, variable corresponding to label name of data source is configured; for collecting based on periodicity, period is configured; for collecting based on cycle, event name is configured. Finally, unit name corresponding to variable collecting value is configured.

There are many modes of triggering event, including event triggering based on detection information and triggering based on parameter of detecting equipment etc; after triggering, it is required to handle the event in accordance with specific logic and release the result on event subscription terminal;

For backstage service, distributed server cluster is used to realize collecting resource coordination, OPC protocol read-write, warning monitoring service, warning push service and message service etc. For specific expression:

A. Resource coordination service:

In case of request sent from the client, the system will uniformly handle the data uploaded in batch according to task type and service priority. Firstly, it is required to judge service required for data handling; then calculate capacity of server where such service located and allocate corresponding server to perform the task, so as to ensure instantaneity of task response and feedback.

B. OPC protocol read-write service:

Encapsulating interface function based on OPC specification into Web Service to help heterogeneous system conduct read-write operation on practical historical database in uniform access method and realize collection and controlling of original data of equipment state parameter.

C. Warning monitoring service:

The service, based on warning rule specified in warning model, is to monitor whether the variable satisfy warning condition. If so, warning information shall be encapsulated into corresponding XML in accordance with warning subscription model, and transmitted to

corresponding client notification or message notification service.

D. Warning push service:

When the client receives warning information send by warning monitoring service, it is required to parse the XML document, trigger audible and visual warning device corresponding to the client and inform relevant personnel, as well as display the warning information on working station.

E. Short message service:

In case of receiving warning information sent by warning monitoring service, it is required to parse the XML document and send the information to mobile phone of contact person in accordance with warning subscription module to notify the warning event incurred.

**Application Case**

A. Software and hardware system construction in production environment

1) Collocating resource coordination server and broadcasting the server's IP and service that can be used for consumption.

2) Collocating each OPC data collecting server and registering the server's IP address, port, username, access password and service that can be used for consumption in resource coordination server center.

B. Group organization structure chart construction

1) To drag and drop group pixel from industrial metabase and collocate group name, group description and group picture.

2) To drag and drop plant pixel from industrial metabase and collocate plant name, plant description and plant picture; drag and drop basic connecting line and establish ownership relation between the group and plant.

3) To drag and drop department pixel from industrial metabase and collocate department name, department description and department picture; drag and drop basic connection line and establish ownership relation between the plan and department.

C. Physical layout construction

As shown in figure 4, taking physical layout modeling of a mixed-flow production line as an example,

1) Drag and drop manufacturing area pixel inside specific department, collocate manufacturing area's name, coding, description and picture and establish ownership relation between the department and manufacturing area.

2) Drag and drop manufacturing location pixel inside specific manufacturing area, collocate manufacturing location's name, coding, description and picture and establish ownership relation between the manufacturing area and manufacturing location.

3) Drag and drop processing unit pixel inside the specific manufacturing location, collocate processing unit's name, coding, description and picture, and establish ownership relation between the manufacturing area; drag and drop and-or-invert ternary connecting line and establish physical connected relation between the processing units.

D. Constructing data collecting model of variable

As shown in figure 3, taking physical layout modeling of a mixed-flow production line as an example.

1) As shown in figure 3, to newly establish variable name and relevance variable set inside the detailed processing unit.

2) To set up essential attributes of the variable, including data source, communication protocol, collecting method and collecting amendment rule etc. Including, data source mainly includes OPC server, SEMI server and manual input; communication protocol mainly includes OPC protocol and SEMI protocol; collecting method mainly includes periodical collecting based on time and collecting based on event; collecting amending rule mainly includes stored procedure and dynamic chained library, which is used to amend physical deviation arising from sensor.

3) For variables collected automatically, variable corresponding to label name of data source is configured; for collecting based on periodicity, period is configured; for collecting based on cycle,

event name is configured. Finally, unit name corresponding to variable collecting value is configured.

E. Data collecting, monitoring and warning

As shown in figure 3, the system will adopt different calculation rules in accordance with different collecting method to judge whether the variable satisfy the data collecting condition.

1) For collection based on periodical data, it is required to acquire collection cycle and the last collecting time, and compare it with the current time. If the sum value of the last collecting time and the collecting cycle is larger than or equal to the current time, the data collecting condition is satisfied; conversely, the condition is not satisfied.

2) For data collecting based on event, it is required to acquire event corresponding variable and stored procedure or DLL corresponding to logical of encapsulating the event, and conduct assignment on its parameter. If the returned value after execution is true, the data collection condition is satisfied; conversely, the condition is not satisfied.

3) For data collecting based on counter, it is required to acquire current value of the variable corresponding to the counter and compare it with the setup upper limit. If the current value is larger than or equal to the upper limit, the data collecting condition is satisfied; conversely, the condition is not satisfied. Unit name corresponding to variable collecting value is configured.

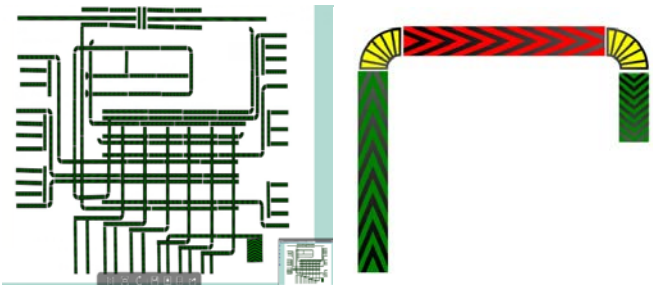

Fig. 3. Physical layout of mix-flow production line and Real-time configuration notification

In case of satisfying the data collecting condition, the system will calculate practical value of the variable data collecting in accordance with amendment rule in data collecting model, and transmit into warning service. Then warning service, based on collecting value and combing warning model, will judge the warning condition is satisfied. In case of satisfying, the warning model will be read in accordance with collocating information in release model. The release method is separately based on the client, user, message and E-mail. The relevant detailed information will be released to the assigned location. If it is released to IP address of the client, audible and visual warning device shall be activated to finish collecting, monitoring and warning of the variables. As shown in figure 3, it is to take terminal conveyor starter as event driving source and display on corresponding dynamic interface. In case of halt, the red light will blink for warning.

## Conclusion

The text, aiming at equipment status data and processing craft data, provides an integrated management method for real-time collecting, monitoring and warning. Consequently, it helps production personnel freed of large quantity of handwork, such as collecting and statistics analysis etc., and effectively avoid misreading or misjudgment arising from individual subjective judgment, which is beneficial to product efficiency and cost reduction. For easier batch processing, it provides system function of batch processing plant model based on XML. Meanwhile, it is equipped with off-line modeling ability, which can ensure smooth completion of modeling operation on the condition of not being able to keep communication with server. Based on SOA framework, it has distributed server load analysis capabilities, to achieve a balanced allocation of tasks; and it has the ability to OPC-based industrial data acquisition agreement, and has secondary development capacity to support additional data collection protocol extension access.

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