26

DEVELOPMENT OF AN AFTER-SALES SUPPORT INTER-ENTERPRISE COLLABORATION SYSTEM USING INFORMATION TECHNOLOGIES

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Abstract: This research paper discusses a manufacturing support system which supports not only maintenance services but also consulting services for manufacturing systems consisting of multi-vendor machine tools. In order to do this system enables inter-enterprise collaboration between engineering companies and machine tool vendors. The system is called "After-Sales Support Inter-enterprise collaboration System using information Technologies" (ASSIST). This paper describes the concept behind the planned ASSIST, the development of a prototype of the system, and discusses test operation results of the system.

Key words: After-Sales Support System, Maintenance, Inter-enterprise Collaboration

1. INTRODUCTION

Manufacturing support systems using IT (Information technologies) such as remote maintenance and remote monitoring systems are available today.

However, such support systems are usually machine tool-specific and depend on individual machine tool vendors. A mechanism does not exist that supports an entire manufacturing system consisting of multi-vendor machine tools implying cooperation between different machine tool vendors. Moreover, the usual scope of applications covering manufacturing support

systems is often limited to the maintenance of machine tools and/or controllers, and does not include after-sales business consulting services.

This research paper discusses a manufacturing support system for a manufacturing system consisting of multi-vendor machine tools. The system not only supports maintenance services but also consulting services in both cases based on inter-enterprise collaboration between engineering companies and machine tool vendors. A hosting service environment is proposed for sharing data, information, and application systems among the collaborating engineering companies, machine tool vendors, and factories. A secure access control environment at factories for the exchange of maintenance information is also discussed. In this way, the manufacturing support system enables inter-enterprise collaboration for maintenance and consulting services using these environments. The manufacturing support system is called "After Sales Support Inter-enterprise collaboration System using information Technologies" (ASSIST).

Section 2 describes the concept for the planned ASSIST project. Section 3 describes the development of a prototype for the system and also evaluates the operation results of the system.

2. CONCEPT BEHIND ASSIST

2.1 Background and Objectives

Typically, maintenance of machine tools often depends on maintenance services for each individual machine tool vendor. Recently, however, machine tool vendors have developed remote maintenance systems using IT such as the Internet.

However, for maintenance of manufacturing systems consisting of multi-vendor machine tools, the overall condition of the manufacturing process has to be considered before specifying the maintenance areas. After assessment of maintenance areas, maintenance services by the machine tool vendors corresponding to the maintenance areas have to be procured. If engineering companies integrate multi-vendor manufacturing systems, the engineering companies are responsible for detecting maintenance areas. This means that it is the engineering companies that have to maintain the manufacturing system in collaboration with the machine tool vendors in question. For that reason, there is a need for a manufacturing support system that can handle maintenance of entire multi-vendor manufacturing facilities that can allow inter-enterprise collaboration between engineering companies and several different machine tool vendors.

On the other hand, in order to ensure improvement of manufacturing systems, it is necessary to collect the operational status information of these systems, analyse the data, track problems, and put together solutions for the problems including an evaluation of the solution plans [1]. For these activities, IT tools, such as TQC (Total Quality Control) tools and manufacturing system simulators, are useful. However, for smaller enterprises, it is difficult to deploy such IT tools because they are expensive and difficult to master. Therefore, ways are needed for engineering companies to contract these improvement activities as a consulting service and/or IT tools providing service by ASPs (Application Service Providers).

The objective of this research is to develop ASSIST as a manufacturing support system for multi-vendor manufacturing systems, which supports not only maintenance services but also consulting services carried out as an inter-enterprise collaboration between engineering companies and machine tool vendors.

2.2 Overview of ASSIST

The organization, which uses the system, consists of more than one multi-vendor manufacturing system, more than one machine tool vendor and an engineering company.

The system consists of these distributed enterprises and the hosting server integrated over the Internet as shown in Figure 1. The hosting server is a data-accumulating, data-providing, and application-providing server for inter-enterprise communication managed by the engineering company or a third party. Characteristics of the system are: managing information such as manufacturing system operational data in XML (eXtensible Mark-up Language) format, and providing data exchange among distributed enterprises using the hosting server. Possible usage scenarios for maintenance and/or consulting services are as follows.

a) Operational data from the manufacturing system is gathered and accumulated in the factory. The data is sent to the hosting server over the Internet when the factory needs maintenance and/or consulting service.
b) In the case of maintenance services, the engineering company provides support by finding trouble spots in the manufacturing system using the accumulated data from the hosting server.
c) Then, if the trouble area concerns a machine tool and therefore maintenance support performed by the corresponding machine tool vendor(s) is needed, the engineering company provides the accumulated data to the vendor(s) in question. After this, collaborative maintenance is

carried out through cooperation between the engineering company and the machine tool vendors.

d) In the other case of consulting services for improvement of the manufacturing system as ordered by the factory, the engineering company analyses the accumulated data from the hosting server using TQC tools and/or manufacturing system simulators. The engineering company then submits the results of the analysis, identifies problems, and proposes solutions for the problems to the factory.

e) Moreover, the engineering company can provide application systems such as TQC tools and manufacturing system simulators to the factory by using the ASP functionality of the hosting server.

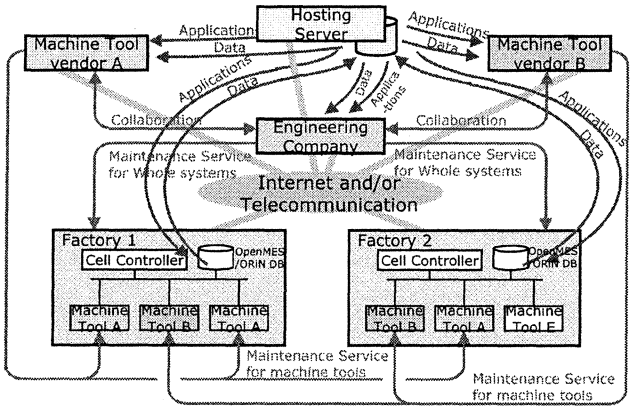

Figure 1. Concept of the ASSIST

3. DEVELOPMENT OF A PROTOTYPE SYSTEM

3.1 System Configuration and Functions of the System

A prototype system for ASSIST has been developed. This section describes the developed prototype system. An evaluation of the test results of the system is presented in the succeeding section.

The developed prototype system consists of a factory system, an engineering company system and a hosting server as shown in Figure 2. Functions and configuration of these systems are as follows.

a) Factory system

(Configuration)

- Multi-vendor machine tools and robots integrated using OpenMES [2], which is a middleware of MES (Manufacturing Execution System) base on CORBA.

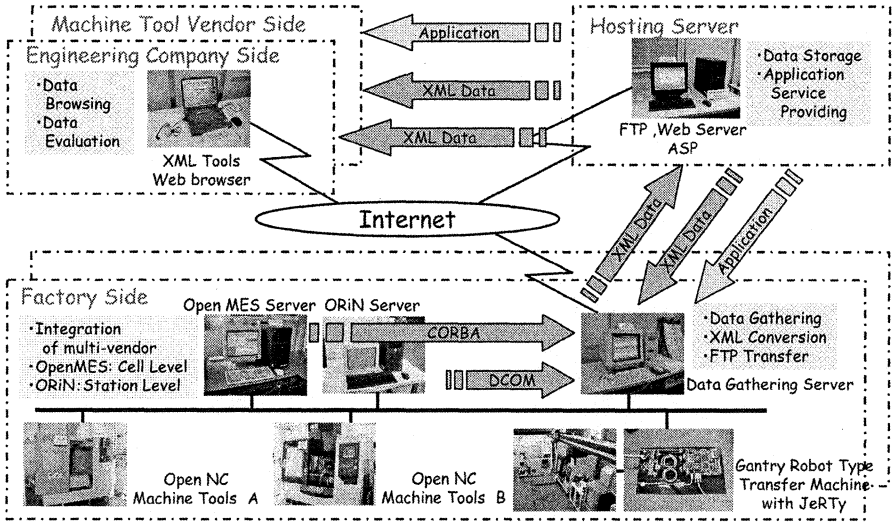

Figure 2. Configuration of the prototype system

- ORiN (Open Robot interface for Network [3]) server for condition monitoring of devices such as machine tools and robots.
- Data gathering server.
- Firewall with VPN (Virtual Private Network) server.

(Functions)

- Gathering of production log data as shown in the Table 1 for the manufacturing system from OpenMES server.
- Gathering of condition log data for devises as shown in the Table 2 from ORiN server.
- Conversion of the log data to an XML file.
- Periodic transfer of the XML file to the hosting server.
- The firewall with VPN (Virtual Private Network) server provides access permission control for machine tools of the factory for the machine tool vendors in question in order to allow maintenance of machine tools as shown in Figure 3.

Table 1. Production log data

Items	An example
Order information of the production	00000001
Product specification ID	MESPART1001
Scheduled production volume	1
Scheduled earliest start date and time	Fri Mar 29 13:00:00 JST 2002
Scheduled start date and time	Fri Mar 29 14:00:00 JST 2002
Actual start date and time	Fri Mar 29 13:52:00 JST 2002
Scheduled completion date and time	Fri Mar 29 14:12:00 JST 2002
Actual completion date and time	Null

Table 2. Device condition log data

Items	An example
Machine name	PV4-IIA
Controller name	MELDAS MAGIC 64
Controller ready status	True
Servo on/off status	True
Zero return status	True
Mode selection status	Auto
Operation status (Reset, stop, pause and start)	Stop
Error status	T02 0204
Error contents	Dry air pressure declined
Actual position X, Y, Z	0.001, 189.996, -0.021
Actual feed rate of the tool	0
Actual time of the controller	2002 Mar. 29 10:21:15

			Facility of the factory (VPN Server side)					
			Vendor name	Machine tool vendor A	Machine tool vendor C	Machine tool vendor B	Engineering company A	Engineering company A
			Facility name	Turning center P	Machining center Q	Machining center R	OpenMES server	ORiN server
Maintenance division of machine tool vendors and engineering companies (VPN Client side)	User name	User ID	IP Address / Password	192.168.xxx.uuu	192.168.xxx.vvv	192.168.xxx.www	192.168.xxx.xxx	192.168.xxx.yyy
	Factory User	AAAAAAAA	aaaaaaaa	permit	permit	permit	permit	permit
	Engineering Company A	BBBBBBBB	bbbbbbbb				permit	permit
	Machine tool vendor A	CCCCCCCC	cccccccc	permit				
	Machine tool vendor B	DDDDDDDD	dddddddd			permit		
	Machine tool vendor C	EEEEEEEE	eeeeeeee		permit			

Figure 3. Permission control of machine tools

b) Hosting server

(Configuration)

- Web service and FTP service using Windows NT and IIS (Internet Information Server) by Microsoft Corporation.

(Functions)

- Transmission and receipt of the XML file using FTP services.
- Web service of the XML files on a web server.

c) Engineering company system

(Configuration)

- Web browser.
- Statistics and analysis tools such as TQC tools that have an XML file interface.

(Functions)

- Receipt of the XML files from the hosting server.
- Analysis of production log data for the manufacturing system using the XML file.
- Preparation of graphs using the results of the analysis.

3.2 Evaluation of Test Operation Results

Test operation of the developed prototype system is performed. Consulting services by the engineering company through analysis of the operating conditions of the machine tools and usage time of the tools, using the production log data from the manufacturing system, are assumed for this test operation.

On the factory side, the manufacturing system worked for one week to manufacture five types of products: *MESPART1001, MESPART2001, MESPART3001, MESPART4001 and MESPART5001*. The production log data and device condition log data on the factory side are gathered and converted to XML files as shown in Figure 4 and sent to the hosting server once a day.

On the engineering company side, one week's worth of production log data as shown in the Table 1 and device condition log data as shown in the Table 2 for the manufacturing system are received from the hosting server. Machine tool operating conditions, including tool usage times, are analysed by use of statistics and, for instance TQC analysis tools. Graph charts for the results of the analysis are also produced. An example of a graph chart of tool usage times is shown in Figure 5.

A prototype test operation was carried out, and the performance and functions of the prototype system consisting of the factory system, the engineering company system and the hosting server integrated over the Internet were evaluated. All things considered, the test operations proved that the system performed quite well, showing promise for a future full implementation of the system.

However, the security system for the hosting server only uses a single user name and password. Therefore, the data sharing security system for the

Figure 4. An example of XML file

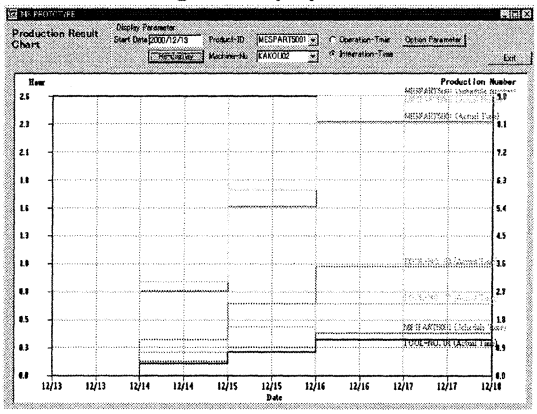

Figure 5. An example of graph chart

hosting server will have to be discussed in order to ensure dynamic sharing of data and information between several virtual enterprise partners. Also the ASP functionality of the hosting server will be discussed in this research. Moreover, test of operations that perform prevention, preservation, and maintenance of a multi-vendor manufacturing system are being considered.

4. CONCLUSION

The concept for a manufacturing support system named ASSIST has been proposed. ASSIST supports not only maintenance services but also consulting services for multi-vendor manufacturing systems carried out as an inter-enterprise collaboration between engineering companies and machine tool vendors.

A prototype system for ASSIST has been developed. A test operation using the prototype was successful. The test covered activities and functions of the prototype system consisting of a factory system, an engineering company system and the hosting server, all integrated over the Internet. According to the results of the test, the system performed quite well and the possibility that the ASSIST concept can be implemented has been confirmed.

The security system of the hosting server for dynamically sharing data among virtual enterprises consisting of more than one will be discussed. ASP functionality for the server will be also discussed in this research.

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