Trends and Prospects for Information and Control System

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1. Introduction

In the more than ten years following the bursting of Japan's economic bubble, Japan has experienced an unprecedented period of low growth. However, according to a business outlook survey for the period from April to June of FY2004, capital investment for FY2004 is expected to increase to 19.8 % compared to the prior year. Although the future appears bright, the business environment remains severe and there is a need for corporate restructuring to enable companies to survive even during periods of low growth. On the other hand, against the backdrop of Japan's deflationary market with falling prices for materials and products, the trend toward globalization is continuing, with manufacturing being shifted to China and other Asian countries.

Under these circumstances, the Japanese manufacturing industry faces domestic challenges involving the shift toward higher value-added products, construction of highly efficient manufacturing systems, and adoption of energy-savings and other measures to reduce the burden on the environment, while also facing such overseas challenges as the stabilization of materials procurement, construction of manufacturing sites, establishment of distribution and sales networks, and compliance with international standards for products and manufacturing processes. The industry is working urgently to overcome these challenges.

In the past, mission critical business systems and manufacturing execution systems (MES), supported by technical advances in information technology (IT), have aimed to optimize production management and operations management. On the other hand, process automation systems (PAS) have a successful track record of optimizing manufacturing processes centering on monitoring and control. However, in an overall production system, the role of an information and control system is to manage these functions as an intrinsically unified system and to create a mechanism for optimizing the overall system.

In light of these circumstances, we believe that information and control systems should be vertically and horizontally integrated solutions, as shown in Fig. 1, realizing both vertical integration that links the field level to the production management and enterprise levels, and horizontal integration that seamlessly connects upstream to downstream processes in a manufacturing plant.

Based on the market trends of information and control systems, analysis of user needs, and technical trends, this paper describes Fuji Electric's efforts in developing an information and control system capable of providing vertically and horizontally integrated solutions.

2. Information and Control Systems: Market Trends and User Needs

Figure 2 shows forecasts of the global, Asian and Japanese markets for distributed control systems (DCS) that are central to information and control systems. Future average annual growth rates are predicted to be 2.5 % for the global market, 6.4 % for Asia (excluding Japan), and 0.5 % for Japan. Although the Japanese market will remain essentially flat, growing by only a small percentage, the Asian market will continue to expand, with most market growth occurring in China [(1)].

According to industry-specific market forecasts, in the global, Asian and Japanese markets, the annual growth rate of the materials production industry will be less than average. Oppose to that the average annual growth rates will be highest in the pharmaceutical, food and beverage industries, followed by the electric power and water and sewage industries.

Under these market conditions, the steel and metal industry, the industries of oil refining and chemicals as well as cement and glass have little demand for new plant facilities and the replacing of equipment is being postponed to later dates. The greatest demands to replace equipment is for maintaining those plants which have previous received capital investment.

Within this market environment, user needs for information and control systems have changed dramatically over the past several years. Namely, such systems have improved their lifecycle cost efficiency by enhancing conventional functions and performance

Fig.1 Vertically and horizontally integrated solution

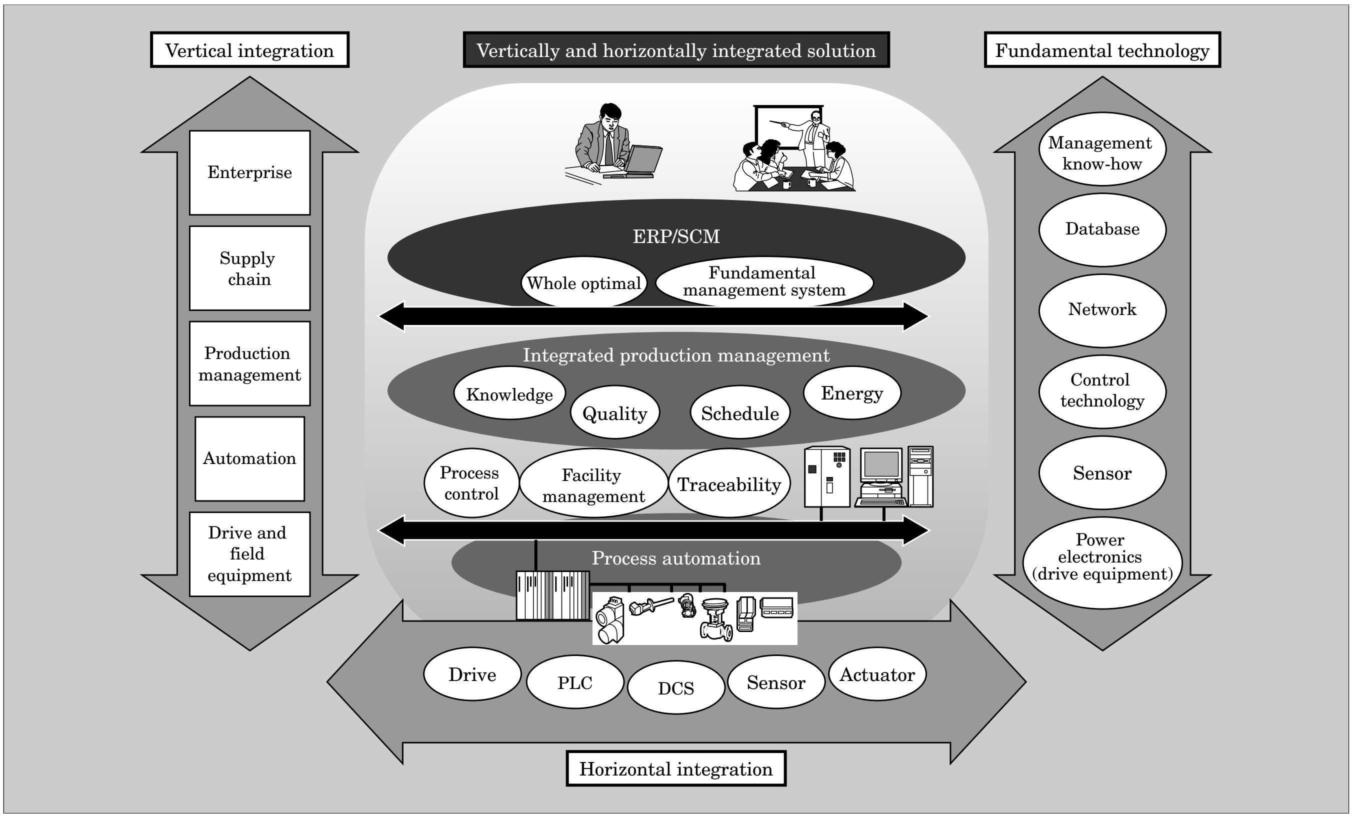
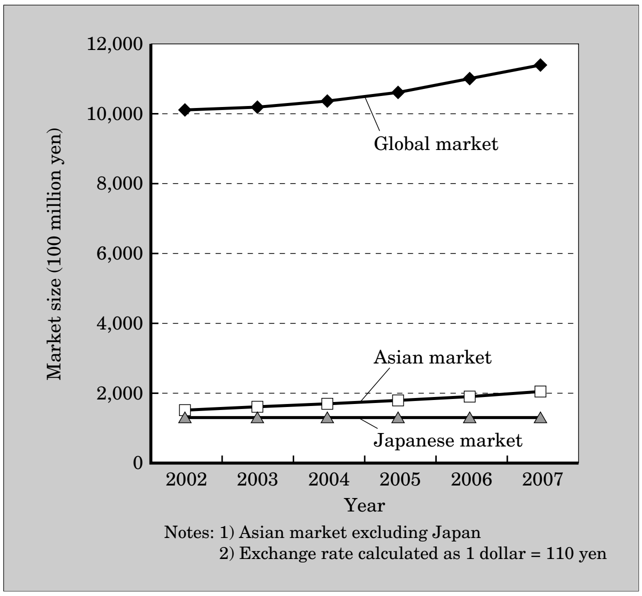


Fig.2 Forecast of global, Asian and Japanese markets for process automation



and by reducing costs at the time of initial investment. Consequently, the lifecycle cost, i.e., the cumulative cost incurred from system construction (planning, design, manufacture and testing) to operation and maintenance, equipment replacement and finally to decommissioning, is reduced. In order to optimize the lifecycle cost of plant equipment, it is not only necessary to limit the initial investment, it is also important to reduce maintenance and preservation costs and equipment replacement costs as much as possible.

Items of tremendous concern for today's customers are listed below.

(1) In the area of maintenance and preservation, in addition to the presumed high level of reliability ensured by the hardware and software platforms which by definition should be elements of an information and control system, the asset management can be systematized.

(2) In the area of equipment replacement, the latest monitoring and control system technology and products can continue to evolve due to advances in IT.

These areas should work together and support the partial replacement of existing equipment to the extent to which user expertise with existing equipment can be transferred to new equipment.

3. Technical Trends of Information and Control System

In response to the user needs described above, information and control systems are evolving while incorporating the latest information and control technology. The main technical trends and future outlook are described below.

3.1 Advances in production system integration

At present, a PAS cannot exist by itself, and interaction with ERP (enterprise resource planning), SCM (supply chain management) and MES mission-critical systems, or in other words, expansion in the vertical direction (vertical integration) is required. Furthermore, expansion in the horizontal direction (horizontal integration) to realize total process control of the incoming materials transport, process control, transport control, and outgoing package transport, as well as utility management, is also required. With the shift of manufacturing to overseas sites, these types of integration, which include the local procurement of materials, present significant challenges.

The following two items are regarded as important in achieving vertical integration with an MES, which is well suited for interaction with monitoring and control systems.

(1) The original role of an MES is to perform process management, in-process control, progress monitoring, record management, production facility management, quality control, etc. However, the MES functionality of today does not stop there and the MES is attracting attention as an enterprise assessment tool for improving processes. It is also analyzing those improvements, based on an evaluation of the process performance, and its role is shifting to the analysis and visualization of record data, which are additions to the conventional management functions.

(2) In the past, it was common to construct an MES using an order-made solution, for which software was prepared individually. In the future, however, it is thought that an MES platform that provides an execution environment and incorporates standard components will be promoted to ensure higher efficiency and reliability of the system design.

3.2 DCS technical trends

(1) Adoption of open technologies

The open technologies produced as a result of the rapid expansion of IT have also rapidly spread to the DCS field. Representative examples of open technologies whose adoption is becoming more widespread are listed below.

① Personal computer and defacto standard OS (Windows*1)

② Standard LAN technology (Ethernet*2, PROFI BUS, Foundation Fieldbus*3, etc.)

③ Standard interface protocols (TCP/IP, OPC, etc.)

④ Internet technology

⑤ Object oriented software technology

(2) Utilization of general-purpose products

There have previously been many instances in which a specially developed and designed component for a DCS has been replaced with a component made from general-purpose products. Ensuring the functionality, performance, reliability and safety of system products with software also has advantages in terms of cost. Typical examples include the use of SCADA (supervisory control and data acquisition) software for the monitoring system and a PLC (programmable logic controller) for the control system.

(3) Compliance with international standards

With the shift of manufacturing to overseas locations and the overseas exportation of plants, there has been an increase in demand for equipment that complies with international standards. Such compliance is essential for facilitating system construction and the procurement of maintenance parts overseas, and for example, in cases where compliance is required by the overseas end user. Moreover, due to the trend toward JIS (Japanese industrial standard) internationalization, the JIS is reflecting the content of IEC standards, and plant equipment in Japan often incorporates technology and products that comply with international standards.

4. Fuji Electric's Efforts

With the emergence of DCSs in the 1970s, information and control systems have realized the advanced functionality and higher performance that exists at present. As can be seen in Fig. 3, Fuji Electric has been supplying products to the market ever since the early days of DCS development. Fuji Electric combined the individually developed E (electricity) and I (instrumentation) functionality developed for its first and second generations of information and control systems in the first half of the 1980s with C (computer) functionality developed for its third generation system to achieve EIC integration. In the latter half of the 1990s, Fuji introduced its MICREX-AX (advanced system), a fourth generation system based on the concepts of open technology and evolution with inheritance. In 2004, Fuji developed and brought to market the MICREX-NX (next generation system), a next-generation information and control system that adheres to prior concepts but also features vertical and horizontal integration and integrated engineering. Figure 4 shows a vertically and horizontally integrated solution based on the MICREX-NX. Figure 5 shows the positioning of Fuji Electric's existing information and control systems and the MICREX-NX.

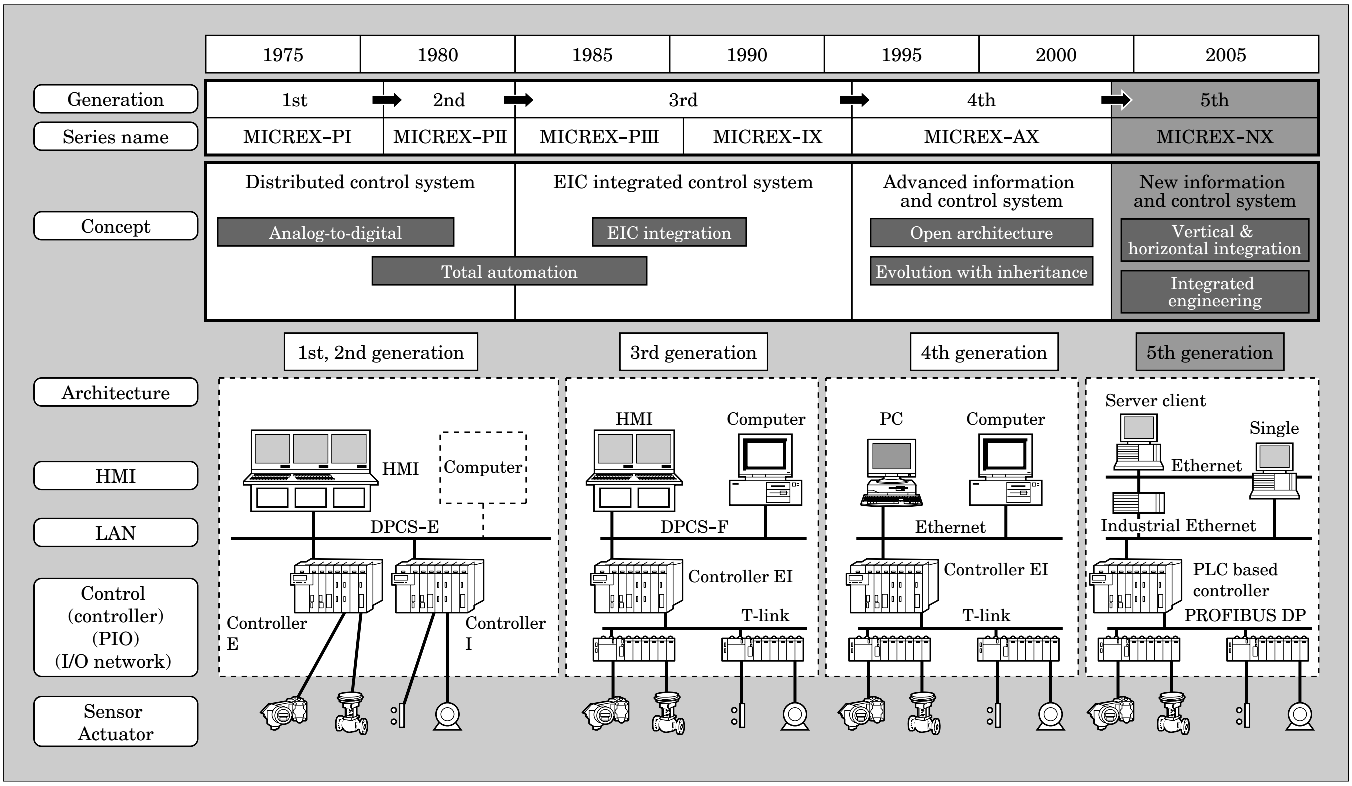
The MICREX-NX next-generation information and control system was jointly developed as part of a collaborative effort between Fuji Electric and the PAS business division of Siemens Corporation of Germany, and is based on Siemens' PCS7 DCS. Sales of the

*1: Windows is a registered trademark of Microsoft Corporation of the USA.

*2: Ethernet is a registered trademark of Xerox Corporation of the USA.

*3: Foundation Fieldbus is registered trademark of the Fieldbus Foundation.

Fig.3 Development of Fuji Electric's information and control system



MICREX-NX began in September 2004.

Based on the MICREX-NX core, a next-generation DCS founded on user needs, Fuji Electric's information and control systems has been strengthened as follows.

4.1 Advances in vertical and horizontal integration

(1) Vertically integrated system

Fuji Electric's MES realizes flexible and highly efficient production planning based on the manufacturing workflow, and enables seamless integration with a PAS. Main features of this MES are listed below.

① Total optimization is realized through the simultaneous real-time control of facilities and equipment, quality inspection, operating instructions, and the operation record.

② Improved operation and ensured traceability of the manufacturing process made possible by the integration of information generated at the manufacturing site and records analysis (process lot flow, correlation analysis, in-process behavioral analysis, etc.)

③ Use of an MES platform establishes an environment in which a system can be constructed by combining standard components.

④ Provides an engineering environment for integrating an MES and DCS

⑤ Easy linking of data between the MES and DCS by means of an interface based on TCP/IP, OPC and other types of international standards for data exchanges

(2) Horizontally integrated system

Advancing the conventional concept of EI integration, in addition to the integrated control of manufacturing processes and electrical machinery, all field level processes from materials transport to distribution and utility are also integrated.

Fuji Electric's horizontally integrated systems have the following features.

① The control component is based on a high-performance PLC. Coordinated operation of electrical machinery control that requires high-speed response and process control that requires a fixed cycle can be accomplished via a shared plant bus (IE: industrial Ethernet). Moreover, integrated engineering tools enable linked system design and testing.

② The field network is configured from a PROFI BUS-DP and/or PROFIBUS-PA, which are international standards, and according to the application, field level equipment from the drive equipment to the measuring equipment can be connected horizontally, enabling monitoring and control to be performed.

③ The linkage between a vertically integrated MES and DCS enables the flexible operation of pre- and post-processes (materials transport, distribution, utility, etc.) according to the operating status of the process line.

4.2 Provision of total solutions for the plant lifecycle

The MICREX-NX is provided with the following mechanisms to reduce cost and ensure stable plant

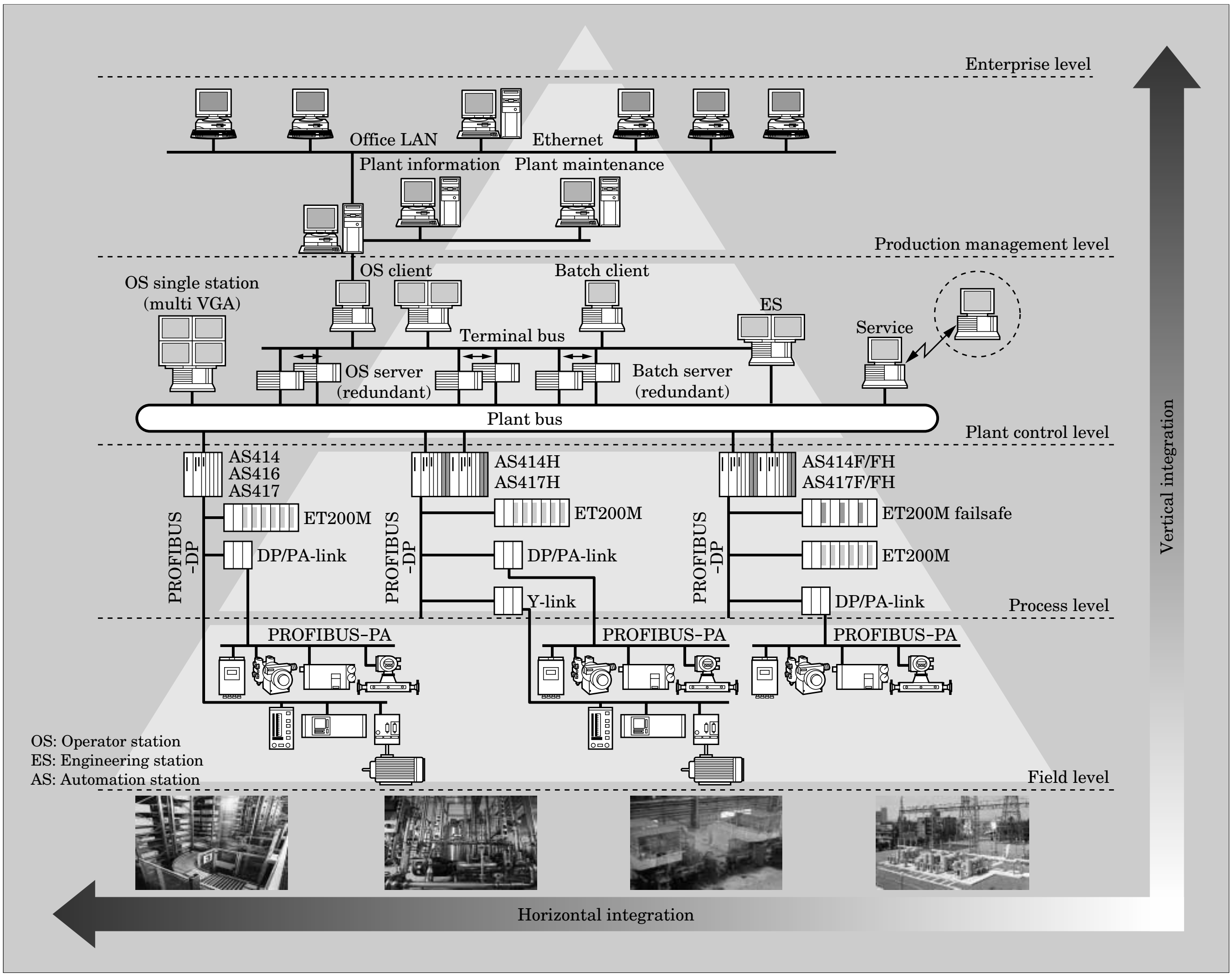


Fig.4 MICREX-NX based information and control system

operation during each phase of the plant lifecycle.

(1) System configuration phase (conception, design, construction, testing)

(a) Scalable system configuration

Two series of products are available according to the scale of the system, an entry system BOX Series for small-scale plants, and a PRO Series scalable from 150 to 60,000 tags for medium and large-scale plants. Because these series both have the same engineering environment, legacy equipment and expertise acquired with minimal investment can continue to be used when expanding the plant, thus enabling the user to recover their investment.

(b) Compliance with international and industry-wide standards

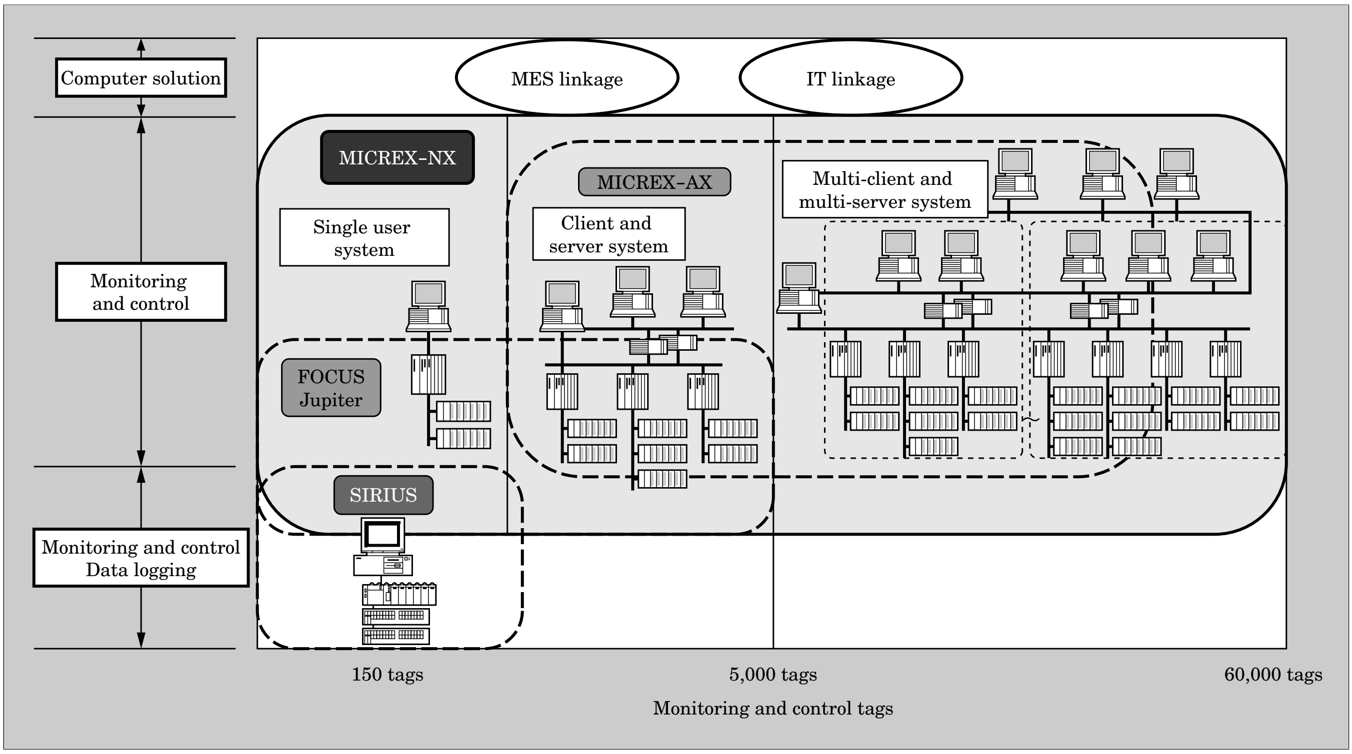
Each level of the plant naturally complies with international LAN standards (such as Ethernet, industrial Ethernet, PROFIBUS-DP/PA, HART, AS-i, MODBUS, etc.) and supports the use of the international standard language IEC 61131-3. Additionally, the SIMATIC*4 BATCH control package (conforming to IEC61512 (ISA S88)) for batch plant-use to enhance global competitiveness, a system for electronic records, electronic signatures, monitoring and recording for food and pharmaceutical manufacturing processes that complies with regulations concerning electronic archives and electronic signatures (FDA 21 CFR Part 11) as established by the United States' Food and Drug Administration (FDA), a safety instrumentation system (conforming to IEC61508), and the like are available.

(c) Integrated engineering

① Integrated engineering is a key concept of the MICREX-NX. An integrated engineering database enables high value-added functions such as a monitoring and operating system, a control system, facility management, SIMATIC BATCH, a safety in-

*4: SIMATIC is a registered trademark of Siemens of Germany.

Fig.5 Positioning of the MICREX-NX



strumentation system, and the like to be configured in an integrated engineering environment.

② A mechanism that enables software, which is the intellectual property of the user, to be stored in a library and reused accelerates the creation of software and the application of expertise.

③ A three-stage simulator of the controller, PIO and plant can be used to implement debugging without using an actual device, thereby achieving more efficient design and testing, and realizing higher quality.

(2) Operation and maintenance phase

(a) Improved utilization rate

The MICREX-NX realizes complete redundancy capable of handling multiple failures in the various levels of the network, database server, operator station, controller, PIO, and power source. Moreover, with a rugged and highly reliable design of the hardware, and the security measure that requires an operator to logon before performing such tasks as plant operation, engineering, testing, software modification, and the like, a high utilization rate is ensured.

(b) Simpler maintenance

In addition to improved capability for system failure diagnosis and status display, the following characteristic mechanisms simplify daily maintenance and shorten the recovery time when a failure occurs.

① Diagnosis and preventative maintenance of equipment and devices horizontally integrated by an integrated facility management system

② A system for managing the different versions of application software by means of a revision history management function

③ Rapid identification of the cause of a failure by means of a 10ms minimum (1ms resolution) time stamp function

④ Online exchange of controllers and PIO modules, and automatic backup after the exchange

(3) Equipment replacement phase

Incremental migration enables a plant to be maintained or expanded flexibly in accordance with a user's plans for replacing equipment. Additionally, a hardware group that links an existing MICREX to a MICREX-NX and a software converter that allows reuse of a user's legacy software assets make possible the long-term inheritance of equipment and expertise with minimal investment.

4.3 Inheritance and evolution of plant expertise and control technology

The extent to which plant expertise and control technology can be continuously utilized and the extent to which it can evolve are important issues for users as well as manufacturers. This content, including plant operating expertise, control expertise, and the tool environment in which this expertise is applied, is being addressed by Fuji Electric as follows.

(1) Control and monitoring-use software components that have been accumulated over many years in the fields of industrial, environmental, water treatment and energy related applications are converted into a shared library under the MICREX-NX's integrated engineering environment. In particular, the control library is packaged as a single object containing a controller component, a human-machine interface (HMI), and additional information such as control algorithms and the like, thereby enabling more efficient reuse of the library and facilitating the inheritance of expertise.

A menu of the control content, from PID control to advanced control and model predictive control, is prepared to allow selection of the optimal usage according to the intended application.

(2) Plant operation expertise exists mainly with the user. The MICREX-NX has enriched its operation support package to allow maximum use of the user's plant operation expertise. For example, the route control package has a large effect on complex piping routes and tank yard operation in the food, beverage, pharmaceutical and chemical fields and the like.

5. Conclusion

Spurred on by rapid advances in IT and the global trend toward technical standardization, information and control systems have continued to evolve year after year. The globalization of manufacturing, as symbolized by the shift to overseas production, is well known, and a more global perspective is adopted. This also applies to the information and control systems that provide plant support so that those systems can continue to evolve while responding to user needs, instead of being developed solely by one company. In other words, the value added to information and control systems depends not only on the hardware and software platform, but also on the extent to which expertise appropriate for a particular region and industrial field can be consolidated and combined to enable future inheritance and evolution. From this perspective, Fuji Electric shares technology with Germany's Siemens Corporation, and also pursues joint development and shared manufacturing responsibility to hasten the production of results and to advance global product development.

Fuji Electric intends to continue to provide solutions based on user needs, and to develop and provide systems that will continue to satisfy users in the future.

Reference

(1) O'Brien, L. DCS Worldwide Outlook. ARC Advisory Group. 2003.