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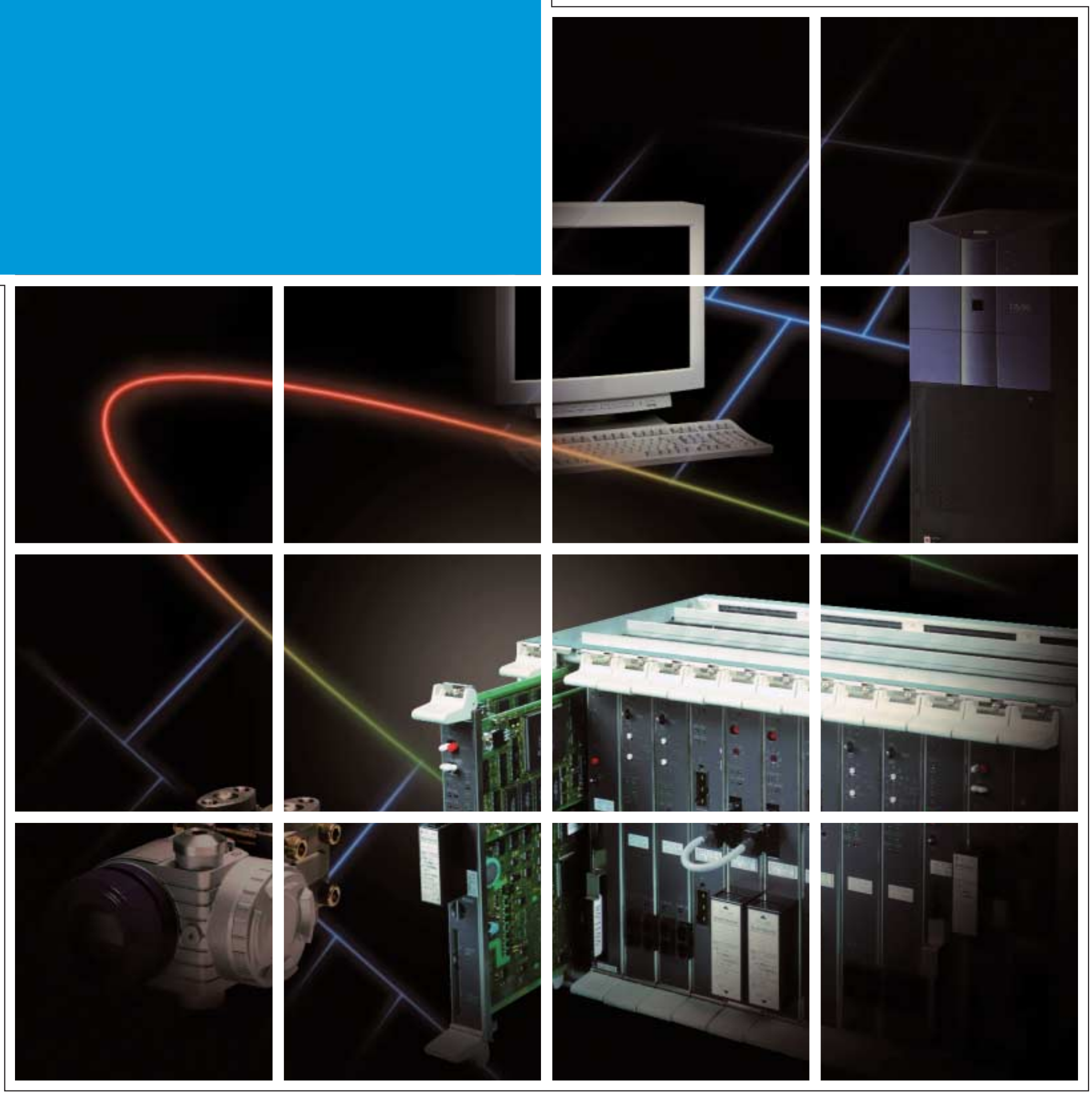

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Creating a Better Tomorrow with Trustworthy Technology

Fuji Electric Helps You Create Information And Control Systems.

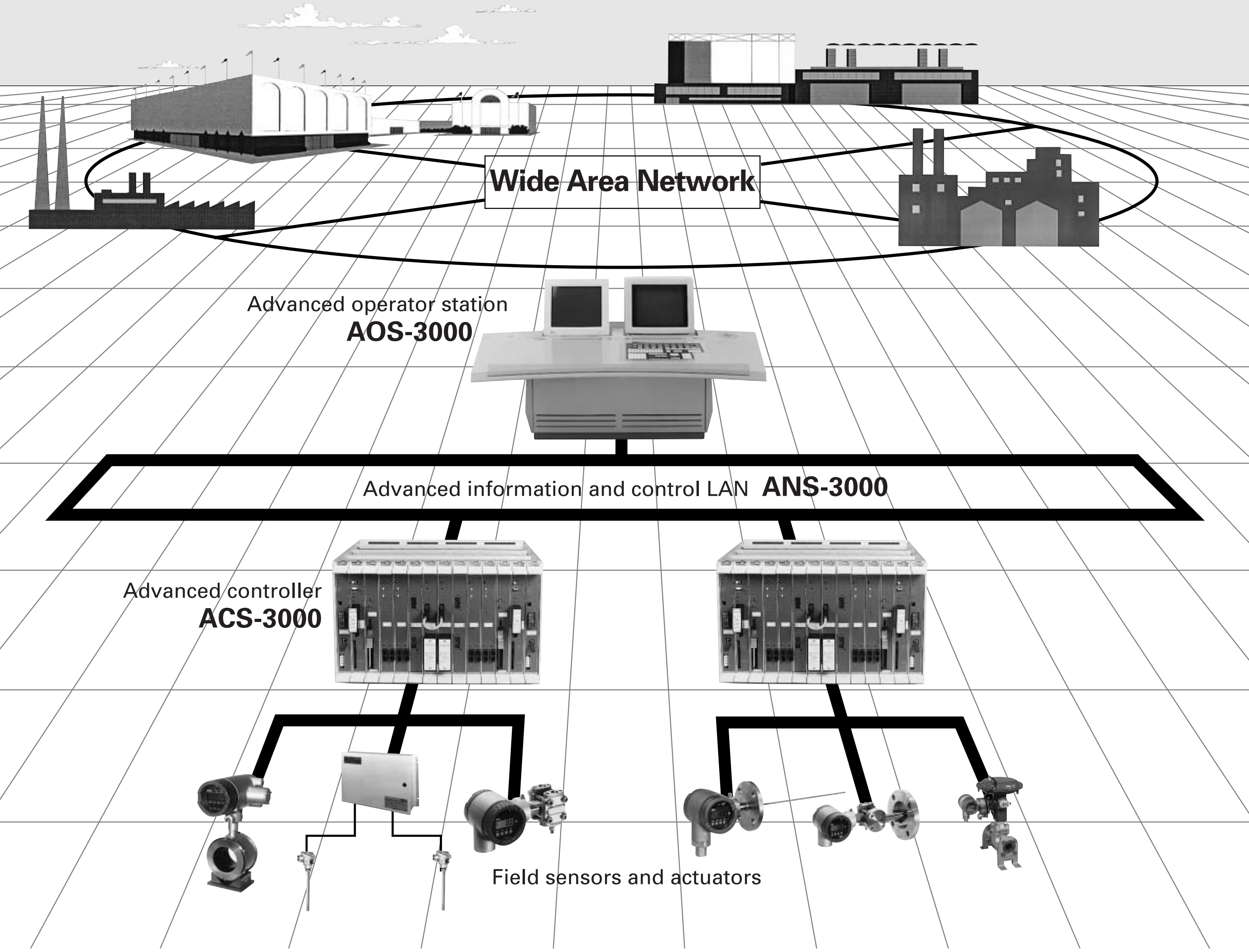
FUJI ELECTRIC

■Advanced operator station **AOS-3000**
Realizes **the multimedia human interface "Scene-based interface"** mainly composed of on-the -spot images, audio, and process data, in addition to the conventional functions of distributed control systems.

■Advanced information and control LAN **ANS-3000**
Conforms to the **international standard FDDI (100 Mbps).**

■Advanced controller **ACS-3000**
Realizes **EIC** integration rational and most suitable to plants and equipment.

■**Computing Processors** installed.



Advanced Information and Control System

MICREX-AX

AX: Advanced information and control system for the next generation

FUJI ELECTRIC
REVIEW

2

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Cover Photo:

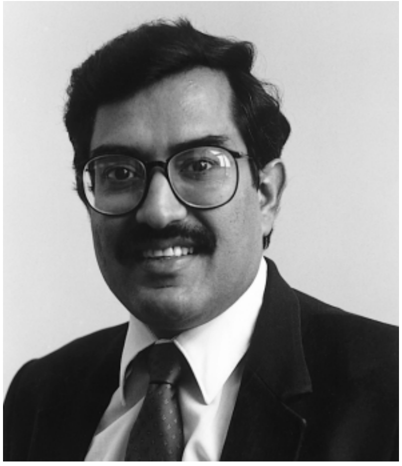
In addition to conventional operating, monitoring, and control functions, recent information and control systems have required integrating management functions for business, the progress of work, and maintenance, and supplying high-efficiency production systems at a cost as low as possible.

With the key concept of integrating information and control, Fuji Electric offers information and control systems utilizing integrated up-to-date computer, network, and software technologies.

The cover photo, with a boundless network and open system components positioned there, images a flexible and scalable system environment and Fuji Electric's information and control technology taking an active part in it.

Fuji Electric Co.,Ltd. Head Office : No.12-1, 1-chome, Yurakucho, Chiyoda-ku, Tokyo, Japan

Special Issue on Multimedia Technology in Process Control Management Systems



Prof. Arif Ghafoor, Ph. D.
Purdue University, School of Electrical and Computer Engineering

Early industrial history is marked by close supervision and extensive interference by humans during all levels in process control and management. The late 1960's and early 1970's saw the pioneering development and use of computers to control and monitor industrial facilities and plants. In the ensuring decades, such systems became significantly more complex, and rigorous specifications, increased standardization of components, and making the systems open emerged as essential aids in the 1990's.

With the above backdrop, the field of process control systems in conjunction with distributed multimedia systems has shown extraordinary growth during recent years. The field is expected to be a major focus of effort in scientific and technological development for the rest of this decade. It is already opening up new opportunities for technological growth in a number of areas such as broadband/multimedia networking, storage systems, distributed systems, databases, real-time operating systems, computer graphics, human-computer interaction, etc. The use of multimedia technology produces greater sense of reality in the plant control room. Significance of different components and complex inter-relationships among them are better comprehended with the rich communicative dimensions of audio, images and video. Abstractions of different parts of a plant can be emphasized or de-emphasized, and appropriately re-scaled in the virtual multimedia control room.

A significant benefit of such process control systems is that without actual presence in the work-area, there is demonstrated reduction in the risks and hazards such as accidents, environmental perils, etc. Multimedia-based data sensing, collection and display allows detached and accurate observation and comprehension of continuing processes in a wide range of control domains including power generation control, water treatment plant control, transportation and rail control systems etc. Such sensory fine-tuning via multimedia will go a long way in reducing noise and distractions for the operators, and allow them to focus on more critical components and processes. With the utilization of current broadband networking and database technologies and techniques, many of these processes previously thought to be unamenable to computerized systems are being handled better than the limited human capabilities. This has the fruitful side-effect that many of the routine and repetitive tasks may be pushed away from the human operators, thus allowing them greater time and freedom for higher-level creative tasks. On a larger scale, this may even translate to greater leisure time for humans coupled with increased levels of productivity and services afforded by such multimedia process control systems.

In order to realize actual working systems, extensive research and development efforts are being undertaken in various areas of process control management as well as high-performance multimedia systems. Such systems must by necessity be safe, robust, efficient, flexible, easily re-configurable as well as economical. While such systems span many facets of technology, our main focus is on those areas which are critical in the development of process control and management systems.

I would like to express my delight upon my affiliation with this special issue related to multimedia process management, which is an extremely important area for the future of human technological progress.

Arif Ghafoor

Present Status and Prospects for Information and Control Systems

Narumi Ibe
Chihiro Nakajima

1. Introduction

Although the economic prospect for economic recovery is still bleak, as reflected in the low production of industrial information and control equipment of Fig. 1, there has, however, been a remarkable increase in the use of personal computers. Because of computer, network, multimedia, and software technology innovations, society is becoming more information oriented and network applications are rapidly increasing in the form of the Internet.

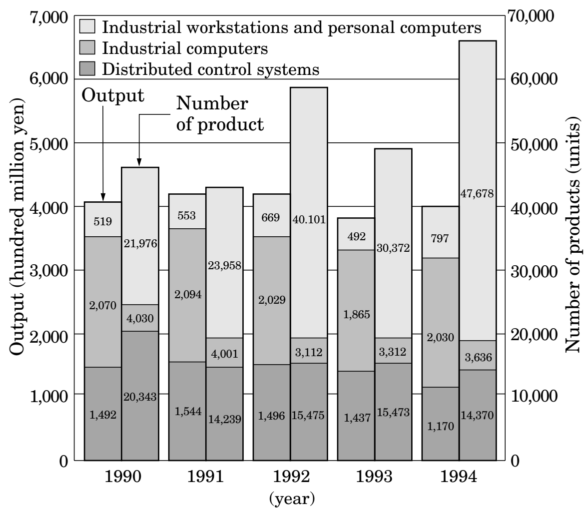
Information and control systems for the purpose of automating production systems, have developed as core devices to perform plant operation, monitoring, and control functions. These information and control systems have been greatly changed by the changing economic and social environment as well as technical innovations. In other words, it is necessary to structure efficient production systems to optimally utilize technical innovations in computer, network, and multimedia technologies at as low a cost as possible. To attain this goal, it is important to consider both sides of production systems: functions represented by EIC (E: electrical control, I: instrumentation, C: computer) and time represented by the life cycle (planning-design-execution-operation-maintenance).

In consideration of the above, information and control systems must be integrated to realize broad management functions, such as product management, process control, maintenance, and equipment management, in addition to conventional operation, monitoring, and control functions.

On the other hand, with regard to the architecture of systems, openness and field distributed control are the keys to system downsizing and flexibility. In this sense, software and network technologies that use international standards and de facto standards are important. In particular, the international promotion of standard specifications and product development for the fieldbus to realize field device networks and field distributed control systems has become an essential systematization technology.

Further, ISO 9000 for quality assurance and ISO14000 for environment management must be taken into consideration when structuring of information and control systems.

Fig.1 DCS and industrial computer production trends



Source : Japan Electronic Industry Association "Investigation of Japan's industrial computer output in 1994"

Within this setting, Fuji Electric has advanced the configuration of the latest information and control system and has recently developed MICREX-AX*1, an advanced information and control system to unify information and control.

This special issue reviews the present status and prospects for information and control systems and introduces new MICREX-AX technologies.

2. Information and Control System Trends

Production systems now require flexibility that enables the high quality and high added value production of various products. Total costs now take into consideration the life cycle of a system.

∗1: The "AX" in MICREX-AX means Advanced information and control system for the next generation.

In information and control systems, therefore, not only are real-time and reliability critical for control, but information and information processing required for operation and maintenance have also become important. In other words, it is important to have plant-wide or enterprise-wide unified control, intrinsically necessary for production systems, and information for efficient management and maintenance.

The requirements of production systems and technologies to realize them are shown in Table 1. The main trends of information and control systems are described below.

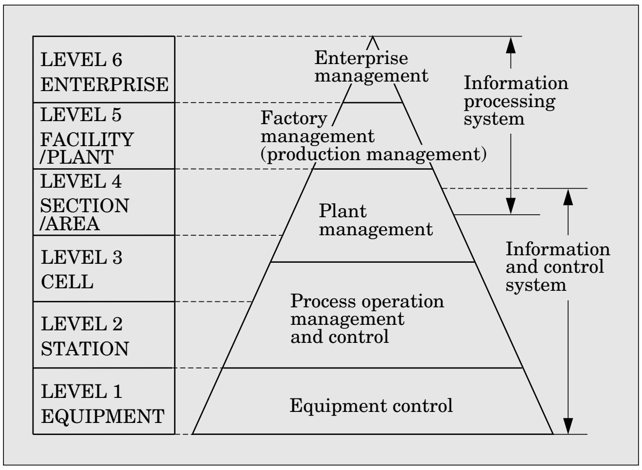
(1) Unification of information and control

Figure 2 shows the positioning of an information and control system for the CIM model in ISO definition. As shown in the figure, fields relating to positioning of the information and control system include equipment control, process operation management and control, and plant management.

Table 1 Production system requirements and necessary technologies

Requirements	Necessary technologies to satisfy requirements
Flexibility Scalability	◦ Open system ◦ Network technology ◦ Autonomous decentralized system, field distributed system ◦ Shared information and control data system ◦ PA, FA, and OA integration technology
Improved productivity	◦ High-speed control, real-time control ◦ Redundant system, fault tolerant system ◦ Preventive maintenance, Equipment diagnosis, remote maintenance ◦ Integrated engineering, concurrent engineering
Improved product quality	◦ AI (fuzzy, neuro), GA ◦ Modeling, simulation ◦ Intelligent sensor ◦ Quality control system (ISO9000)
Human beings and environmental consideration	◦ Object-oriented system, Agent-oriented system ◦ Multimedia ◦ Environment-friendly system (ISO1400)

Fig.2 Positioning of information and control system in the CIM model



To operate systems efficiently, there is a growing necessity to enhance information processing functions and to unify information and control even at the level of equipment control, which was formerly specialized.

(2) Openness

Open systems aim to freely combine characteristic products from different manufactures to construct an optimum system.

The key to open systems is the use of a standard operating system (OS), network, and database. The popularity of Windows[*2], UNIX[*3], and Ethernet[*4] has had a great influence on the openness of information and control systems and has resulted in their wider use. On the other hand, there are many problems in the reliability and real-time characteristics of open systems in control application. It is necessary to use the right system in the right place.

Fuji Electric is promoting open systems with the belief that further progress in hardware, improvements in operating system functions, and the innovation and spread of internet technology will advance information and control systems toward increased openness.

(3) Cost reduction and right sizing

The right sizing concept is to realize a system with appropriate (right) functions and performance of as low a cost as possible.

Fuji Electric achieves right sizing with its line of products that correspond to the scale and function of the system application and its line of packaged solutions for individual fields.

(4) Advanced operator interface

As systems become more sophisticated and complicated, their operation (monitoring and handling) becomes difficult. However, to hold down rising labor costs, operation by few operators or without an operator is demanded.

This requires visual interfacing with multimedia technology and operation support with AI functions.

Fuji Electric has attached user-friendly concepts to human engineering considerations to develop desk designs, picture coloring, and operation.

In addition, Fuji Electric has developed an intelligent alarm that uses AI functions to give guidance in case of emergency and a scene-based interface which integrates on-site pictures, audio, and process data on the operator station using multimedia technology to monitor and operate the system.

(5) Integrated engineering support

The ratio of engineering cost to construction cost of an information and control system has rapidly increased and is a dominant influence on system cost.

*2 Windows: A trademark of Microsoft Corp., USA
*3 UNIX : A registered trademark of X/Open Company Ltd.
*4 Ethernet: A registered trademark of Xerox Corp., USA

In an EIC-integrated system where many different types of functions are closely linked, and in large-scale systems requiring group engineering and concurrent engineering by several members, integrated engineering support over the life cycle of the system is required.

On the basis of the above thinking, Fuji Electric has developed and applied an integrated engineering support environment having a unified integrated engineering database and a descriptive language for automatically generating controller programs from operation procedures, piping and instrumentation diagrams.

(6) Fiber-optic fieldbus and field distributed control

The fieldbus is both a network technology that realizes digital communication and openness on the field device level and also a systematization technology that changes the configuration of information and control systems. That is to say, the fieldbus can form a field distributed control system in which a combination only of field devices with control functions, such as AI/AO (analog input and output) and PID will form a control loop. Figure 3 shows an example of a field distributed control system with a fiber-optic fieldbus.

By providing diagnostic and maintenance functions to field devices and communicating through the fieldbus, a unified information and control system can be constructed.

Fuji Electric developed the optical fieldbus according to international standard specifications based on FFI (fiber-optic field instrumentation) and is using the Fieldbus Association to promote openness. MICREX-AX is being prepared to be compatible with these electrical and optical fieldbuses.

(7) Sophisticated applications

There are demands for sophisticated applications in various fields such as multivariable control, model prospect control, and neuro control in the field of control, plant operation support and plant simulation in the monitoring and operation fields, and schedulers in the process control field.

Fuji Electric has developed various algorithms to meet the demands of these sophisticated applications, and also offers various packaged solutions with engineering support functions.

Fig.3 Example of an optical field distributed control system

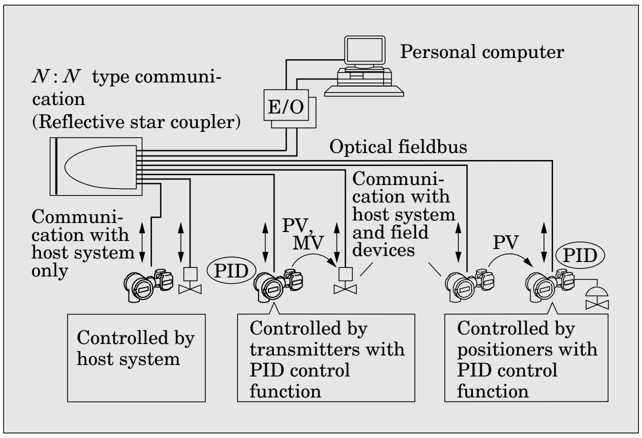
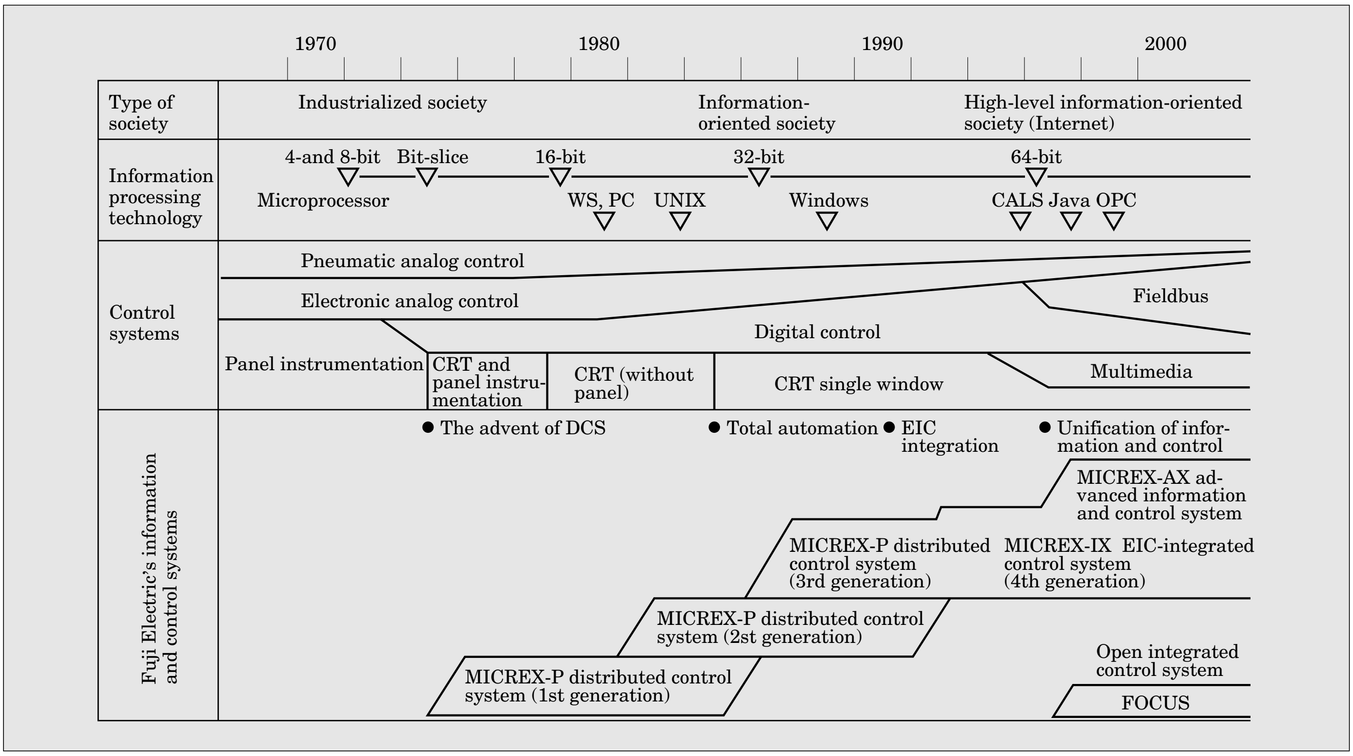


Fig.4 History of Fuji Electric's information and control systems



3. Fuji Electric's Development Information and Control Systems

As shown in Fig. 4 since the advent of the DCS (distributed control system) in 1975, Fuji Electric has always developed products ahead of other companies.

Fuji Electric's latest efforts for information and control systems as well as the MICREX-AX advanced information and control system are introduced below.

3.1 Basic concept of MICREX-AX

Plant facilities equipped with information and control systems are maintained for 10 to 20 years. The information and control systems must be capable of long-term operation and must also be flexible to allow expansion and remodeling of the equipment. On the other hand, technical innovations cause new products to be developed every three months. Information and control systems must also be capable of incorporating technical innovations and providing timely solutions to user requirements.

With a policy to develop flexible systems that utilize advanced technology, Fuji Electric has developed the new MICREX-AX information and control system in which the concepts of total automation and EIC-integrated control system have been expanded upon.

To realize the above, the network, database, and data interface belonging to the infrastructure section that forms the base of the system, the computer, workstation (WS), personal computer, HCI (human computer interface), controllers and field devices are clearly separated and defined as components that evolve independently at short intervals.

As a result, as long as the specified data interface is maintained, each component can evolve independently.

Although the principle is not new, this technique is characterized by using advanced technology with the concept of unified information and control, to realize an open infrastructure section and interface in which the control performance does not suffer.

In addition, the system is scalable from medium to large systems and flexible to facilitate the expansion and remodeling of plants.

3.2 System configuration and component functions

Figure 5 shows the MICREX-AX system configuration.

MICREX-AX consists of a computer (DS/90), WSs, personal computers, an advanced multimedia HCI (AOS-3000), advanced controllers (ACS-3000), a telemeter and telecontrollers, and field devices, which are organically linked by an advanced information and control LAN (ANS-3000) and a database (installed in the HCI).

MICREX-AX is supported by an advanced engineering support system (AES-3000). Functions of each component are listed Table 2.

3.3 Changing requirements

Fuji Electric developed the MICREX-AX system with consideration of the following changing require-

Fig.5 MICREX-AX system configuration

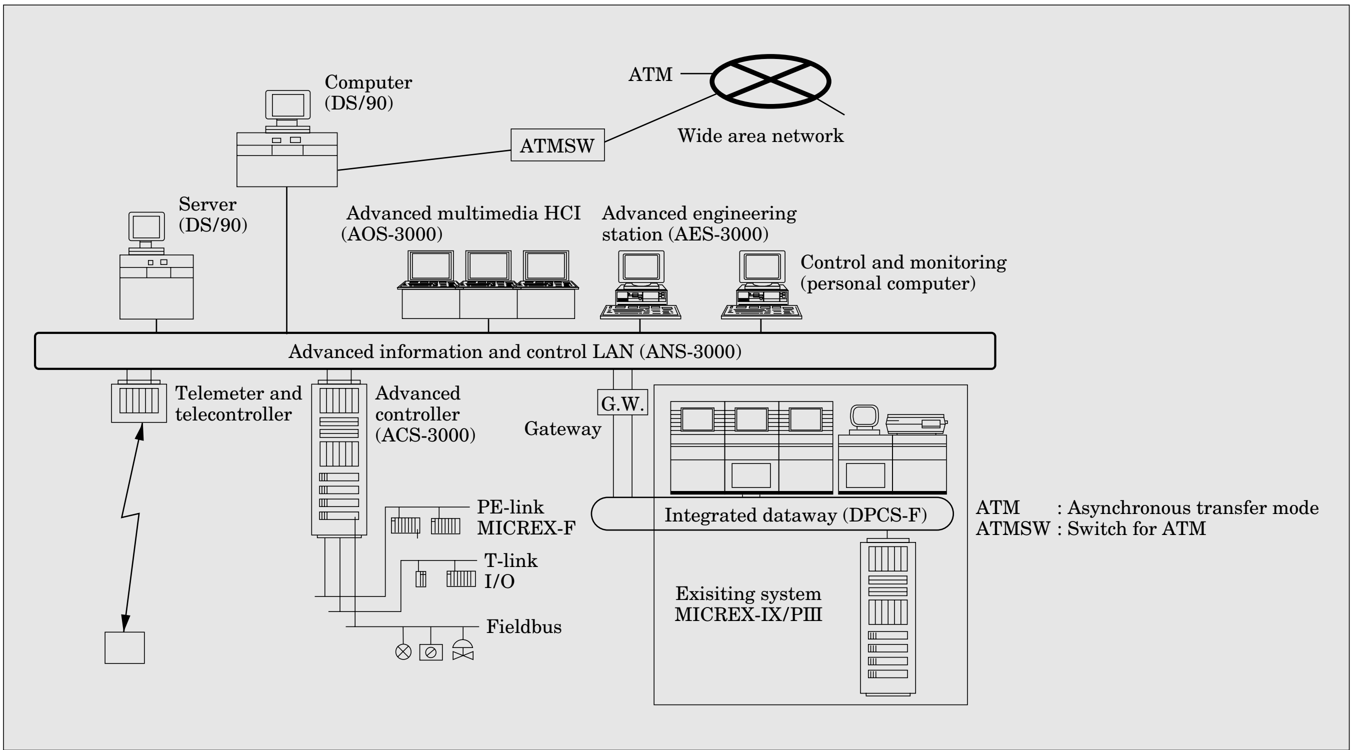


Table 2 Information and control system component functions

Function		Computers C	HCI	Engineering support	Controllers I	Controllers E	Controllers T	Field devices
Planning and management	Production planning	◎						
	Production management	◎						
	Quality control	○						
	Plant and equipment management	◎						
Operation	Operation control	◎	○					
	Operation data collection	◎ - - - -	○		○ - - - -	○ - - - -	○	
	Operation support		◎ - - - -	◎				
	Monitoring and operation		◎					
Communication	Transmission	○ - - - -	○ - - - -	○ - - - -	○ - - - -	○ - - - -	◎ - - - -	○
Control input and output	Control				◎	◎	○	○
	Process input/output				○	○	○	◎
Others	System maintenance	○	○	○	○	○	○	○
	AI	○	○	○	○	○		○
Fuji Electric's typical products		DS/90, PC	AOS-3000	AES-3000	ACS-3000			ACS-3000, DS/90, PC

◎: Main function ○: Sub-function - - - -: Linking function I : Instrumentation E : Electrical T : Telemeter and telecontroller
PC : personal computer

ments for new information and control systems.

(1) System changes

One problem of DCS is the lack of flexibility. Each individual manufacturer has promoted its own standards and it is difficult for the mature products to accept new user requirements.

In MICREX-AX, the key to attaining flexibility is considered to lie in openness, and openness is realized in the network, HCI, data interface, and engineering support tools.

(2) Control device changes

Innovation in microprocessor and communication technology has made field devices intelligent and enables the transfer of control functions to lower level devices and the addition of information for maintenance and monitoring. For this reason, the role of controllers has changed to perform integrated control functions and some of the information processing functions formely implemented by computers.

The ACS-3000 advanced controller for MICREX-AX enables a mutiprocessor configuration that closely links control processors and computing processors on the same system bus.

(3) Monitoring and operation device changes

The AOS-3000 monitoring and operation equipment for MICREX-AX integrates the computer system and DCS with open materials on the WS platform (DS/90 or SUN) and can monitor and operate the field conditions according to multimedia information.

(4) Network changes

Information and control systems have come to handle not only conventional control information but also a large quantity of operation support and maintenance information. Therefore, the system's backbone LAN (local area network) is desired to be an integrated network that can handle both control and information systems.

MICREX-AX uses the international standard FDDI (fiber distributed data interface) 100Mbps optical LAN that can handle multimedia information, to realize a unified information and control LAN. Also it is possible to connect to an ATM (asynchronous transfer mode) network. Optical fieldbuses are mainly being used to realize low-level open networks.

4. Conclusion

This paper has introduced the MICREX-AX advanced information and control system newly proposed by Fuji Electric and based on the present status and prospects for information and control systems at this turning point of changing requirements.

The concept of MICREX-AX is unified information and control, which coordinates human beings (information) and systems (control).

It is our goal to change former systems that rely too heavily on humans for system control and to rethink optimal control, operation, handling, monitoring, and maintenance methods.

The MICREX-AX Advanced Information and Control System

Tohru Yoshida
Shin Hashimoto
Chihiro Nakajima

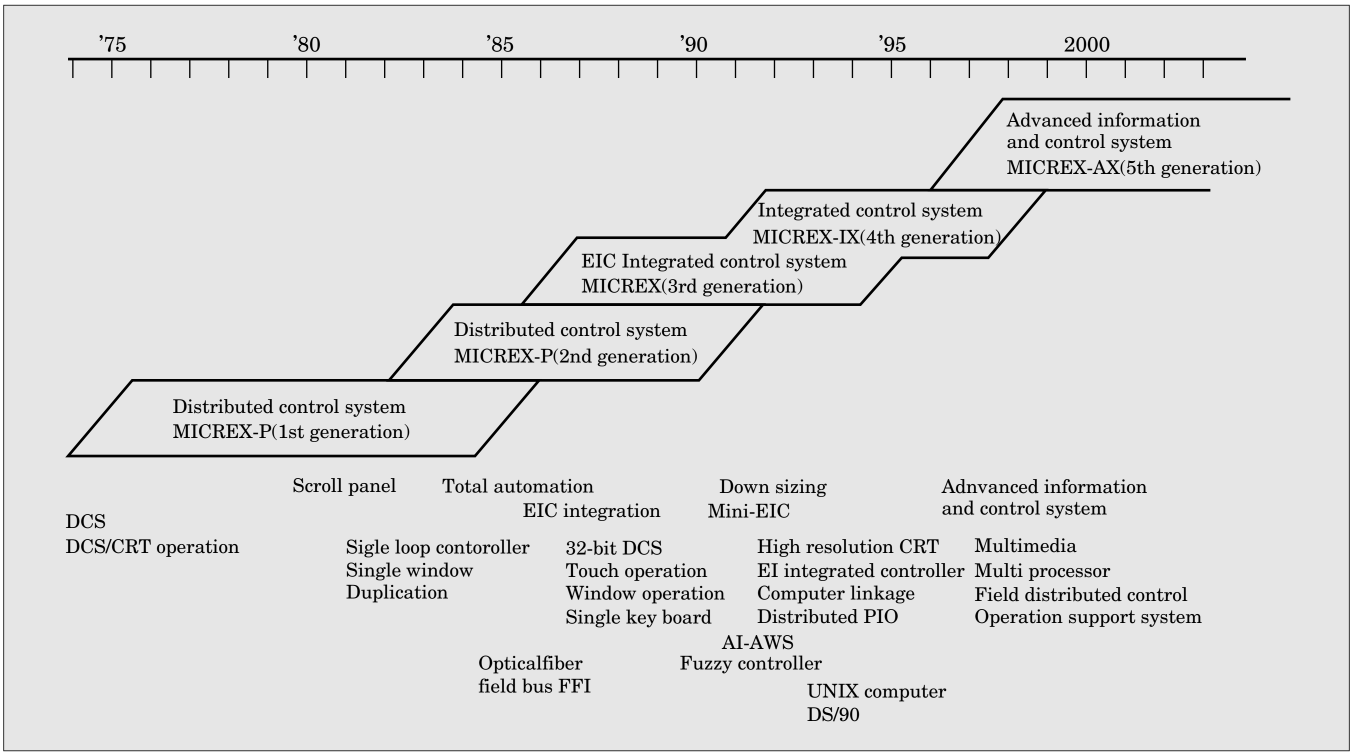
1. Introduction

In the present time of low economic growth, investments in the industrial field tend to put emphasis on concentration or updating outworn installations, and automating or making more efficient small scale systems to increase price competitiveness, rather than building extensive production facilities. On the other hand, the rapid progress and price reduction of personal computers (PCs), workstations (WSs) and networks, as well as the new monitoring systems they have made possible, are promoting futuristic systems in which human beings play the leading role.

The history of Fuji Electric's information and control systems began with the advent of the distributed control system (DCS). The first generation MICREX-P with CRT operation progressed to the second generation with single-loop, single-window and duplex controllers. In 1987, the third generation MICREX-P with a 32-bit DCS, introduced as the first EIC-integrated system in the world, led to a general style of operation control having touch operation and window operation. Next, the fourth generation MICREX-IX integrated control system with a high resolution CRT, EI-integrated controller and computer linkage, was introduced in 1992 and has been offering solutions to many users through its continuous expansion and modification of functions (Fig. 1).

Meanwhile the requirements of users have become more demanding and more user-specific. It has been difficult to satisfy these requirements with only conventional products which generally consist of a standard system and some options, because users ask for such systems to be either seamlessly expandable from small scale to large scale, while maintaining functional continuity, or to have a wide range of selections from

Fig.1 Changes of distributed control system MICREX



simple to high-grade.

The MICREX-AX[*1] advanced information and control system can meet the above demands and is constructed with a new system architecture and inherited know-how from the MICREX-IX. This paper describes an overview of the MICREX-AX system.

2. Development Concepts

(1) Open

An open system is vital to realize price reduction, to integrate and supplement functions, to link with different types of systems, and to achieve increased added value. MICREX-AX is a system that promotes maintaining reliability through open components, data and methods.

Figure 2 shows the concept of the open MICREX-AX. WSs running on UNIX[*2] are used as operator stations and a high speed optical LAN (local area network) based on the FDDI (fiber distributed data interface) with a transfer rate of 100Mbits/s is used as the central LAN. Operation is performed with the TCP/IP protocol. The interface responds to process data such as physical values and data status according to requests in the form of data names. Support tools based on Windows[*3] have been developed.

(2) Flexible

A necessary condition for DCS is that a reliable system can be built with simple engineering to achieve safe and comfortable operation. MICREX-AX is a system which realizes flexibility of its functions and scale size to satisfy the necessary conditions of DCS.

Figure 3 shows the flexibility of the MICREX-AX, which makes it possible not only to select the functions of HCI (human-computer interface), but also to integrate database stations with operator stations. The system's structural unit (plant block) has been set to a middle scale, where there are many practical examples. Extending this plant block unit to a large scale system is possible without any influence on existing systems. In addition, it is also possible to define the linkage to existing plant blocks through simple engineering.

(3) Advanced

Since 1975 DCS functions for monitoring, operating and controlling, have been continuously improved, increasing product output as well as improving productivity. As demand changes from quantity, quality and variety to sensitivity, new ideas are being used to develop advanced systems. MICREX-AX is intended as such a system that will meet the needs of the new age.

Figure 4 shows an example of the MICREX-AX advanced concept including: operator stations with multimedia processing, integrated support systems which unify and manage the design information of the total system and provide a grouped engineering environment under its open architecture, advanced control functions that enable increased productivity and safe plant operation, and various operation support functions for high-level plant operation.

Fig.3 Flexible development of MICREX-AX

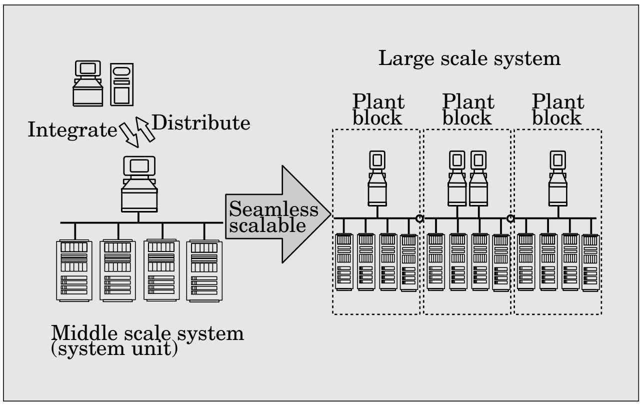
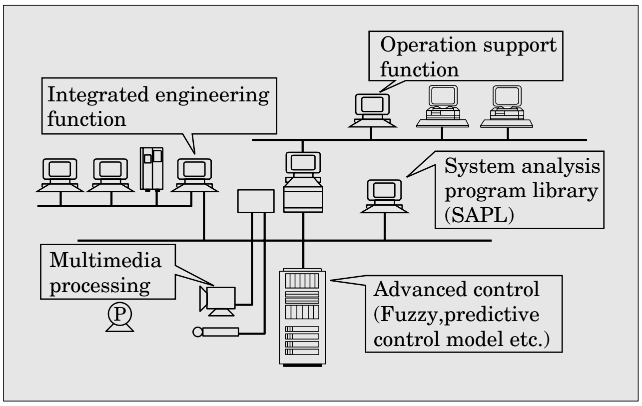


Fig.4 Advanced development of MICREX-AX



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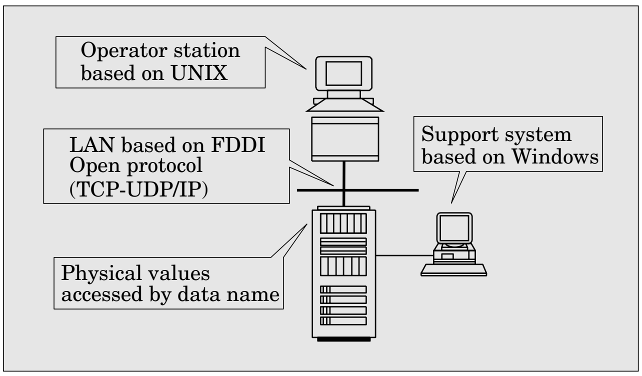
*1 "AX" of MICREX-AX is the model name that refers to "Advanced information & control system for next generation".

*2 UNIX : A registered trademark of X/Open Company Ltd.

*3 Windows: A registered trademark of Microsoft Corp., USA

Fig.2 Open development of MICREX-AX



3. System Structure

3.1 System overview

(1) System structure

Figure 5 shows the general system structure of the MICREX-AX. The system basically consists of an advanced operator station (AOS-3000) as the monitoring and operation center, an advanced integrated LAN (ANS-3000) for realizing highly reliable fast communication, an advanced controller (ACS-3000) for achieving high speed control with greater added value, and an advanced engineering station (AES-3000) to support the controllers. If necessary, an advanced database station (ADS-3000) for unifying and managing plant data, general purpose data servers, and PCs and WSs with various of operation control functions are also attached.

Because this system not only monitors and controls plants, but also off-site installations, it can be used over a wide range from small to large scale applications. A cooperative monitoring system with multiple screens is provided as a new monitoring method.

(2) System data linkage

Control system process data has conventionally been defined based on the control functions of controllers. Therefore to utilize the data, a special protocol for general purpose computers was necessary and information such as data addresses and base full scales had to be provided, making operation difficult. The MICREX-AX provides an interface which responds to requests of user-defined data names with industrial values. As for general data, a computer filing interface and a general purpose database interface are provided in a distributed file environment, making it possible to utilize the data in an open environment.

(3) Logical structure of MICREX-AX

Open components and methods have been introduced wherever possible in the MICREX-AX system. To maintain its flexibility, the interface for linking functions is logically regulated. Therefore, it is possible not only to configure systems freely, but also to easily link general systems to the MICREX-AX system, because the functions do not depend on physical equipment.

For instance the database function can be implemented on either the dedicated station (ADS-3000) or an operator station (AOS-3000).

3.2 Advanced operator station (AOS-3000)

The software configuration of the AOS-3000 is shown in Fig. 6. Its features are described below in comparison to the existing integrated operator station (IOS-2500).

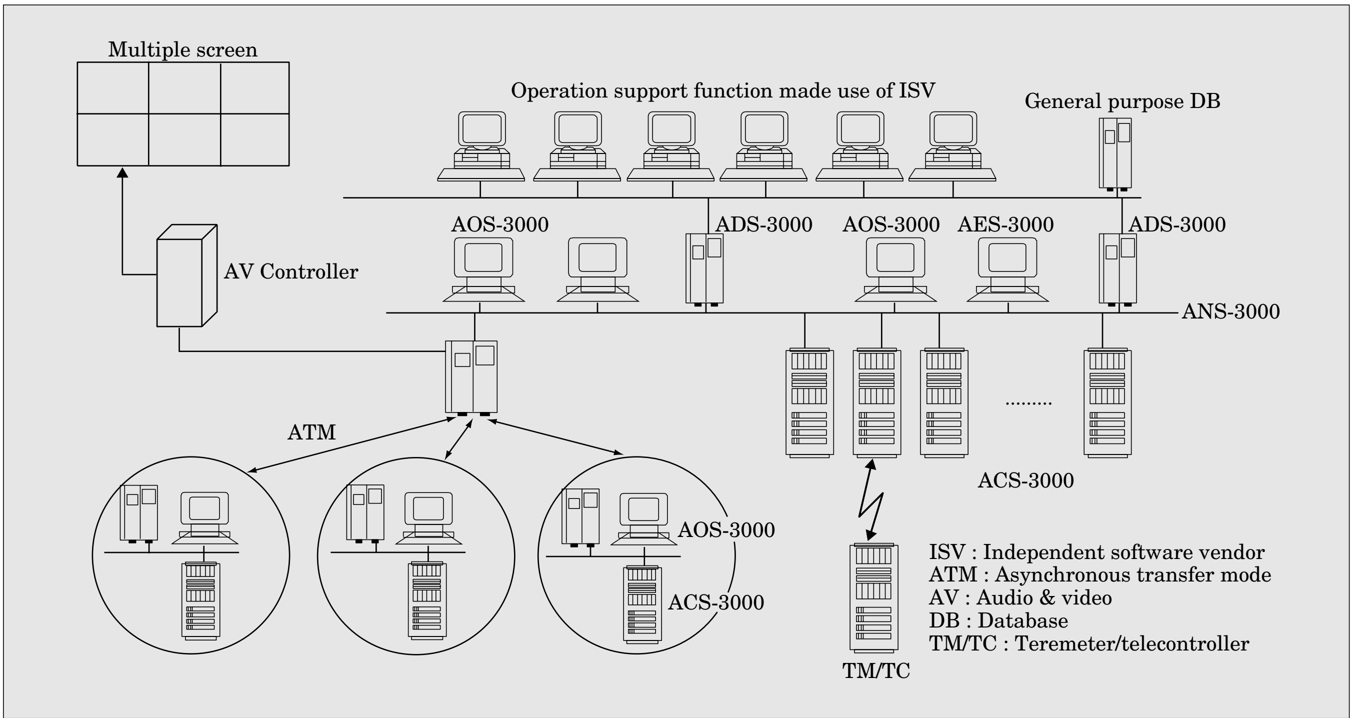
3.2.1 Open platform

The monitoring and operating functions have such a structure as to work under the command of realtime execution support and drawing packages. Both packages, have been developed by Fuji Electric based on many practical experiences, so their structures can be extended freely and quickly.

3.2.2 Multi-platform

It is increasingly desired to allow general use of the software resources by making the monitoring and operating functions common, regardless of the system scale. This monitoring and operating software can ran

Fig.5 Example of advanced information and control system



on both SUN compatible machines (Solaris) and environmentally safe, long life industrial WSs (UXP/DS).

3.2.3 Development of field compatible system

The AOS-3000 is a system that is easily compatible with the field in which it is used. As shown in Fig. 6, the software structure, based on much practical experience, and the operation description, specified to maintain system reliability, have made it possible to improve the efficiency in which field-oriented or customer-oriented systems are developed.

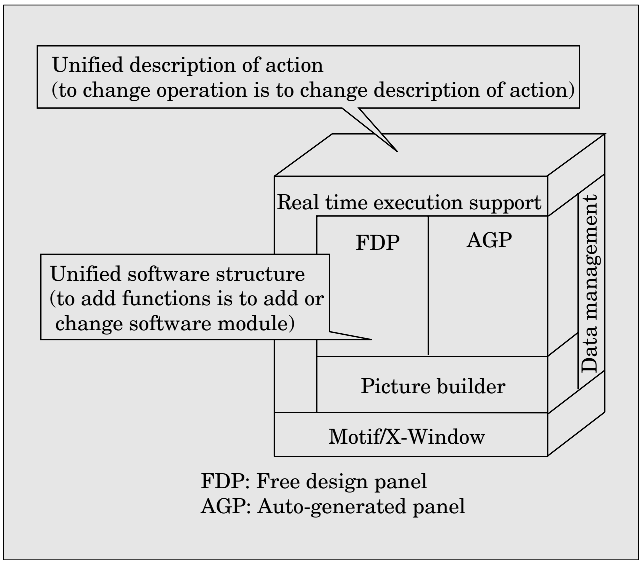
3.2.4 Automatically generated panel

An AGP (auto-generated panel) function is provided to improve engineering efficiency. This makes it possible to display standard panels (module relevant screen, alarm relevant screen, etc.) by engineering only the controllers. The panel generation needs no engineering. Therefore, soon after the controller engineering, a test using the operator station can be performed.

3.2.5 Multimedia compatibility

The AOS-3000 can simultaneously handle information such as plant pictures or sounds as well as the process data. The SBI (scene based interface) that deals with ITV image data is one such example. The feeling it creates of actually being on-site leads to an intuitive and clear monitoring system.

Fig.6 AOS-3000 software structure



3.3 Data management functions

Data management functions of the MICREX-AX are designed not only for operator stations but also for all the clients connected to the central LAN. The following services are provided (Fig. 7).

3.3.1 Data access by name

This function accesses data with data names which are arbitrarily defined for temporary data by a server (a data source, usually a process control station). From the client's viewpoint (usually an operator station or computer), functions can be classified as follows.

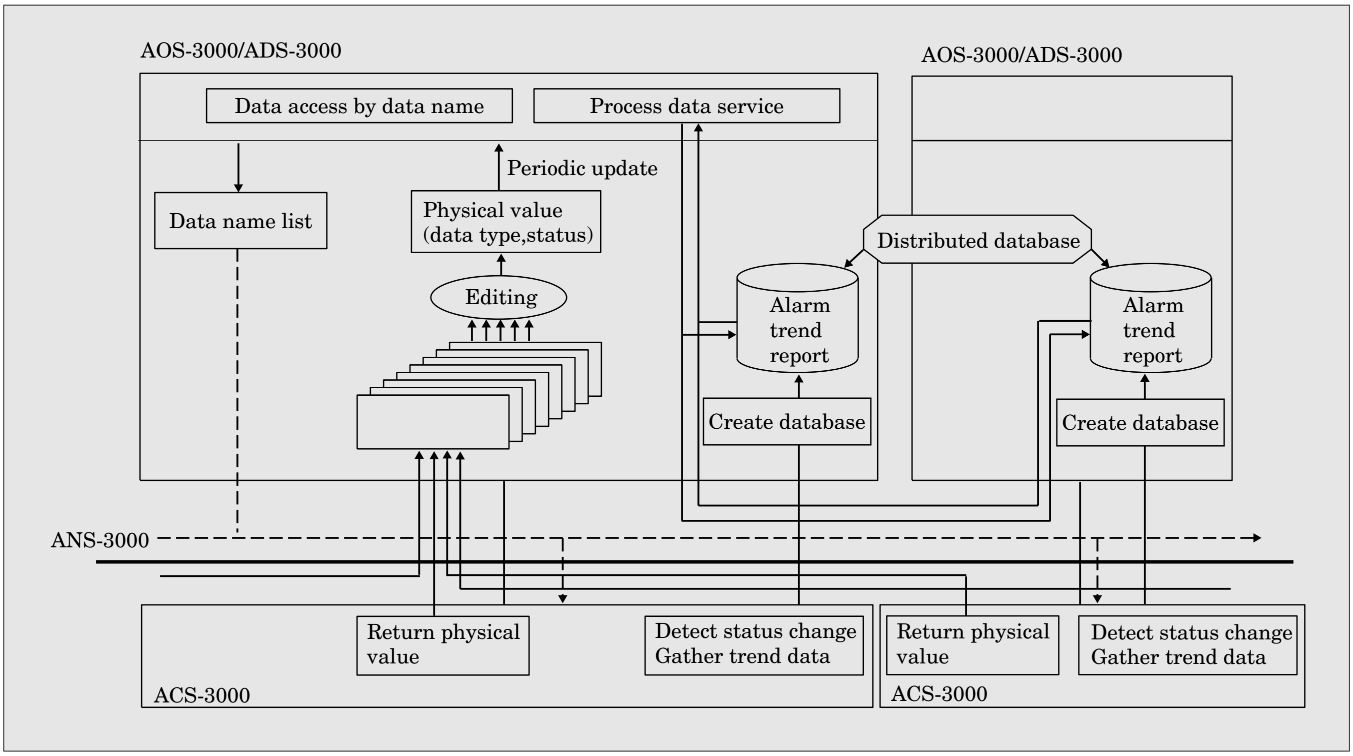
(1) Read data list

This is a function that reads from a certain station, a name list of temporary data managed by that station.

(2) Read data attributes

This function reads each data attribute (unit, scale, data name etc.) using the data name as a parameter.

Fig.7 Overview of data management functions



(3) Read temporary data

This is a function that repeatedly reads at fixed periods the value and status of each unit of data using the data name as a parameter.

Client processing of the above functions can be run on general purpose computers (we are planning to offer it as a packaged program). This makes it possible for clients to handle data of different type stations through identical interfaces.

3.3.2 Process database collecting function

This function collects process and stores process data in a time sequence, such data includes status transition information (alarms). Such as the occurrence of process trouble and the restoration of normal operation, fluctuation of process values (trends) and operation result data (reports). This data is normally used in plant operation and control.

(1) Alarm database

Status transition data and the occurrence or restoration of alarms are stored with a resolution of 1-second. Since the time clock is managed consistently throughout the system and control stations are able to detect events, this function can be utilized to analyze an occurring sequence of events extending into several stations.

(2) Trend database

This function stores temporarily varying process data in a time sequence. Short periodic data is collected by controllers; time and status data are gathered and managed together. This information may be used for various analysis.

(3) Report database

Operation results are stored as report data. The specifications for processing data are passed down from the existing system functions. On the assumption that user processing will be performed with an ISV (independent software vendor), the filing interface has been designed to allow easy use from an ISV.

(4) Process data service

This is a function that serves operator stations and general purpose computer systems with collected data. A function is provided that allows unrestricted data editing as well as an interface for using screens. Process databases are often distributed to limit machine capacity or to disperse risk. However, when using this service function it is not necessary to be aware of the data location.

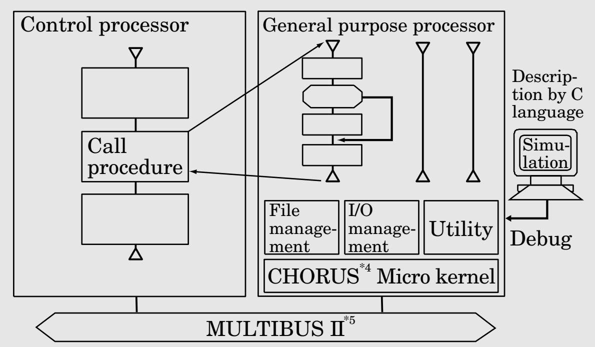
3.4 ACS-3000 advanced control station

Fuji Electric's controller has expanded the role of the EI controller. It has evolved into an EIC controller which will support new advanced systems with future technologies, while maintaining compatibility with conventional products, especially the recycling software resources and running client function for data management.

3.4.1 Higher speed

To meet the requirement for increased software capacity, the operating speed of the processor has been increased (2.5 times faster than before). In addition, by realizing a high speed data transfer on the system bus (up to 10 times faster than before), the ACS-3000 is suitable for a high speed LAN connection and a multi-processor system configuration.

Fig.8 Realization of value added functions by general purpose processor



*4 CHORUS : Developed and licensed by Chorous Systems Corp., France
*5 MULTIBUS II : A registered trademark of Intel Corp., USA

3.4.2 Added value function

A general purpose processor (computing processor) installed in the controller can be utilized as an assistant to the control processor. This has enabled complex control computing and large amounts of data processing without any influence on the control processor load (Fig. 8).

3.4.3 High reliability

Communication between processors by transferring messages has made it easy to configure highly reliable and maintainable systems.

3.5 ANS-3000 advanced network system

From the requirements of high level production systems, the trend of information communication is moving toward larger capacity and higher speed. The demand for open system components has made open communication a necessity.

The central LAN of the MICREX-AX (ANS-3000) is an integrated LAN for information and control that conforms to FDDI specifications and meets the above requirements.

3.5.1 Requisites of control LAN

The main principle in developing the ANS-3000 was to realize the following requirements of control systems: high speed (the required quantity of data can be transmit at the necessary speed), time definitiveness (communication can be performed within a designed time) and high reliability (operation safety functions that include preventive maintenance).

3.5.2 Cyclic transfer function

I/O or other data that different controllers need to reference is normally stored in the memory of one station. This function transfers that information between stations at high speed and in constant periods, and has been realized on the FDDI. With this function not only are complex procedures to obtain information unnecessary, but desired controls can be realized with simple logic, as the status (normal/abnormal) of other stations can be recognized as well.

3.5.3 Transparency of communication

ANS-3000 has adopted TCP/IP as an open protocol. This makes it easy to communicate with general purpose computers or PCs. For instance, controller engineering through the operator station (AOS-3000) and ANS-3000 has become possible from an engineering station connected to the information LAN. However, engineering to support controllers has to be carried out through direct connections to the advanced controller (ACS-3000).

3.6 AES-3000 advanced engineering station

The MICREX-AX has inherited existing engineering tools for controllers and offers a new computer-like support function for operator stations.

3.6.1 Succession to FPROCES

FPROCES-C, with its good reputation in existing MICREX-IX systems, is used with enhanced functions for controller support. Therefore, existing software can be recycled without any problems.

The tag definition which had positioned the data definition in conventional operator stations, is to be unified and managed as the data definition of the controller, together with the label definition of the electrical control function. As a result, the operator station test for scrambling data between controllers has become unnecessary.

3.6.2 Compatibility with integrated engineering support

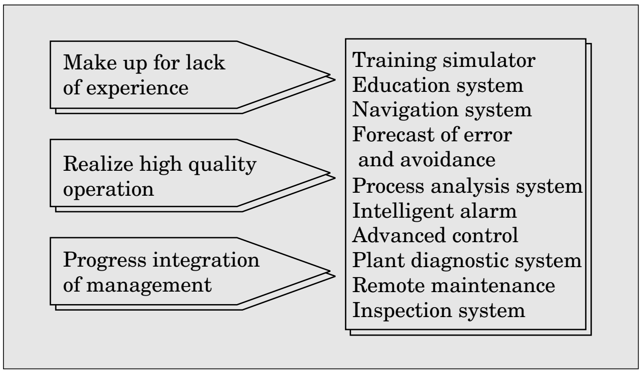
Improvement of engineering efficiency through the realization of a grouped engineering environment is considered fundamentally important for the MICREX-AX, and will be provided as a follow up to the MICREX-IX.

4. Future perspectives

The greatest features of the MICREX-AX advanced information and control system are the unfixed system and easy to expand functions.

In this era where increased sensitivity is being demanded, especially with uniform operator station functions, it has become difficult to sufficiently satisfy this demand. Since it is necessary to continuously improve productivity, tools to increase efficiency as well as changes in system architecture will be required.

Fig.9 Enhanced operation support functions



The MICREX-AX advanced information and control system will deal with such problems as follows.

(1) Utilization of PCs and ISV

To increase the value added to systems it is effective to utilize PCs and ISV. Based on the network and the open data environment of the MICREX-AX we will promote their use in systems.

(2) Compatibility with diversified demands

We will prepare a variety of packaged program solutions that are compatible with various fields, and will optimize them to meet demands. By selecting components appropriate for the targeted implementation, we will continuously offer highly cost-effective systems.

(3) Complete operation support function

Expectations are increasing for operation support functions that will realize highly efficient operation. Fuji Electric will promote the development of such functions as shown in Fig. 9.

5. Conclusion

Development concepts, features, an overview and future perspectives of the MICREX-AX advanced information and control system have been described.

Japanese industry is beginning to respond to the changing industrial structure through personnel reduction and configuration of highly efficient production systems, while shifting production abroad to improve price competitiveness. A new system centered around people has been proposed but its progress has been slowed as a result of the current low growth economy, we are hoping that this new system will begin to be promoted.

Fuji Electric is confident that our MICREX-AX advanced information and control system is such a system. To meet user's expectations we will acceralate our pursuit of the problems mentioned above.

The ACS-3000 Advanced Controller

Akira Nishikawa
Kouji Kawaguchi
Nobuo Taguchi

1. Introduction

The EIC-integrated system MICREX-IX, released in 1992, is the fourth generation of the distributed control system (DCS) developed by Fuji Electric. Many of these systems have been adopted as the core of automation systems in various industries. Now, the advanced information and control system MICREX-AX has been developed, a further extension of the original system.

The concept of EIC (electric, instrumentation and computer) integration is the realization of a closely knit combination of the product and its production process. For the DCS, this requires an integration of the product-oriented computer and the process-oriented controller.

The controller of the MICREX-series adopts a standardized architectural formula, achieving simplified EIC integration through a hierarchical arrangement of the function boards, package software and network, based on common technologies of the hardware and software.

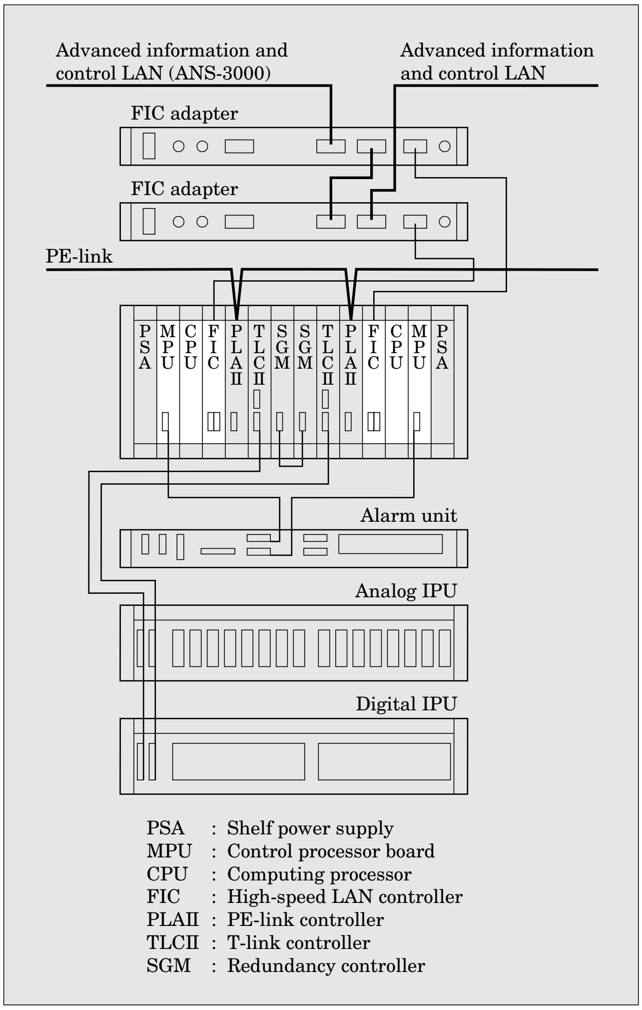
The newly developed advanced controller "ACS-3000" aims to realize an optimal system construction. This was achieved minimal engineering costs and by fusion of the computing function into the controller and mounting integrated data handling and support systems on its standardized architecture.

The features of the system include:

(1) a "multiprocessor" structure, which has a control processor together with a computing processor
(2) a high-speed computer connection via the LAN, based on the international standard FDDI (fiber distributed data interface)
(3) a "controller data handling system" based on the data name and physical value
(4) an engineering system that supports the above features

In this paper, the architecture and its accompanying basic technologies are described for the ACS-3000, which realizes effective engineering.

Fig.1 Basic hardware configuration of the ACS-3000



2. Hardware

Figure 1 shows the basic hardware configuration of the ACS-3000, and Fig. 2 shows the external view of its MPU shelf.

The ACS-3000 has the same architecture as the controller of the conventional MICREX series and can be connected commonly to the remote PIO (IPU, CIO, TK-capsule) via a T-link and directly to the PIO, P-link and PE-link.

2.1 Features

The ACS-3000, with its basic concept of flexibly constructing various systems with a combination of common components, is structured so that function unit boards are mounted on a 19-inch shelf. This shelf is then installed in a special cabinet. In addition, a stand-by redundancy system is achieved with a single shelf.

International interchangeability at the board level is achieved by utilizing a MULTIBUS II[*1], a 32-bit system bus (ANSI/IEEE1296).

2.2 Hardware architecture

Figure 3 shows the function block of the ACS-3000. Various types of independent boards for each function can be connected to construct an optional control system if needed. The multiprocessor configuration having a controlling processor board and a computing processor board enables the realization of multiprocessing or parallel processing of control and data processing.

*1 MULTIBUS II : A registered trademark of Intel Corp., USA

Fig.2 External view of MPU shelf

2.2.1 Control processor board

The control processor board (MPU) executes the functional control language (FCL), an intermediate language between the application programs and the controller. We developed 32-bit FCL chip in which the hardware executes not only sequential and arithmetic instructions but also floating point arithmetic operational instructions. The chip is more than twice as fast as the conventional one.

Table 1 shows the control specifications of the ACS-

Table 1 Control specifications of the ACS-3000

Item		Specifications
Instruction	Language	Functional control language (FCL)
	Instruction processing speed	Sequence instruction : 0.08 to 0.52µs Fixed-point addition and subtraction : 0.12 to 0.56µs Fixed-point multiplication : 0.16 to 0.64µs Fixed-point division : 4.00 to 4.44µs Floating-point addition and subtraction : 0.16 to 0.64µs Floating-point multiplication : 0.16 to 0.64µs Floating-point division: 1.40 to 1.84µs
Memory capacity	Program memory	512k Byte (128k step)
	Data memory	1M Byte (512k word)
Number of I/O points	Digital	T-link I/O For all IPU configurations : 8,192 points For all CIO configurations : 4,096 points Directly connected I/O : 512 points Total number : 8,704 points
	Analog	T-link I/O For all IPU configurations : 2,048 points For all CIO configurations : 2,048 points Directly connected I/O : 128 points Total number : 2,176 points
	Timer	1,024 points
	Counter	128 points
	Keep relay	1,024 points
	Differential relay	1,024 points

Fig.3 The function block of the ACS-3000

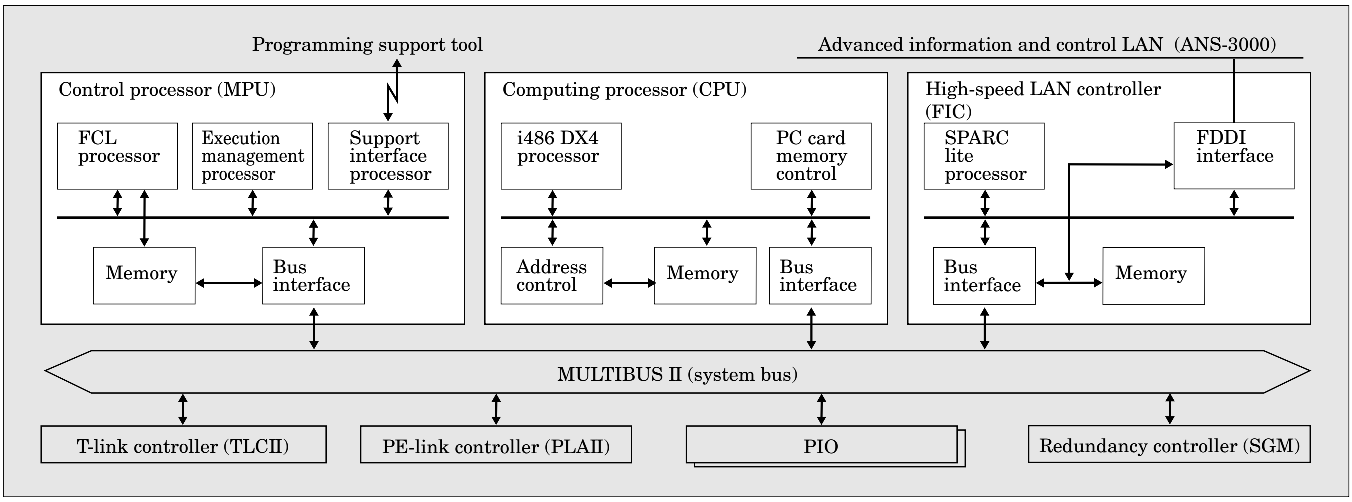
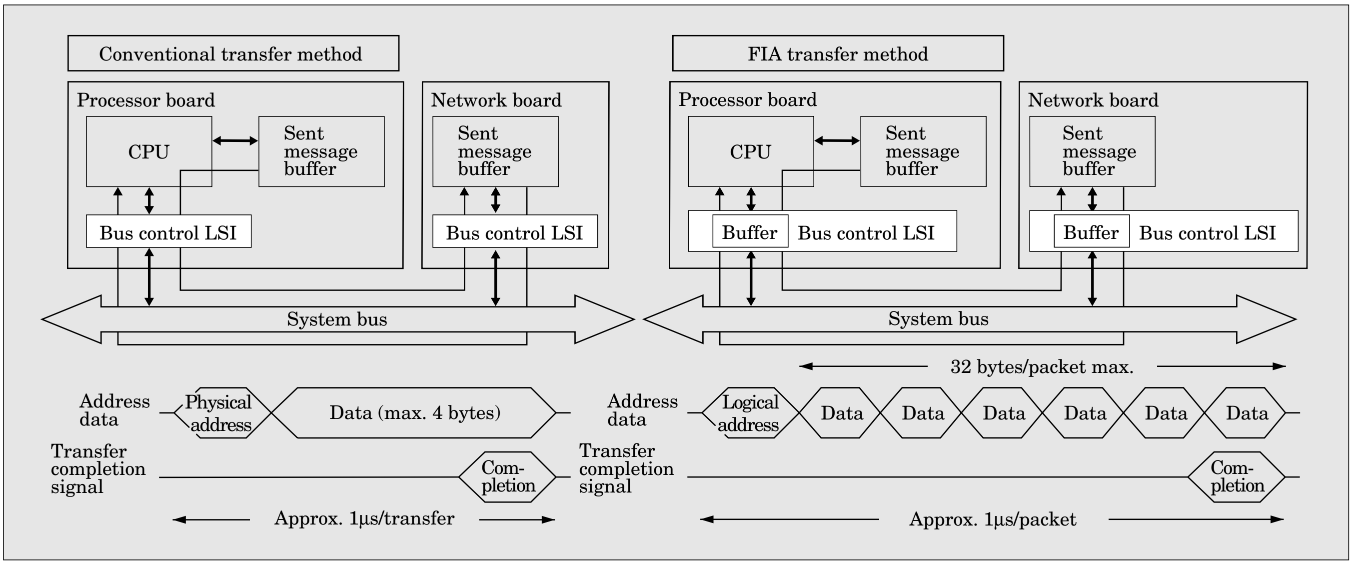


Fig.4 Data transfer method of the bus



3000.

2.2.2 Computing processor board

The computing processor board (CPU) uses the INTEL 486DX4, which is suitable for data processing. The micro kernel technique is adopted for its OS, enabling a real-time function by means of a "multi-thread" method.

In addition, two PC card memories can be mounted, which can be used for storing application programs as well as data names and physical value definitions.

2.2.3 High-speed LAN controller board for process control

The high-speed LAN controller board for process control (FIC) is a high-speed LAN controller for process control based on and extended from the FDDI, with a speed of 100 M-bits/second. By using the FDDI, high-speed communication to the advanced operator system AOS-3000 using a workstation and open connection to a computer system has become possible.

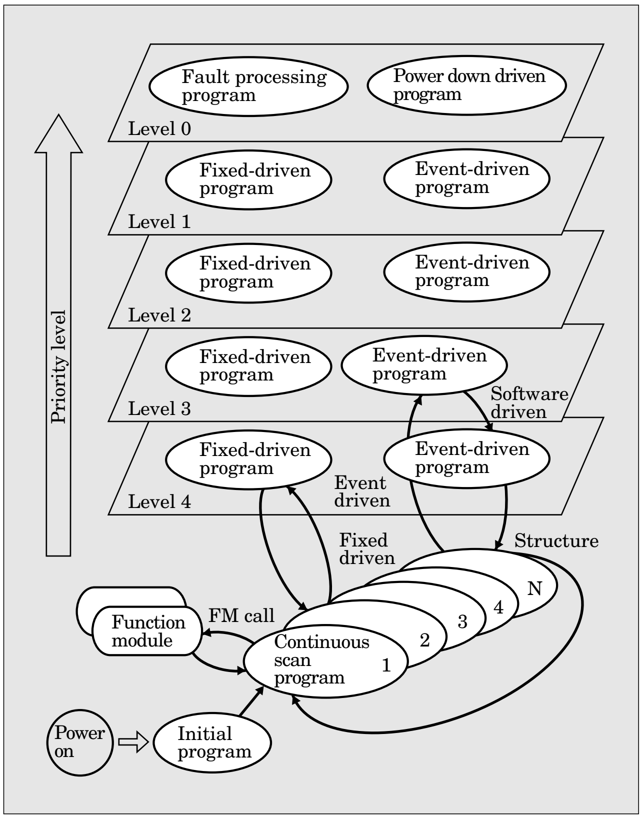
For further information on the high-speed LAN controller, please refer to the article "The ANS-3000 Advanced Information and Control LAN" in this same special issue.

2.3 Flexible system bus (FIA)

The FIA protocol greatly increases system bus transfer capability of the control processor board, the computing processor board and the network control board. The bus control LSI which executes this (MBC chip) has also been developed.

The data transfer method of the FIA (flexible interconnection architecture) is shown in Fig. 4. Within the time of transferring 4 bytes (32 bits) of data by the conventional physical transfer, 32 bytes of data are transferred by the FIA method. The transfer capability of the system bus has increased 8 times, ensuring sufficient capacity of bus transfer for the large data transfer volume between the multiprocessors and from network control boards.

Fig.5 Outline of program execution management



3. Application Interfaces

3.1 Programming language and program execution management

(1) Programming language

The programming language FCL has been used for the conventional MICREX series and can also be used for conventional software properties. FCL can develop various programming expressions including ladder diagrams, FB charts and SFC according to the control purpose. It is optimal as the intermediate language between the controller and the programming support system.

(2) Execution management of application programs

Program management, which controls execution of application programs in real time according to time sequence or to situation, is an essential factor in determining control function. An outline is shown in Fig. 5.

Program execution management controls four kinds of execution-continuous scan, fixed cycle driven, event driven and software driven-according to their priority levels.

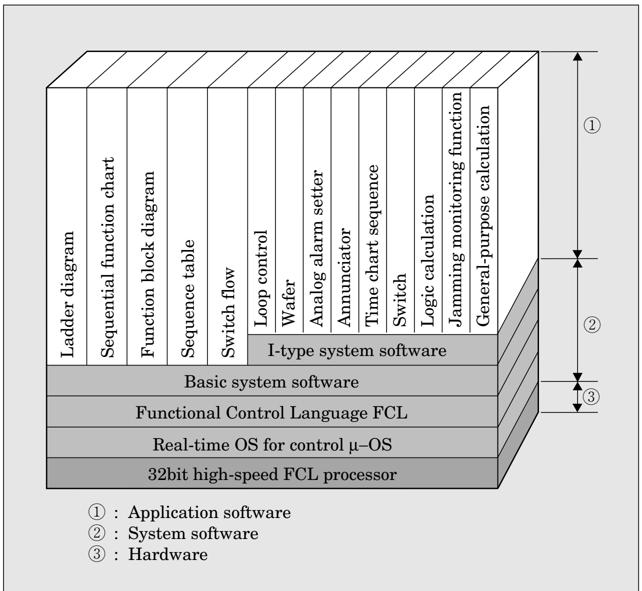
Also, the execution ratio of electric control (E), instrumentation control (I) and applications can each be set optionally, so that various control systems can be flexibly constructed. As programs can be executed as function modules, repeated use is simplified.

4. System Interface

4.1. System software

As shown in Fig. 6, the system software of the ACS-3000 is structured hierarchically, with instrumentation system software (I-type) packages mounted on the basic system software. Therefore, the ACS with only its basic system software operates as an electrical control (E-type) programmable controller (PLC). By adding the I-type software package, it then becomes an electrical and instrumentation (EI-type) controller. The control functions used by the I-type include loop control (internal instruments), analog alarm setter, annunciator, time chart sequence, switches, logic calculation and jamming monitoring function.

Fig.6 Software classes of the ACS-3000



4.2 Data management

Regarding the process data to be controlled by the controller, the purposes of data management are:

(1) to have the definition for control (the physical value definition), so that the application programs using the physical value definition can operate process data in unity

(2) to have the definition for process management by the operator (the attribute definition), so that the operator station using the attribute definition and physical value definition can indicate, operate and store process data in unity

In this system, the adding of the data management function to the ACS has enabled unified management, unified operation and access to the process data definitions within the system that includes the operator station AOS-3000.

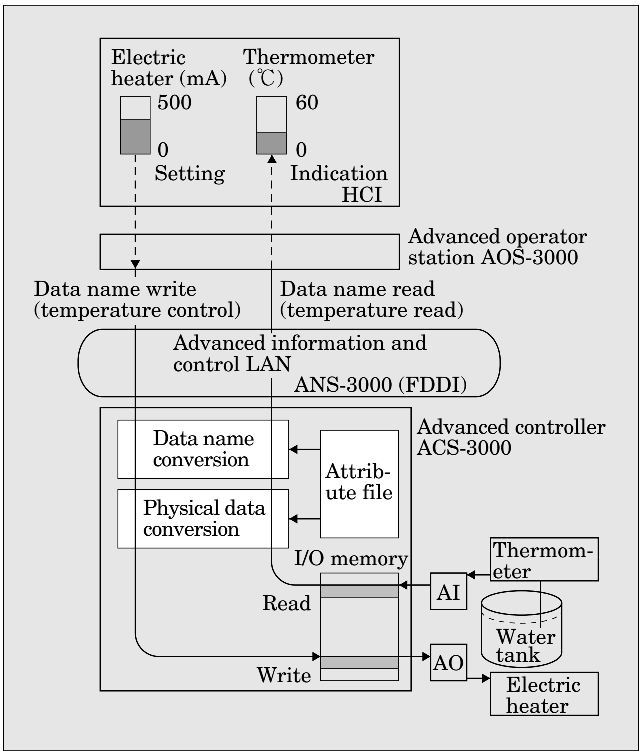
This has achieved a revolutionary improvement in system engineering efficiency. Moreover, as they are unified in the physical data definition also on the network, open interface with the computers has become possible.

4.2.1 Unified data management

Data management is defined by the engineering support system (AES-3000 or FPROCES-C). It is function within the ACS-3000 that manages in unity unique data names (tag number and label), attribute value definitions (comments and messages) and physical value definitions (unit, scale and unit quantity).

Under unified data management, the AOS-3000 accesses process data after first up-loading definitions

Fig.7 Data name access method



of the controller. Even for often executed changes such as scale, simultaneous changes throughout system are enabled by changing only the attributes of the ACS form the support system.

4.2.2 Physical value operation

In the ACS-3000, the physical value definitions can be set optionally for input/output data, internal data and instruments. As a result, the application programs can execute their process data operations without regard to the data type. Consequently, function blocks with physical value, specified by the fieldbus, can be easily programmed.

Furthermore, since both conventional %-data and floating-point data are treated as internal data formats, it is possible to utilize existing software properties as they are.

4.2.3 Data name access

The data name access function enables the AOS-3000 access by indicating the unique data name within the system defined by the process data.

With data name access, the AOS can broadcast and send access requests to every ACS-3000. Each ACS, after checking to see if the corresponding data name exists within itself, can send back its result, if any, to the requesting source. An example of data name access is shown in Fig. 7.

In the data name access method, equipment of a higher class such as the AOS and computer systems can be accessed by merely using its data name. Because the ACS executes access-operation to find the data name from its own data name definition, equipment of a higher class does not need to know , to which ACS the data belongs. Furthermore, the data name is unique within a system. When the data arrangement is changed within the system or between systems, it is only necessary to change the data name definition of the ACS. No change of higher class application programs is required.

4.3 HCI interface function

The ACS-3000 has been installed with functions conventionally executed by an exclusive database stations. These functions include storage of historical data such as state change and trend and HCI-interface function such as a system clock. The ACS and AOS-

Fig.8 State transition

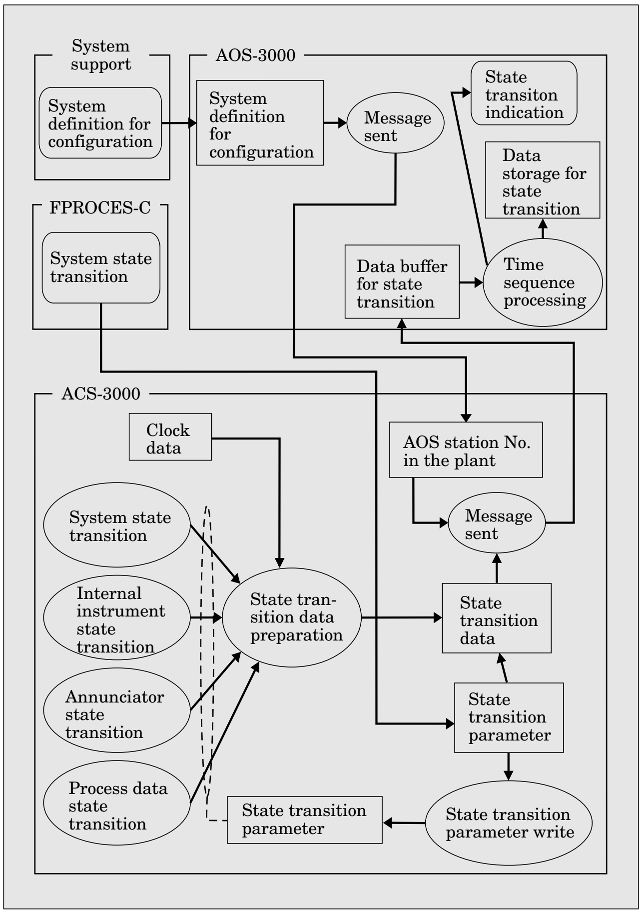


Fig.9 Usual trend / batch trend function

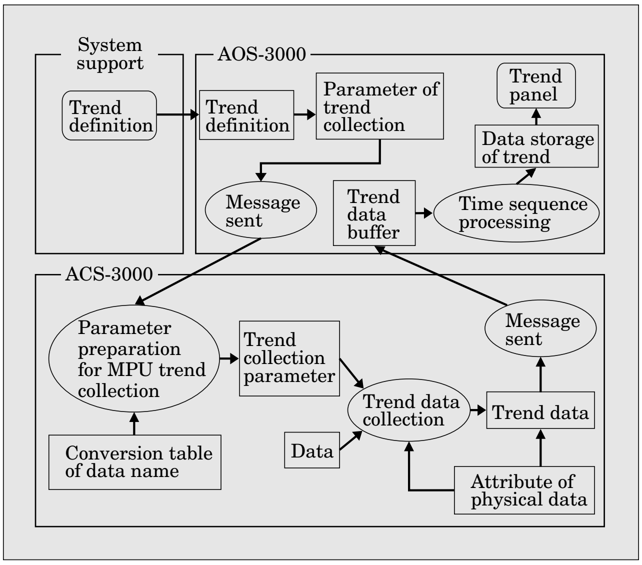
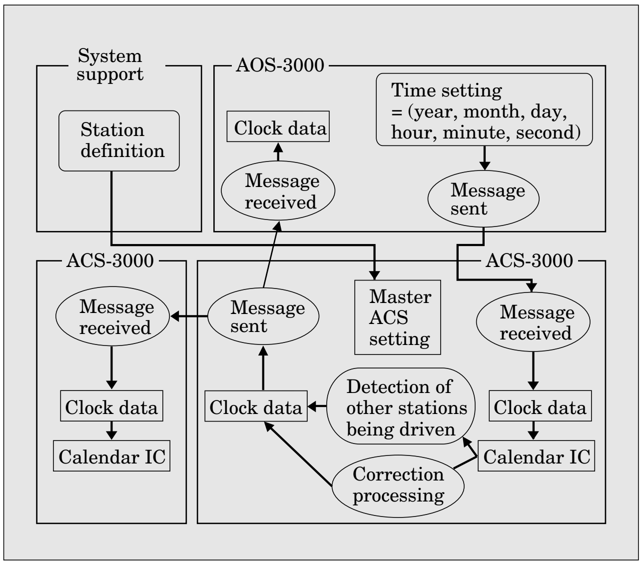


Fig.10 System clock function



3000 are solely capable of configuring simple yet complete system.

4.3.1 State change function

The ACS-3000 is able to detect state changes of process data and alarm signals in the internal instrument and can send this information, attaching the system clock time, to the AOS-3000. As a result, it can store and indicate the history of state transitions in the entire system, along with their correct times occurrence. (Fig. 8)

The state change function of the ACS is divided into four types and attached with its occurrence time in milliseconds:

(1) System state transition

Its function is to report the system transitions in the ACS and contains the following details:

- (a) normality/abnormality of such boards as the TLC II, PLA II and SGM
- (b) normality/abnormality of the PIO
- (c) normality/abnormality of such instruments as the FCX transmitter and FFI equipment

(2) Internal instrument state change

This reports occurrence/return of alarm signals of the internal instruments (PID controller, alarm indicator, etc.)

(3) Annunciator state change

This reports occurrence/return of the annunciator output.

(4) Process data state change

This reports the positive/negative edge of bits.

4.3.2 Trend function

As the ACS-3000 samples and stores process data and PIO data and sends them to the AOS-3000, it can execute correct sampling during the data collection cycle or at the collection's start/stop signal. (Fig. 9)

There are two kinds of trend functions, normal-trend and batch trend. The normal trend collects data according to the set cycle, and the batch trend collects data at each collection's start/stop signal.

4.3.3 System clock function

In this system, a master system clock is built into a specified ACS-3000. By coordinating the synchronized time correction of the ACS and AOS-3000, the system time lag for each system is kept to a minimum. (Fig. 10)

(1) Time setting function

The AOS-3000 sets time data (year, month, day, hour, minute and second) into the ACS-3000, which contains master system clock. The master ACS with the set time sends the time data to the other ACS and AOS and sets system clocks for all stations. The clocks of the stations which have been driven during system operation are also set.

(2) Clock correction function

Once the clocks have been set, the master ACS transmits the clock's correction data in a fixed cycle in order to correct the system clock of each station.

Each station corrects its own system clock using the transmitted clock correction data. The clock correction function keeps the time lag between station to tenths of a millisecond.

5. Conclusion

The aims, architecture and basic technologies of the ACS-3000 advanced controller are described in this paper. The architecture of the ACS-3000 is extensible due to the fact that it takes technological development into consideration. We plan to propose systems which support connection of the ACS to various networks and equipment, including fieldbuses.

We propose to develop software packages for various application areas including advanced control for rational development of applications and to develop engineering tools for integrated support.

Moreover, we will continue our efforts, kindly supported by our customers, to further improve our systems.

The AOS-3000 Advanced Operator Station for Multimedia

Yoshihiro Ikawa
Yukio Koga
Masakiyo Oshiba

1. Introduction

Automated and unmanned control of monitoring equipment have increasingly been adopted in many plants. However many inspection, operation and monitoring tasks are still performed manually.

Recent and remarkable developments in the infrastructure and technology for multimedia have made it possible to integrate multimedia data such as image, voice, and process data. In the future it will be important to realize visual operator interfaces that utilize the above technology, making it possible to detect abnormal conditions accurately and quickly.

To cope with the rapid progress of technology, Fuji Electric has made it possible to construct an operator workstation utilizing a workstation in an open system. An advanced human-computer interface (HCI) can be installed in the operator station to facilitate supervisory control through multimedia.

This paper outlines the function of the AOS-3000 advanced operator station and describes a multimedia human interface to realize visual monitoring and control.

2. Overview of the AOS-3000

2.1 Characteristics

(1) Open platform

The AOS-3000 has used UNIX workstations[*1] for a long time as a hardware platform that can utilize recent technical developments. This enables a system construction with up-to-date and open technology.

“S-family” workstations, installed with the latest version of UNIX are used. These workstations provide the necessary hardware and software for monitoring. Therefore, an enormous amount of distribution software as well as standard communication protocols such as Ethernet[*2] and FFDI (fiber distributed data interface) can be used. In addition to the S-family, operator stations can also be constructed from Fuji Electric’s industrial-use DS/90 UNIX computer.

(2) Flexible system

It is necessary for the operator station to expand and change functions in response to changing plant conditions.

To accommodate this requirement, the operator station has a changeable software configuration and is installed with software suitable for load distribution. Figure 1 shows the software configuration.

(3) User-friendly human-computer interface

The AOS-3000 utilizes multi-window operation, enabling the monitoring and operation of two or more conventional operation panels at the same time.

The introduction of multimedia functions into the functions of the conventional operator station allows the AOS-3000 to accurately and quickly determine site conditions.

2.2 Functions

The operator station is composed of the following seven function blocks.

(1) Message communication function

This function allows the operator station to exchange messages through dataways with controllers and computers connected to those dataways.

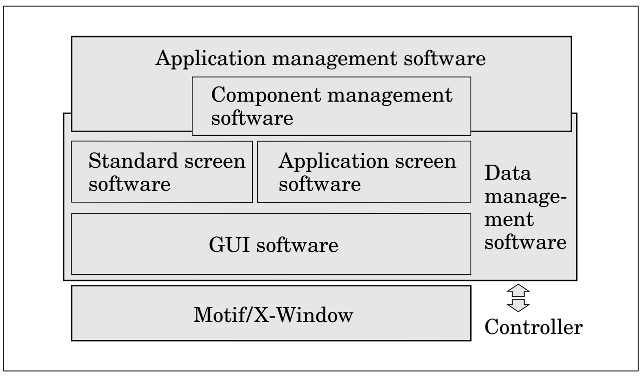
(2) Data management function

This function allows the operator station to use the message communication function to read and write

∗1 UNIX : A registered trademark of X/Open Company Ltd.

∗2 Ethernet: A trademark of Xerox Corp., USA

Fig.1 AOS-3000 software configuration



data from controllers and computers connected to the dataways. In addition, this function allows the operator station to collect and store time series data and document data as well as to receive, record and store events such as alarms generated by controllers.

(3) Document function

This function allows the operator station to print daily, monthly and annual reports based on the data collected by the data management function.

(4) Window operation function

This function allows the operator station to perform overall window management and various types of processing in addition to window display, such as alarm events.

(5) Standard screen function

This function allows the operator station to provide a standard monitoring operation screen. Since definition information is collected from the corresponding controller, monitoring screens can be displayed without much engineering effort.

(6) Supporting function for monitoring operation screen

This function supports the creation and display of monitoring operation screens such as a system screen created for each system. Various components for creating screens are provided to facilitate the design and creation of screens.

(7) Multimedia HCI function

This function allows the operator station to display an on-site image on the screen, and to monitor the on-site sound and process data in synchronization with that on-site image. This function is described below.

3. Multimedia Human-Computer Interface (HCI)

Fuji Electric has already realized the following functions in multimedia HCI.

(1) Window display of site image by the selection of camera icons on various monitoring screens

(2) Synchronized recording and playback of image, voice and process data before and after abnormalities.

Fuji Electric has recently developed a scene-based interface that utilizes site images, to performing remote monitoring as if on-site.

The scene-based interface is described below.

3.1 Functions

Figure 2 shows a schematic diagram of the scene-based interface.

When an image that includes the object to be monitored is displayed by camera operations such as panning, tilting and zooming, the scene-based interface determines what the object in the image is and automatically displays the image with information necessary for the operator. As a result, plant conditions can be easily monitored, as if the site were being surveyed.

Table 1 lists the scene-based interface functions and Figs. 3, 4 and 5 show examples of monitoring screens.

3.1.1 Multimedia display function

Figure 3 shows an example of a monitoring screen when a camera and a monitored image of an air-conditioned room have been selected. A control panel, meters and valves are displayed on the screen, and the site image is overlaid with their names and instanta-

Fig.2 Schematic diagram of scene-based interface

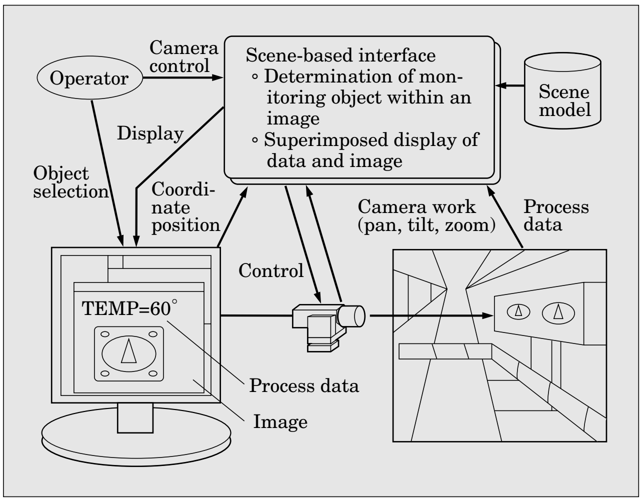


Table 1 Function of scene-based interface

Function name		Contents
Multimedia display	Video window display	The site image is displayed in a window on the screen of the operator workstation.
	Overlay display	Object name or process data are overlaid near the monitored object on the image.
	Monitoring window automatic display	The monitoring screen (trend graph, operation panel, guidance, etc.) for the monitored object in the image is automatically displayed in different windows.
	Site sound output	Sound from an on-site microphone in the image is output.
Operation as if on-site	Camera control through button	The camera is controlled from camera control buttons.
	Camera control by pointing to the image	The camera is controlled by pointing to the image and the pointed location in the image is displayed in the center of the video window.
	Camera control by pointing to the object	The monitoring object in the image is zoomed in when pointing to in image.
	Monitoring window display by pointing to the object	A detailed monitoring screen for the monitoring object is displayed in a different window by pointing to the object on the image.
Monitoring information input on image	Memo input	A memo (voice, text, etc.) is defined at the pointed position in the image. Memo mark is displayed on the target position in the image.
	Memo output	The memo is redisplayed by pointing to the memo mark.

Fig.3 Example of monitoring screen 1

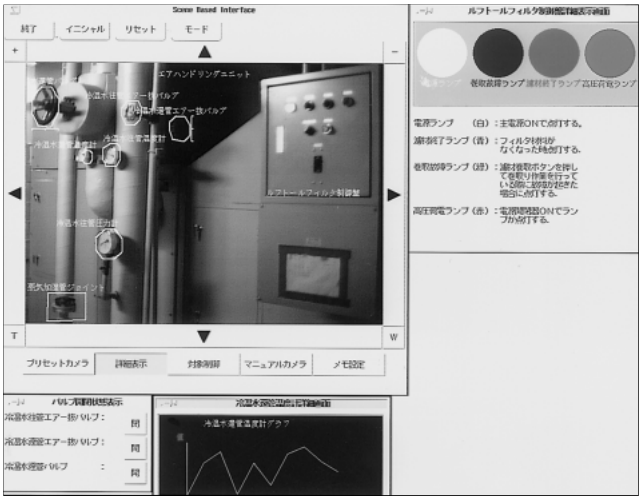


Fig.4 Example of monitoring screen 2

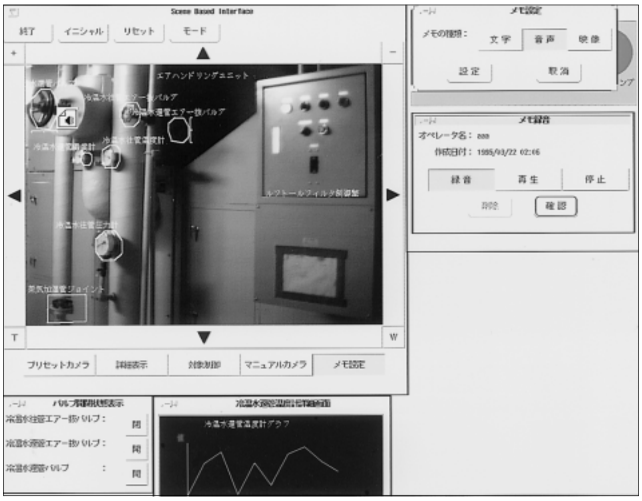
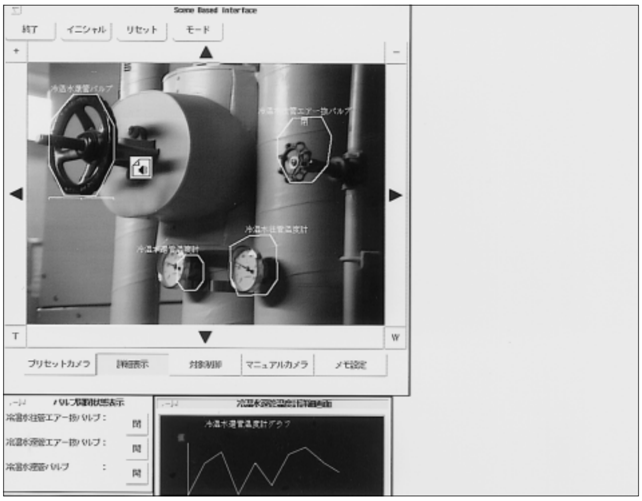


Fig.5 Example of monitoring screen 3



neous values of the related process data. A description of the control panel within the image is automatically displayed on the upper right window of the screen. A trend graph and a valve operation panel are automatically displayed in the bottom window of the screen. In addition, if a microphone is in the image, a microphone mark is displayed at the position of the microphone to indicate the position at which audio data is collected. The collected audio data is automatically output.

Figure 5 shows a zoom-up of the monitoring screen in Fig. 4. Because the control panel has disappeared from Fig. 4, the corresponding window in the upper right hand corner of the screen is not displayed. Information superimposed on the image is redisplayed at the corresponding object position.

Thus, the monitoring screen is automatically updated by operating a camera to display the monitoring object. Plant conditions can be easily monitored using multimedia image, audio and process data.

3.1.2 Virtual on-site operating function

Guidance information about meter indicators, which cannot be displayed simultaneously on the monitoring screen in Fig. 3, can be displayed in other windows by pointing to the meter image.

A camera can be controlled to face any desired direction either by pointing to a monitoring object or by pointing to any of the ▲ buttons located to the right, left, above and below of the image.

3.1.3 Setting function for image monitoring information

Figure 4 shows a monitoring screen in which a voice memo is input by pointing to the upper left valve position in the image and a memo mark is displayed next to the valve.

The memo mark can be set by pointing to the concerned position.

By selecting the record button in the window displayed at the upper right of the screen in Fig. 4, a voice memo can be input. Later, the input memo can be output by selecting the memo mark on the screen.

Once the above setting is made, the memo mark will be displayed at the position of the monitoring object even when a camera is controlled. For example, the voice memo set on the monitoring screen of Fig. 4 is still displayed next to the valve even when the screen switches to that of Fig. 5.

3.2 Method

3.2.1 Processing method

To realize the above functions, the on-site scene structure should be modeled in an operator workstation and the monitoring screen corresponding to each monitoring object should be saved.

When an operator selects a monitoring image, it is assumed that the operator's intent is reflected in the camera parameters (pan, tilt, zoom).

The monitoring object displayed in an image is determined from the scene model on-site and the camera parameters. Figure 6 shows the processing flow diagram of the scene-based interface.

3.2.2 Scene model

Cameras are usually installed in a fixed location such that an operator can only see the scene projected

Fig.6 Flow diagram

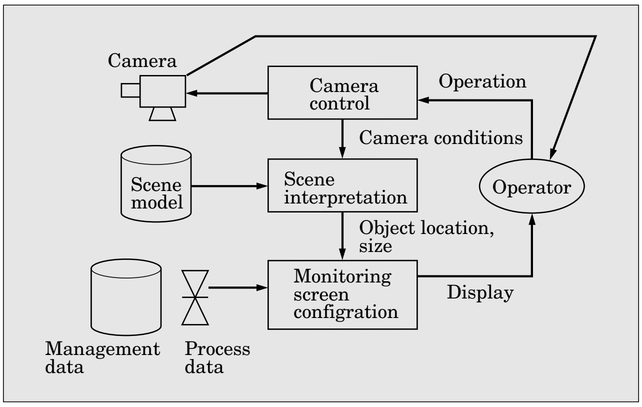
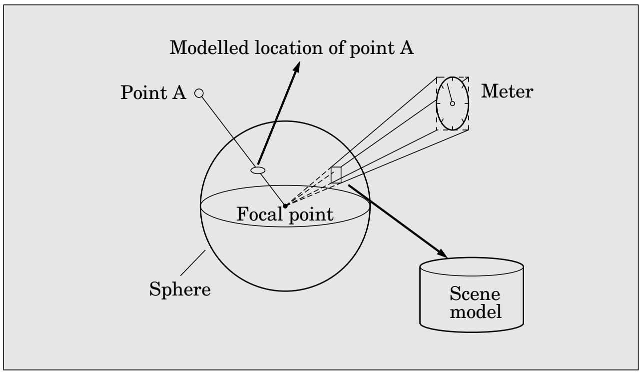


Fig.7 Scene model



on the image plane. Therefore the distance to the object is not necessary for modeling the site scene. As shown in Fig. 7, the structure of the site scene in which a camera is installed is obtained as a spherical projection, with the focal point of the camera at its center. From this, the external form of the projected monitoring object is modeled. As a result, the complete surroundings of the camera can be modeled, and the position and size of the monitoring object can be estimated by determining camera parameters. Once the positions of the object and memo mark are defined using the scene model, the scene-based interface can be realized with various camera parameters.

3.3 Features

(1) In the past, images and distributed control system process data were monitored on separate screens. Now they are correlated and displayed on the same screen. This facilitates the control and operation of monitoring while confirming on-site conditions.

(2) Operation items and their related information are displayed together with images, thereby reducing the work load for operators.

(3) A spherical model is utilized for the scene model. This facilitates the definition of a scene model that realizes a scene-based interface from camera parameters. The system configuration is also simplified.

4. Conclusion

In this paper, advanced operator stations have been introduced, focusing on a scene-based interface, a scene-determining-type, multimedia human-computer interface.

Advanced operator stations are playing an increasingly important role in monitoring control systems as the only point of contact between a plant and operators. Multimedia HCIs are also playing an important role, and it is expected that they will be widely used not only in more intelligent ITVs, but also as a new interface in remote monitoring control.

Fuji Electric will continue to improve applications and related functions so that operator stations will be widely used.

The ANS-3000 Advanced Information and Control LAN

Masao Fujikawa
Fumihiko Fujita
Hideaki Takishita

1. Introduction

Manufacturing systems require various networks with different characteristics to handle the different types of information processing that are dependent upon the level of production management and control in computer integrated manufacturing (CIM).

Fuji Electric has supplied DPCS-F, Ethernet[*1], and T-link control networks to meet the needs of these management and control levels.

Control systems are progressing toward larger capacity and higher speed communication to cope with increasing industrial demand for improved productivity and advanced systems. In addition, open communication systems have become essential for the construction of flexible systems that will be able to incorporate future devices in this rapidly progressing field. Fuji Electric has integrated conventional LANs to develop the advanced network system 3000 (ANS-3000), an advanced, high speed integrated LAN that satisfies the next generation requirements mentioned above (refer to Fig. 1). The ANS-3000 introduced in this paper is a basic LAN, to which operator stations, controllers, and control workstations are connected. Systems may also be configured with integrated information networks.

*1 Ethernet : A registered trademark of Xerox Corp., USA

2. Control LAN Trends

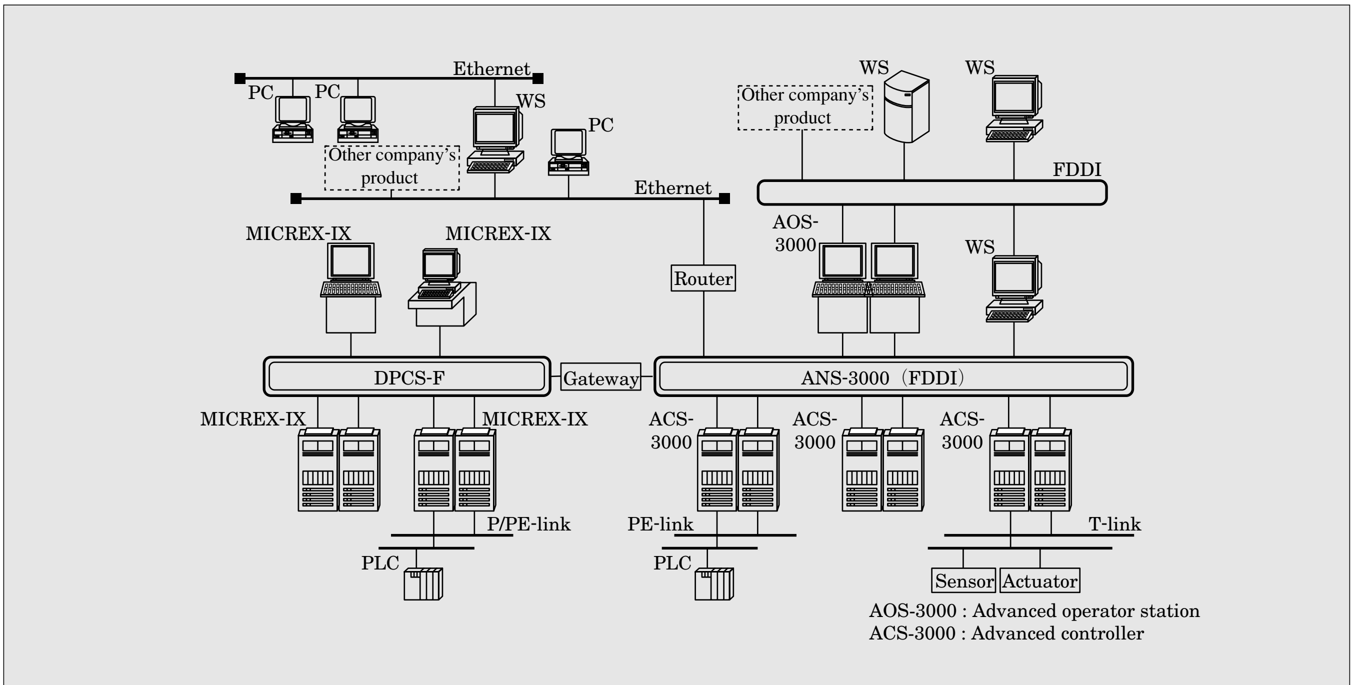
The trends toward larger capacity, higher speed and open control LANs are described below.

2.1 Larger capacity and higher speed information communication

(1) Human-computer interface improvements

Because of the improvement in their cost performance, workstations (WS) and personal computers (PC) have come to be used as the main components in human-computer interfaces.

Fig.1 MICREX-AX system configuration



Remarkable improvements in the processing speed and display functions of this information equipment has created a need for higher speed communication that can gather large amounts of and many types of data.

(2) Efficient engineering

Conventional control LANs would sometimes become solely occupies with the transfer of control data, and the transmission of other data through the LAN was difficult. This would happen in cases where large programs or large amounts of definition information were transmitted. If a high-speed LAN of 100Mb/s is used, information (i.e. a large amount of engineering defined data and a large numbers of programs to be downloaded) other than control data can be transmitted even when the system is operating.

The merits reduce turnaround time for developing a system.

(3) Securing response time

There are many devices and communication line that constitute an advanced, wide area system. To secure the required response time from end-to-end, overhead time in each of the devices and lines should be as small as possible. As a result, increasingly higher speed LANs are being required.

2.2 Open LAN

In a manufacturing system, there has been strong demand for a control LAN with an open protocol such as TCP/IP that can utilize a wide variety of information equipment and information processing functions having excellent cost performance, and will allow shared use and reuse of information. Open protocols allow multi-vendors to build manufacturing systems.

3. Overview of the ANS-3000

Under these circumstances Fuji Electric has developed the ANS-3000, a high-speed information and control integrated LAN, to meet the large capacity and high-speed information communication requirements for future control LANs and to realize higher reliability.

3.1 ANS-3000

In a manufacturing system, the network used will have a scale appropriate for the system.

Figure 2 shows the system configuration of the MICREX-AX system, supplied by Fuji Electric.

The ANS-3000 can be used in a high-speed control LAN in both medium-scale networks and in large-scale information networks.

As shown in Fig. 1, the ANS-3000 allows communication between WSs, AOSs (advanced operator station), ACSs (advanced controller), and DPCS-F through a gateway. The ANS-3000 is an information and control integrated network system, which permits open communication over a unified information network.

The direction of development for the ANS-3000 is described below.

(1) Realization of a highly reliable 100Mb/s LAN

A fiber distributed data interface (FDDI) was utilized as a highly reliable 100Mb/s LAN. The FDDI is an open, internationally standardized optical LAN specified by ANSI X3T9. The FDDI allows direct communication with an information network.

(2) Utilization of an open protocol

An open communication system is realized by a communication function based on TCP/IP.

(3) Realization of high-speed transmission between controllers

Shared memory communication (cyclic transmission) with a refresh cycle time of up to 2ms (4k bytes) between stations (controllers) is realized.

(4) Realization of high reliability

Highly reliable functions allow the location and isolation of faults in a network and preventive maintenance of the network.

3.2 Topology

Figure 3 shows an example topology of the ANS-3000. FDDI cards (Fig. 4) and FDDI adapters have been developed as components of the ANS-3000.

(1) FDDI card

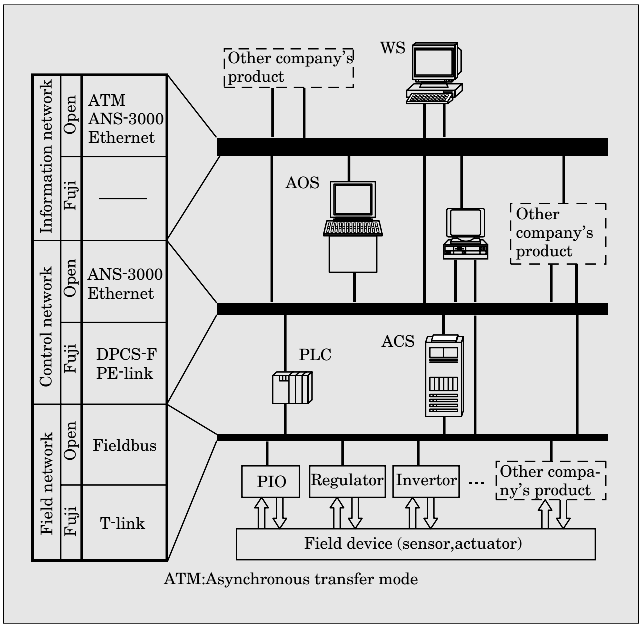
The card is a communication card for FDDI, mounted on an ACS.

The entire ANS-3000 communication, protocol, including TCP/IP, is executed by firmware programs in the card, thereby reducing the load on the main CPUs in controllers.

(2) FDDI adapter

The adapter corresponds to a device known as a concentrator in the FDDI standard. This adapter

Fig.2 Fuji Electric's network configuration



connects a card to the trunk (double ring) of the FDDI and allows TCP/IP communication for collecting maintenance information. In the ANS-3000, two adapters can be connected to a card to form a dual configuration, known as dual homing.

4. Features of the ANS-3000

Features of the ANS-3000 will be described below. Table 1 lists the basic specifications of the ANS-3000.

4.1 Utilization of FDDI

In consideration of the following benefits, it was decided to utilize on FDDI optimized for an information and control integrated LAN in the ANS-3000.

(1) The FDDI is the most widely used and most stable international standard, 100Mb/s high-speed open LAN.
Because of its double ring of optical fibers, the FDDI has the low noise and low maintenance characteristics required for a LAN.

Fig.3 ANS-3000 topology

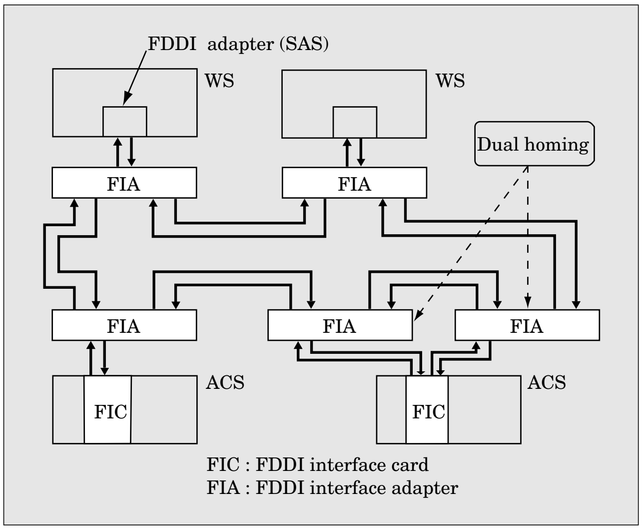
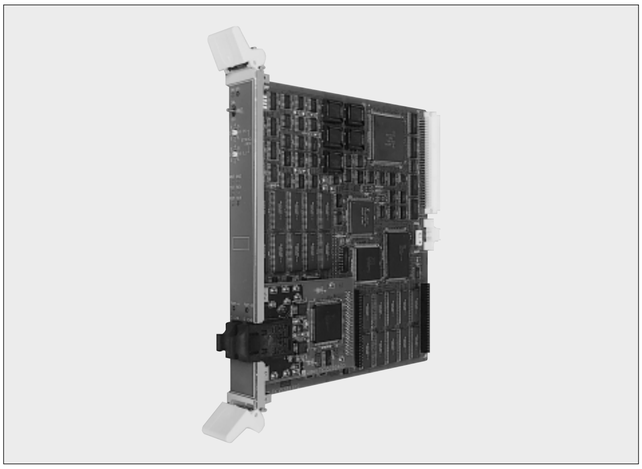


Fig.4 FDDI interface card



(2) High-speed and real time performance essential for information communication can be guaranteed with the FDDI.
Because the FDDI has adopted a limed token passing method, each station can secure equal transmission rights (token).

(3) As will be described later, the ANS-3000 provides various highly reliable functions such as preventive maintenance. The highly reliable FDDI protocol is very useful in the realization of these functions.

4.2 Control message transmission protocol

A control message transmission protocol is built on the TCP/IP and used for the variable access of controllers, alarm notification, and loading of engineering information (Fig. 5).

The ANS-3000 utilizes TCP/IP as open protocol. However, TCP/IP has the following disadvantages for control LANs.

(a) Byte stream transmission is used for the TCP transmission but packet transmission is more desirable for control applications.

(b) Since the TCP transmission requires connection control, it is too complicated to be used as

Table 1 Basic specifications of the ANS-3000

Applicable standard		FDDI ANSI X3T9
Transmission speed		100 Mb/sec
Cable Distance between stations		Fiber optic cable (G1 50/125µm) 2km
Total fiber path length		Max. 200km
No. of stations		Up to 255 stations (up to 127 stations in redundancy case)
Topology		Double ring
Sustained transmission rate		80 Mb/sec
Maximum receiving frames/station		5,000 frames/sec
Maximum frame length		4,500 bytes
Message transmission	Transport layer protocol	TCP/IP
	Type of transmission	Connectionless transmission
	End point	Station number + Message number
	Maximum message length	4k bytes
	Redundancy	Provided
	Priority sending	Provided
Cyclic transmission	Broadcasting	Provided
	No. of max. sending blocks	16 blocks
	No. of max. receiving blocks	512 blocks
	Size/block	Max : 4096 bytes Min : 4 bytes
	Refresh cycle time	High level : 2 to 100ms Low level : 10ms to 60 s
Redundancy		Duplex station Dual homing Double-ring loop back

is by controller programs. The overhead of connection control retards the high-speed response necessary for a control LAN.

To solve these problems, Fuji Electric has developed a control message communication protocol for the ANS-3000. The features are described below.

(1) The protocol provides a function that enables applications to communicate with each other via packet data.
(2) The protocol automatically controls establishment of the TCP connection and recovery from errors. The protocol mechanism always maintains the connection.

This has released applications from the burden of connection control.

As shown in Fig. 5, MICREX-AX ensures system expandability and reliability through performing variable access, loading of engineering information, and communication such as collection of maintenance information with the same control message protocol, between operator stations (AOS), controllers (ACS) and supporting systems (FPROCES-C mounted on PCs).

4.3 High-speed cyclic transmission

Cyclic transmission is a protocol that realizes shared memory through transmitting data between ACSs at high speed and a constant period. The shared memory allows shared ACSs to share control data.

High speed cycle transmission is directly built on the FDDI without using TCP/IP so that it can operate with a minimum overhead.

The features of high speed cyclic transmission are described below.

(1) High speed transmission with a period of 2ms (total 4k bytes) between all stations is realized.
(2) Large shared memory transmissions of up to 2M bytes are possible with send and receive combined.
(3) Shared memory transmission, realized through broadcast communication, also provides a group function to enable only necessary station, to receive necessary data. This function relieves the system from the increased load of receiving unnecessary data.

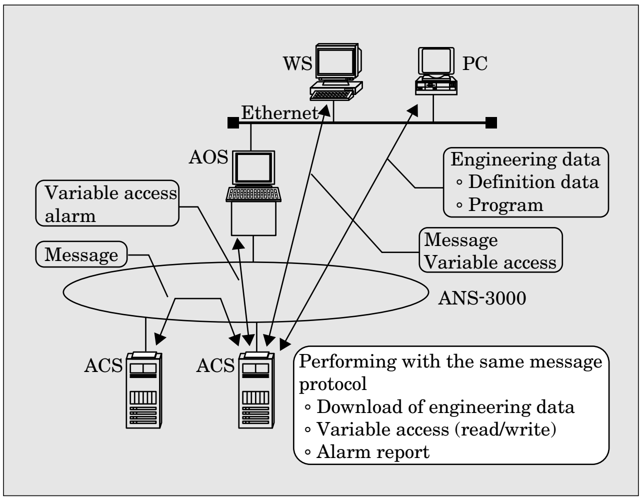
4.4 High reliability

Fuji Electric has realized a network management system that ensures high reliability through the utilization of FDDI in Fuji Electric's proprietary network. Functions that provide high reliability are described below.

(1) Ring redundancy

The FDDI utilizes a double ring. Even if the line breaks in one place or a station becomes inoperative,

Fig.5 Communication by the same message protocol



normal communication can continue using a spare ring.

(2) Line diagnostic function

When a station is connected to a ring, that station and the line between neighboring stations are examined. If any fault is found, the faulty section is separated so that operation can continue. As a result, communication is prevented from falling into an unstable condition.

(3) Line fault detection and alarm notification

Each station has a function to monitor line status. The line status is continuously monitored. It is possible to detect the occurrence of errors above a certain rate which could make communication unstable.

Stations which detect a faulty section notify operator workstations with an alarm. This preventive maintenance ensure that network communication does not become badly obstructed.

5. Conclusion

This paper has introduced the ANS-3000 and the high-speed LAN trunk for MICREX-AX. In the future Fuji Electric is determined to make efforts to construct a variety of advanced applications. In the field of monitoring control systems, field networks such as a fieldbus are being standardized. In addition, next generation communication such as multimedia communication using ATMs is being realized. Fuji Electric is activity engaged in this research and development, and is determined to do its very best to supply a flexible, optimum and cost efficient manufacturing system to its customers.

The Integrated Engineering Support System

Masanori Hikichi
Yosiyuki Saito

1. Introduction

High-level and complex control systems can now be configured due to the recent highly advanced functions of the control equipment. Consequently, the content of engineering has become large and complex, and hardware costs of the control equipment has decreased. On the other hand, engineering fees, primarily dependent on intellectual work, have increased in proportion to soaring manpower costs. As a result, the portion of engineering fees for configuration of the control system has rapidly increased and has already accounted for half of the system cost. Moreover, engineering tasks which depend on intellectual work cause difficulties in maintaining high system quality in addition to a shortage of system engineers possessing advanced engineering abilities.

To end these situations and improve engineering efficiency, various support tools for engineering tasks have been developed, having positive results.

We will outline the current situation as well as problems to be solved in the engineering support system. Also in this paper we will describe the efforts and future prospects of Fuji Electric.

2. Current Situation and Problems of the Engineering Support System

2.1 Current situation of the engineering support system

Engineering can be defined as a "means and process concerning the life cycle of the control system's configuration". It is generally divided into the processes shown in Fig. 1. In the present situation, however, even if the engineering tasks share the same process, the contents of the tasks differ from each other in their control fields, such as electric control and instrumentation.

Therefore, engineering task is uniquely defined by two factors — the "process" and "control fields". As shown in Fig. 2, the support tools for such engineering task can be clarified with their positioning in a two-dimensional space.

Fig. 1 The engineering life cycle

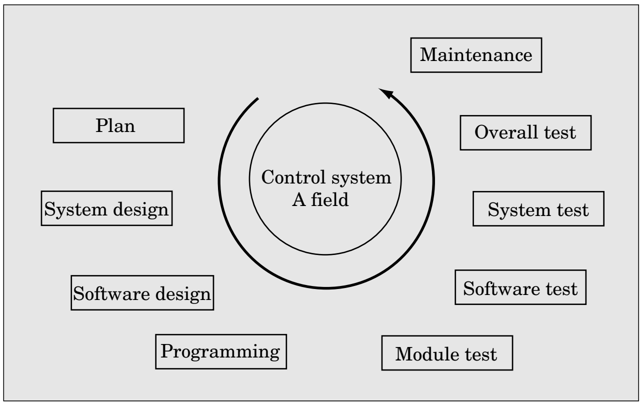
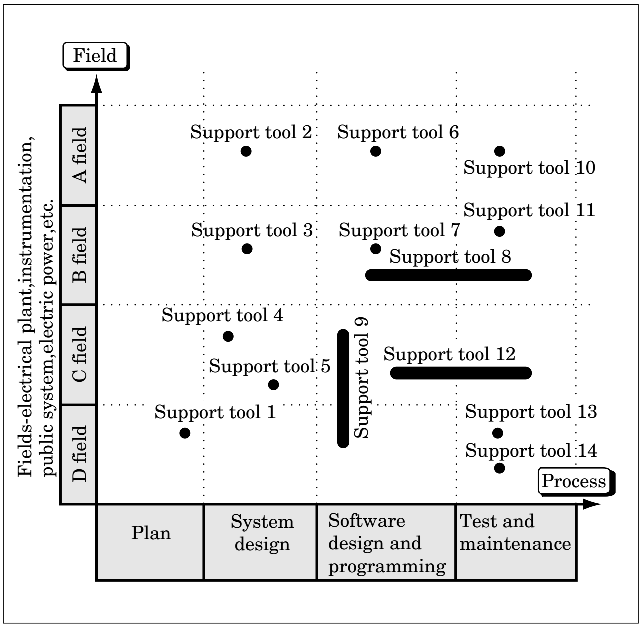


Fig. 2 Current state of engineering support tools



In Fig. 2, support tool 7 supports software design and programming in the B field. But support tool 8 independently supports software design and programming as well as test and maintenance, even though it is also in the same B field. As clearly seen from Fig. 2, current engineering support tools can be expressed as "support for points and lines".

2.2 Current problems to be solved

2.2.1 Adaptation to the EIC-integrated control system

Recent information and control systems closely integrate not only specific control in each control field, but mixed control functions in some control fields (including electrical control and instrumentation). This is represented by the EIC (electric, instrumentation and computer) integrated control system. An integrated support system is highly desired to perform engineering for such a system, as the engineering support system up to now has been difficult to adopt.

2.2.2 Trend from device to system support

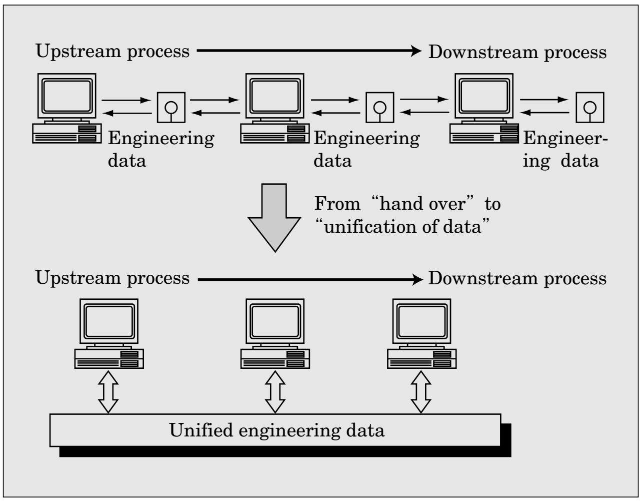
The elements which comprise information and control systems have highly distributed functions. These devices are closely linked to each other, forming a system. In an environment where engineering support for these elements is independently performed without integrated support for the total system, the engineering load increases. Therefore, there is an increasing need for the engineering environment to support the total system.

2.2.3 Information integrity among processes

The current engineering support system supports only a part of the total processes of the upper to lower process. Therefore, plural support systems must be used, each having a specific database for the processing and exchange of engineering data among these systems in order to perform a series of engineering tasks.

The current systems have some problems regarding "management" and "exchange" of information as a large amount of information is generated in the engineering task. Under "management", since information is separated and duplicated then managed in each group, recognition of updated data and information maintenance may be sometimes problematic. Under "exchange", information is not always exchanged smoothly among the groups, and there are some cases in which information is "handed over" to "management" (refer to Fig. 3).

Fig. 3 Unification of engineering information



2.2.4 Improving engineering efficiency and quality

The acceleration of the high-level functions, complexity and increasing software in information and control systems accompany the development of various technologies. These systems require a further improvement in engineering efficiency and quality. Especially required are:

(1) Improving software productivity and quality
(2) Shortening engineering lead time

3. The Integrated Engineering Support System

Fuji Electric has promoted the development of an integrated engineering support system to solve the problems of the support system, described above, and to improve efficiency and quality of engineering. Below is a summary of the integrated engineering support system.

3.1 Integration of the engineering environment

As described above, the current engineering support system consists of "points and lines". Therefore, in the newly developed integrated engineering support system, we achieved integration while aiming at the "support of plane" (see Fig. 4). Features of this integration are detailed below.

(1) An engineering environment able to support all control fields

This environment can unify the configuration of the system, which includes some control field. For example, engineering tasks for electrical control and instrumentation functions with the same user interface can be performed.

(2) An engineering environment able to support all engineering processes

This environment can support all engineering processes, from planning to system design to software design and programming to testing.

Fig. 4 Integration of the engineering environment

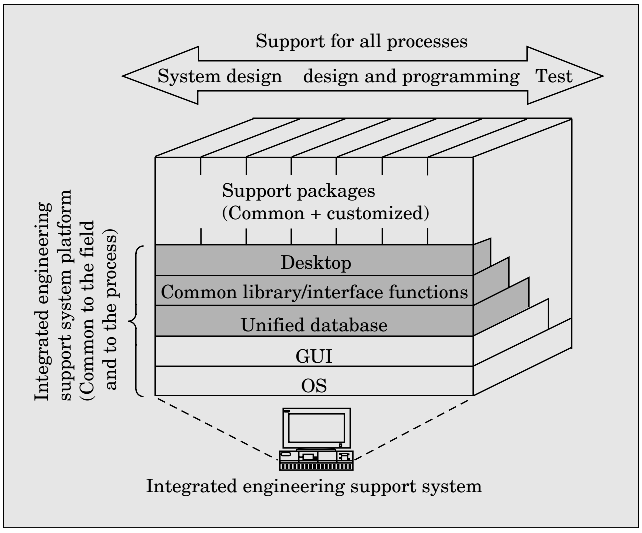
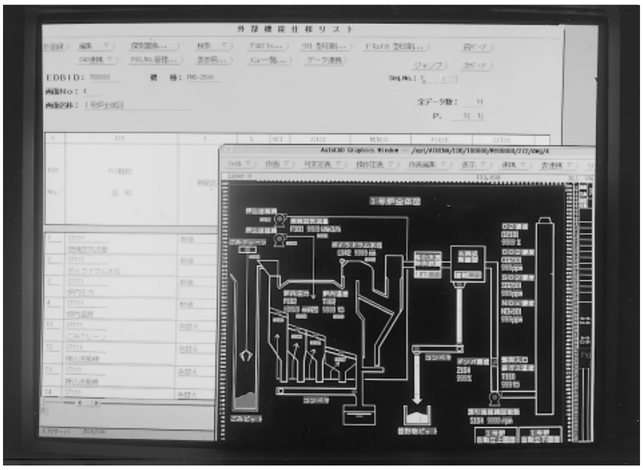


Fig. 5 Example of a worksheet for monitoring and operation function



(3) An engineering environment able to support various types of controllers

With the same user interface, this environment can support the electrical controller, instrumentation controller and operator station for monitoring and operation. An example in Fig. 5 shows a worksheet of the monitoring and operation function.

3.2 Unification of engineering information

It is effective to unify the engineering data to improve work efficiency. Unification solves various problems regarding “management” and “exchange” and contributes to the improvement of work efficiency.

The unification of information was realized by the RDB (relational database) and file server. However, an exclusive work function is required to maintain the integrity of the unified information, and this generally results in decreased work efficiency. Therefore, in this system, the unification of information is realized by minimizing and optimizing the unit of work exclusion.

3.3 Common platform

The hardware, basic software, database and desktop environments are configured as a common platform in all control fields so that all work can be conducted in a single working environment.

In particular, the databases are clearly separated into a common database for all control fields and a specific database for individual fields. The common database is made common up to the data table configuration. As a result, the unification of data is possible in systems having mixed control fields, as represented by EIC-integrated control system.

3.4 High-level function of specification descriptions

The aim of high-level functions is to improve productivity and quality of the control software. One of the factors that obstructs this aim is the human’s understanding of the specification and expanding the detail of the system design processes in order to

Fig. 6 Improvement of the specification description

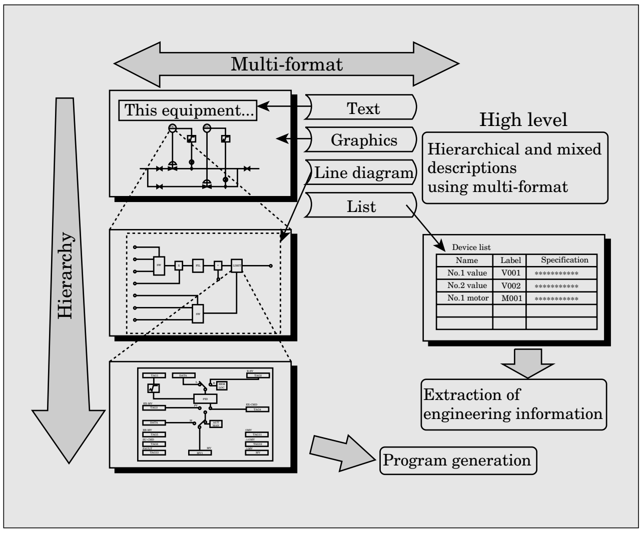
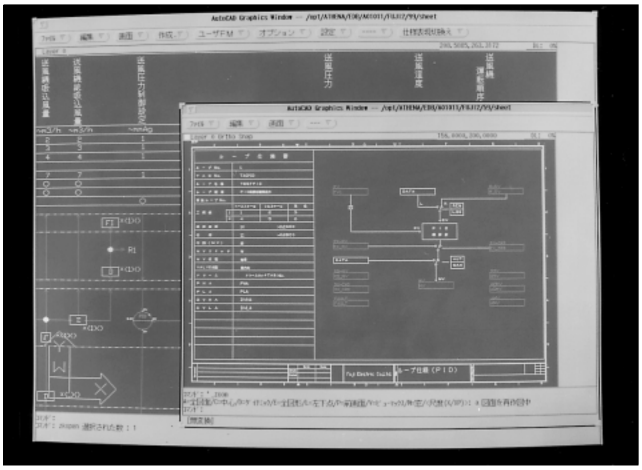


Fig. 7 Example of hierarchical description



develop a software design specification from the control specification, program and test.

Since there are a number of specification expressions and workers involved in the processes, it takes time to understand the specification, and a lack and misunderstanding of information are likely occurrences. These are the factors that obstruct improvement of software productivity and quality.

The integrated engineering support system removes these obstructions and aims to improve software productivity by improving work efficiency and quality by eliminating human error in one series of the works. As a result, the following functions are achieved:

(1) Improvement of the specification description

This is realized by improving expression of the specification description itself. The features introduced are hierarchical description and mixed description using a multi-format (see Fig. 6). Hierarchical description offers the user either a top-down or bottom-up environment. Mixed description improves expression of the specification as a document by utilizing a mixture of descriptions for text, graphics and lists. In

Fig. 7, an example of hierarchical description is shown.

Furthermore, in the conventional support system, the system design process required specified controllers or programs. In this support system, specification of the controllers or program is not required, reducing the user's work load.

(2) Automatic program generation from the specification description

This function automatically generates a program from a control specification, which is a document in the system design process, with an algorithm corresponding to the type of specification description (see Fig. 8).

With this function, the system design process, software design and programming process, and test process use the same expressions of specification. In addition, the human's role in understanding and expanding the specification is minimized. Therefore, software productivity and quality are improved.

There are several types of specification descriptions depending on the control fields, and this support system supports the expressions of data flow, switch flow, time chart, logic table, etc. Figure 9 shows an example of data flow.

In packages such as instrumentation flow and operation flow, the control specifications are made using the specification expressions listed above. A function that automatically generates a program from the control specification is also provided.

(3) Extraction of engineering information from the specification description

An automatic program generating function and an extraction of engineering information in a narrow sense, such as device ordering information, are possible in some specification descriptions, contributing to improved work efficiency.

Fig. 8 Automatic program generation from the specification description

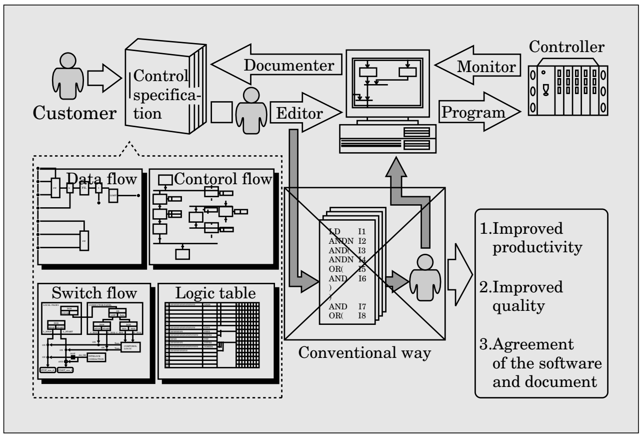
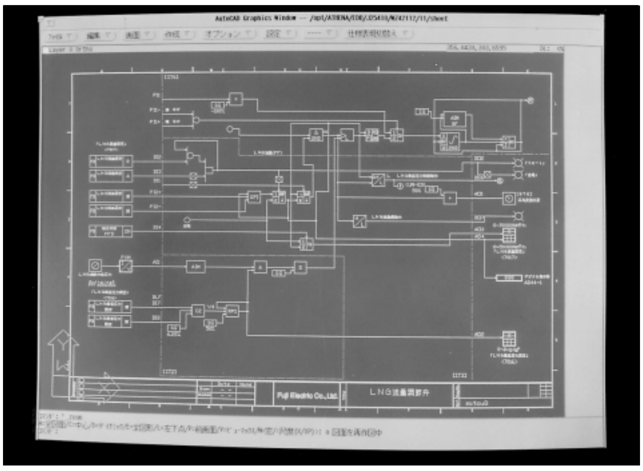


Fig. 9 An example of data flow



3.5 Group engineering environment

Many groups, such as system design, software design and programming and testing, participate in engineering tasks. Most of the work in these groups is occupied by intellectual work. Therefore, efficiency depends on manner in which the work is performed and without unnecessary work.

In the integrated engineering support system, an environment is created in which the users in each group can work closely together. Using unified engineering information, they are connected to other groups under the distributed environments, which are linked to each other via a network.

Such an engineering environment enables concurrent engineering by the groups and has a considerable effect in shortening lead time.

3.6 Software structure

Figure 10 shows the software structure of the integrated engineering support system. The structure has various support packages implemented on a platform of the integrated support system. Interface functions to the platform commonly used by the

Fig.10 Software structure

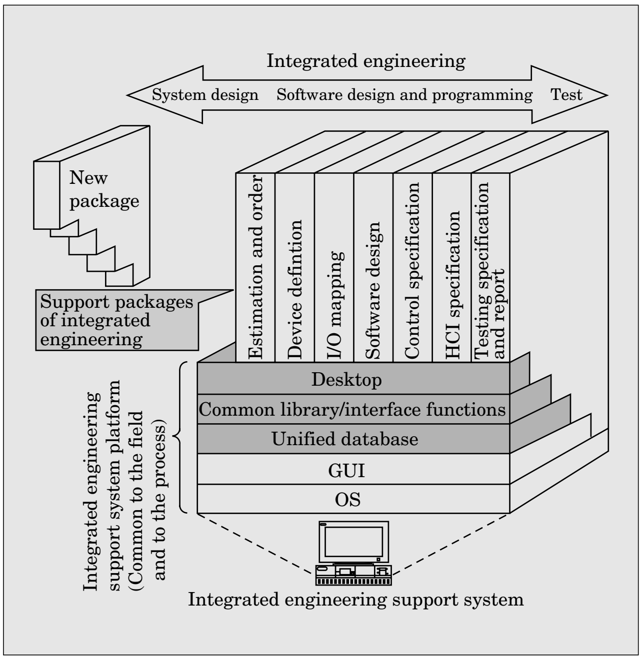
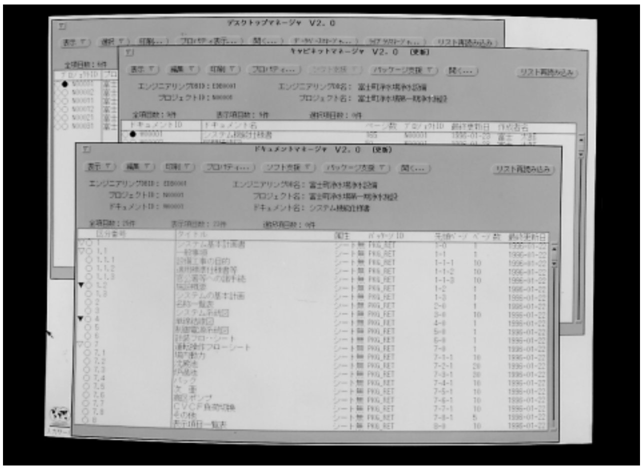


Fig.11 Desktop environment



packages are managed as a common library, improving development of the packages.

Since management of the engineering information is unified among these packages, the user can work regardless of data linkage and data integrity.

3.7 Desktop environment

The desktop environment is an interface between the user and the integrated engineering support system and presents a document management function for the user. In Fig. 11, an example of a screen is shown.

When beginning work, the user selects a project from the desktop environment, displays a list of documents for the project, and selects a desired document. Next, since a table of contents is displayed, the package is automatically started after the user selects the page to edit, and work is begun.

Since the table of contents itself has an editing function, the user can edit the contents of the document to move, copy and delete pages and easily change chapter configuration.

4. Future Engineering Environment Prospects

When considering future trends and prospects for the engineering environment, present ability to solve problems and the development of computer technology cannot be overlooked. After prolonged consideration of these two effects, we foresee following goals for the support system, detailed below.

4.1 From low-level to high-level support functions

From now on, the standard level of each support function will be gradually improved, step-by-step, in the engineering support functions.

For example, the following technical development actions will be taken in the design and test phases of the software:

(1) Support technology for “design”

Automatic design technology will progress remarkably. For example, the function which automatically generates a program directly from the control specification of an upper process document, with an algorithm responding to the format of the specification description, will reach a higher level.

(2) Support technology for “verification”

“Verification” is generally divided into “test” and “analysis”.

“Test” checks the functions of the configured system by trial and error, to verify whether the functions are performing as the designer intended. In this case, a high-level visual simulation, more functional than an actual test, is expected.

“Analysis” deductively and mathematically verifies whether an unsafe situation such as a deadlock or conflict occurs. The results of presently ongoing research are eagerly anticipated.

4.2 From specific to open system architecture

Rapid progress of software technology in personal computers and work stations will further change the architecture of the engineering support system. OLE (object linking and embedding) in Windows*1 and CORBA (common object request broker architecture) in UNIX*2 facilitate the configuration of the organically-integrated engineering support system by combining the individual support modules as software components, thus assuring a perfectly open environment. This open system environment enables a link with the software available on the market and realizes a flexible engineering support system that can be easily developed. From now on, many engineering support systems similar to these will begin to appear.

5. Conclusion

In this paper, we have described the current situation, problems to be addressed, the efforts of Fuji Electric and future prospects for the engineering support system. We at Fuji Electric developed the integrated engineering support system based on these prospects.

It is a well-known fact that the engineering support system is vital, and it is not too much to state that the support system determines the capabilities of the information and control system. The technology necessary for improving the support system environment is advancing remarkably. We endeavor to create a system having an improved environment for the user by applying this advanced technology.

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*1 Windows: A trademark of Microsoft Corp., USA

*2 UNIX : A registered trademark of X/Open Company Ltd.

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