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FUJI ELECTRIC INTEGRATED CONTROL SYSTEMS

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1. FOREWORD

It has been approximately 20 years since the computer control system (C) was commercialized, in addition to the long history of the electrical control system (E) and instrumentation control system (I).

Integrated control systems integrate these three control systems planned separately by manufacturers and users up to here and are aimed at not only integration of architecture, but also reduction of life cycle costs.

Manufacturing systems are also oriented toward flexibility to cope with the diversification of product needs, and the realization of a variable kind, variable quantity system is becoming an important theme. That is, a manufacturing system which can cope with the movements of the market quickly and flexibly is demanded. Therefore, closer coupling between product and process has become important.

Viewed from the information standpoint, this is the realization of CIM (Computer Integrated Manufacturing). Viewed from the control system stand-point, it is important in the realization of integration.

If divided into two, control systems consist of product oriented computer systems and process oriented controller systems and an integrated control system which combines these systems organically is necessary.

2. BACKGROUND OF INTEGRATION

2.1 Social background

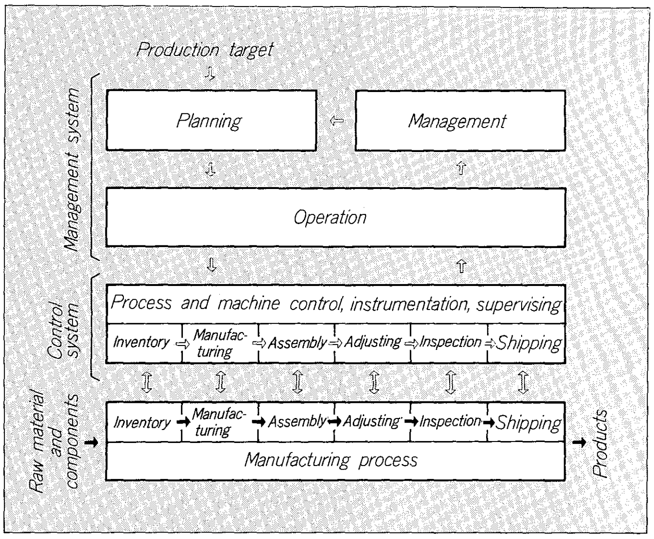
The following are considered as the social background which requires an integrated control system:

(1) Diversification of consumer needs
Consumer needs are changing from quantity to quality and the diversification of goods/products is demanded.

(2) Change of the labor market
The consciousness of laborers is changing from enterprise centered to individual centered and to a society which stresses individual latitude and abundance.
The labor shortage has deepened, especially about the young layer.

(3) Globalization
For our country, which occupies 14% of the world's GNP, globalization of engineers and technology is increasingly important.

Fig. 1 Automated manufacturing system material and information flow



(4) Maintenance of industrial vitality and competitive power
More efficient productive activity and exhibition of creativity are demanded.

2.2 Technological background

The following points are important as the technological background which contributed to the birth and development of the integrated control systems:

(1) Development of micro-electronics technology
High level functions/high efficiency, expansion of the control sphere, and distribution of components have been made possible by the advance of micro-electronics. On the other hand, the problem of optimal allotment of functions has grown up in step with this.

(2) Development of control LAN
Accompanying the development of LAN, component distributed allocation and organic combination of information and control have become possible.

(3) Development of man-machine interface
Accompanying the intelligentization of the man-machine interface equipment, realization of a single console as a common use MIMI (Man Machine Inter-

face) for EIC systems has become possible simultaneously with high-level functions/high performance of equipment.

(4) Popularity of the personal computer/work station
Distributed processing of information and improvement and completion of engineering functions have become possible by using a personal computer/WS.

3. FEATURES OF CONTROL SYSTEM AND ITS TRENDS

3.1 Automated manufacturing system

The automated manufacturing system performs optimal operation of resources and manufacturing processes based on the production plan, and attempts to manufacture products automatically from raw material keeping the target quality, cost, and delivery period. *Figure 1* shows this as an example for hierarchy processing of material and information flow. Planing operation management are performed mainly by computer and process and machine control instrumentation supervising are performed by controller. Information transfer in and between these hierarchies is performed by network.

3.2 Control system information flow and distributed processing

3.2.1 Information flow and data transparency

An automated manufacturing system must realize variable kind variable quality production matched to demand dynamically, quickly, and optimally. For this purpose, the flow of material on the manufacturing process and the state of the process must be reflected in real time as information in the control system. Therefore, for information transfer in the control system, high responsibility synchronized with operation and material flow of the manufacturing process is demanded.

Moreover, for the control system, a lot of controllers and computers, etc. are combined, and it is essential that the data transmitted between these components have an integrated expression and integrated meaning. That is, common use of data is essential.

3.2.2 Characteristics of data processing in control systems

Control systems in manufacturing process demand the following:

(1) Rapid response to high-speed movement of the target process

(2) Tracking of movement of multiple processes which operate concurrently

(3) Since the target process moves dynamically, grasping of time-serial data is necessary.

Concerning data processing at a control system, data input/output, process status monitoring, and control algorithm processing must be executed concurrently (multitask) and in real time.

Furthermore, order development and information preprocessing for optimally controlling the manufacturing process in accordance with operation orders from the management system are performed and product amounts, producting situation, facility normal/abnormal, and other primary information are collected and the data group is formatted to a standard format and fed back to the management system.

3.2.3 Characteristics of data processing in management system

Variation, high quality of products, variable kind variable quantity manufacturing, and complication and speeding up of the production process are advancing rapidly and quick processing of more voluminous data and high capacity and high speed access of data base are demanded.

For a management system, receiving, development and scheduling of accepted production orders from above, generation and transmission of operation data to low level control system, and acquisition and processing of data from the control system are executed concurrently in real time.

The real-time responsibility of the control system demands millisecond order response, but the related data processing amount is comparatively small. The management system allows second order response, but the related data processing amount is large. That is, the former demands response-oriented and the latter demands throughput oriented real-time processing.

3.2.4 Data locality and distributed processing

In a control system, there is deeply related data at a close position. For example, Data related to one machine of a production process can be acquired adjacent to it and local control and data processing are possible and data transmission with others should be performed only when other commands are required or when cooperation with others is necessary.

Generally, for an information processing system, since the probability that related data is at a physically close position is high, efficiency can be increased by distributing a group of these data to multiple computers and processing them independently and concurrently. Moreover, for highly common data, system performance can be improved greatly by mass data central processing by high-speed computer (data base) and data storage, retrieval, operation and distributed processing with integrity by data base machine (data base servor).

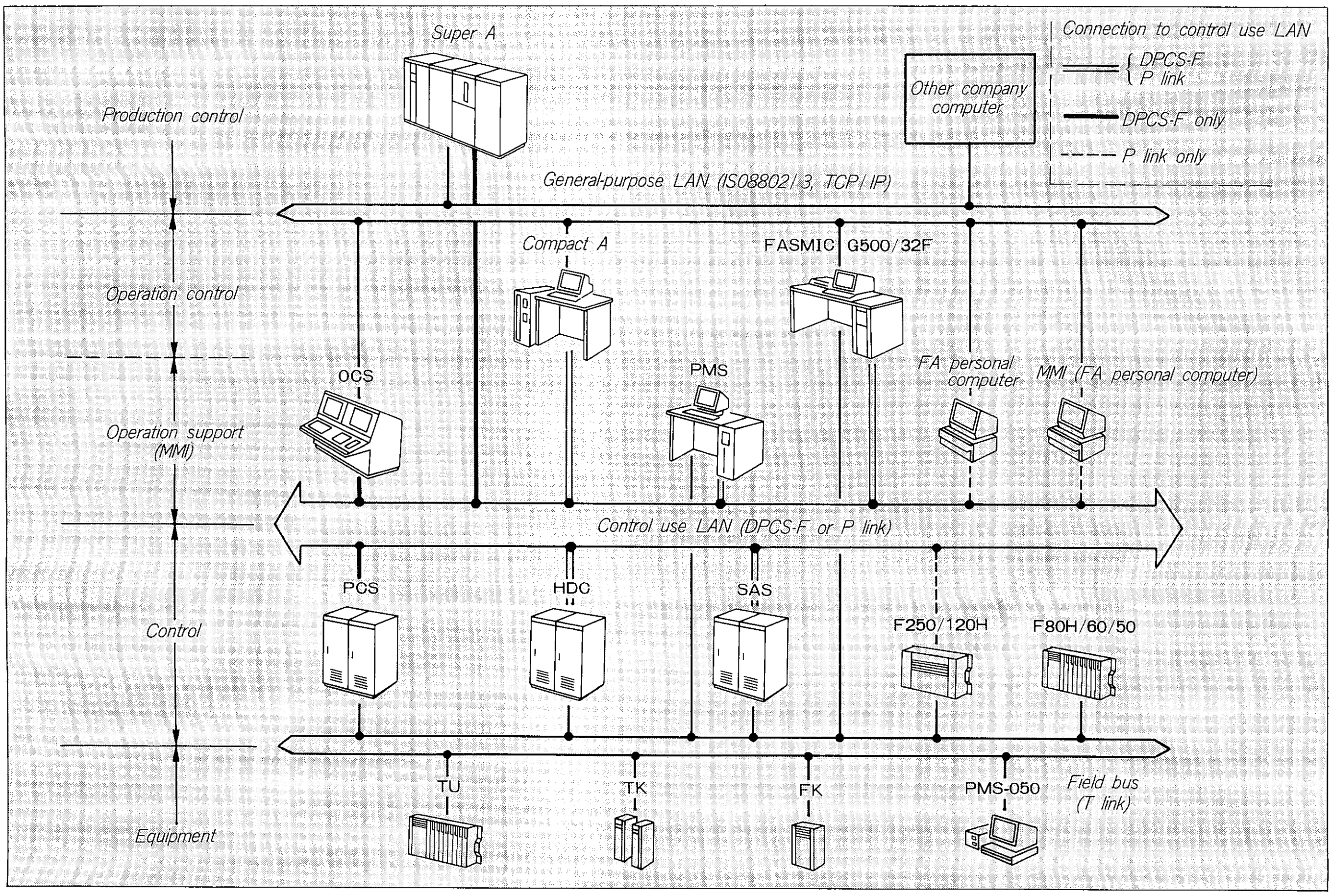
Local independence of systems by distributed processing makes danger distribution against fault generation possible and simplifies constuction of backup system and fault-tolerant system, and contributes to raising the flexibility, maintainability and expandability of the system.

3.3 Recent trends

3.3.1 Advance of multi-vendor (open system)

Recently, multi-vendor of control systems has advanced at unexpected speed. This makes interconnection between different brands of machines and the constuction of a multi-vendor system as a result of improvement of the functional independency of each component from integration of control systems which began as single-vendor oriented.

Fig. 2 Integrated control system configuration



Originally, the best seller machines and suitable market differed with the manufacturer and the customer demand for minimum cost and maximum quality is considered, multi-vendor is, of course, directional and is expected to advance steadily in the future.

In the future, multi-vendor of software including data control, task control, software development will become an important topic.

3.3.2 Use of personal computer (PC)

Application of the personal computer to the control world is flourishing. The personal computer originally popularized for office use was preferable even as a control system component because of its price and abundance of software. Recently, improvement of the real-time facility and industrial environmental proof of the personal computer has been accompanied by its use as a simple functions control computer, controller software development workstation, small or medium size MMI equipment, etc.

The personal computer is an open component and also promotes further multi-vendor of integrated control systems.

3.3.3 Use of general purpose relational database

Recently, the number of cases where a general purpose distributed relational database has increased even in the control system world.

The reasons for this are considered to be:

(a) The necessity of a high-level distributed database as the control system itself is increased.

(b) A database compatible with an upper class management system corresponding to the increasing CIM is desirable.

(c) A database which is used in common by many kinds of business computers, minicomputers, and personal computers has become necessary.

By using a general purpose distributed database, construction of a flexible distributed control system can be realized easily by high transparency data control with upper class management level and data base servor installation.

4. NECESSITY AND AIM OF INTEGRATED CONTROL SYSTEM

4.1 Necessity of integrated control system

The necessity of an easy-to-use integrated control system based on distributed processing is rising to meet the demand for CIM of automated manufacturing system. The conditions demanded for an integrated control system can be summarized into the three points below.

4.1.1 Common use and elimination of waste

The target control system can be flexibly and efficient-

Fig. 3 MMI equipment using an FA personal computer

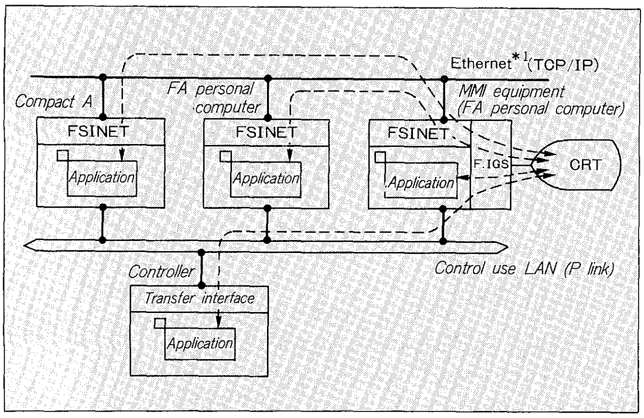
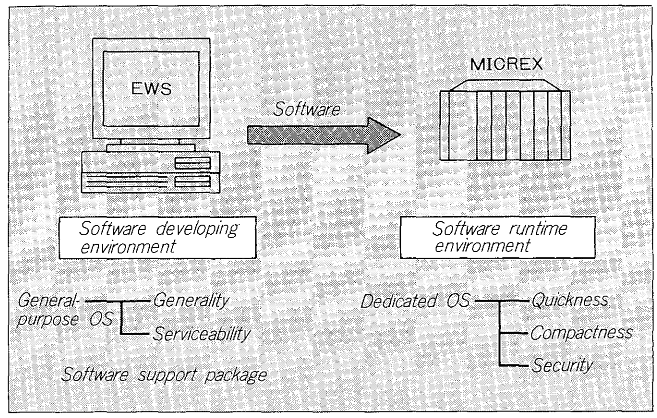


Fig. 4 Separation of software developing environment and runtime environment



ly built by components, engineering tools, and engineering techniques defined in common as an integrated control system. For example, common use of processor for electrical and instrumentation controller, common use of process input/output for electrical and instrumental controllers and computers, common use of man-machine interface (MMI), unification of data control, common use of software engineering tools, etc. have become possible.

Moreover, common use also provides large merits from the standpoints of reduction of spare parts and maintenance work.

4.1.2 Special use and elimination of excess

A high cost-performance control system without any waste can be built by providing special use equipment for application on the common architecture of the integrated control system.

For example, the control hardware has the same architecture, but a hardware composition by individual field and individual use and expert software packages and software modules are available. Application software with a good outlook can be designed by using these.

The same is also said for the MMI and computer.

4.1.3 Open system

Integrated control systems are finally directed toward open system. The foundation of these is connection between different components by network, operating system which guarantees software portability, and software developing environment of controller.

4.2 Aim of Fuji Electric integrated control systems

Fuji Electric is advancing integration of control systems based on the following aims:

(1) Pursuit of basic concept
Optimal functional allotment and necessary component line-up

(2) Correspondence to open system
Correspondence to use of standard LAN and multi-vendor system

(3) Integration of data management
Completion of good real-time data management for distributed system and introduction of general purpose database technology

(4) Integration of software development
Development of easy-to-use tools which can be used in common with EIC system

(5) Reduction of life cycle cost
Reduction of cost through planning, design, programming, test, operation, and maintenance

5. FUJI ELECTRIC INTEGRATED CONTROL SYSTEM

Fuji Electric practicalized an "integrated control system" several years ago and delivered them to customers of many fields and receives favorable comment. This system is outlined below.

5.1 System configuration

The Fuji Electric integrated control system configuration is shown in *Fig. 2.* The control system forms the functional hierarchy as shown in the figure. The computer, MMI, and controller are vertically distributed according to the functional hierarchy and the components are horizontally distributed in each hierarchy. An optimum integrated system construction for the purpose is made possible by such vertical and horizontal distribution combination.

Moreover, each component can also be used as a separate system by making it a highly independent functional structure.

Correspondence to multi-vendor systems is possible by opening the external interface of these componets.

One of the ideals of an integrated control system is function relocatability. If a certain application software is assumed to work in each E, I, or C system, it must be developed with tools which are common to EIC systems. Unification of architecture makes this easy.

5.2 Network

The network is made a high, middle, low 3-layer configuration corresponding to the function hierarchy. The high level LAN uses international standard ISO 8802/3

(TCP/IP) and corresponds to open system. The middle level LAN uses a Fuji Electric original control LAN from the standpoint of stressing total performance. DPCS-F 10M bit/sec) is applied for large system use and the P link (5M bit/sec) is applied for medium and small system use. The Fuji Electric standard T link (500k bit/sec) is used as the low-level field bus. It is connected to the plant devices and equipment via PIO and function modules.

5.3 Data management

Unified distributed file system (FSINET) at the entire integrated control system exceeds the kind of network and makes it possible to access data distributed to each component by common interface.

Besides direct access and access by name of data in distributed files, FSINET also services loading, saving, message transfer functions of individual files.

Since each component can independently define its own data on a distributed file environment, high flexibility integrated data management is possible and expandability is excellent.

5.4 MMI equipment (single console)

The MMI equipment are designed to be subordinate to conventional computers and controllers. However, single console which can be used in common from computer and controller is realized by raising the independence of MMI equipment.

This allows unification of not only the supervising and operation functions, but also the picture making-up function.

FA personal computers are used as the element of popular type MMI equipment and is used as common use MMI. (See *Fig. 3.*)

5.5 Software development support

From the system overall standpoint (ease of use, capability, reliability, cost, etc.), software development support uses a work station (WS). The computer uses a UNIX system*2 WS and the controller uses a personal computer (PC) WS.

For the controller, a development support system (ES50) that can support both electric and instrumentation is offered. This provided unified support for controller software development, testing, and maintenance. (See Fig. 4.)

The computer (minicomputer) uses a UNIX system WS. However, software development supoort is expected to progress in the form in which delivery machine and WS are used together.

5.6 Controller unification

In controllers, there are loop control, sequence control, remote control, and various other devices, but standardization and unification of the hardware architecture is realized. MULTIBUSII*3 use, common usage elements, printed board standardization, and standardization of device configuration are performed and low-cost and improved maintainability are realized.

5.7 Engineering tools

Desirable engineering environment for the suplier is organizing efficiently the vertical product line from customer order to customer maintenance service and horizontal components line concerning E.I.C. systems and performing target system without waste, excess and irregularity.

Networking and database sharing are performed between each department as the infrastructure for this and real-time and integration of the flow of engineering data are progressing.

6. CONCLUSION

Regarding integrated control systems, an optimal control system for the purpose can be easily built and flexible correspondence to expansion and contraction is a big feature. High performance, small size, and low price of the controller and computer and other subsystems and self-integrity of control and processing make these possible. Especially, the contribution of the extension of high speed and high level functions controller to small models, the appearance of the high performance personal computer, and realization of a high speed, low cost net-work is large. We will pour our power into smaller size, high speed, high level function, and lower price in the future.

For an integrated control system, unified control of data is essential and unified data control by distributed file system was practicalized before and an open data control system which joins this is under development.

In recent years, control system software has become increasingly complex and large and rationalization of software development is urgent. Fuji Electric is promoting standardization of the software development support environment from an integrated standpoint.

In the future, integrated systems are expected not to stop at EIC integration, but to be fused with the OA area jointly with CIM and SIS.

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*1 Ethernet: Registered trademark of Zerox Corp.

*2 UNIX: OS developed by ATT&T Bell Research Laboratories

*3 MULTIBUS II: Registered trademark of Intel Corp.