Information Processing System for Water and Sewage Treatment Plants

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1. Introduction

The trend of recent information processing systems in water treatment plants is toward the enhanced requirements of reduced construction, maintenance and managing costs, together with requirements of high functionality, following the rapid progress and improvement of electronics and information processing technologies.

To respond these requirements, Fuji Electric realized an open architecture information processing system, employing the latest technologies as well as technologies and expertise that have been cultivated over many years, based on open architecture. In this paper, we will introduce this latest information processing system.

2. Latest Information Processing System for Water Treatment Plants

2.1 Realization of medium to small-scale systems

2.1.1 SCADA

Fuji Electric has developed FOCUS (Fuji open control universal system) as a SCADA (supervisory control and data acquisition) system. This system can realize a low cost, highly functional control system by applying expertise of the dedicated DCS (distributed control system) system cultivated by Fuji Electric up to the present. The system is configured with an operator station (FOCUS) and controllers. Low cost construction of an open integrated control system is possible using an Ethernet*1 as a LAN to connect the two systems.

(1) System specifications

(a) Hardware specifications

PC/AT*2 compatible personal computers can be used in all operator stations. Windows NT 4.0*3 is used as the OS and InTouch*4 is employed as the fundamental part of the HCI (human-computer interface). An Ethernet is utilized as the LAN for control, but PE/P-LINK (enhanced processor/processor link) made by Fuji Electric can be also used. The following controllers made by Fuji Electric may be connected: ACS (advanced controller) -2000, ACS-250, MICREX-F and MICREX-SX. Commercially available devices such as network printers for the printing logging panel, color ink-jet printers for the copying panel and magneto-optical disks for data banking can be used as peripheral devices of the FOCUS (personal computer). In this manner, a low priced system can be constructed.

(b) Software specifications

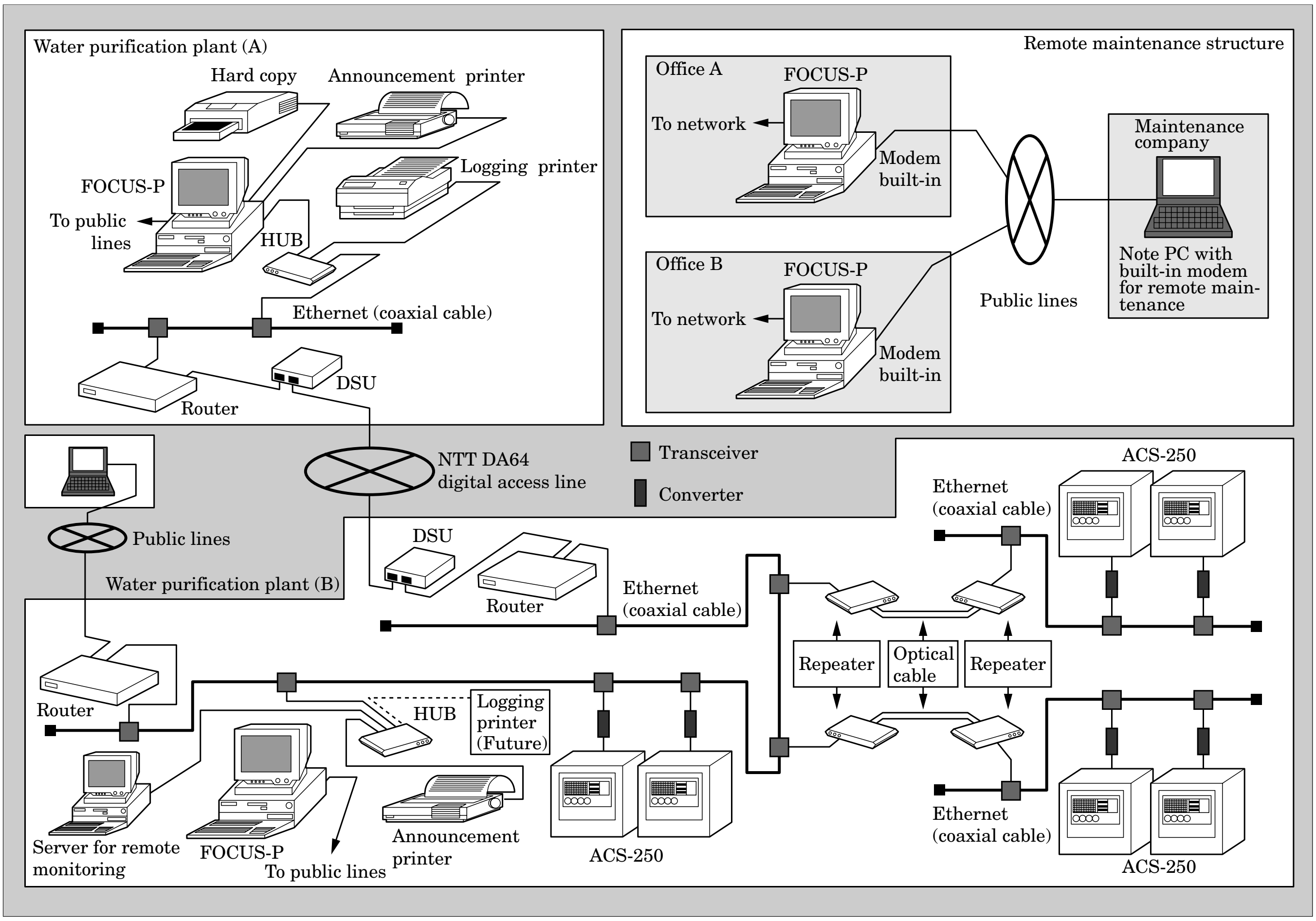
For the FOCUS, a standard panel shown in Table 1

Table 1 Standard panel specifications

Process input	Process value	576 points
	Integrated value	Including the above points
	Digital	10,240 points
Process output	Setup value	128 points
	Operation	512 points
Trend panel		8 pens × 64 pages Storage period: 5 days/1 min collection
Plant panel		Panel sheet: 100 sheets
Logging panel		Sheet: Daily report : 20 sheets Monthly report: 20 sheets Annual report : 20 sheets Storage period: Daily report : 62 days Monthly report: 12 months Annual report : 5 years
Computation expression		Within the limits of Excel
Group loop panel		Displays by grouped instrument modules
Alarm panel		Displays alarms in time series 20 points/panel, 100 panels
Historical message panel		Displays historical messages in time series 20 points/panel, 100 panels
System condition panel		Displays system condition
Remarks	Restriction of signal points: All using Tag= within 44,000 Tags AI per point = using 50 Tags Others per point = using 1 Tag	

*1 Ethenet : A trademark of Xerox Corporation
*2 PC/AT : A trademark of IBM Corporation
*3 Windows NT 4.0 : A trademark of Microsoft Corporation
*4 InTouch : A trademark of Wonderware

Fig.1 Remote monitoring system



is provided. Each panel is made with InTouch and has an excellent operability due to ample incorporation of Fuji Electric's water treatment technologies.

For engineering support, a plant panel, central to the monitoring operation, can be easily made into visual panel using InTouch. Further, the logging panel format is designed with Excel*5. Therefore, the engineering of the FOCUS is an easy-to-use monitor, able to realize EUC (end user computing).

(2) Examples of FOCUS system applications

Several examples configurations will be indicated below.

(a) Remote monitoring

In addition to stand-alone use, the FOCUS can perform remote monitoring utilizing the merits of an Ethernet. This system configuration is shown in Fig. 1.

Routers are provided for the control LANs of local controllers. These LANs are constructed from an Ethernet. Routers and the FOCUS are connected to the network on the remote side (such as an office). This configuration makes the remote FOCUS able to perform the same operation as the local FOCUS.

(b) Remote maintenance

The water and sewage treatment plant is an important piece of lifeline equipment. When an obstruction occurs in this monitoring system, immediate measures are necessary. In such a case, if diagnosis, status investigation and software modification of the system are possible from the remote side (such as a manufacturer's office), the restoration time can be shortened. In the FOCUS system, collection of RAS information, straightforward correction or modification of the software and investigation of defects can be performed via a telephone line from a remote station.

(c) Wireless LAN system

When utilizing FOCUS and a wireless LAN, it is possible to use most FOCUS functions with notebook type personal computers from a remote position or freely moving, instead of from fixed CRTs. In this manner, one can visually monitor a plant, into which monitoring CRTs cannot be introduced because of cost or the installation location, by carrying a notebook type personal computer with him. An example system configuration is shown in Fig. 2. The device is configured by simply attaching an antenna to the notebook type

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*5 Excel: A trademark of Microsoft Corporation

Fig.2 Wireless LAN system

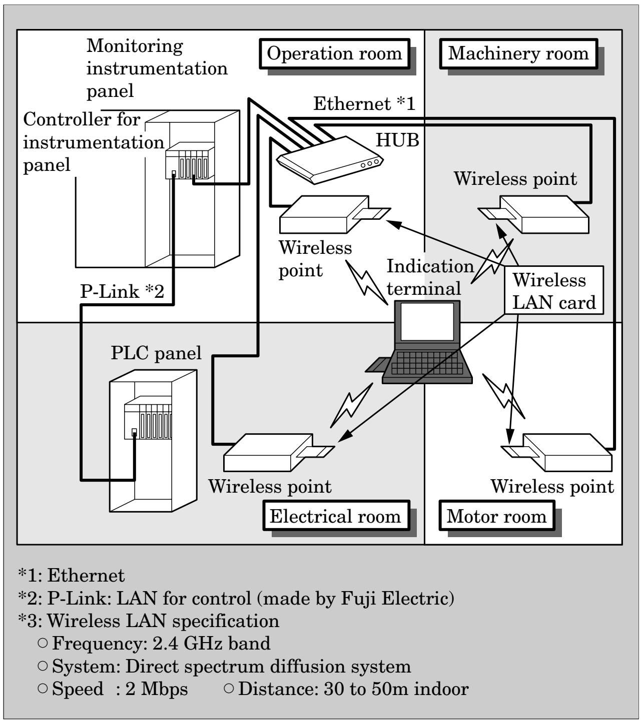
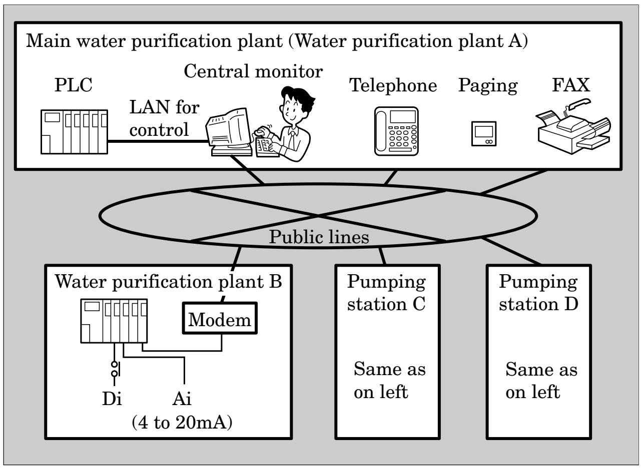


Fig.3 Small-scale system



personal computer and providing onsite access points.

2.1.2 Small-scale wide-area monitoring system

This centralized monitoring system is for a medium to small-scale town to improve the efficiency of maintenance and management (Fig. 3). This system uses a general-purpose personal computer and a public line (including use of a portable telephone) instead of a dedicated line, and has a low price, regarded as important by the management.

A central monitor collects data from each facility at a fixed period or an arbitrary dial-up time. The data is used as panel, trend and logging data.

When an abnormality occurs in any facility, an emergency report is issued to emergency report devices (telephone, paging, etc.) and the central monitor.

2.2 System for large to medium-fields

This system is constructed with a standardized architecture so that it can be applied to all systems from large to small-scale. This system achieves flexibility and low cost in response to the requirements of operation in a plant and yearly systematic construction.

2.2.1 Development concept

As a general trend in information and control system, rapid advances are being made in systematization technology closely related to network systems such as field dispersion, autonomy dispersion and open architecture systems.

This system, based on the above-mentioned trend, is developed to incorporate general-purpose technologies such as the personal computer and the Ethernet, aiming to improve maintainability and to achieve high functionality, high performance and high reliability corresponding to the open architecture.

This system enables configuration of systems that conform to the present state and in which the combination of old and new systems is becoming commonplace. This system is planned as a successor to the resources (hardware and software) constructed for the MICREX-IX integrated control system released in 1992.

The introduction of new technologies, compliance with an open architecture environment, enrichment of the service environment, and flexible response to user requirements, and guarantee of reliability are also planned for this system.

2.2.2 System requisites

When constructing an advanced open process automation system, it is necessary to maintain the past high reliability and real-time performance and further, to employ an open architecture, an important concept for information control. Requisites for the advanced open process automation system will be described below.

(1) Open architecture of data

The process data, operation and history data and trend data stored in the information processing system should be able to be freely exported to a personal computer connected to the network, and be used for such applications as the creation of statistic materials, evaluation of maintenance and management, development of operation plans, etc,

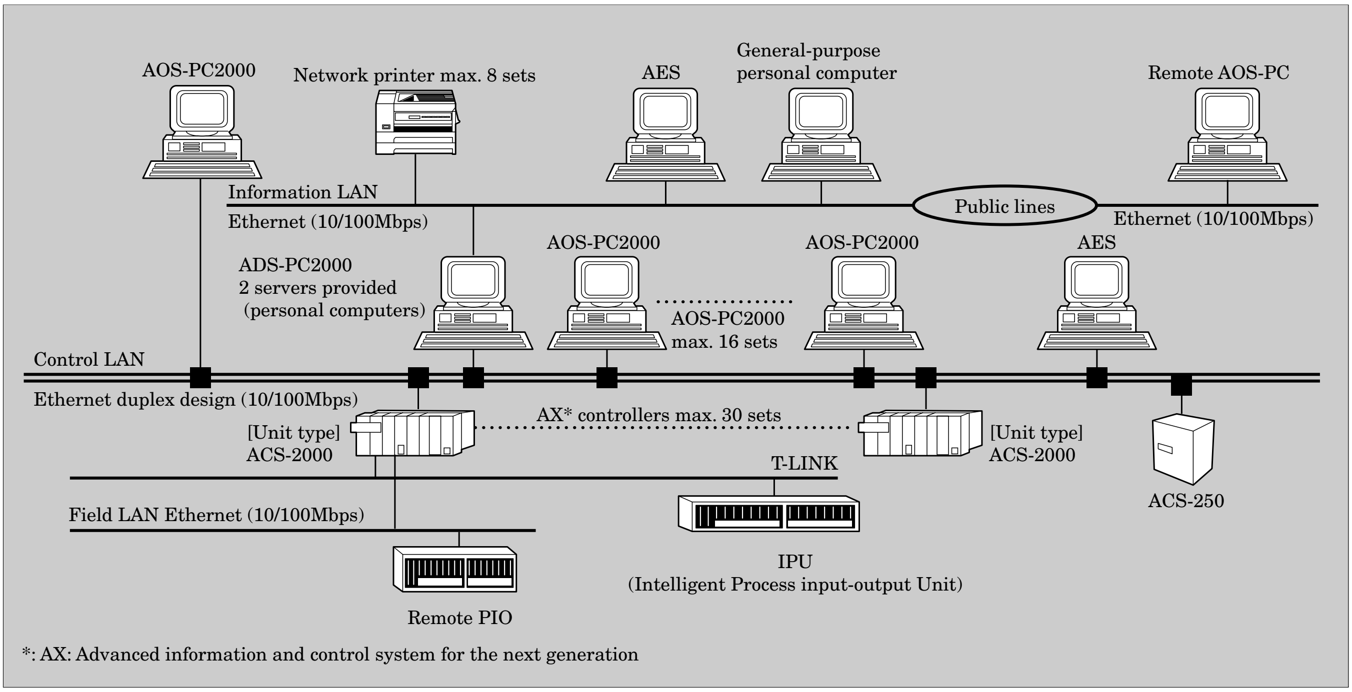
(2) Realization of end user computing

Through offering a support system that utilizes an easy to understand, personal-computer-like graphical user interface and ISV (independent software vender) software, the system should be able to be improved or modified by the user himself.

(3) Freedom and cost reduction

In the past manufacturer’s standard, DCS (distributed control system), the user’s freedom of selection was restricted to some extent to realize high reliability and comfortable operability.

Fig.4 System for large to medium field



Coupled with the adoption of an open architecture, utilization of de facto standards eliminates dependence upon manufacturer standards and results in demand for systems with a high degree of freedom, and downsizing results in cost reductions.

(4) Fusing of control and information

Due to the open architecture of the database, the user should be able to effectively utilize stored data, which could not be sufficiently utilized in the past. Further, the data should be able to be used in a high-level information and control package, and in the systems of business management, work management, utilization and opening of information, equipment maintenance, etc.

(5) Realization of general-purpose hardware

The system should be constructed using the latest devices on the market as components.

2.2.3 System configuration and features

The system configuration is shown in Fig. 4.

This system realizes an information system consisting of: operator stations, open database stations, high-speed control LANs, high-speed control stations and intelligent field centers. Furthermore, the configuration of this system integrates functionality through a high-speed LAN with operation control systems, work support service systems, multi-media communication systems and computer network systems, providing solutions to the aforementioned requisites.

(1) Open architecture

With the integration of monitoring and control, it is inevitable that demand increases for system integration with a production control system. However, since there is a large difference between plant control and production control from the viewpoint of processing speed and function, coexistence of the plant control with the production control is a big problem.

In response to this problem, an operation environment is realized in which there is a link function between the process data and management data by employing an Ethernet, an open network, as the LAN for control in this system.

In addition, an SQL server is mounted on the database to provide open data so that the user can utilize the plant data freely and easily. The stored data can be edited and modified by using a commercially available spreadsheet program or database software.

Moreover, the user can utilize the same functions as in a HCI device through a general-purpose LAN from an AOS (advanced operator station) -PC (personal computer) for HCI use located at an arbitrary site.

This system is an open information processing system, is a successor to the high reliability and high performance of DCS, and will comply with future networks.

(2) Excellent reliability and maintainability

This system realizes high reliability and maintainability with an advanced self-diagnostic function and RAS information based on the technologies cultivated in the IX series for custom devices.

To achieve the required reliability of the operation system, duplex design for an Ethernet that uses any information, control or onsite LANs is made possible in addition to the conventional duplex system for the devices.

To achieve the required maintainability of the support system, it is possible to read the various types of RAS information and write programs from an AES (advanced engineering station) that is remotely located and connected to information and control LANs. Coexistence of AES and AOS functions in the same personal computer provide the benefit that a manager in office or a maintenance person in a maintenance room can obtain RAS information in addition to monitoring the operation state.

2.2.4 Overview of the system

(1) Control LAN function

This system utilizes an Ethernet, a practical de facto standard in the OA field, and at this time, newly employs an FL-Net compatible protocol, recognized by JEMA as JPCN-2, allowing easy connections with products made by other manufacturers, while maintaining the real-time characteristic of data. In the past, this characteristic was considered difficult to maintain.

With this protocol, cyclic transmission, the transmission of information within a definite time, and message transmission, the transmission of management information and schedule information, are realized.

The FL-Net compatible protocol uses UDP/IP, a standard Internet protocol, as a basic part, and employs a token function, to avoid the collision of information and guarantee the reliability and real-time characteristic.

(2) HCI function

This innovative system can display panels identical to those of the HCI of the plant via public lines (ISDN, frame relay, etc.) from the remote-side general-purpose PC and the combination of an AOS-PC2000 (personal computer), an HCI using open architecture material, and commercially available general-purpose software. Further, a remote control monitoring system visible through a browser can be realized.

Moreover, in the operator station, the system can monitor camera images of a local patrol terminal. Onsite images can be monitored and controlled using remote connections, mobile computing and wireless technology.

The visibility of HCI itself is improved by increasing the number of colors and enabling color expression for the targeted plant. Operability is also improved by the Windows-like panel configuration, panel development, three-dimensional appearance of operation switch buttons, etc.

Either "mouse" or "touch" can be selected as the pointing device. Figure 5 shows examples of the panel.

(3) Data base function

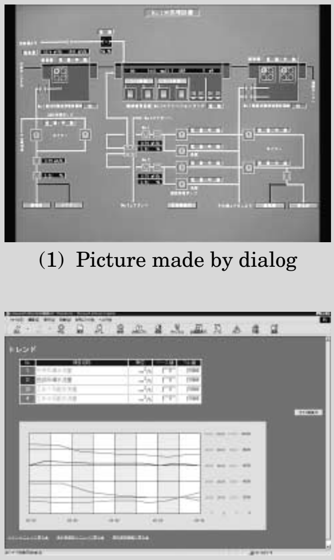
Connection with general-purpose database

In business reporting by the user, instances of report generation based on operation data and control data are increasing.

Therefore, it is desired that the user himself can easily extract the operation data and control data, and then edit the data with general-purpose software.

In the ADS, connection with a general-purpose database is possible (Fig. 6). The general-purpose database is equipped with a Windows SQL*6 Server of the Microsoft Corporation. The trend, logging, alarm and operation history data managed by the ADS (advanced database station) has been stored in the general-purpose database. The user is offered an environment where he can freely manipulate this data using general-purpose software such as Excel and Access*7 through an Ethernet line on the persona

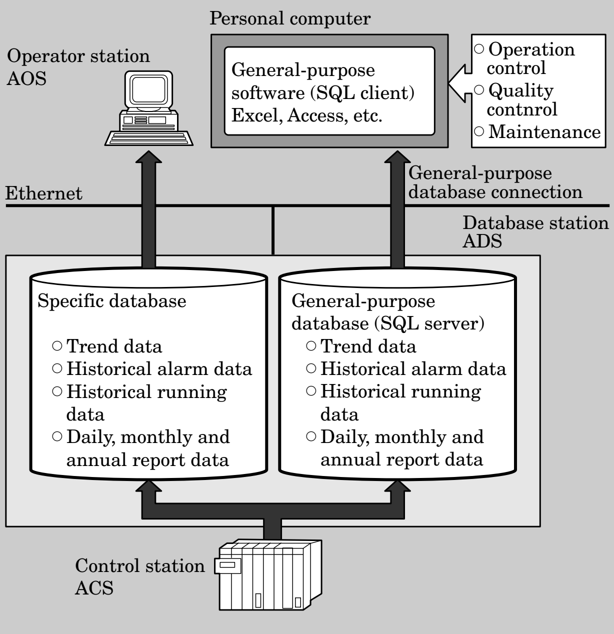
Fig.5 Examples of panels



(1) Picture made by dialog

(2) Trend panel

Fig.6 Database connection



*6 Windows SQL : A trademark of Microsoft Corporation

*7 Access : A trademark of Microsoft Corporation computer of a client.

(4) Controller function

For process control devices, open architecture and information-orientation are promoted by upgrading conventional technologies. New devices such as an intelligent field center and local handy terminals are provided.

Durable PC boards (PCU), which employ static type RAM disks having no moving parts can be mounted on the ACS-2000 controller. In this manner, advanced control (analysis and forecast calculation), conventionally required of workstations, can be computed on devices in the local field. This functionality can be realized on distributed controllers in the local field by improving the calculation speed and real-time characteristics. Further, the product series is strengthened with regards to telemeter and telecontrol functions.

(a) Intelligent field center (IFC)

The intelligent field center (Fig. 7) realizes onsite LAN (Profibus*8) transmission of all signals by integrating the conventional functions of control centers and auxiliary relay panels into a dedicated electronic control unit.

The control unit is equipped with a protection function, and memory functions of fault electrical current and operation history. Facilitating the collection of RAS information makes it possible to shorten the MTTR (mean time to repair).

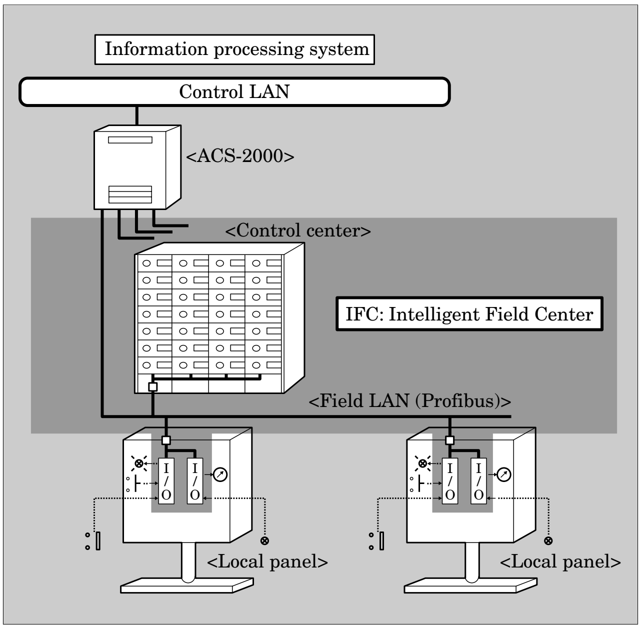
The employment of an onsite LAN (Profibus) facilitates cable cost reduction, wiring work rationalization and the addition of devices, as well as making possible the integration of management and control information, reduction of maintenance cost, promotion of sensor intelligence and construction of an inter-operable multi-vender system.

(b) Coagulation control system (advanced control)

It was confirmed by various experiments that the coagulation and sedimentation processes in a water purification plant depend on the size of particles in coagulation flocs. An advanced coagulant feed system (Fig. 8) combining a device to measure the coagulation flocs in real-time (coagulation sensor) with a model forecasting control device (coagulation controller) has been developed.

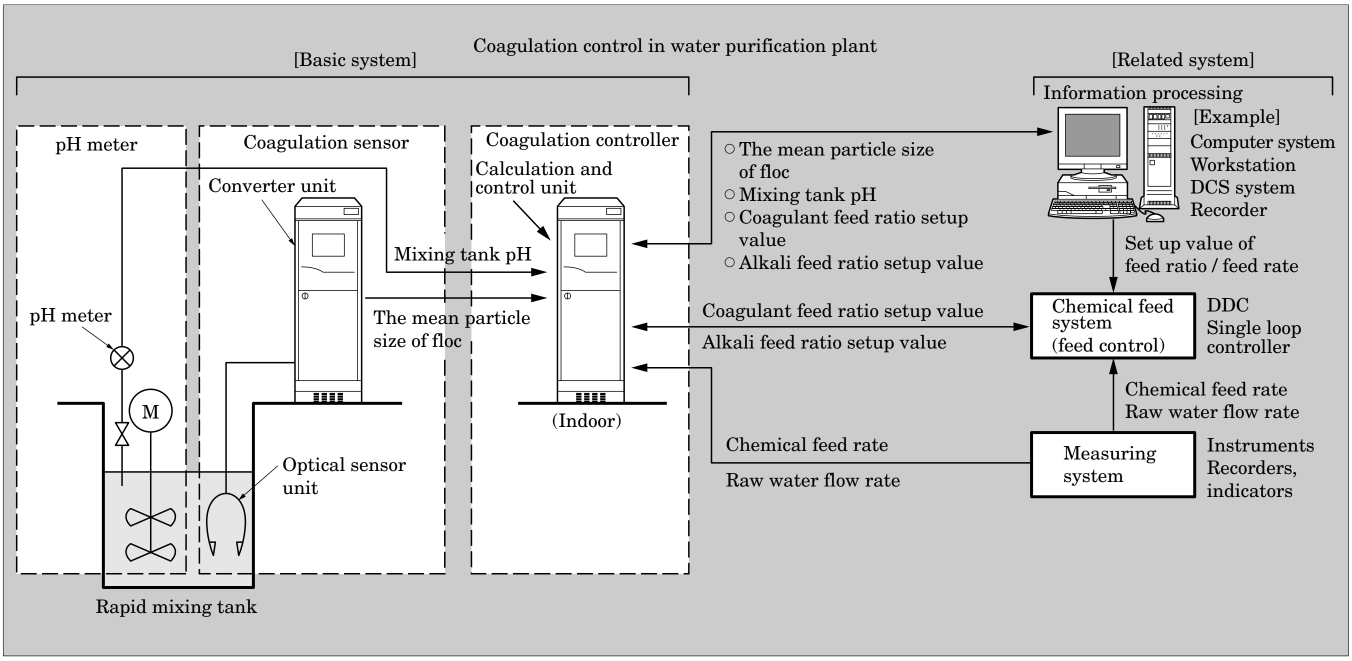
Conventionally, due to chemical feed ratio control

Fig.7 Configuration of intelligent field center system



*8 Profibus: A trademark of Siemens A.G.

Fig.8 Advanced control system



based on raw water turbidity (feedforward control) or chemical feed control based on operator's experience, too much coagulant has often been injected. However, due to feedback control based on the floc particle sizes, the coagulant came to be adequately injected.

In this control, since parameters must be adjusted depending on the characteristics of each mixing tank and water, it is necessary to gather data for a fixed period after introduction. However, this data analysis and parameter setting can be easily performed with support tools and engineering support.

(c) Telemeter and telecontrol

ASA (advanced supervisory and data acquisition)-2000 is a TM/TC (telemetry and control equipment) device that can be connected through a dedicated line on the voice call band to multiple large-capacity slave stations.

Connection between a master station and other controllers or HCI devices is possible with a company specific LAN (DPCS (distributed process communication system) -F and P/PE-LINK) and an Ethernet (compatible with FL-Net), making flexible configurations possible.

The master station can be connected with slave stations of various scales and functions such as the SAS (supervisory and data acquisition system) -50 in addition to the ASA-2000.

The slave stations can be constructed as multi-function devices by attaching not only a transmission function but also various sequence functions.

The transmission system can perform high-speed (maximum 9,600 bps) and highly reliable transmission by employing the HDLC (high-level data link control procedure) transmission method in addition to the CDT (cyclic digital telemeter) transmission method (cyclic transmission method).

The SAS-15 is a 1:1 type, compact-size and highly expandable TM/TC device that transmits over a dedicated line on the voice call band. Since the capacity and layout are fixed, such software as a layout table is unnecessary.

Since the master station can be connected via a T-Link (terminal link) to sequencers of the company and other controllers, flexible configurations are possible.

(5) Process I/O functions

In addition to the conventional IPU (intelligent process input-output unit), an open architecture PIO (process input-output control unit) is employed in the system.

The open architecture PIO*9, a remote process input-output device developed under the basic principle of "small and high-reliable open architecture PIO", is connected to a 10 Mbps or 100 Mbps Ethernet.

Features of the open architecture PIO are listed below.

(a) Remote process input-output device connected with an open architecture IO bus

The I/O bus that connects process input-output devices is an Ethernet that is an open architecture LAN. The interface technology is open so that controllers from other companies in addition to those from Fuji Electric may be connected.

(b) Process input-output device equipped with features for the PAS (process automation system) market

This process input-output device is equipped with features for the PAS market such as a RAS function, redundancy function and resistance to the environment.

(c) Process input-output device conforming to international standards

This process input-output device conforms to international standards such as safety standards, CE marking specifications and intrinsic safety standards, adapting to the worldwide market.

3. Conclusion

In this paper, we have introduced the latest information processing system for water and sewage treatment plants.

In the future, we will offer products and services for system lifecycle management, from daily maintenance through renovation, for the safe operation of this system.

*9 Incollaboration with Yokogawa Electric Corporation and Fuji Electric e-Front runners