The ANS-3000 Advanced Information and Control LAN

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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

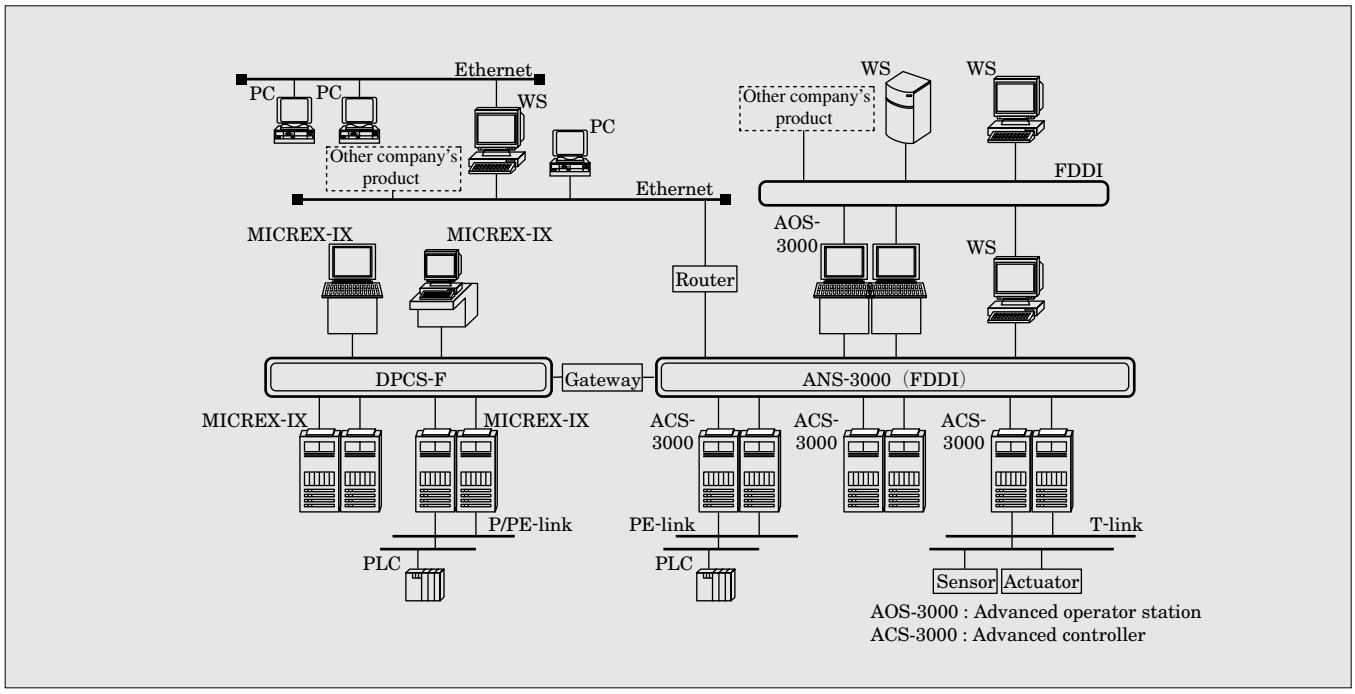
The trends toward larger capacity, higher speed and open control LANs are described below.

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

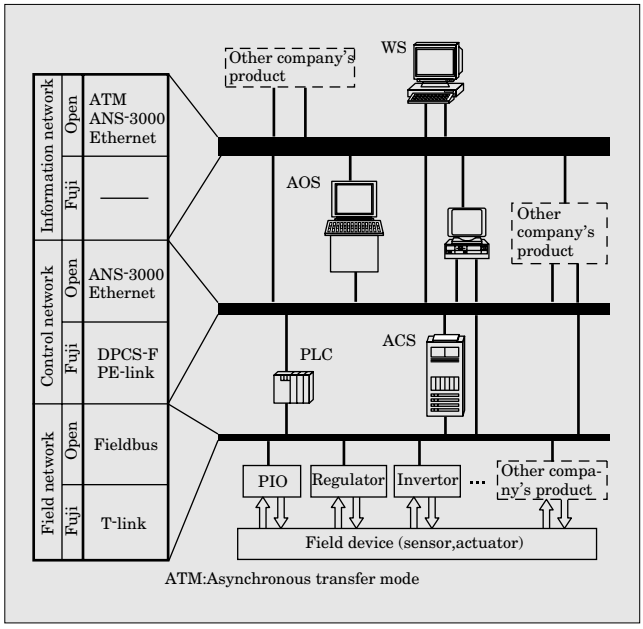
The card is a communication card for FDDI, mounted on an ACS.

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

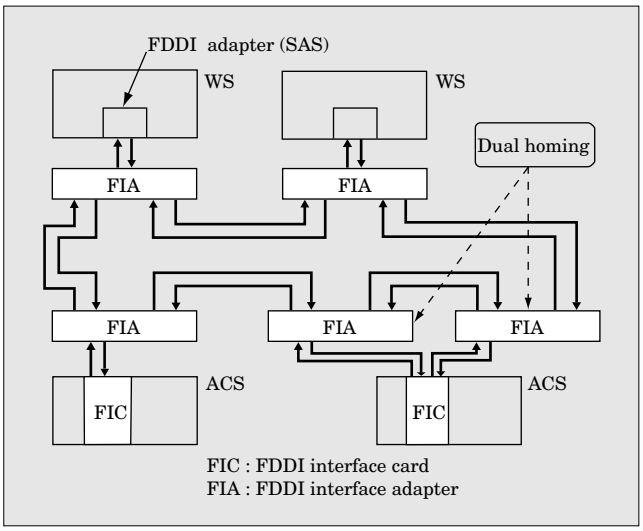
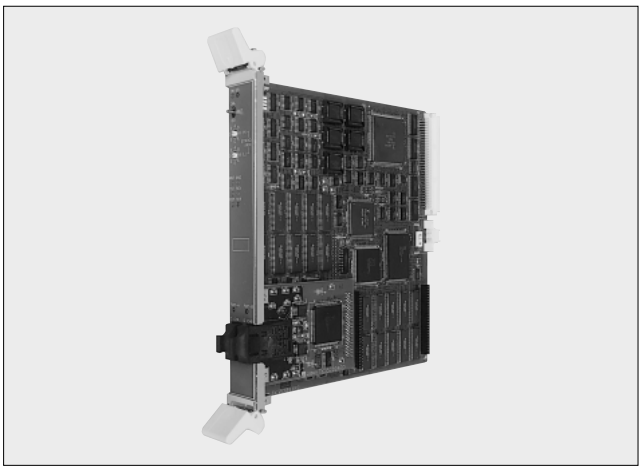


Fig.4 FDDI interface card



(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, normal communication can continue using a spare ring.

(2) Line diagnostic function

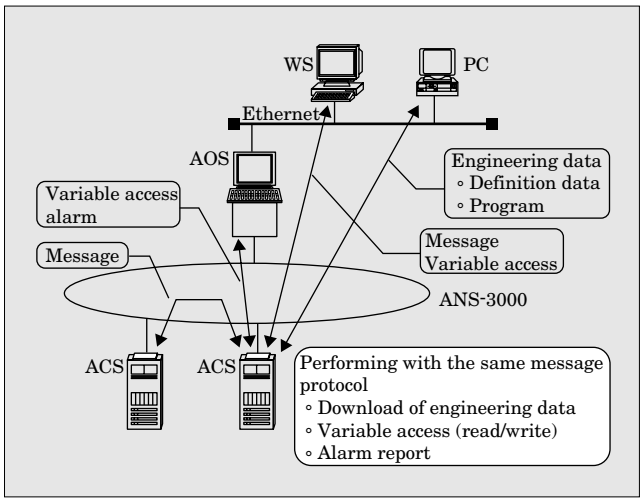
When a station is connected to a ring, that station and the line between neighboring stations are examined. If any fault is found, the faulty section is separated so that operation can continue. As a result, communication is prevented from falling into an unstable condition.

(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.

Fig.5 Communication by the same message protocol



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.