# Open Control Systems and DeviceNet Applications

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*Recent years have seen significant changes in Japan's manufacturing environment. Even as the country has entered a period of low economic growth, globalization of manufacturing through a shift to overseas production has been on the increase. Within this environment, changes are also taking place in information control systems that today integrate everything from databases to manufacturing lines. The increasing use of personal computers, Ethernet applications and so forth is rapidly making such systems more open while also making them more cost-effective. Additionally, field devices such as sensors and actuators (hereafter devices) are requiring less wiring and consequently are becoming lower in cost with the increasing use of field-level networks(hereafter field networks) to connect them.*

*This paper describes recent trends in technologies being used to increase the "openness" of information control systems. It furthermore introduces and describes the features of "DeviceNet", a field network whose superior real-time performance makes it well suited for application to the FA field.*

## 1.THE TREND TOWARD MORE OPEN CONTROL SYSTEMS

The manufacturing industry has undergone major changes in recent years, including a shift towards slower growth, drastic overhauling of price structures, and an increasing trend towards internationalization in the sector (Fig. 1). Customer needs have also changed from the era of mass consumption, with ever-increasing demand for greater diversity in products and shorter lead time in bringing them to the market.

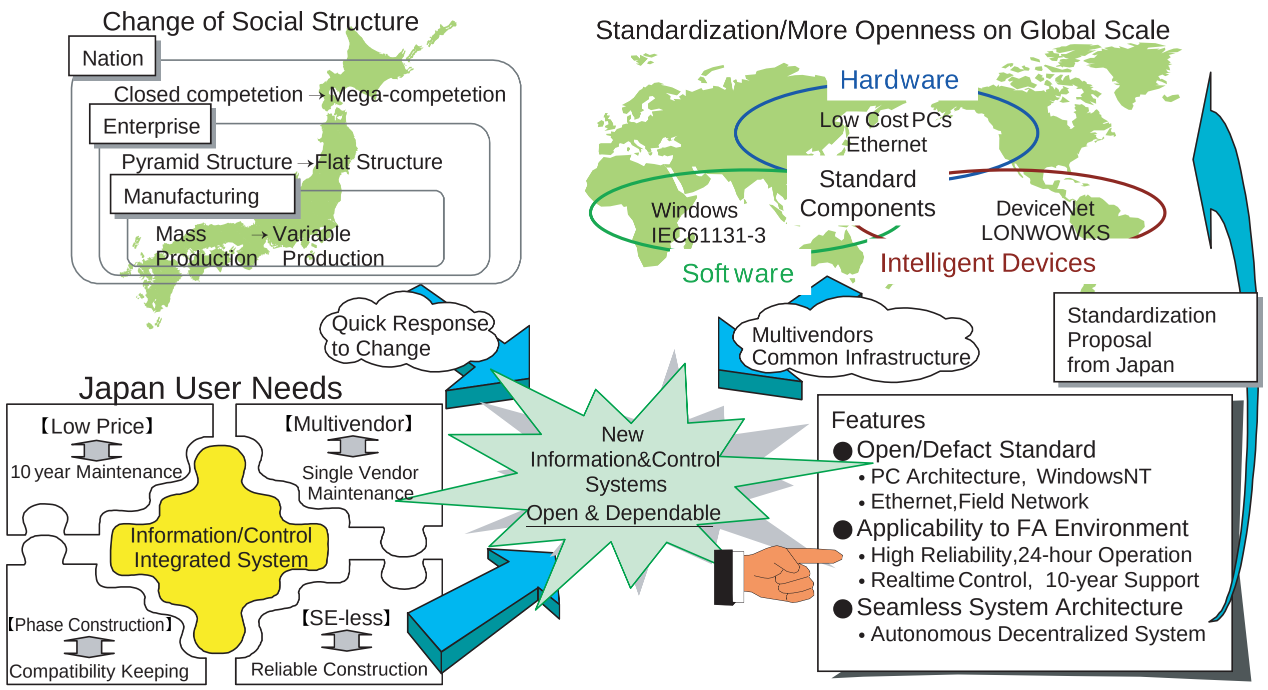



*Fig. 1—Environment Around Information&Control Systems*

For manufacturing systems to keep up with these changes, they need to made more flexible so that they can respond quickly to changes, and they need to lower the cost of bringing out products.

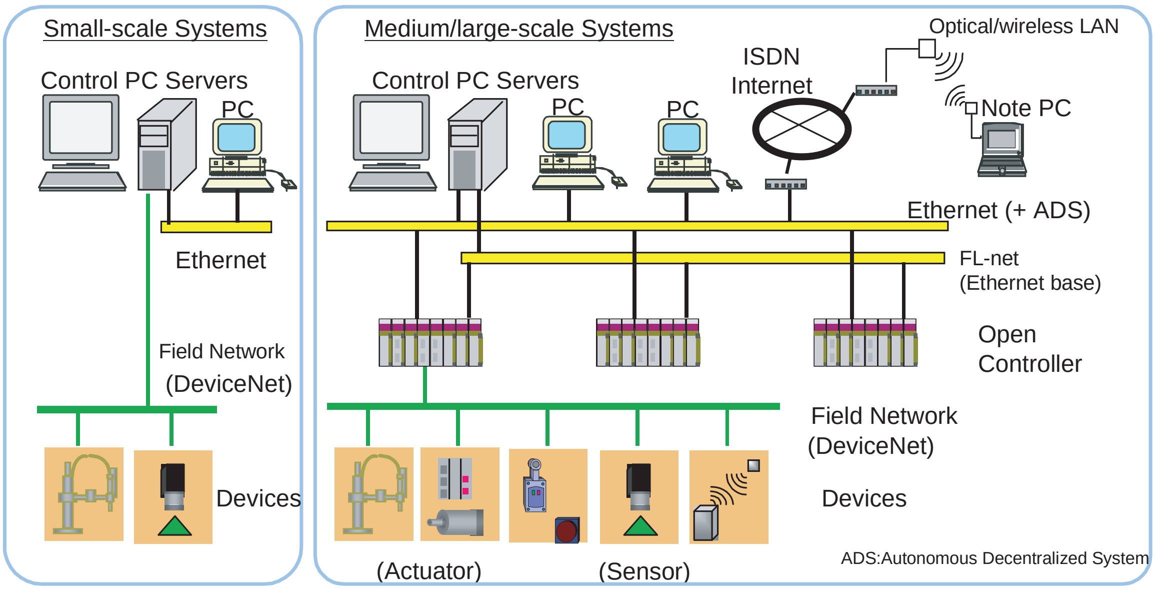
The computer industry, too, has undergone remarkable changes of late. Striking developments have been made in technologies to improve the performance, lower the cost, and increase the openness of Local Area Networks (LANs) comprising personal computers (hereafter PCs), the Ethernet and so on. These technologies are rapidly finding more and more uses and applications in both the office automation (OA) and factory automation (FA) fields.

Against this background, many have eagerly awaited the development of a manufacturing system that can bring out products at low cost and respond quickly to changes in the market, by being able to freely and immediately adopt the latest technology developments in a multivendor environment.

The rush to incorporate the newest in open technologies into the OA field has, however, created problems from the standpoints of both reliability and real-time performance. Manufacturing lines cannot be allowed to go down with the same frequency that ordinary PCs do; they must have the real-time performance that is required of a manufacturing line. They also have to have long-term operability consistent with the operating life of the line equipment. Manufacturing systems, furthermore, should have a seamless architecture for everything from devices to information systems, in which multivendor equipment works together in a smooth and unified manner, enabling the system to be changed and improved easily.

To achieve such systems, then, requires that the FA field adopt and strengthen the newest open technologies that have been put to use in OA and other fields. In response to these needs Hitachi has developed a new information control system, adopting "open" and "dependable" as keywords, "dependable" being synonymous with "having high reliability". The main features of the system are (1) its openness based on the use of PCs, Ethernet, field networks and so on, (2) its applicability to an FA system environment based on its high reliability and use of real-time technology, and (3) its seamless system architecture based on autonomous decentrilized system (hereafter ADS) technology.

In increasing the dependability of systems, they should be made more open so that system equipment from different vendors can work together smoothly instead of operating as separate units, so that signals can be transmitted using internationally standardized protocols, not simply domestic ones. Let us consider Hitachi's ADS technology as an example of this. When the technology was made open at the end of 1996, the use of its interface specifications enabled multiple-vendor PCs, servers, and controllers to be freely and flexibly connected to the standard Ethernet.




Features
(1) Open (PC/AT Compatible,WindowsNT, Ethernet, DeviceNet, IEC61131-3)
(2) Dependable (High Reliability/maintainability, Real-time Performance)
(3) Seamless (Small- to Large-scale, Unified Architecture from Devices to Computers)

*Fig. 2—New Information&Control System Structure (Example)*

Furthermore, this technology was proposed by ODVA (Open DeviceNet Vendor Association) for DeviceNet, a representative example of a field network, and was incorporated as a standard specification in Release 2.0. This has made possible the development of seamless system architectures in everything from devices to information systems.

Figure 2 shows an example system structure of the new information control system.

In man-machine systems employing low-cost PCs, a great deal of inconvenience is the result whenever a server goes down. Thus control PC servers employ a PC architecture that makes use of high-reliability technology to ensure long-term stable operation. In LANs both information systems and control systems both make use of the standard Ethernet, and an Ethernet-based FA control network with added real-time performance is employed in the high-speed connections between controllers. A field network (e.g., DeviceNet) is applied in the connections to devices, and costs are kept low by minimizing the amount of wiring needed.

In Japan, standardization in the FA field is chiefly being advanced by the Japan FaOpen Systems Promotion Group (JOP) of the Manufacturing and Science Technology Center (MSTC) supported by the Ministry of International Trade and Industry. The organizational structure of MSTC is outlined in Fig. 3.

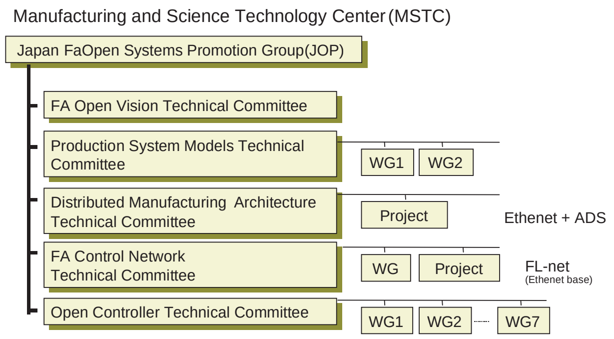



*Fig. 3—Japan FaOpen Systems Promotion Group (JOP)*

As an example of the work MSTC is doing, the Distributed Manufacturing Architecture Technical Committee is incorporating expanded specifications that make distributed production systems easier to use into JOP standard specifications, using the autonomous distributed system based on the Ethernet standard as a foundation. Another example is the FA Control Network Technical Committee's promoting the standard FA control network "FL-net" which include real-time performance based on the Ethernet standard. As a result of these standardization activities, FA Open systems are expected to proliferate rapidly in the future.

Regarding interfaces to devices such as sensors and actuators, in recent years there has been a rapidly accelerating move away from conventional individual parallel wiring to serial wiring that utilizes field networks. There are any number of open field networks that are open networks, and the chips that support them are being marketed, but there has been little progress made in unifying them into a single network such as Ethernet. Instead, different types of field networks are applied to different fields. In the next chapter we compare the characteristics of DeviceNet, the mainstream field network applied in the FA field, with those of other types of field networks.

## 2. DEVICENET FEATURES

DeviceNet is a field network whose superior real-time performance makes it well suited for application to the FA field. The range of devices supported by DeviceNet and other major field networks is shown in Fig. 4.

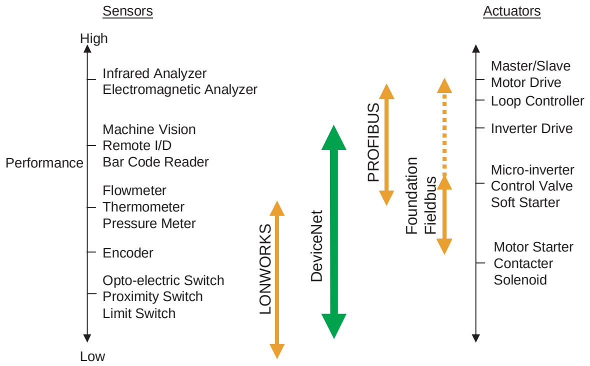



*Fig. 4—Range of Devices Supported by Field Networks*

DeviceNet supports a wide range of devices, from switches to drive controllers. A comparison of DeviceNet specifications with those of other major field networks is shown in Fig. 5.

The main features of DeviceNet are as follows:

### (1) Cost performance

DeviceNet employs a CAN (Controller Area Network) in both its physical layers and its datalink layers. CAN was developed by Bosch as an on-board network for automobiles (BMW and Mercedes-Benz), and is standardized under ISO standard 11898. The CAN chip that supports DeviceNet is at present mainly used in automobiles, and around 10 million chips are produced annually. The chips are supplied by multiple vendors including Motorola, NEC and Hitachi, which helps to ensure stable chip supply at low cost.

### (2) Real-time performance

DeviceNet's per-transmission data volume is as

| Item | Major Field Network | | | |
|---|---|---|---|---|
| | DeviceNet | LONWORKS | PROFIBUS(-DP) | Foundation Fieldbus |
| Max. No. of Nodes (including master node) | 64 | 127 / subnet (255 subset / domain) | 256 | 256 |
| Extention Distance | 500m (extendible with optical fiber) | 2km | 1.2km | 1.9km |
| Max. Distance between Nodes | Not stipulated | 2km | 200m | Not stipulated |
| Transmission Medium | Twisted pair (optical fiber also possible) | Twisted pair<br>Wireless<br>Infrared rays<br>Optical fiber | Twisted pair<br>Optical fiber | Twisted pair<br>Wireless<br>Optical fiber |
| Transmission Rate | 125kbps/ 250kbps/ 500kbps | 9.8kbps~ 1.25Mbps | 9.6kbps~12Mbps | 31.25kbps [High speed version 1Mbps/ 2.5Mbps] |
| Bus Access Mode | CSMA/ NBA Mode | Predictive CSMA Mode | Polling Mode | Link Active Scheduler Mode |
| Data Length of Frame | 0~8 Bytes | 2~32 Bytes | 1~246 Bytes | 1~256 Bytes |
| Standardization Organization | ODVA (USA) | - (ECHELON Co.) | PROFIBUS International (Germany) | IEC / Fieldbus Foundation |
| Main Application Field | F A (North America, Japan) | Building Management (North America, Japan) | F A (Europe) | P A (North America) |

Fig.5 Comparison of Major Field Network Specifications

*Fig. 5—Comparison of Major Field Network Specifications*

much as 8 bytes less than that of other field networks, and thus its device response time is within 1 ms. It employs CSMA/NBA (Carrier Sense Multiple Access with Non-destructive Bitwise Arbitration) as its bus access mode. A comparison of this mode with the general-use CSMA mode is shown in Fig. 6.

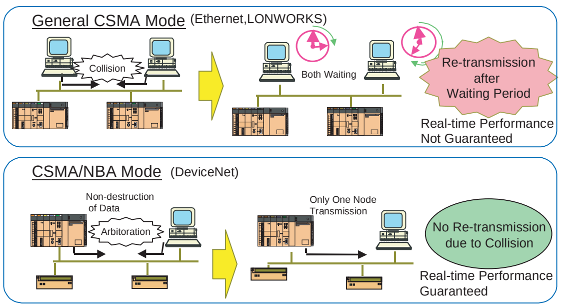



*Fig. 6—CSMA/NBA Operation*

In Ethernet's CSMA/CD (Carrier Sense Multiple Access/ Collision Detection) mode, for example, when multiple nodes begin transmissions at the same time and collisions occur on the bus, the transmission is broken for all of the nodes. A waiting period is then established for each of the nodes, by random number selection for example, and re-transmission begins after the time period has elapsed. Thus wasteful waiting time is incurred, and since there is no guarantee that there will be no collisions even with the re-transmission, real-time performance cannot be guaranteed. LONWORKS employs a predictive CSMA mode in which collision frequency is lower than in CSMA/CD, but even with this lower collision frequency real-time performance cannot be guaranteed.

In contrast, with the CSMA/NBA mode employed by DeviceNet, collisions occurring when multiple nodes begin transmissions at the same time are detected, and the transmission from one node only is allowed to continue while the others are broken off. Thus no wasteful waiting time is incurred even if collisions occur, all the node transmissions are completed within a fixed time frame, and real-time performance is guaranteed. It is this feature that makes DeviceNet particularly well-suited for the FA field, where real-time performance is in high demand.

### (3) Openness

Adding media such as connectors and cables to the transmission protocol ensures that the physical layer specifications are open. To make devices and equipment from multiple venders mutually compatible, the I/O data format and profile for each different type of device or equipment are stipulated by the international standardization body ODVA (Open DeviceNet Vendor Association). Thus the connecting and exchanging of multivendor equipment is made easy.

### (4) Network power supply

The system cables contain a power supply line in addition to the twisted-pair line for transmitting, thus

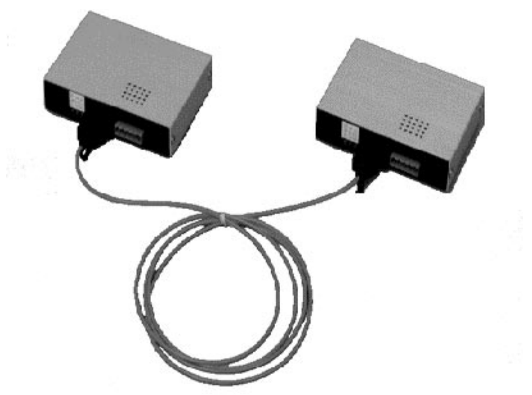


*Photo 1—DeviceNet Optical Repeater*

low-power- consumption equipment does not need to have its own power source but can be supplied power from the network.

(5) Optical transmission

Cables often must be located in the field in areas where transmission performance may be degraded due to noise generation. Optical connections are needed to prevent this, and optical repeaters have been developed for this purpose (Photo. 1).

## 3. DEVICENET APPLICATIONS IN AN OPEN-SYSTEM ENVIRONMENT

DeviceNet offers a wide variety of products supported by a large number of domestic and overseas vendors, thus making flexible system construction possible (Fig. 7).

There are many possible applications of DeviceNet, among them in (1) automated warehouses and delivery accounting in the distribution field,(2) welding in the automobile industry, (3) washing and diffusion equipment in the semiconductor industry, (4) beer brewing in the foodstuffs industry, (5) electronic parts equipment production in the electricity/ electronics field, and (6) motor control in the steel industry and in waterworks equipment.

In April 1999, DeviceNet has been supported by 303 vendors, and DeviceNet nodes totaled more than 200,000. Since then, the node count has been tripling annually, and with the ongoing addition of new devices it is forecast that it will find application in an even wider range of fields in the future.

In using DeviceNet in an open-system environment, however, it is important that users be able to construct and monitor networks easily. For this purpose, a DeviceNet construction and monitoring tool called NxConstructor/NxMart has been developed. By expanding ADS technology into DeviceNet, this tool supports DeviceNet construction and monitoring in an open systems environment.

This tool applies ADS technology to a total system, from devices to computers, to obtain a unified architecture and support a highly flexible and expandable system operation. The tool has a number

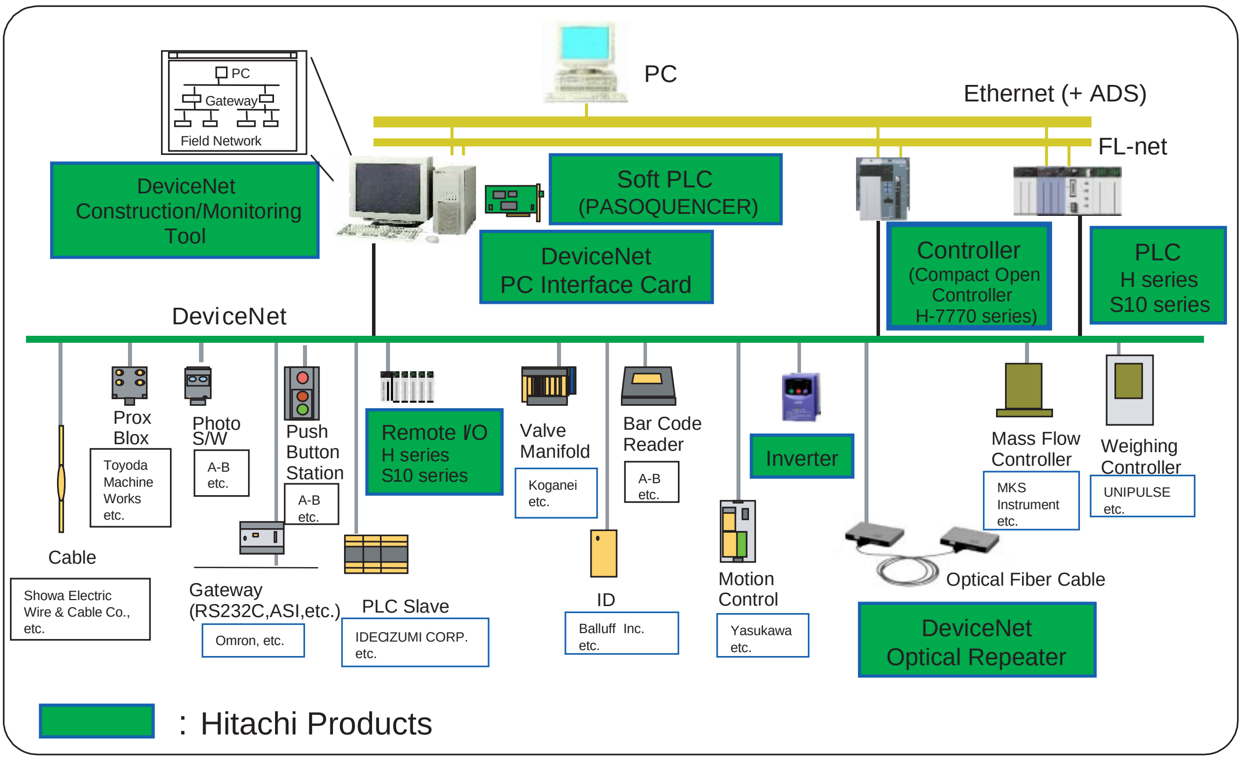



*Fig. 7—DeviceNet Products*

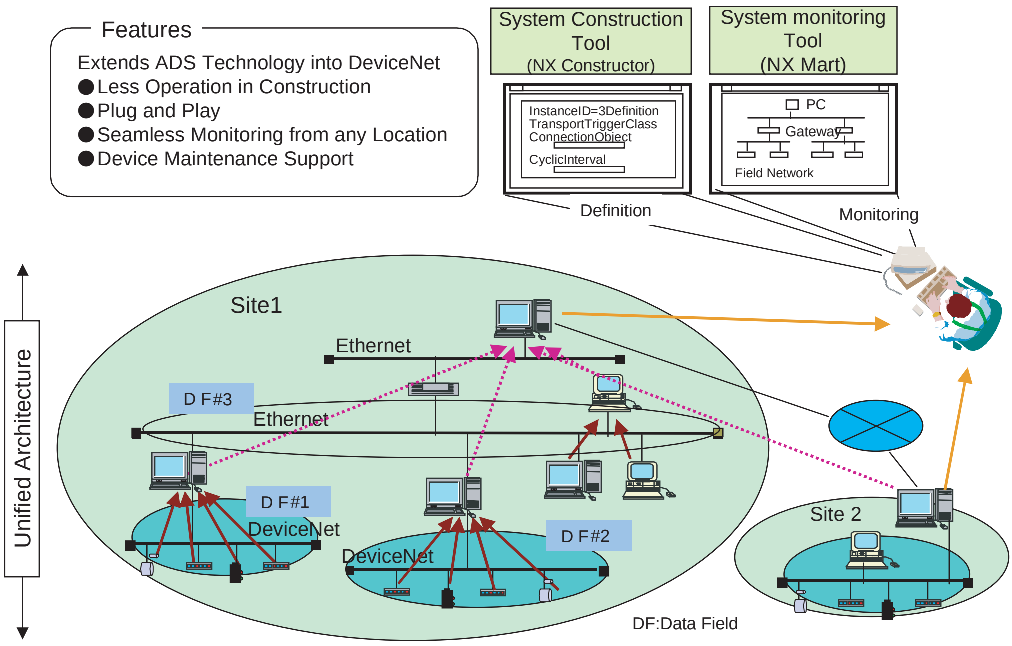



*Fig. 8—DeviceNet Construction/Monitoring Tool*

of distinct features, among them (1) less operation for construction tasks, (2) plug and play in devices, (3) seamless monitoring from any location, (4) control of lamps that light up to indicate a device needs maintenance support.

In summary, the trend toward more open FA using PCs, Ethernet, field networks and so on is expected to increase rapidly in the future as with increased standardization and the development of new products. Hitachi, Ltd. will continue to pursue R&D activities with a view to making significant contributions to this trend.

* Windows NT is a trademark of Microsoft Corp. (USA)
* Ethernet is a registered trademark of Xerox Corp. (USA)
* DeviceNet is a registered trademark of ODVA (Open DeviceNet Vendor Association)
* Autonomous Decentralized System is a product name of Hitachi, Ltd.

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