

Industrial Communication Networking: An Ethernet Based Implementation

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Abstract

Recent advancements achieved in industrial communications and networking technology have made it possible to apply Ethernet-based communication networking system at all levels of industrial automation, especially at the controller level where the capacity to do data exchanges in real-time is mandatory. This paper describes the development of an industrial communications network based on the Ethernet protocol and its implementation in a Computer Integrated Manufacturing (CIM) system. The application of Ethernet protocol in such a system is aimed at overcoming the difficulties experienced when trying to communicate in real-time using serial communication networks, such as when attempting to access and retrieve data from other stations. Other advantages of this approach include the relative ease of achieving system integration and the possibility of simple upgrading to include the management and enterprise levels in the industrial automation system pyramid. In this work, the Ethernet module is installed onto a supervisory PLC to integrate all the stations present in the existing CIM system found in our laboratory. The workability of this approach is analyzed and compared with the conventional serial communication network.

Keywords:

Industrial automation, computer integrated manufacturing (CIM), Ethernet, programmable logic controller (PLC)

Introduction

Ethernet, the well-known local area network (LAN) standardized by IEEE has been largely utilized in industrial communication. The Ethernet network has gained the capability of communicating in real-time and thus opening an attractive scenario, implementation of Ethernet at all the industrial automation levels. Ethernet has been used in industrial communication systems at control and supervisory levels, but the earlier version was not able to satisfy the real-time requirements needed by field levels. Recently, new improvements in data transfer speed and the introduction of switches practically have overcome limits due to non-determinism of CSMA/CD protocols [1]. Several

Ethernet compatible protocols have been proposed to support real-time traffic [2]. Implementing Ethernet even at the lowest level is suitable for a better interface to the last-generation PLCs [3], as Soft-PLC, allowing the reuse of existing infrastructures. Independently from the communication model, a real-time protocol based on Ethernet is expected to have better performance than the currently available field-buses. This assertion account for two opposite issues, namely the transmission speed and the communication efficiency [4].

The aim of this paper is to present the results of the work carried out by the authors on the application of Ethernet-based communication network to an existing computer integrated manufacturing system. The main objectives are to develop a hardware infrastructure of CIM system communication network based on the Ethernet protocol, and to identify and thus overcome the arising real-time communication issues so as to allow easier integration between the different stations of the CIM system via Ethernet unit on the supervisory PLC.

Approach and Methods

Ethernet Communication Networking

Industrial Ethernet Communication System

Recently, the real-time industrial network has become an important element for intelligent manufacturing systems. Especially, as the systems are required to be more intelligent and flexible, the systems should have more field devices such as sensors, actuators, and controllers. As the number of field devices in manufacturing systems grows and the functions of the system need to be more intelligent, these devices need to exchange the rapidly increasing amount of data among them.

In creating an Ethernet network, there a few basic devices from the Ethernet interface on the equipment to the hubs/switches that tie it all together. Any equipment connected to an Ethernet network must have an Ethernet port that the network cable plugs into which is otherwise called a Network Interface Card (NIC). In industrial PLCs, the interface is built into a plug-in module like Ethernet unit (ETN-21) manufactured by OMRON. This Ethernet unit is capable of operating at 100 Mbps. The difference between hub and switch is that in the hub the signal will transmit to all

stations while a switch directs packets only to the station for which it is intended. In other words, it switches the signal between input and output port as illustrated in Figure 1.

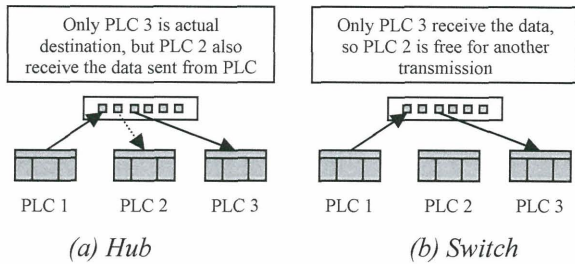


Figure 1 - Ethernet network method using hub/ switch

Application Example

In this work, an Ethernet based communication system was implemented in the existing CIM system located in the authors laboratory. The controller used in the CIM system is OMRON PLC (CJ1M series). While it is acknowledged that there are available PLCs in the market which have TCP/IP over Ethernet protocol built into the PLC processor, we have decided to utilize OMRON package [5-6] to implement the Ethernet-based communication network to take full advantage of the existing technology and also to minimize the development effort.

Ethernet Based Communication in CIM-70E Network

There are two major issues to be addressed in this work, namely, Ethernet network installation and software development. For identification purposes, the Ethernet-based communication system developed in this work is named in this paper as the CIM-70E system. The CIM-70E system is multiple PLC link up through Ethernet networking where each PLC station, excluding the Vision Inspection Station, has one Ethernet unit and a RJ45 unshielded twisted-pair (UTP) cable is connected through a 100Base-TX switch.

Hardware Installation

The basic configuration for the Ethernet-based networking system consists of one switch/hub to which nodes are attached using twisted pair cables. The hardware used and installed on the CIM-70E system is show in Figure 2. The standards and specifications applied to the connectors for the Ethernet twisted-pair cables conform to IEEE802.3 Electrical specifications standards and the connector structure is RJ45 8-pin Modular Connector which conforms to ISO 8877. An overview of the start up procedure for Ethernet unit installation is illustrated in Figure 3.

Communications Test

The PING command sends an echo request packet to a remote node and receives an echo response packet to confirm that the remote node is communicating correctly. The PING command uses the ICMP echo request and responses as illustrated in Figure 4. The echo response packet is automatically returned by the ICMP. This command is normally used to check the connections of remote nodes when configuring a network. The Ethernet unit

automatically returns the echo response packet in response to an echo request packet sent by another node (host computer or other Ethernet units).

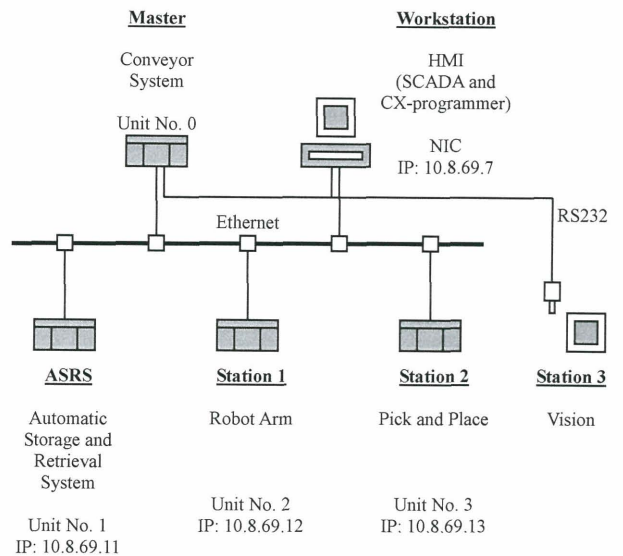


Figure 2 - CIM-70E system architecture

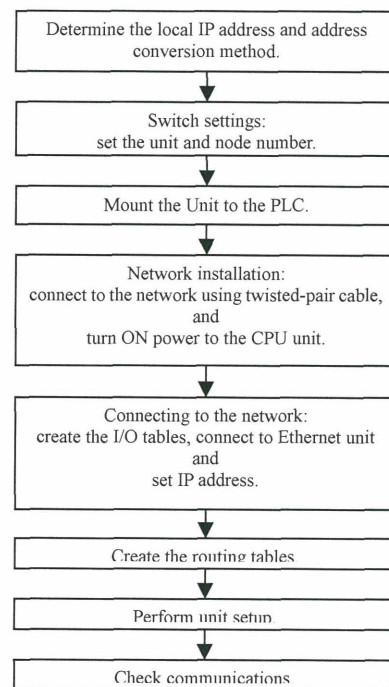


Figure 3 - Overview of Ethernet unit installation procedure

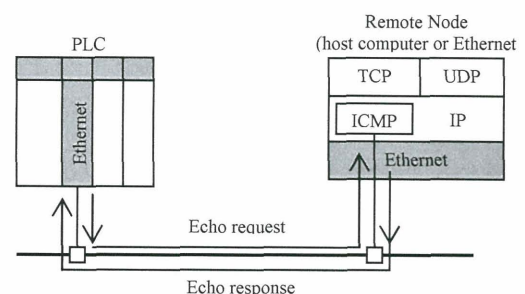


Figure 4 - PING command [6]

Software Development

A thorough understanding of the General Factory Interface Network Services (FINS) program is a prerequisite to its successful application in an Ethernet network. The ladder program was created through OMRON CX-Programmer software. A ladder program which concentrates on data exchange through Ethernet networking of CIM-70E system was developed and is presented below.

Programming Development

Some extra care must be exercised when using network instructions (SEND(090), RECV(098), and CMND(490)) to send commands from the CPU unit: (i) these instructions are converted to the same format for FINS commands that are sent to CPU units on networks, (ii) a program must be created to process the commands received by the host computer, and (iii) some control data settings will be different when these instruction are executed as shown in Table 1 for the ASRS Station.

Table 1 - Control data for ASRS Station

Word	Contents		Description
D 00	00	19	Number of reception words = 25
D 01	00	10	Serial port 0 Source network address = 10 (CIM-70E)
D 02	0B	00	Source node address = 0B (ASRS Station) Source unit number = 00 (inner board)
D 03	01	05	Response required, communication port no. = 01 Number of retries = 5 times
D 04	00	00	Response monitor time = 2 sec (default)

Results and Discussion

The results obtained by comparing the Ethernet based communication installed into the CIM-70E system with the conventional serial communication in the original CIM-70A system. The communication test was performed using the command prompt window and the CX-Programmer software in order to ensure the connection is established. Then, the real-time monitoring test was performed to show the workability of the Ethernet based communication network setup.

The main difference between the CIM-70A and the CIM-70E system setup is in term of their CIO memory area capacity, where 25 words are allocated for the CIM-70E system while only 10 words are allocated for the CIM-70A system. The bigger memory area allocated in the CIM-70E systems allows more information data to be interchanged through Ethernet networking such as station status, transferring data, Email function, automatic clock adjustment and etc.

The main advantage of using Ethernet based communication as compared to the current serial communication is its ability to monitor all stations from any point in the system.

Conclusion

In this paper, the successful implementation of an Ethernet-based communication network for a CIM system was presented and the results discussed. We hope to further develop the system in the near further by taking full advantage of the Ethernet protocol to add more system functionalities.

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