IMPLEMENTATION OF REAL TIME MONITORING USING ETHERNET FOR TEACHING AUTOMATION NETWORK SYSTEM

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Abstract – In teaching the automation network system programming, students are frequently not capable to apply the theoretical concepts to the real implemented system. The understanding of the real time implementation will be presented in an assignment study of real time Ethernet protocol and thus implement it into Computer Integrated Manufacturing (CIM) system. The purpose of this paper is teach the students methods to overcome real-time communication in which the accessibility of data exchange is very difficult in terms of retrieving data from other stations and time consuming. The Ethernet module is installed onto supervisory OMRON PLC to integrate several of stations in the CIM-70A system which is located at Robotic Laboratory in Universiti Tun Hussein Onn Malaysia (UTHM). The workability of this communication technique is analyzed and compared with the conventional serial communication which widely used in automation networking systems. And help student to visualize the whole concept of networking system in actual automation environment.

Keywords: *CIM, Ethernet, OMRON, real time*

INTRODUCTION

Learning process provides greater impact to the student's experience in adapting the theoretical knowledge with the actual life scenario especially in working environment. To facilitate students to explore the behavior of automation networking , the Ethernet will be implement in automation environment ;where data communication and networking may be the fastest growing technology in our culture today [1] (Sterling and Wissler, 2003). Ethernet, the well-known local area network (LAN) standardized by IEEE has been largely utilized in industrial communication. The Ethernet network have gained the capability of communicating in real-time thus opening an attractive scenario; implementation of Ethernet at all the industrial automation levels (Fig. 1).

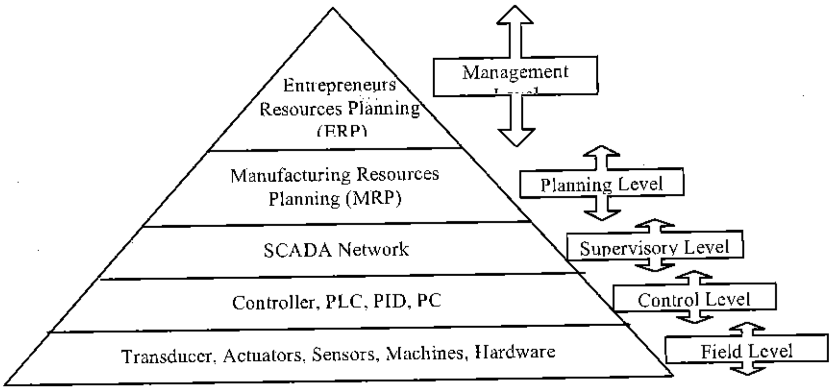


Figure 1. Pyramid of industrial automation system.

Real-time communication has become some major issue in automated manufacturing system. Some problems such as data and status monitoring, transmission data size and speed, online program editing, and accessibility of controller are encountered in conventional serial communication networking such as in CIM system.

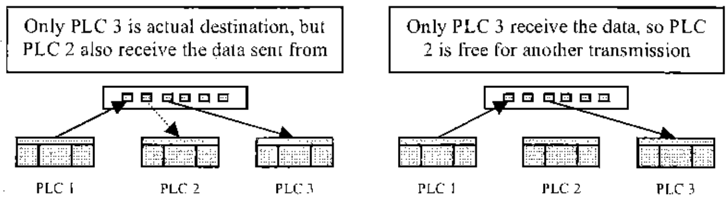
This paper presents an application of Ethernet communication in CIM-70A system. The objectives of this project are: (i) to develop a hardware infrastructure of CIM system communication network based on Ethernet, (ii) to familiarize and thus overcome real-time communication issues so that allows easier integration between the different stations of the CIM system via Ethernet unit on OMRON CJ1M PLC, and (iii) to verify and validate the functionality, feasibility and workability of the project.

This paper is organized as follows: Section 2 reviews an industrial Ethernet communication background for deeper student understanding and development by describing the concept and issues in Ethernet communication as well as manufacturer offered technique i.e. OMRON. Section 3 presents the methodology used to implement Ethernet based communication in terms of hardware installation and software development. Section 4reports on the results obtained and section 5 concludes the paper.

Recently, new improvements in data transfer speed and the introduction of switches practically have overcome limits due to non-determinism of CSMA/CD protocols (Vitturi, 2001). Several Ethernet compatible protocols have been proposed to support real-time traffic (Szabo, 1997). Implementing Ethernet even at the lowest level is suitable for a better interface to the last-generation PLCs (Maciel, 1998), as Soft-PLC, allowing the reuse of existing infrastructures.

Independently from the communication model, a real-time protocol based on Ethernet supposed to have better performance than the currently available field buses. This assertion account for two opposite issues which are the transmission speed and the communication efficiency (Bertolluzo et. al., 2002).

In creating an Ethernet network, there a few basic devices that students must be familiar with the Ethernet interface on the equipment to the hubs/ switches. Any equipment connected to an Ethernet network must have an Ethernet port that the network cable plugs into which often called 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 to operate at 100 Mbps. The difference between hub and switch are the signal will transmit to all station using hub 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 illustrates in Fig. 2.



(a) Hub (b) Switch

Fig. 2. Ethernet network method using hub/ switch.

The application of Ethernet communication system was implemented in this project. This communication approach was applied in CIM system i.e. CIM-70A which available at Robotic Laboratory, UTHM. The controller used in CIM-70A system is OMRON PLC (CJ1M series). Some PLC manufacturers offer programmable controllers with TCP/IP over Ethernet protocol built into the PLC processor. To the full advantage of existing technology and minimize development effort, it was decided to utilize OMRON package for implement communication networking based on Ethernet (OMRON Corporation, 2005).

ETHERNET BASED COMMUNICATION IN CIM-70A NETWORK

This section provides the overview of how the laboratory activity for providing students with the hands-on practice to enhance learning the networking issue. There are two major methodologies applied in order to realize the objective of the Ethernet network installation and software development in CIM-70E system. The CIM-70A is changed to CIM-70E system for distinguishable purpose so that the Ethernet network installation and software development will refer to CIM-70E system. The CIM-70E system is multiple PLC link up through Ethernet networking where each PLC station excluding Vision Inspection Station has one Ethernet unit and a RJ45 unshielded twisted-pair (UTP) cable is connected through 100Base-TX switch.

Hardware Installation

The basic configuration for Ethernet system consists of one switch/hub to which nodes are attached using twisted pair cables. The hardware used and installed on CIM-70E system is show in Fig. 3. The standards and specifications applied to the connectors for the Ethernet twisted-pair cables are conforming to IEEE802.3 Electrical specifications standards and connector structure is RJ45 8-pin Modular Connector which conforming to ISO 8877. Overview of start up procedure for Ethernet unit installation is illustrated as Fig. 4.

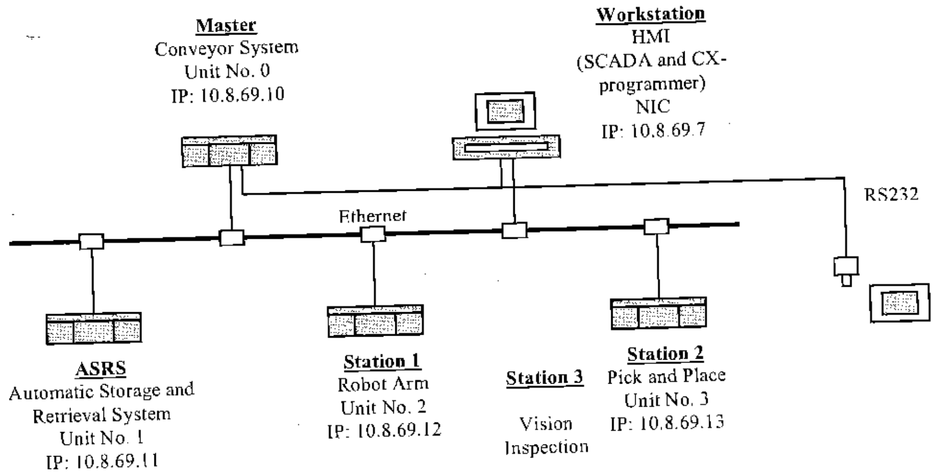


Fig. 3. CIM-70E system architecture

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 5. 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 unit).

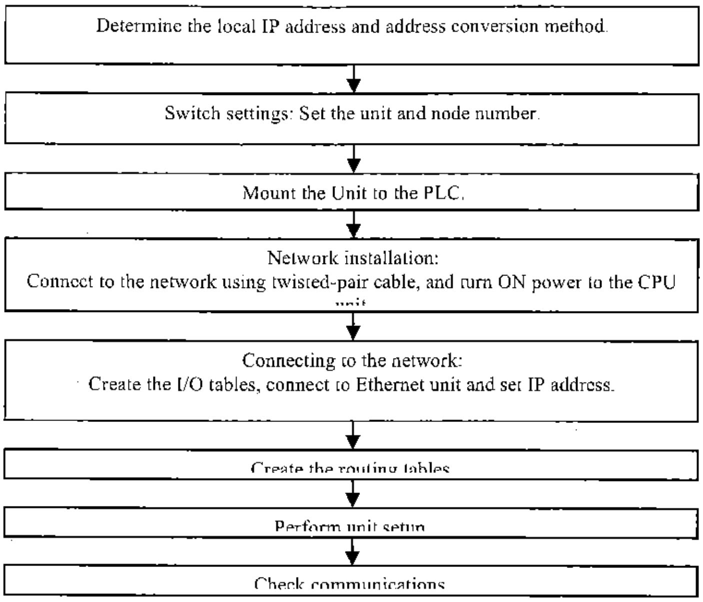


Fig. 4. Overview of Ethernet unit installation procedure

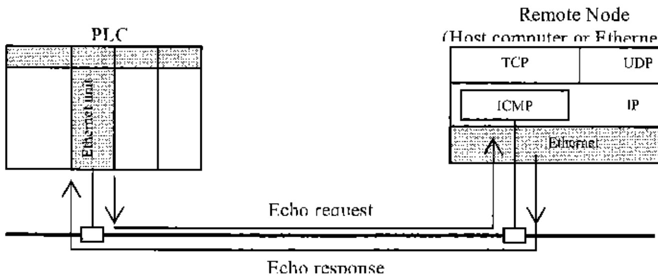


Fig. 5. PING command [8]

Software and Programming Development

General Factory Interface Network Services (FINS) program is studied in order to apply into Ethernet network. The ladder program was created through OMRON CX-Programmer software. Ladder programs which concentrate on data exchange through Ethernet networking of CIM-70E system were developed and presented. Some consideration has been made when using network instructions to send commands from the CPU unit. These instructions are converted to the same format for FINS commands and some control data settings will be different when these instructions are executed as Table 1 for 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 were compared between Ethernet based communications and the conventional serial communication methods in CIM-70E and CIM-70A system respectively. The communication test was performed using command prompt window and CX-Programmer software to ensure the connection is established. Then, the real-time monitoring issue was performed to show the workability of the Ethernet based communication network setup.

Major different between CIM-70A and CIM-70E system setup is their CIO memory area capacity whereas there are 25 words allocated for CIM-70E system while only 10 words allocated for CIM-70A system (Table 2). It allows more information data to be interchanges through Ethernet networking such as station status, transferring data, Email function, automatic clock adjustment and etc.

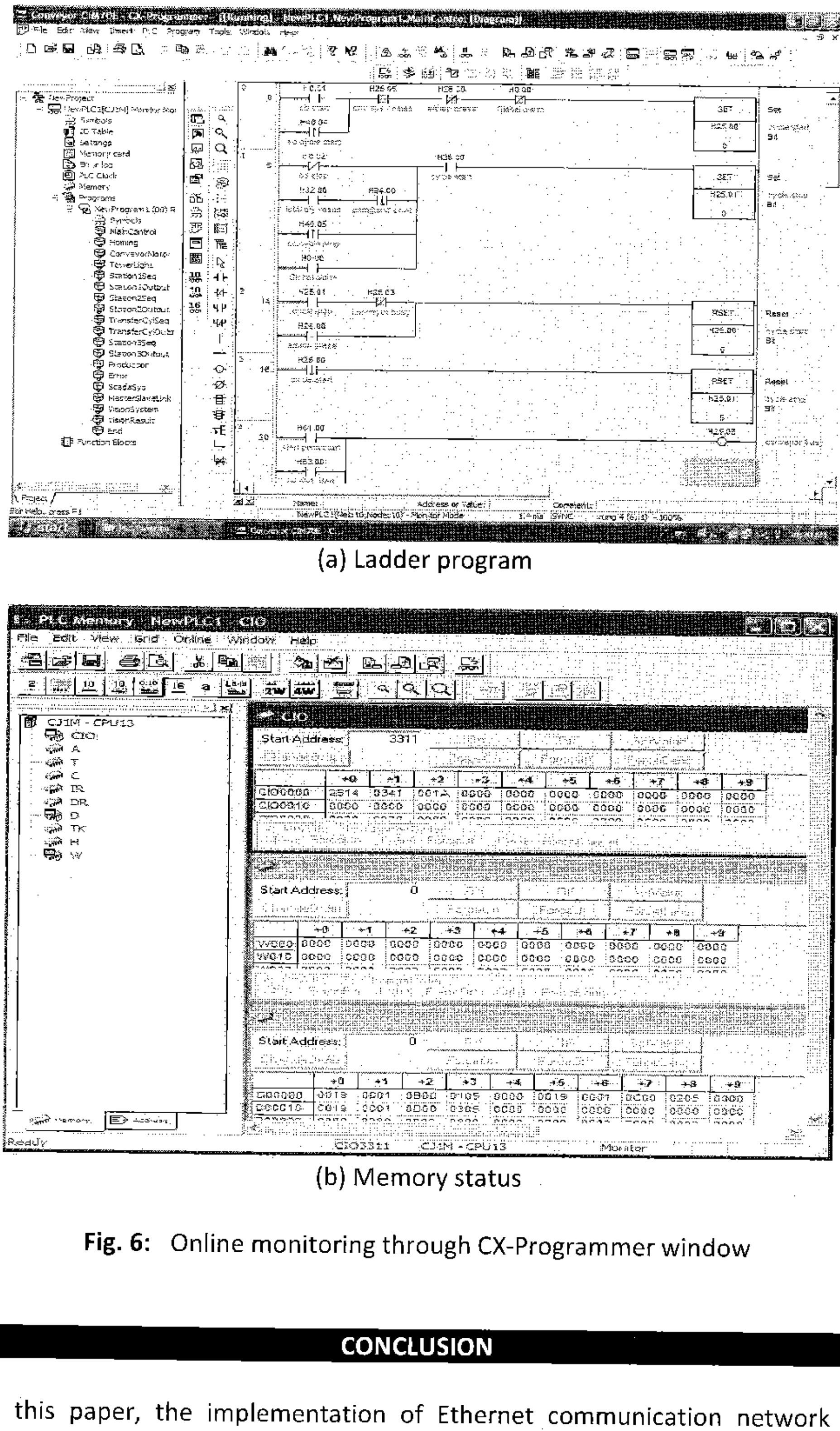
Table 2. CIO memory area comparison

Station	CIM-70A	CIM-70E
Conveyor System Station	CIO 3100-3109	CIO 1500-1524
ASRS Station	CIO 3110-3119	CIO 1525-1549
Station 1: Robot Arm	CIO 3130-3139	CIO 1550-1574
Station 2: Pick & Place	CIO 3120-3129	CIO 1575-1599

Once a program and I/O routing tables of the project networking has been setup, the CX-Programmer software was run to monitor data online as shown in Figure 6. All data status; input, output and memory area, uploading and downloading program, program editing, mode changes, network routing tables etc. are successfully monitored.

It is possible to monitor the values within PLC addresses from within the main ladder and mnemonic display. For each operand, a value is displayed or power-flow is shown to indicate the state of the operand as Fig. 6(a).

The results showed that the main advantage of using Ethernet based communication as compared to the current serial communication is its ability to access as well as real-time monitor all stations at any point.



(a) Ladder program

(b) Memory status

Fig. 6: Online monitoring through CX-Programmer window

CONCLUSION

In this paper, the implementation of Ethernet communication network for CIM system was presented. The Ethernet unit was installed at each PLC station and software. Students can evaluate and troubleshoot the networking as well as understand the issues in implementing the theoretical concept in real world. This hands-on experience gives students an experimental environment for and bridges the gap between fundamentals and real world designs.

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