A STUDY ON INDUSTRIAL COMMUNICATION NETWORKING: ETHERNET BASED IMPLEMENTATION

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For my beloved wife,
Norasiah binti Md Aspan

My father and mother,
Hashim bin Mohd Said and Uminah binti Kaseran@Hj. Yusof

My family,
Zainita, Mohd Rizal, Mohd Nazree, Norzela, Mohd Haizam, Md Syfulnizam,
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ABSTRACT

Recent enhancement of an industrial communication and networking technology has made it possible to apply Ethernet networks at all levels of industrial automation, especially at controller level where the data exchange in real-time communication is mandatory. This thesis presents a study on the development of industrial communication network based on the Ethernet and its implementation on a Computer Integrated Manufacturing (CIM-70A) system which located at Robotic Laboratory in KUiTTHO. The Ethernet module was installed on supervisory OMRON PLC to integrate the various stations in the CIM-70A system. The workability of this communication technique was analyzed and compared with the conventional serial communication which is widely used in automation networking systems. Through this approach, the communication and integration of CIM systems can be accessed easily and hence available to be upgraded to the management and enterprise levels of automation.

ABSTRAK

Penambahan penggunaan komunikasi dan rangkaian industri sejak akhir-akhir ini telah menjadikan rangkaian Ethernet boleh diaplikasikan di semua peringkat automasi perindustrian, terutamanya di tahap pengawal di mana penukaran data dalam masa nyata adalah mandatori. Tesis ini membentangkan satu kajian pembangunan perindustrian rangkaian komunikasi berdasarkan Ethernet dan seterusnya akan diaplikasikan kepada sistem pembuatan komputer bersepadu (CIM-70A) yang terletak di Makmal Robotik, KUiTTHO. Modul Ethernet telah dipasangkan kepada pengawal logik boleh aturcara (PLC) jenama OMRON (siri CJ1M) untuk menyepadukan pelbagai stesen pengeluaran di dalam sistem CIM-70A. Kebolehkerjaan teknik komunikasi ini telah dianalisis dan dibandingan dengan sistem konvensional yang begitu meluas digunakan di dalam rangkaian sistem automasi iaitu komunikasi bersiri. Menerusi pendekatan ini, komunikasi dan integrasi sistem CIM lebih mudah dicapai dan seterusnya boleh dipertingkatkan ke peringkat pengurusan dan perusahaan di dalam sistem automasi.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE

LIST OF TABLES

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE

LIST OF ABBREVIATIONS

ACK	-	acknowledgement
ARP	-	address resolution protocol
ASRS	-	automatic storage and retrieval system
AUI	-	attachment unit interface
BACNet	-	building automation and control network
CAN	-	controller area network
CD	-	compact disc
CIM	-	computer integrated manufacturing
CiN	-	CAN in automation
CIO	-	common input/output
COM	-	component object model
CPU	-	central processing unit
CSMA/CD	-	carrier sense multiple access with collision detection
DCOM	-	distributed component object model
DEC	-	Digital Electronic Corporation
DIX	-	DEC, Intel, and Xerox
DM	-	digital memory
DNS	-	domain name system
EHS	-	European Home System
ERP	-	entrepreneurs resources planning
FA	-	field assembly
FF	-	Foundation Fieldbus
FINS	-	factory interface network service
FINS/TCP	-	factory interface network service/transmission control protocol
FINS/UDP	-	factory interface network service/user datagram protocol

FIP	-	factory instrumentation protocol
FKEE	-	Faculty of Electrical and Electronic Engineering
FTP	-	file transfer protocol
HART	-	Highway Addressable Remote Transducer
HMI	-	human machine interface
ICMP	-	internet control message protocol
ID	-	identity device
IDA	-	interface for distributed automation
IEEE	-	Institute of Electrical and Electronic Engineer
IEC	-	International Electrotechnical Commission
IP	-	internet protocol
ISA	-	Instrument Society of America
ISP	-	interoperable system project
KUiTTHO	-	Kolej Universiti Teknologi Tun Hussein Onn
LAN	-	local area network
LLC	-	logical link control
LonWorks	-	local operating networks
MAC	-	medium access control
MAU	-	multi-station access unit or medium attachment unit
MES	-	manufacturing execution system
MRP	-	material requirement planning
MRP-II	-	manufacturing resources planning
NIC	-	network interface card
OSI	-	open system interconnection
PC	-	personal computer
PID	-	proportional, integral and derivative
PING	-	packet internet groper
PLC	-	programmable logic controllers
POP3	-	post office protocol version 3.0
Profibus	-	Process Fieldbus
P-Net	-	Process Network
SCADA	-	supervisory control and data acquisition
ScTP	-	screened twisted-pair cable
SDS	-	smart distributed system

SMTP	-	simple mail transfer protocol
SNTP	-	simple network time protocol
STP	-	shielded twisted-pair cable
TCP	-	transmission control protocol
TCP/IP	-	transmission control protocol/internet protocol
UDP	-	user datagram protocol
UTP	-	unshielded twisted-pair cable

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Project Overview

Data communication and networking may be the fastest growing technology in our culture today (Forouzan, 2001). It is extensively used in an industrial network to integrate both office and manufacturing equipment. During the last two decades, the industrial communication system have evolved at a rapid pace and passed from the traditional serial communication to the fieldbuses. The term fieldbus applies to a large family of two-way digital communication protocols that were specially developed to overcome the physical and performance limitations of low level digital and analogue standard (Sterling and Wissler, 2003). A full fieldbus protocol can handle byte size data for complex transmitters and valves as well as diagnostics or control information. Any control device requiring extensive communication for configuration requires a full fieldbus.

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 level of an industrial automation system (Figure 1.1).

1.2 Problem Statement

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 Computer Integrated Manufacturing (CIM) system. Furthermore, the integration into higher level of automation system; Manufacturing Resources Planning (MRP-II), Manufacturing Execution System (MES) and Entrepreneurs Resources Planning (ERP) has difficulty to implement (Figure 1.1).

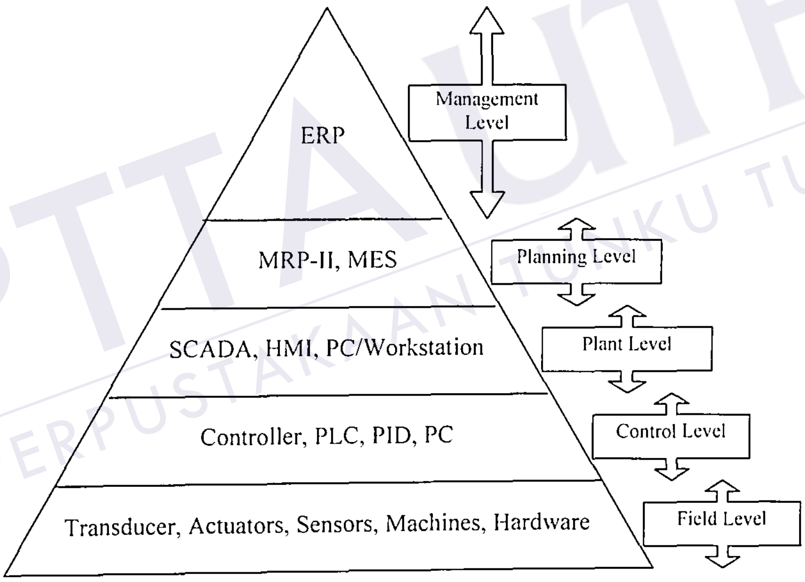

Figure 1.1: Pyramid of industrial automation system

1.3 Objective

The objectives of this project are:

i) To develop a hardware infrastructure of CIM system communication network based on Ethernet protocol.

ii) To familiarize and thus overcome real-time monitoring issues so that allows easier integration between the different units of the CIM systems via Ethernet module on OMRON PLC CJ-series.

iii) To verify and validate the functionality, feasibility and workability of the project.

1.4 Scope of Work

This project is concentrating to develop a CIM system communication network based on the Ethernet protocol. The work will involve using OMRON PLC controller (CJ Series) attached with Ethernet module to integrate the various production units in the CIM system including supervisory workstation. The environment of this implementation is established CIM-70A systems developed in the Robotics Laboratory, Faculty of Electrical and Electronic Engineering (FKEE), Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO).

1.5 Thesis Layout

This thesis is organized as follows: Chapter 1 explains the overall background of the study. A quick glimpse of study touched in first sub-topic. The heart of study such as objective, problem statement and project scope as limitation of this project and thesis layout is presented well through this chapter.

Chapter 2 will cover the literature research based on industrial Ethernet communication background, development and implementation. Chapter 3 explains and discusses the overall concept and issues in Ethernet communication network as well as manufacturer offered technique i.e. OMRON to overcome a real-time communication issues.

Chapter 4 presents the methodology used to implement Ethernet based communication in terms of hardware installation and software development. The current CIM-70A system setup is explained first. Further detailed explanations are attached in appendices.

Chapter 5 will reports and discuss on the results obtained that reflect my problem statements as stated in first chapter. The results from communication test and real-time monitoring performance based on Ethernet communication network will be analyzed with helps from set of figures and tables.

Chapter 6 will go through about the conclusion and recommendation for future works. This entire thing is done after completing my dissertation. References cited, and supporting appendices are given at the ends of this thesis while a documentation CD also available and attached on this thesis back cover for future reference.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction of Industrial Communication

Industrial communication protocol also known as fieldbus is a communication network bus at a low level industrial control and instrument devices. According to the definition of International Electrotechnical Commission (IEC) and Instrument Society of America (ISA), a fieldbus is a digital, serial, multi-drop, data bus for communication with low-level industrial control and instrumentation devices such as transducers, actuators and local controllers. Fieldbuses are serial information transfer buses used in industry, oriented to data transmission in discrete and continuous processes. Before the appearance of fieldbuses, the connections between process units; Programmable Logic Controllers (PLC), and field devices; sensors, actuators, etc., were point-to-point links. It meant complex and expensive installations. Also the maintenance and modification tasks were harder.

These problems are solved with fieldbuses, because all devices are connected through a single physical medium; twisted pair, coaxial, two wires, optical fiber, etc., extended over the whole area of the distributed control process system. So, new devices can be added, connecting to the fieldbus without additional wiring which easier in terms of maintenance and modification.

Another advantage of fieldbuses is that they allow the distribution of the intelligence of the control process which comes closer to the sensor devices. It can be said that fieldbuses emerged as a response to the some of following needs (Mariño *et al.*, 2004):

i) wiring reduction in installations
ii) easily reconfigurable systems
iii) reduced transmission times
iv) reliability in data transmission
v) intrinsic security in hazardous areas
vi) improvement of transmitted signal
vii) increase of information flow
viii) integration of manufacturing data in the information system of the enterprise
ix) increase of processing capacity (intelligence) of the sensors and actuators
x) decentralization of the processing resources for making distributed process systems
xi) control equipment with standard connections to guarantee the inter-networking of different products, and the compatibility of equipment and designed software.

The fulfilment of these needs makes fieldbuses very useful in industrial automation applications such as in CIM system (Habbadi and Sahraoui, 1992). The criteria for choosing a fieldbus solution are complex where the key factors include speed, topology, distance, redundancy, data transfer rate, number of stations, determinism, cost, simple operation, diagnostics, and the ability to integrate third-party products.

2.2 Fieldbuses Standard

During the last two decades, many fieldbus standard have been developed and successfully implemented for meeting real-time communication needs in the industrial automation system. Out of these the following protocols are leading contenders for the fieldbus standard:

i) **Bitbus** - developed by Intel in 1984, can be claimed to be the original fieldbus. This is based around the 8044 microprocessor and operates with one master on the bus with multiple slaves.

ii) **CAN (Controller Area Network)** –developed by Robert Bosch GmbH for automotive applications. In 1992 a CAN in Automation (CiN) group was formed as a support group for applications in industrial control and other non-automotive applications. The network management is very simple with each node reading all transmissions and filtering relevant massages depending on a 29 bit identifier.

iii) **FIP/WorldFIP (Factory Instrumentation Protocol)** - FIP is a specified French national standard. The FIP Club, a group of manufacturers and users mainly based on France and Italy was setup to support the FIP.

iv) **LonWorks (Local Operating Networks)** – this technology is from Echelon Corporation, founded by Markkula, A.C. in 1986 and is a privately owned company. LonWorks technology possesses all the seven layers of the OSI protocol stack.

v) **Profibus (Process Fieldbus)** - Profibus was started in 1987 by a German Government funded consortium of companies headed by Siemens AG. Profibus is a token passing network that allows multiple masters and multiple slaves on a bus and implements the full OSI level 7 protocol.

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