REALIZATION OF PLC CONTROLLER-TO-CONTROLLER VERTICAL COMMUNICATION BY USING OPC-UA

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DECLARATION

I declare that this thesis entitled “REALIZATION OF PLC CONTROLLER-TO-CONTROLLER VERTICAL COMMUNICATION BY USING OPC-UA is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

APPROVAL

I hereby declare that I have checked this report entitled "REALIZATION OF PLC CONTROLLER-TO-CONTROLLER VERTICAL COMMUNICATION BY USING OPC-UA" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Programmable Logic Controller (PLC) plays an important role in the automation process in the manufacturing industries. Typically, more than one type of PLC is used in a complete manufacturing automation process. Supervisory and control of every process in a manufacturing process are needed in modern industries to ensure a smooth and efficient manufacturing production process. Interoperability standard is needed to achieve the communication between the PLCs in the field layers with the upper supervisory level. OPC-UA is a platform independently interoperability standard for the open source controller and devices. The objectives of this report are to determine the function of client-server in OPC-UA implementation, to establish the architecture of OPC-UA for vertical communication between PLC and Upper-level controller devices or the SCADA system using KEPServerEX OPC-UA server, and to analyze the performance of OPC-UA in the communication. A simple OPC-UA server and client had been developed to visualize the working principle of OPC-UA client-server by using Node.js. The server is also connected to the UaExpert OPC-UA client to testing and verify the developed server. Vertical communication between the Omron CP1E PLC and Ignition SCADA system through KEPServerEX OPC-UA server with the Omron Fins Ethernet connection had been established and presented. The data of the PLC in the communication also being observed using UaExpert OPC-UA client. Experiments had been set-up to analyze the performance of OPC-UA architecture in communication by measuring the average time taken to complete the READ/WRITE instruction to the data tags under different hardware specification and security profile configuration by using the performance tools of UaExpert OPC-UA client.

ABSTRAK

Pengawal Logik yang Boleh Diprogram (PLC) memainkan peranan penting dalam proses automasi dalam industri perkilangan. Biasanya, lebih daripada satu jenis PLC digunakan dalam satu proses automasi pembuatan lengkap. Pengawasan dan pengendalian setiap proses dalam proses pembuatan diperlukan dalam industri yang moden untuk memastikan proses pengeluaran pembuatan yang licin dan efisien. Standard interoperabilitas diperlukan untuk mencapai komunikasi antara PLC dalam lapisan lapangan dengan lapisan penyeliaan atas. OPC-UA adalah satu standard platform interoperabilitas bebas untuk pengawal dan peranti sumber terbuka. Objektif laporan ini adalah untuk menentukan fungsi klien-pelayan dalam pelaksanaan OPC-UA, menubuhkan arsitektur OPC-UA untuk komunikasi menegak antara PLC dan peranti pengawal peringkat atas sistem SCADA dengan menggunakan perisian OPC-UA KEPServerEX dan menganalisis prestasi OPC-UA dalam komunikasi. Sepasang pelayan dan klien OPC-UA yang ringkas telah dibangunkan untuk memvisualisasikan prinsip kerja OPC-UA client-server dengan menggunakan node.js. Pelayan tersebut juga disambungkan dengan klien OPC-UA UaExpert untuk mengujikan dan mensahkan pelayan tersebut. Komunikasi antara sistem Omron CP1E PLC dan Ignition SCADA melalui KEPServerEX OPC-UA pelayan dan Omron Fins Ethernet telah distabilkan dan dibentangkan. Eksperimen-eksperimen telah dijalani untuk menganalisasikan prestasi OPC-UA dalam komunikasi dan hasilnya telah dibincangkan. Pretasi OPC-UA dalam komunikasi dinilaikan dengan mengukurkan masa yang diperlukan untuk habiskan arahab READ/WRITE pada data tags yang lokasi pada mesin yang mempunyai spefifikasi dan sekuriti profil yang berbeza dengan menggunnakan alat menguji pretasi pada UaExpert OPC-UA klient.

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LIST OF SYMBOLS AND ABBREVIATIONS

PLC	-	Programmable Logic Controller
HMI	-	Human Machine Interface
I/O	-	Input/Output
SCADA	-	Supervisory Control and Data Acquisition
RTU	-	Remote Terminal Unit
OPC	-	Open Platforms Communication
OPC-UA	-	OPC Unified Architecture
IP	-	Internet Protocol
GACR	-	Compound Annual Growth Rate

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CHAPTER 1

INTRODUCTION

1.1 Motivation

A Programmable Logic Controller (PLC) is always related when we are talking about industrial automation. A Programmable Logic Controller (PLC) is a reprogrammable special form of a microcontroller-based controller that can be used by users with limited knowledge of computers to control the machines and process [1].

The usage of PLC in the process industries such as oil and gas, food and beverage, mining and etc. to automate the process are getting higher and higher over the years. According to the PLCs Report 2017 by the IHS Markit, the global PLCs market including the smart relays, various type of PLCs, software and the services, is reaching $8.5 billion in the year 2017 and is expected to exceed $ 9.5 billion by the year 2021 [2]. From the report, we can see that the market of PLCs is still having the potential to grow in the coming future.

Smart Factories or industry 4.0 production system is one of the core ideas of the concept of Industry 4.0 (I4.0). According to the Global Programmable Logic Controller (PLC) Market 2018-2022, the increasing requirement of PLCs in smart factories is one of the factors that lead to the growth of the PLC market in the period of 2018 to 2022 [3].

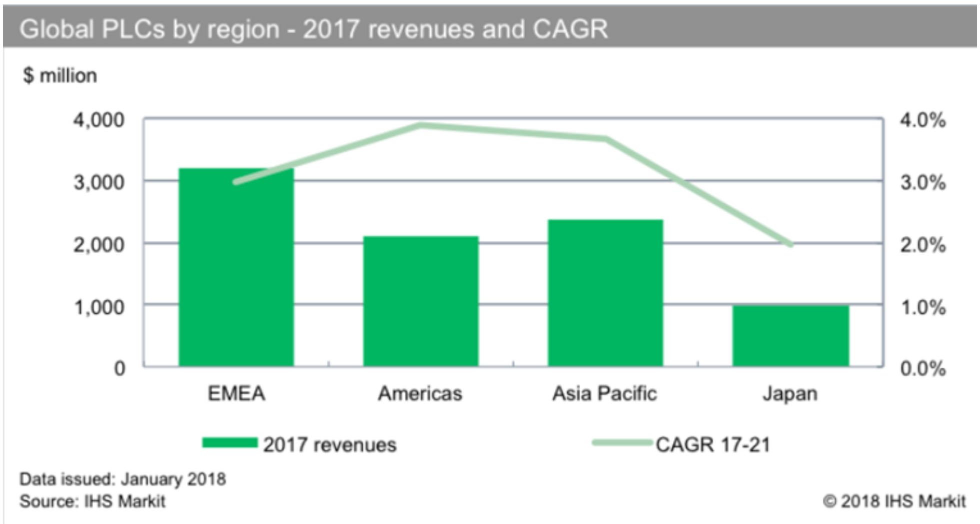

Figure 1.1 Global PLCs by Region – 2017 Revenues and CAGR [2]

Interoperability and connectivity are important elements in industry 4.0 concept [4]. Since there are many PLC vendors in the global PLC market such as Siemens, Omron, Mitsubishi Electric, Schneider Electric, etc. Therefore, in order to make sure PLCs are able to achieve the requirement of the market demands, PLCs from different vendors must able to achieve the interoperability between machines or devices.

OPC-UA is an industrial interoperability standard to define the specifications of the PLCs communications. Therefore, it motivates me to determine the function of OPC-UA in PLCs communications, establish a vertical communication between PLCs and analyzed the performance of OPC-UA in data communications.

1.2 Problem Statements

PLCs are widely used in industrial automation since many years ago. With the aids of the PLCs, the automation processes or machines can be control and monitor by the operator. An industrial automation process is often involved of more than one PLC in the process. In most situation, these PLCs might not the same and sometimes it might from different PLC vendors or manufacturers. Hence an interoperability standard is needed to co-operative and communicates between these PLCs.

OPC is an industrial interoperability standard that developed and maintained by the OPC Foundation. OPC consists of a series of specifications that developed by the industry vendors and the end-users as well, which defined the interface of the Clients-Servers and the Servers-Servers including data acquisition and monitoring [5].

OPC-UA is the next generation of the conventional OPC, OPC-UA is platform independent architecture that integrated all function of the conventional OPC and provides more secure, extensible and able to model the complex information compared to the conventional OPC [6].

Human Machine Interface (HMI) is part of the SCADA (Supervisory control and data acquisition). HMI is a graphical user interface that connects persons with the device, machine, and system. HMI can be used to visualize, tracking, monitor and more in industry setting [7]. Therefore, HMI can be considered as parts of the supervisory level of a process control system.

There are some levels in a complete process control system such as field level, supervisory level, and control level. In order to realize the vertical communication between the PLC controllers (field level) and the supervisory level, OPC-UA is used to acts as medium or standard to establish communication between both levels. Through this research, a simulation will be conducted to realize the communication between the SCADA and the PLC by using the OPC-UA standard. Performance of using OPC-UA will be tested throughout this research.

1.3 Objectives

The objectives are:

1. To determine the function of client-server in OPC-UA implementation.

2. To establish the architecture of OPC-UA for vertical communication between PLC and SCADA system by using Kepware OPC-Server.

3. To analyze the performance of OPC-UA in PLC Communication.

1.4 Scopes

The scopes are:

1. Compare the OPC-UA with OPC Classic and PROFINET.

2. Develop an OPC-UA Server and Client by using Node.js

3. Verify the developed OPC-UA Server by connecting it to the OPC-UA Client and UAExpert OPC-UA client.

4. Set-up a communication between PLC and the Ignition SCADA system by using KEPServerEX OPC-UA Server (Monitor and Control).

5. Evaluate the performance of the OPC-UA communication under different hardware specification and security profile configuration using UaExpert OPC-UA client.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory

2.1.1 Data Communication

Data communications are the process of sending and receiving digital data or information between two locations or points over a data network [8]. Communications only occur when there is a path or medium either wired or wireless for the data to transfer [8].

2.1.2 Network Topologies

Network topologies are the arrangement of nodes or links in a data communication network. A few basics type of network topologies is shown in figure 2.1.

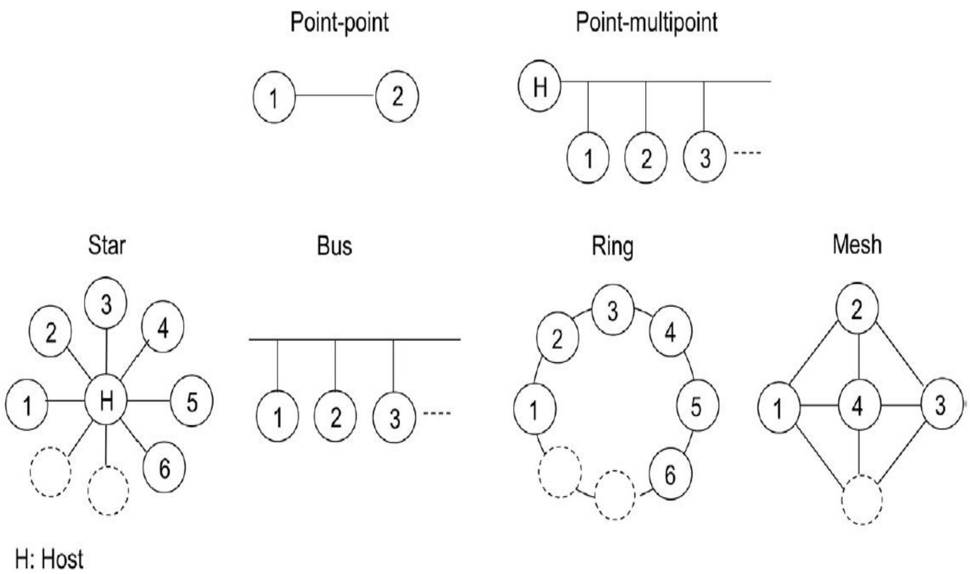

Figure 2.1 Network Topologies [8]

2.1.3 Interprocess Connection

Interprocess communication is the processes or applications that sharing data among themselves whether within a device or many devices in a network [8]. Client/server architecture is the most commonly used architecture among others that used to establish data transfer between two partners [8].

2.1.4 OPC (Open Platform Communication)

OPC (Open Platform Communications) or originally OLE (Object Linking and Bedding) for process control is a technology and an open standard for interprocess communication. There are two main components of the OPC which are the OPC Server and the OPC Client. An OPC Server is a software application that works as a "standardized" driver that read and write any data sources such as PLCs, RTUs, and etc [9]. Where an OPC Client is a software that written to communicate with the OPC Server, to send or received data or information from the OPC Server [9]. Figure 2.2 shows the overviews of the OPC family.

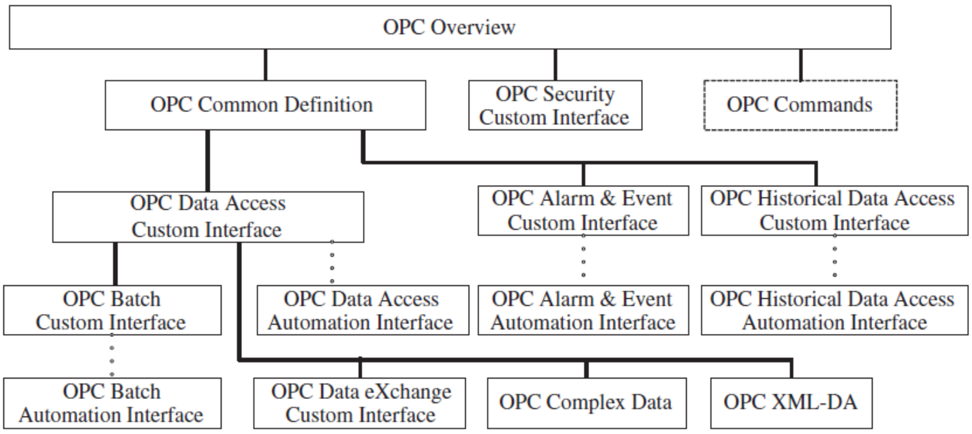

Figure 2.2 Overview of OPC Family [10]

The specification of OPC Classic can be categories into three main definitions; DA (Data Access), AE (Alarm & Events), and HDA (Historical Data Access). The OPC DA defines the exchange of data (values, time and quality information), where the OPC AE defines the exchange of the alarm and event type information, variable states and state management, and the last is OPC HDA. In OPC HAD, the specification defines the query methods and analytics that may be applied to the historical, time-stamp data.

2.1.5 OPC-UA (OPC Unified Architecture)

OPC-UA can be considered as the next generation of the OPC Classic. According to [11], there are many new functions are added in the OPC-UA. In [11], authors claim that OPC-UA is platform independent, secure, and reliable technologies compared to the Class OPC. OPC-UA provides a consistent, integrated Address Space and service model. Besides that, OPC-UA also allows data to be exposed in many diverse formats, adds support for many relations between nodes and designed for a wide range of servers. Figure 2.3 shows the illustrator of major elements of the server/client architecture of OPC-UA:

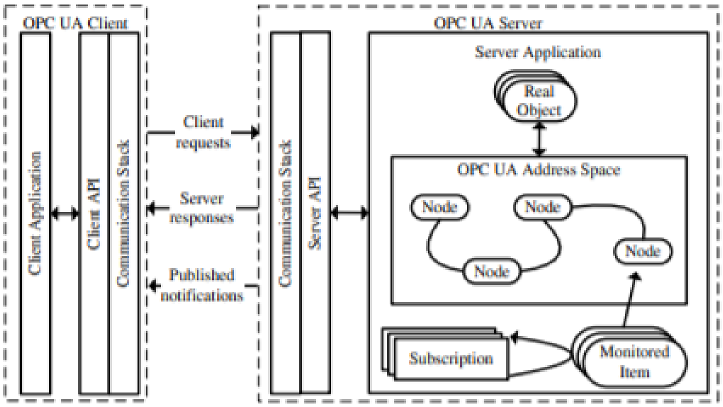

Figure 2.3 OPC-UA Server/Clients Architecture [12]

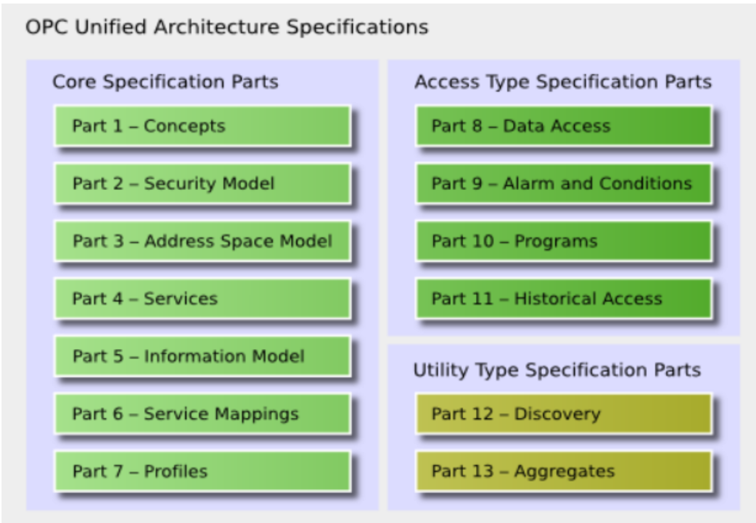

Figure 2.4 OPC-UA Specification [13]