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Improved control and monitor two different PLC using LabVIEW and NI-OPC server

Ignatius Deradjad Pranowo, Dian Artanto
Mekatronika, Fakultas Vokasi, Universitas Sanata Dharma, Yogyakarta-Indonesia

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ABSTRACT

This paper proposes an improved control and monitors between two different PLCs, the Mitsubishi, and Omron. The main advantage is interoperability and communication between both PLC. The use of NI OPC server as the software interface reached interoperability and communication. There were developed two field applications to test interoperability. Laboratory virtual instrument engineering workbench (LabVIEW) uses as the software application for creating the user interface to control and monitor. This improvement show OPC server technology solves data compatibility issue between different driver controller's and reducing development cost. Regardless of whether there are more than two different PLCs, it's enough to use the NI OPC server. So the benefit of the NI OPC server is not limited to two types of PLC used right now but can also use the other manufacturers. Besides, the improvement of the previous study is the use of the LabVIEW makes data from the OPC server displayed more realistic. The use of LabVIEW allows additional monitoring functions, one of which is LabVIEW vision. Data utilization becomes more flexible, and so it can use for more complex purposes. It is envisaged that this is very useful for Integrator engineer to implement this method in industrial automation.

Corresponding Author:

Ignatius Deradjad Pranowo
Mekatronika, Fakultas Vokasi
Universitas Sanata Dharma
Yogyakarta-Indonesia
Email: dradjad@pmsd.ac.id

1. INTRODUCTION

System integration requires a tremendous exertion, particularly for enormous scope infrastructures. All in all, these facilities include an immense number of devices and applications with various communication conventions. In a system that utilizes a few distinct devices and must exchange information, they should gather, break down, and show information from different devices utilizing various conventions. This assignment isn't simple. Each device driver requires software from its vendor. Changes in convention determinations bring about communication failure, and modifications must be made.

This problem must be solved when confronting the plan and systems integration of infrastructures under cutting edge draws near. The choice of communication interface to accomplish a successful interoperability and heterogeneity the executives is an extraordinary choice that truly influences perspectives, for example, financial costs, viability, expand-ability, security, and versatility [1]. In this sense, OLE-object linking embedded-for process control (OPC) proved as an effective communication middle-ware mainly in industrial application. OPC provides technology to support interoperability and heterogeneity in control and automation applications, mainly devoted to industrial manufacturing [2]. The so-called classic OPC was

developed by the industrial automation industry task force in 1996 to provide communication protocol for the personal computer-based software applications and automation hardware [3].

OPC, as a standard interface, can communicate between numerous data sources, including devices in a factory, laboratory equipment, and database. There are a large number of papers reporting OPC applications. Each one of them focuses on specific features, just to name some are hardware in the loop [4], remote laboratory [5-8], share workspace [9, 10], SCADA and PLC [11, 12], process control data acquisition and monitoring [13-17].

The new enhancements made in the automation of the industrial processes were realized through integration among OPC PLC and LabVIEW. The OPC provides open connectivity meanwhile, PLC from the different manufacturers can communicate, and LabVIEW provides the user interface so the operator can easily control and monitor the applications system. Just to mention some previous works of the integration among OPC PLC and LabVIEW are [18-23]. Despite the numerous works carried out on the same subject, none investigated the interoperability and connectivity between two PLC different protocols or manufacturers.

This paper provides system control and monitoring between two different PLCs using OPC and LabVIEW. The current study contributes to the knowledge expansion in this field by addressing process control available in communication between Mitsubishi and Omron PLC based on OPC technology and LabVIEW user interface. The organization of the paper is as follows. The method of communication between two PLC different protocols (Mitsubishi and Omron) using NI-OPC server and LabVIEW explain in section 2. The result and discussion of this study provide in section 3 and section 4, respectively. In section 5 gives a sum of the conclusion.

2. METHOD

The primary commitment of the current work was the upgrade of interoperability and connectivity between two PLC various protocols and vendors, in view of OPC and LabVIEW. The experimental work was designed and set up among the sequence of NI-OPC server, PLC, and LabVIEW. Table 1 gives the exposed experiment pointing out the field application system, the OPC role, the software involved for both client and server, and the hardware appliances.

Table 1. The experimental OPC-based systems developed

Field application system	OPC role	OPC server	OPC client	Hardware
Bottle Unscrambling	Control & monitoring, Interface connectivity	NI OPC server	LabVIEW	Mitsubishi PLC FX3U, Windows-based PC
Bottle Filling	Control & monitoring, Interface connectivity	NI OPC server	LabVIEW	Omron PLC CP1E, Windows-based PC

2.1. NI-OPC server and LabVIEW

The utilization of the OPC interface prompted by demand of using PLC Mitsubishi and Omron also the SCADA system established in LabVIEW. Thanks to the proficiency of the OPC, their integration was easy and effective. Such systems reveal the OPC standard as an effective tool of integration of networks of controllers, sensors, and instruments regardless of the automated process. As a rule, the capacity of an OPC is to get to the information of a field device and make them available to OPC clients, i.e., programming applications that speak to activities with such information. In this work, the NI OPC server 2013 is utilized to set up an OPC server. To do this, among other parameters to be enumerated, the used addressed in the PLC memory the format of the data and the type of access. A PC, with OS Windows 10 Professional and Intel i3 CPU, pursues as the hosting of the NI-OPC server 2013, the LabVIEW 2015 application, and the software for the configuration of the PLC.

National instruments LabVIEW package is a powerful graphical language with an impressive built-in function. LabVIEW 2015 utilized to configure the virtual instrument (VI) as the OPC Client of the OPC server depicted formerly. The variables transferred by such an OPC Server added to the library of a VI, so controls and indicators connected to them. Indicators related with signals that read from the PLC, controls used to create variables to the PLC [8]. Accordingly, the collected values available for operations commanded from the LabVIEW Front panel, then imported the controls and indicators. The LabVIEW connector element is required, so it has to be continued and configured in the LabVIEW front panel. The NI-OPC server published the controls and indicators of the VI, then the LabVIEW connector ready to import and link them to the corresponding variables in the LabVIEW front panel. By this path, the instructions renewed those controls and indicators. The selection of LabVIEW is not only intended to facilitate data visualization but also because of the additional functions, one of which is LabVIEW vision. LabVIEW vision can be used to

inspect field applications, such as detecting the presence or absence of labels and bottle caps. In general, the LabVIEW vision works by comparing the images taken by the camera with the images used as template patterns. LabVIEW vision will output the similarity level of the two images. By setting the similarity level limit, an application will be generated that can detect the presence or absence of certain parts of the field application. All image processing features are provided. Users don't need to do complicated programming, just take the desired feature (in the form of an icon), and add it to the image. The results obtained by adding these features are also shown on the screen so that users can adjust the results according to what they want [24].

2.2. PLC and field application

In signal management relate to the PLC's digital input and output ports, sensors and actuators were exploited to acquire signals in the automation process. Such PLC controlled the field application. The Omron controlled the bottle filling process, and Mitsubishi controlled the bottle unscrambling process. Each PLC has software from its manufacturer, Omron-CP1E used CX-Programmer and Mitsubishi-FX3U used GXWork2.

Both field applications were connected to the PC using a USB cable. The connection between PLC and OPC server used the RS232 Serial. The PLC was configured as a new OPC to communicate with the NI-OPC server. This leads to adding client access to the server. The Path makes a chance for OPC Client to access all PLC registers. In the LabVIEW, a VI created to connect OPC server [23].

2.3. Proposed architecture

Figure 1 brings the block diagram of the system exploited the interconnection between two different PLC protocols. OPC technology is utilized in this situation using NI-OPC server and augmented the benefit of LabVIEW as a control and monitoring system function. Interconnection between Mitsubishi FX3U and Omron CP1E is made feasible by the role of the NI-OPC server without the need to synchronize the two controllers or contribute each protocol from the respective vendors.

The experimentation setup for controlling and monitoring of two different PLCs OPC based was proposed as shown in Figure 2. This work used two field applications, namely bottle unscrambling and bottle filling. Both of the field applications can communicate through NI-OPC server with some variable settings. Through these arrangements, the filling water process will happen if bottles delivered from the bottle unscrambling process have aligned to with position the bottle's head is above. This data got since the bottle filling controller read data from sensors as a result of the presence detection of the bottles sent from the bottle unscrambling process. Meanwhile, the bottle unscrambling process suspend if the bottles queuing on the bottle filling process is full, and it will reactivate if the queue reduced or depend on the PLC program [25].

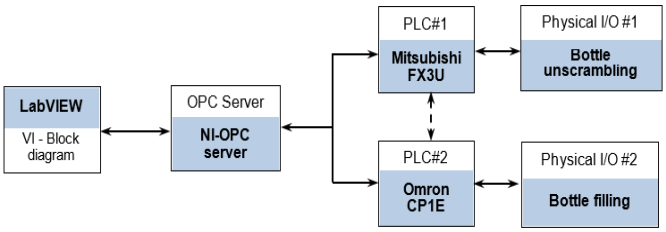

Figure 1. Block diagram of the proposed architecture

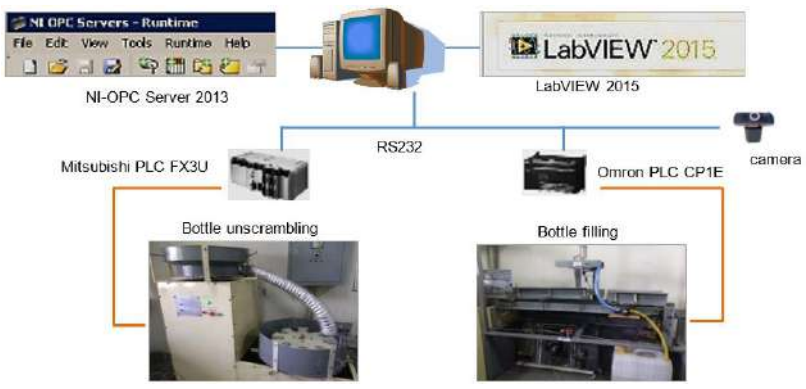

Figure 2. Experimentation setup of the control and monitor two-PLC based on OPC

3. RESULTS

In the OPC standard, this client-server communication is the significant key of the entire framework. The client application is not associated with device management. The server application is answerable for dealing with the device utilizing a standard interface. Equipment suppliers and programming designers can emerge from different vendors. LabVIEW gives two answers for associating OPC clients to the OPC framework: i) Running LabVIEW DataSocket in the LabVIEW advancement framework, ii) Running the LabVIEW DSC module. This work embraces the principal answer for making a thing of OPC Client. By utilizing the front panel information joining capacity, objects (buttons, indicators, and so forth) can be connected to things in the OPC server through the DataSocket server. Subsequently, the trial procedure control in the LabVIEW application is made through the element item, which is designed on the server. Figure 3 outlines the nearby OPC framework utilized for communication between LabVIEW and PLC applications. The PLC communicates with the OPC server through the Serial port. At the point when the OPC server gets PLC information through the Serial port, the information is changed over to a standard OPC position that can be gotten to by the OPC client. OPC client can understand information and compose new information to the device by utilizing OPC server [26]. In this work, the names of NI OPC server tags were set up, following the input-output made on the Mitsubishi and Omron PLC programs. The first is the procedure for how to set up communication on the NI-OPC server, and then the second is the procedure for how to communicate between LabVIEW and the NI-OPC server.

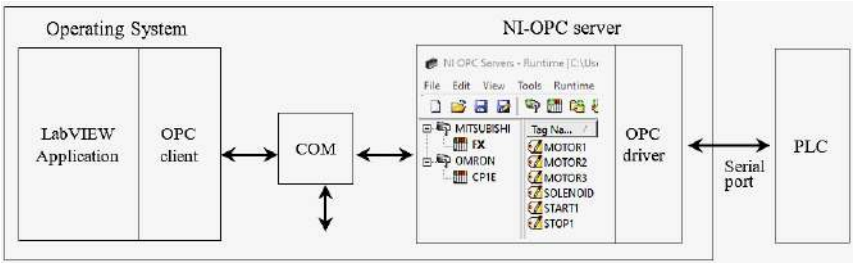

Figure 3. OPC for communication between LabVIEW and PLC

3.1. Steps for communication settings on NI-OPC server

The steps for communication settings on the NI-OPC server are as:

- Open NI-OPC server 2015.
- Since there are two PLC connected, create 2 channels on the NI-OPC server. Name both channels according to the PLC name.
- Add to each channel the type of PLC model used. For Mitsubishi PLC type "FX" and for Omron PLC type "CP1E".
- Add a tag to each type of PLC according to the input-output device connected to it. For Mitsubishi PLC add six tags, namely "*Motor1*", "*Motor2*", "*Motor3*", "*Solenoid*", "*Start1*" and "*Stop1*" as shown in Figure 4. For Omron PLC add seven tags, namely "*Counter*", "*EmergencyStop*", "*Reset*", "*Start*", "*Stop*", "*StopKom*" and "*StopProses*" as shown in Figure 5.

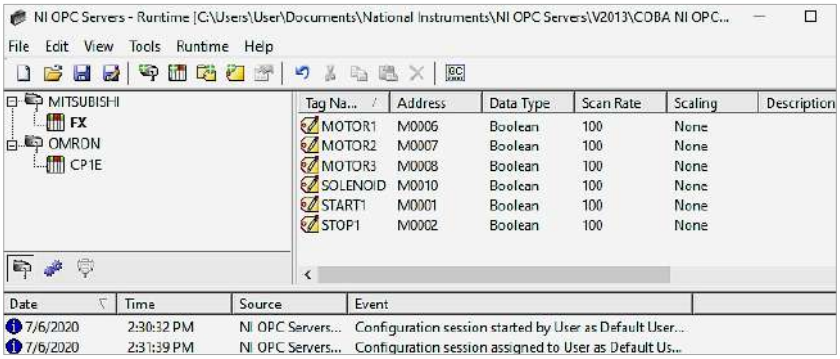

Figure 4. Six tags correspond to the I/O devices connected to the Mitsubishi PLC FX3U

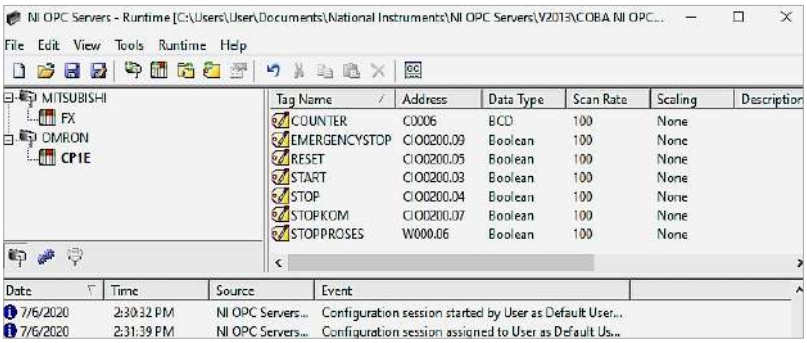

Figure 5. Seven tags correspond to I/O devices connected to the Omron PLC CP1E

– Run "*OPC Quick Client*". In the "*OPC Quick Client*" window, select the "*Mitsubishi.FX*" folder as shown in Figure 6. If the connection and driver selection are correct then the quality column on all tags will display the status "*Good*". Likewise, for the "Omron.CP1E" folder the quality column in all tags should display the status "*Good*" as shown in Figure 7.

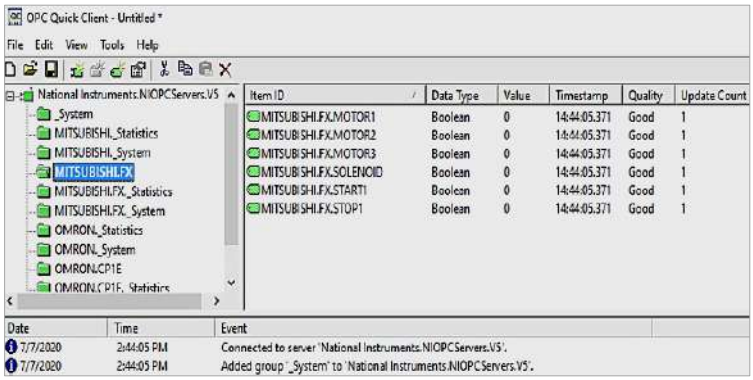

Figure 6. The OPC quick client shows the status of all tags from Mitsubishi FX is good

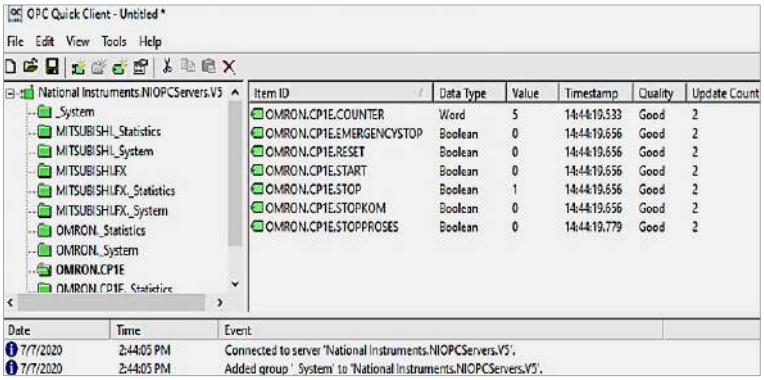

Figure 7. The OPC quick client shows the status of all tags from Omron CP1E is good

3.2. Steps to connect LabVIEW with NI-OPC server

The steps for connecting LabVIEW with NI-OPC server are as follows:

– Create a "*new project*" on LabVIEW.
– In the "*new project*" window, right-click on "*My Computer*" then select "*New*" - "*I/O Server*" as shown in Figure 8.
– In the "*Create New I/O Server*" window, select "*OPC Client*" then click "*Continue*"

- In the "*OPC Server list*" select "*National Instruments.NIOPCServers.V5*"
- In the "*new project*" window, right-click on "*OPC1 object*" and select "*Create New Bound*" to create a variable in LabVIEW that corresponds to all the tags on NI OPC server. For tags Mitsubishi, go to "*OPC1-Mitsubishi-FX*" shown in Figure 9. For tags Omron, go to "*OPC1-Omron-CP1E*" as shown in Figure 10. Select all the tags and then click "*Add*" button to create variables for them in LabVIEW. The variable with the same name as the tags will appear under the *OPC1* folder in the *New Project* window.
- The next step is to display the variable data and process it in the LabVIEW program as shown in Figures 11 and 12.

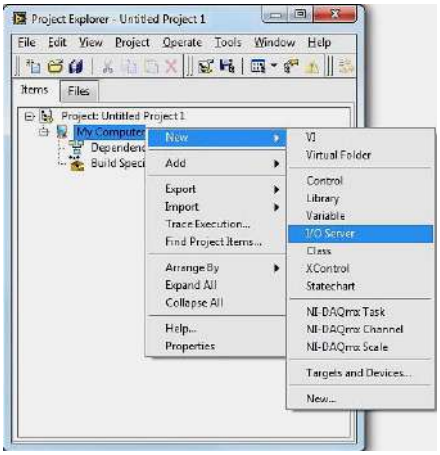

Figure 8. Connecting LabVIEW with NI-OPC server through I/O server

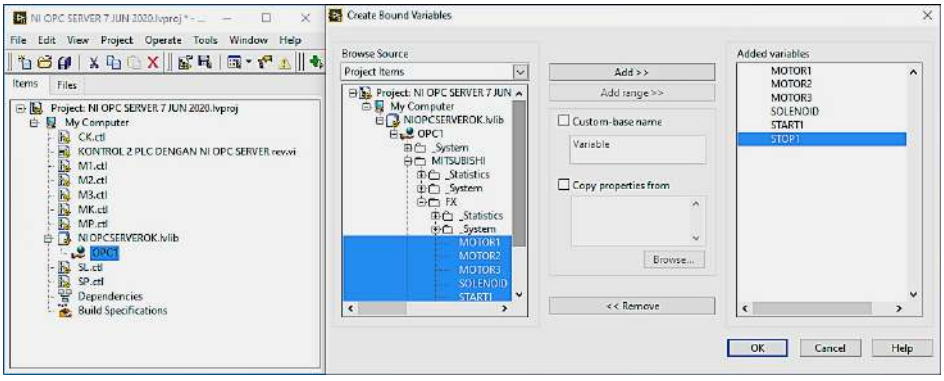

Figure 9. Creating variables associated with all Mitsubishi PLC tags on the NI OPC server

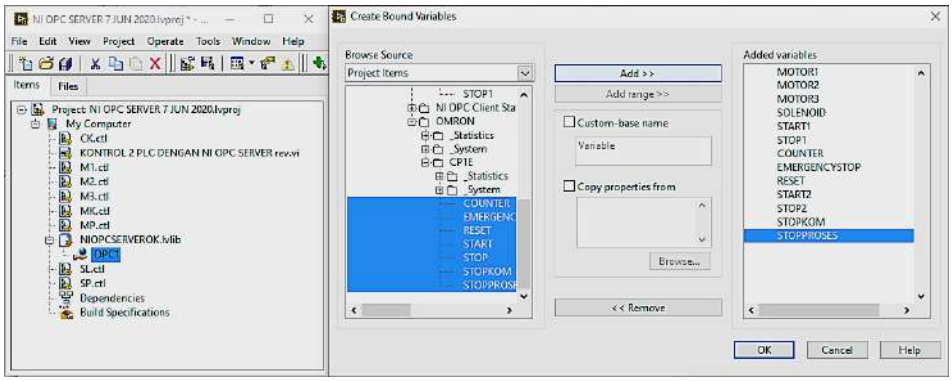

Figure 10. Creating variables associated with all Omron PLC tags on the NI OPC server

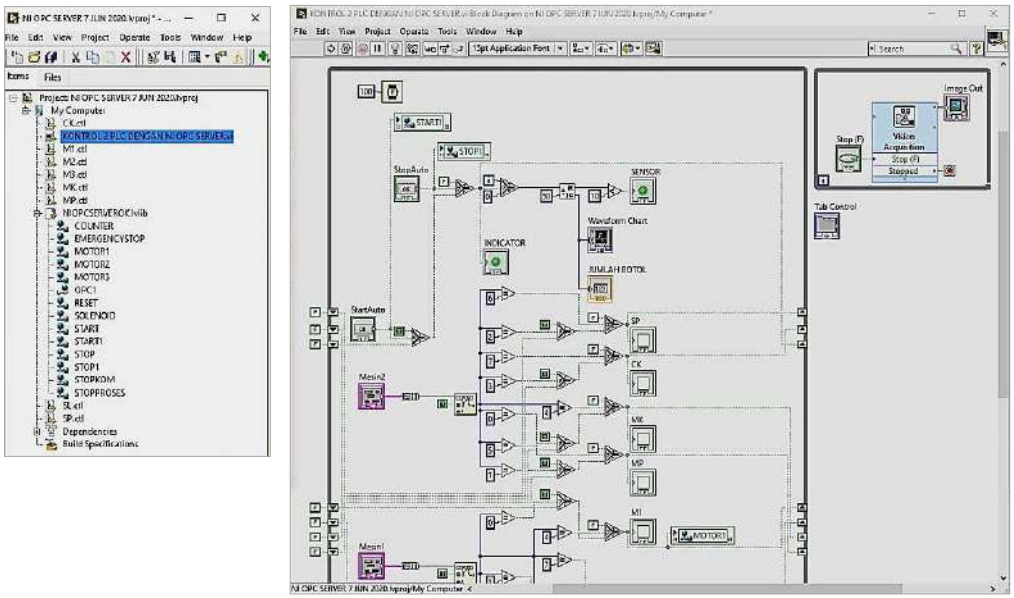

Figure 11. Variables data associated with OPC tags in the LabVIEW

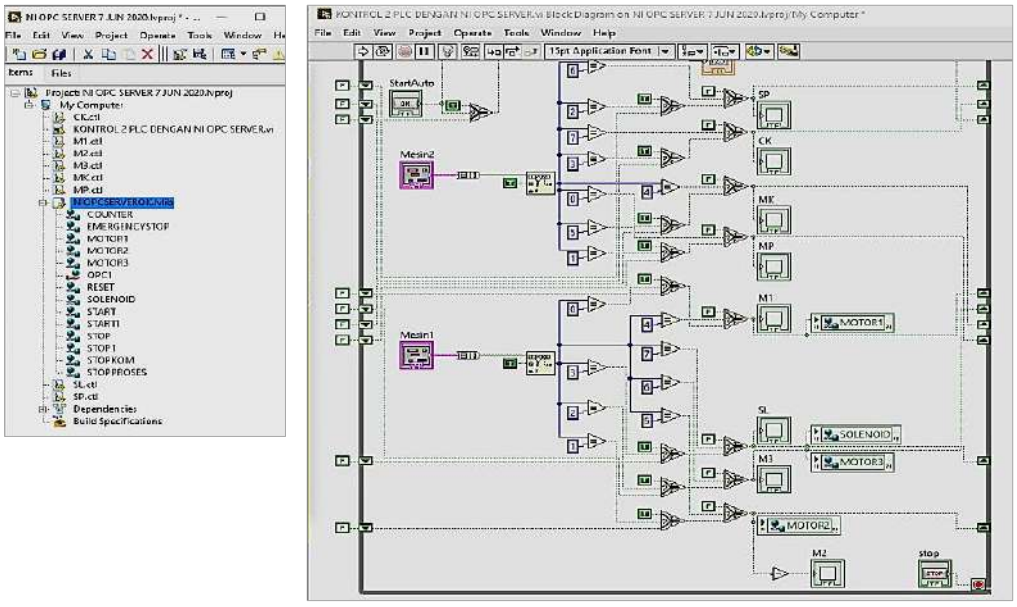

Figure 12. Variables data associated with the OPC server tag in the LabVIEW

As a result, monitoring and controlling of two PLCs became easy by using NI-OPC server and LabVIEW. In the NI OPC server there is a facility for setting or selecting various PLC drivers start from Allen Bradley, Beckhoff, GE, Honeywell, Mitsubishi, Omron, Siemens, Telemecanique, Toshiba. So that the efficacy of the NI OPC server is not only limited to the two types of PLC used in this paper. In addition, the improvement from the previous study is data from OPC server can be displayed and visualized more realistically using the LabVIEW program; and data utilization becomes more flexible which can be used for more complex purposes as shown in Figure 13. In this work, the bottle cap detection application has implemented using LabVIEW Vision and a webcam. By using LabVIEW vision, we can monitor workpieces and even labels; so that monitoring can cover all aspects, not only counting the quantity but also the condition of the product. Figure 14 shows that LabVIEW Vision will be able to detect the bottle cap if there is a manual bottle cap feeding process.

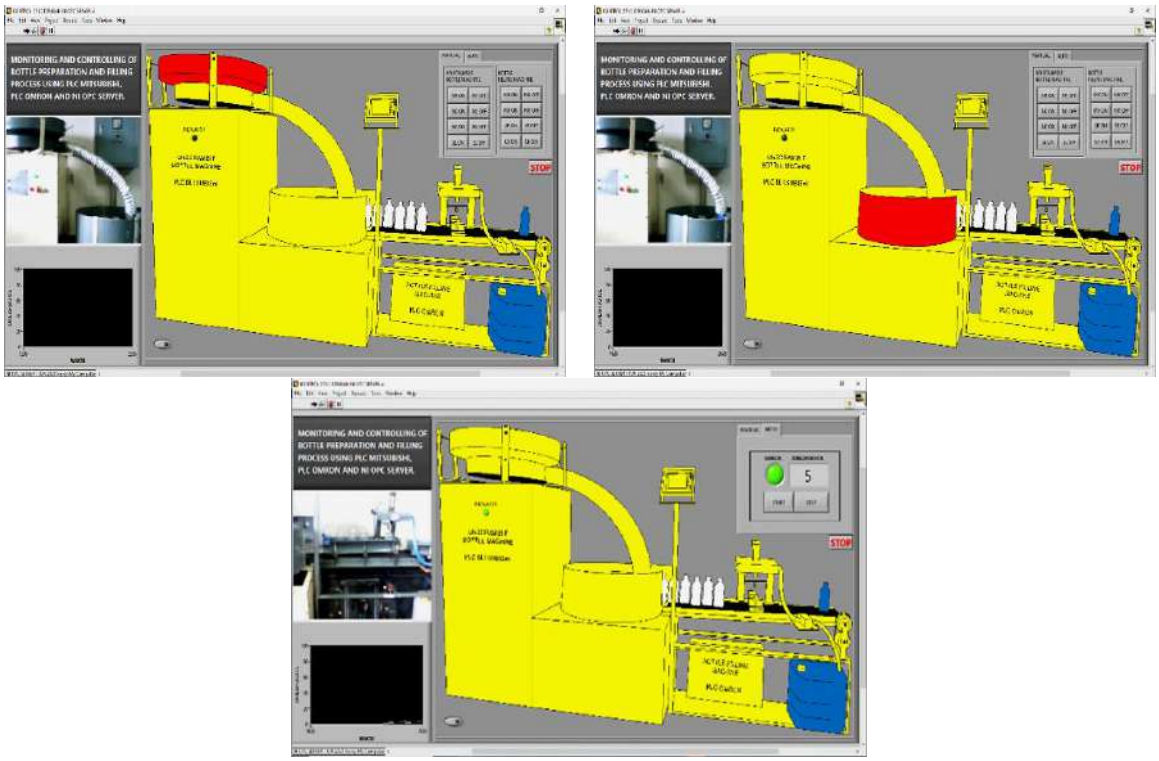

Figure 13. The result of display in LabVIEW according to the actual physical conditions on the field application

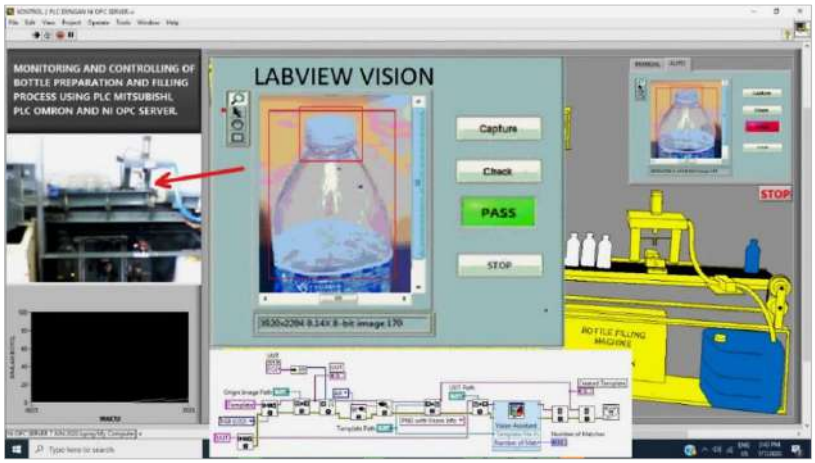

Figure 14. The LabVIEW vision application display for bottle cap detection

4. DISCUSSION

In several previous papers have discussed the use of OPC server. All references in this work using the OPC server for data acquisition and interconnection between different controllers. These references use the PLC as a controller, but none are from different manufacturers. There is a reference [27] using two PLCs, but it comes from one manufacturer. Therefore, the use of OPC server has become less exposed. Solely reference [25] indeed used two different PLC types, but having a limitation in the client program not upheld by the user interface to control and monitor quickly. In any case, this was better than simply applying a PLC to perform the heterogeneity and interconnectivity in control and automation applications. Table 2 provides some related works heretofore, with its focus on the type of OPC software used, the type of protocol communication used, and the hardware used.

Table 2. Selected papers of the related works

Related works [ref.]	OPC software	Communication protocol	Hardware (PLC)
González I *et al.* [8]	NI-OPC server LabVIEW, JIL (client)	Ethernet/PROFINET	Siemens S7-1200
Şahin C. and Bolat E. D. [19]	OPC server Delphi (client)	RS232 ASP-Internet	Siemens S7-200
Lakshmi S. A *et al.* [23]	RSView 32 SCADA	RSLinx-TCP/IP	Micrologix-1200
Pranowo I. D *et al.* [25]	KEPServerEx6	RS232	Mitsubishi FX3U Omron CP1E
Aleksandrov S *et al.* [27]	OPC Easy server LabVIEW (client)	LAN-TCP/IP	Festo FC-34 Festo FC-640
Nithyarani N. [28]	NI-OPC server LabVIEW (client)	Ethernet-TPC/IP	Honeywell HC900-C30
This work	NI-OPC server LabVIEW (client)	RS232	Mitsubishi FX3U Omron CP1E

Figure 13 approved that the improved control and monitoring between two PLC different protocols using NI-OPC server and LabVIEW user interface can be done. The developed control and monitoring system has two selection modes, namely the manual and the automatic. In automatic mode, when the Start button is squeezed, the system will run consistently starting from the bottle adjusting process until the bottle filling process and stop only when the Stop button is squeezed. This can happen due to the capacity of the NI-OPC server as a scaffold for the two PLC with various protocols, so they can impart without paying attention to the drivers of the two software.

In accordance with the title of this paper, the tools for improving control and monitor here is not only using NI-OPC but also using LabVIEW software. LabVIEW software was chosen because this software provides strong support and easy connection with various hardware devices. With many additional features in LabVIEW, one of which is LabVIEW Vision, it allows a lot of development to be done. In this study, the LabVIEW Vision and a webcam have implemented to detect the bottle cap. In addition, the LabVIEW graphical programming language makes it easier to implement the program even for inexperienced. This is the idea proposed in this paper.

5. CONCLUSION

The goal of this work proposes an improved control and monitors between two PLC various controllers in the modern manufacturing process. This study has successfully exhibited the strength of the NI-OPC server in communicating two different PLC protocols particularly between Mitsubishi FX3U and Omron CP1E. This work has been boosted an advantage in controlling and monitoring through the functions contributed by the LabVIEW user interface. In this work, the use of two different PLC Mitsubishi FX3U and Omron CP1E contributes a precise figure of the benefits of OPC server technology. What has become an improvement from previous work is the more realistic OPC tag data visualization and more flexible data utilization using LabVIEW. Also, the use of LabVIEW allows the addition of many controls and monitoring features, one of which is LabVIEW vision, which can perform inspection functions on the field application. Because of the utilization of NI-OPC server and LabVIEW, the advancement cost investment funds in the modern manufacturing process will be more proficient. Say if, for two different types of PLC manufacturers can be handled by the software interface, namely NI-OPC server. If there are more than two, it is sufficient to utilize the software. So, it is an outstandingly away from the level of the venture finances will be gotten. In spite of field application was a prototype, but this work used the PLC as a genuine industrial device on automation. Further work ought to be done, structure up the web base, so the communication among the controllers can be observed and controlled remotely.

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