Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

Andon System using Industrial IoT for Controlled Production Line by conventional PLC

Aloisius Genza Pratama Riyanto[1]
Student
Faculty of Electrical Engineering
Telkom University
Bandung, Indonesia

Azam Zamhuri Fuadi[2]
Lecturer
Faculty of Electrical Engineering
Telkom University
Bandung, Indonesia

Muhammad Ary Murti[3]
Associate Professor
Faculty of Electrical Engineering
Telkom University
Bandung, Indonesia

***Abstract*— The Andon system is created to increase and improve production lines by notifying worker if the production line needs to be stopped or even stopped by itself. However, most of the control and monitoring production is still carried out locally. By diverting the Internet of Thing (IoT) in the industrial world (Industrial IoT), users can monitor and control industrial processes remotely via the internet.**

In this study, a control and monitoring system (Andon) will be made that can be applied to industries that use PLCs through the Raspberry Pi as a gateway to IoT Cloud (ANTARES). Users can see the system and on the android application so that they can access and manage the system anywhere and anytime while connected to the internet.

Keywords*— *Control System PLC, Andon System, Industrial IoT, PLC

I. INTRODUCTION

Andon, derived from Japanese for paper lanterns, is a term for a visual control system that uses an electric light board (or other signaling device), so workers can call for help and stop the production line. It was originated by Toyota[1].

One of the devices that can be used for the Andon system is a PLC. A PLC is basically a computer specifically designed to control a process or machine. PLCs are very commonly used in the industrial world because PLC can control all industrial processes consistently, so that PLC can increase productivity in general[2].

Currently the IoT is still developing and has entered the industrial world or what is commonly called the Industrial IoT[3]. So, there is a need to create an Andon and control system that can be accessed online.

Unfortunately, not all devices especially PLC are able to directly communicate to IoT. So, IoT Gateway is used to connect PLC with Andon system so the Industrial IoT can be applied. In this study a raspberry pi is used as an alternative IoT Gateway.

This work divided into a few sections. Section II gives a short review about previous work related to this project. In section III explains the system overview followed by the result in Section IV. After that, any improvement needed in future work will be shown at Section V. Finally, at Section VI, there are some conclusions based on this work.

II. RELATED WORK

Numerous researches have already been conducted in both Andon system and Industrial IoT. The Andon system has been proved to improve product quality in terms of effective production rate when repair times are short by quantitative analysis [4].

Industries have strong interest in deploying IoT devices to develop industrial applications such as automated monitoring, control, management, and maintenance[5]. [5] also provide some basics key in Industrial IoT. Some work even conducted a test in IIoT protocol. [6] compares OPC UA versus ROS, DDS, and MQTT in IIoT.

Some paper also provides a latency comparison and evaluation between MQTT and WebSocket Protocols for Industrial use[7].

This project is mainly focus on applying Andon system and Industrial IoT into a real scenario using PLC and IoT gateway.

III. SYSTEM OVERVIEW

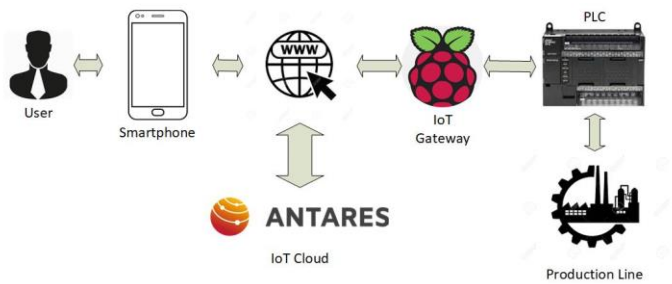

Fig. 1. Block diagram of system.

User will send the control data with android application to IoT Cloud (ANTARES). Then, IoT gateway will read the control data and write the data to PLC. The PLC controls the input and output of production line. IoT gateway will also read data from the PLC for monitoring purposes and send it to cloud. The android app will act as a user interface to inform the data back to user.

A. Production Line

The production line is created using conveyor, photoelectric sensors, and pneumatic as a simulation to real world production line. Photoelectric sensor is used to counting the box and pneumatic will be used to push the box to the conveyor. The box is made of wood and to be used as goods in production line. The dummy production line is shown as Fig. 2.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

Fig. 2. Dummy production line.

B. Programmable Logic Controller (PLC)

Programmable Logic Controller (PLC) is an industrial computer that can manage devices such as limit switches, proximity sensors, and others. PLCs were created because of the industrial need to replace electromagnetic relays, mechanical timers, and counters. PLCs have been designed in such a way that they can work in industrial conditions safely[2]. In this project, we use PLC CP1L from OMRON as shown in Fig. 3.

Fig. 3. PLC OMRON CP1L.

C. FINS Protocol

The IoT gateway is connected to PLC via USB cable. The IoT gateway will use FINS protocol to read and write the PLCs data.

Factory Interface Network Service (FINS) is a network protocol used by Omron PLCs. It is provide connection between different physical networks like Ethernet, Controller Link, and RS-232C[8]. The protocol its-self is configurable and easy to understand. Fig. 4. and Fig. 5. show some of header command used to read and write data on PLC.

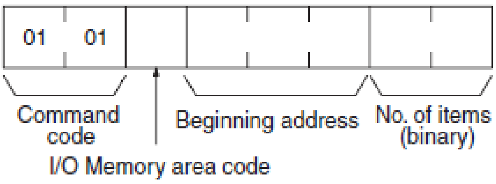

Fig. 4. Memory read command structure FINS[8].

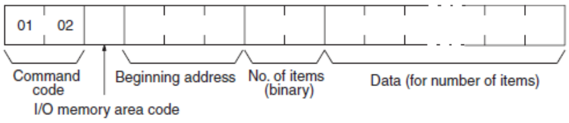

Fig. 5. Memory write command structure FINS[8].

D. Industrial IoT

While the IoT affects among others transportation, healthcare, or smart homes, the Industrial Internet of Things (IIoT) refers in particular to industrial environments[3].

In TABEL I. shows the classification of various use in IIoT based on latency its needed.

TABEL I. Classification of IIoT[9].

Industrial Type		Latency
Diagnostics & maintenance		20ms - 100ms
Discrete manufacturing		250µ - 1ms
Warehousing & Logistics	AGV	15ms – 20ms
	Automation Process	50ms – 2s
	Augmented Reality	10ms

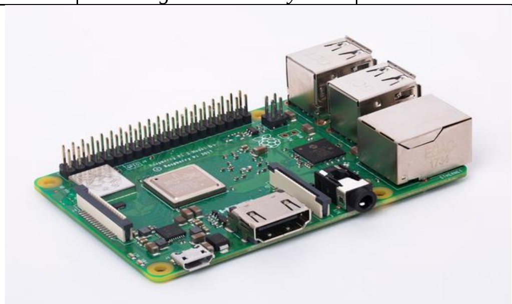

Fig. 6. Raspberry Pi 3 Model B+ [10].

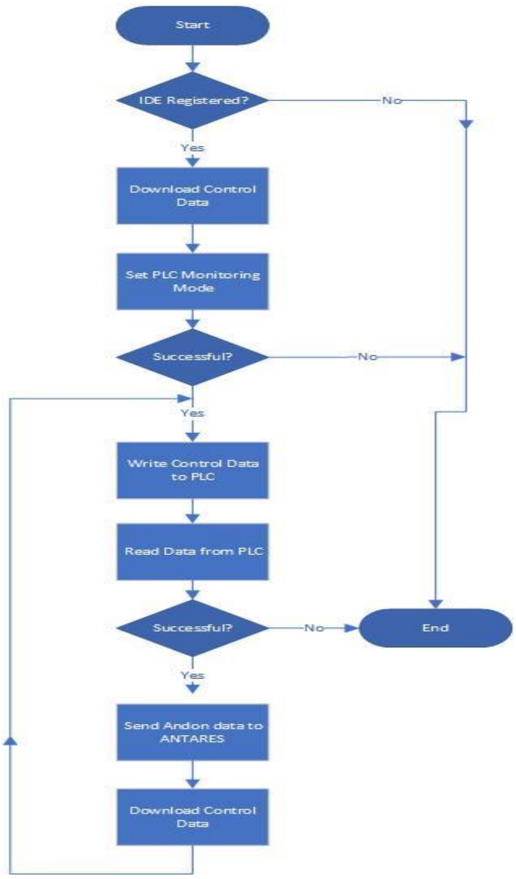

Fig. 7. Flowchart Raspberry pi (IoT gateway).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

E. IoT Gateway

IoT gateway is invented, whose goal is to settle with the heterogeneity between various sensor networks and mobile communication networks or Internet[11].The IoT gateway is simply a bridge between system to IoT. The IoT gateway will send data received from PLC to Cloud.

In this project, Raspberry pi 3 Model B+ is used as IoT gateway as shown in Fig. 6.

The Raspberry Pi is a credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse[12]. Raspberry pi can be used as an alternative IoT gateway because simply it is cheaper and programmable. The connection to internet will be possible via Wi-Fi.

In the beginning, Raspberry pi will check the ID of PLC. If it is a match, program will continue. Then, Raspberry pi will download the control data (target and time production).

Raspberry pi will set the PLC to monitoring mode. Only after that Raspberry pi will be able to read and write the memory of PLC. Any unsuccessful command of the program will cause the system to end. But Raspberry pi will restart the program itself, so the system is continuing to run. This workflow of Raspberry Pi can be seen in Fig. 7.

F. IoT Cloud

IoT cloud is a part of IoT environment for distributing or saving data. It is usually has many protocols to connect with many IoT devices. In this project, ANTARES will be used as IoT cloud platform.

ANTARES is an IoT platform solution from PT Telekomunikasi Indonesia. It has support some known protocol like HTTP, MQTT, and CoAP[13].

IV. RESULT

The IoT gateway and PLC used in this prototype is shown in Fig. 8. The small box in the top is Raspberry pi in a hardcase (IoT gateway). PLC and its power supply located in the big box. PLC is connected to IoT gateway via USB cable.

Fig. 8. IoT gateway and PLC.

A. Raspberry Pi

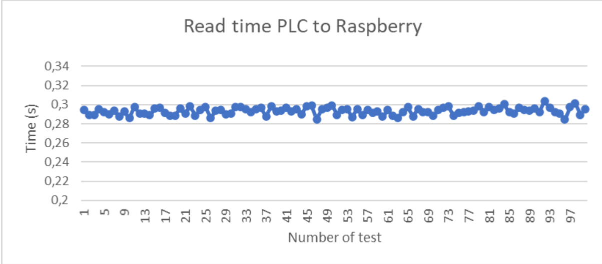

Fig. 9. Read time between PLC and Raspberry pi

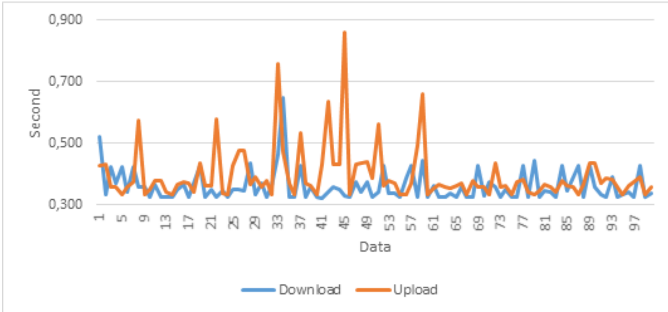

Fig. 10. Latency between IoT gateway to Cloud.

Fig. 9. shows that there is latency between PLC and Raspberry pi (IoT gateway) with average of 0.29 second. The result is quite stable because the session between PLC and Raspberry pi is never closed until they restart.

There is also a latency in sending data between IoT gateway and IoT cloud as shown in Fig. 10. with average result of upload (gateway to cloud) is 0.395 second and download (cloud to gateway) is 0.361 second. In summary, the transfer data between IoT gateway to cloud take 0.685 second in average.

In TABEL II. show that Raspberry pi send 7.8 KB in average each upload and receive 6.8 KB in average each download.

TABEL II. Size data Raspberry pi.

Test	Amount of data	**Total Data Size (Bytes)**		**Average each Data (Bytes)**	
		Download	Upload	Download	Upload
1	5	33,945	38,815	6789.00	7763.00
2	10	67,890	77,630	6789.00	7763.00
3	15	101,850	117,705	6790.00	7847.00
4	20	139,325	156,705	6966.25	7835.25
5	25	169,799	196,948	6791.96	7877.92
6	30	206,110	246,630	6870.33	8221.00

B. Andon System

The Andon system in this project is using an android application as platform and consist of simple elements as shown as Fig. 12. There are two section on the android application, Control and Monitoring.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

The control part give access to user to set the target production and time production. This data will be sent to PLC via IoT gateway. User can change the data at any time if connected to the internet.

The monitoring part give user information about the production line. User can see the amount of target, goods production, bad and good product, the production time, and production speed. In this way, user can monitor the production line at anytime and anywhere. If user find something wrong, for example production speed is to low, user can immediately contact the operator to check the production line.

C. Android Application

After the data is stored in cloud, the user can see the data via android apps. The apps not only show the Andon data, but also can send control data.

The android apps use http protocol to communicatee with ANTARES (IoT cloud). Fig. 11. shows that there is latency in receiving data from IoT cloud (download) with an average of 0.575 second and sending data to IoT Cloud (upload) with an average 0.297 second. TABEL. III. shows that the android application uses 1,856.184 bytes or 1.8 KB for each Andon data.

In summary, total latency in receiving Andon data from PLC to user (android) is 0.29s + 0.395s + 0.575s = 1.26s. These imply that the Andon system can be used in automation process based on TABEL II.

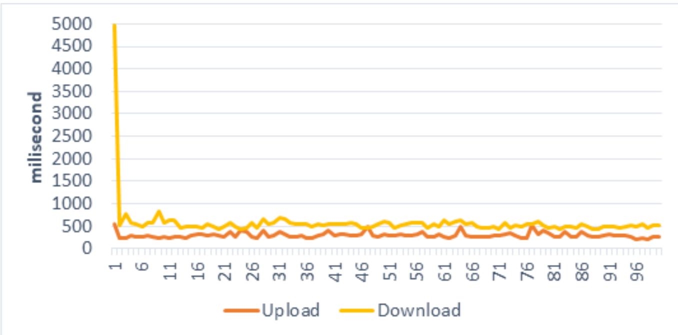

Fig. 11. Latency android apps.

TABEL III. Size data android application.

Test	Amount of Data	Size Data (bytes)	Size each Data (bytes)
1	5	12,148	2429.6
2	10	18,948	1894.8
3	15	25,908	1727.2
4	20	32,788	1639.4
5	25	39,748	1589.92
Average			1856.184

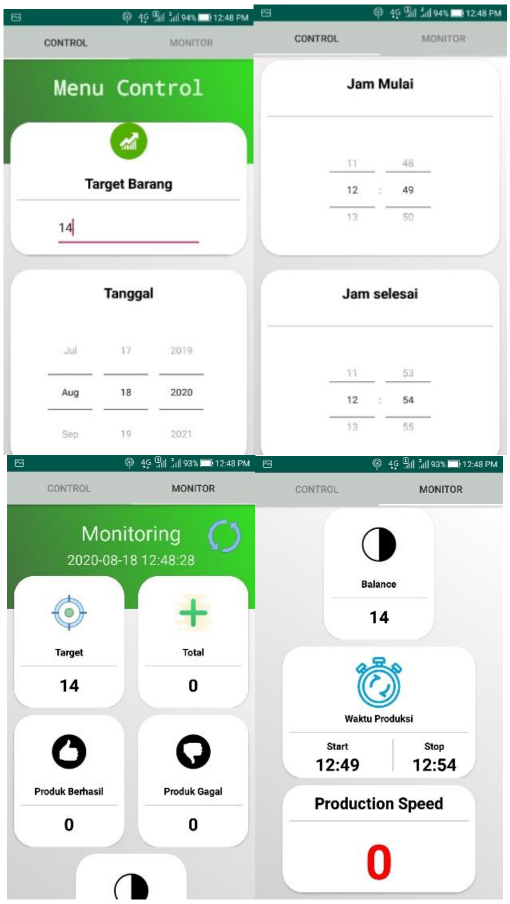

Fig. 12. User interface android application.

V. FUTURE SCOPE

In this project only one type of PLC is used. In general, the manufacturing process uses various PLCs with different types. Further research is needed to determine the compatibility of Raspberry Pi with various PLCs.

This Andon system use only one line production. The real manufacturing process may use more than one line. Therefore, it needed more research to create a system Andon multi line production with raspberry pi as IoT gateway.

VI. CONCLUSION

This project has succeeded in creating an Andon system that is integrated with IoT. The Andon system consist of control and monitoring section. Users can view the Andon data online through the android application.

Secondly, the IoT gateway need an average 0.29 second to read the data from PLC. There is also a latency in transfer data between IoT gateway to cloud, for upload 0.395 second and for download 0.361 second. The IoT gateway use an average 7.8 KB for each data uploaded and 6.8 KB for each data downloaded.

Thirdly, the android application has latency 0.575 second for download from cloud and 0.297 second for upload to cloud in average. The android application also uses 1.8 KB for each Andon data.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

The total latency from PLC to user is 1.26 second in average. This latency can be used in Industrial IoT especially in automation process.

REFERENCES

[1] J. Liker, *The toyota way*. Esensi, 2004.
[2] G. Dunning, *Introduction to Programmable Logic Controller*. United State of America: Delmar, 2002.
[3] M. N. O. Sadiku, Y. Wang, S. Cui, S. M. Musa, and R. G. Perry, “Industrial Internet of Things,” *ijasre*, vol. 3, no. 11, pp. 1–5, 2017.
[4] J. Li and D. Blumenfeld, “Quantitative analysis of a transfer production line with Andon,” *IIE Trans. (Institute Ind. Eng.*, vol. 38, no. 10, pp. 837–846, 2006.
[5] L. Da Xu, W. He, and S. Li, “Internet of things in industries: A survey,” *IEEE Trans. Ind. Informatics*, vol. 10, no. 4, pp. 2233–2243, 2014.
[6] S. Profanter, A. Tekat, K. Dorofeev, M. Rickert, and A. Knoll, “OPC UA versus ROS, DDS, and MQTT: Performance evaluation of industry 4.0 protocols,” *Proc. IEEE Int. Conf. Ind. Technol.*, vol. 2019-Febru, pp. 955–962, 2019.
[7] D. R. C. Silva, G. M. B. Oliveira, I. Silva, P. Ferrari, and E. Sisinni, “Latency evaluation for MQTT and WebSocket Protocols: An Industry 4.0 perspective,” *Proc. - IEEE Symp. Comput. Commun.*, vol. 2018-June, pp. 1233–1238, 2018.
[8] OMRON, *Reference Manual*, vol. 1, no. July. OMRON, 2009.
[9] Ismet Aktas, “Funktechnologien für Industrie 4.0,” *(VDE), Verband der Elektrotechnik,* 2017.
[10] Raspberry Pi Foundation, “Raspberry Pi 3 Model B+.” [Online]. Available: https://www.raspberrypi.org/products/raspberry-pi-3-model-b/. [Accessed: 04-Oct-2019].
[11] Q. Zhu, R. Wang, Q. Chen, Y. Liu, and W. Qin, “IOT gateway: Bridging wireless sensor networks into Internet of Things,” *Proc. - IEEE/IFIP Int. Conf. Embed. Ubiquitous Comput. EUC 2010*, pp. 347–352, 2010.
[12] Raspberry Pi Foundation, “What is a Raspberry Pi?” [Online]. Available: https://www.raspberrypi.org/help/what- is-a-raspberry-pi/. [Accessed: 04-Oct-2019].
[13] PT Telekomunikasi Indonesia, “ANTARES | Reliable IoT Platform.” [Online]. Available: https://antares.id/id/docs.html. [Accessed: 04-Oct-2019].