IoT based sorting system of consumer goods production

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Abstract. Most industries use the manual sorting process to sort consumer goods production. The problem of manual sorting is taking a long time to complete the work. The industry should be demanded to be faster and more efficient in meeting consumer needs. The purpose of this research is to make a tool that can sort goods automatically into the warehouse using RFID technology by combining Arduino and PLC as the controller. The number of items that have been sorted can be monitored remotely by using the Internet of Things (IoT). By identifying the items using RFID makes work more concise and efficient. This research uses an experimental method. The automatic sorting system uses an RFID reader to read ID cards that have been installed on the goods side. The ID cards are processed into Modbus data to be sent to the PLC Siemens S7-1200 via Ethernet Shield that is connected to the Arduino Mega 2560. The PLC will select items to be placed on each conveyor. The results of this study showed that the system can work automatically in the sorting of consumer goods and can monitor the process of its work system on the GOIOT platform via the internet network.

1. Introduction

Automation systems in the industrial world today have developed very rapidly and even become a parameter of technological growth. The industry is demanded to be faster and more efficient in meeting consumer needs. However, most industries still use the manual sorting process to sort consumer goods production. The problem of manual sorting is taking a long time to complete the work and causing delays in delivery time. One of the automatic controls widely used by industry is PLC. PLC is a programmable controller that works digitally based on logic operations according to the algorithm programmed with it. In the manufacturing industry, many PLCs are used as controllers in the process of selecting goods through a conveyor to improve the performance of the system. The process of automatic object sorting with PLC control can be done based on the height of an object using proximity sensors [1,2]. The items can be automatically selected with Delta PLC control based on size using infrared sensors [3]. Other researchers developed an automatic sorting process for products on conveyors based on their color using a PLC as a controller [4,5].

One of the widespread automatic identification technologies is RFID (Radio Frequency Identification). RFID is a non-contact automatic identification technology that makes use of radio waves to transmit identification information. Where information is digitally encoded into tags that can be used to uniquely identify a product. Based on a combination of tags and readers, RFID technology has widely been applied in various areas including supply chain, logistic and production systems in the industry. RFID technology is used to detect items that are loaded on the trolley and the number of items can be
displayed on the trolley using the internet network [6]. The PLC and RFID technology is used in the design of AGV (Automatic Guided Vehicle) systems for logistics systems in the industry, where RFID is used as an object detector while PLC is used as a control center to detect AGV positions and load positions, and control movement [7]. RFID technology can also be used to automatically select parcels using a PLC controller [8]. In Zeng et al. [9], they designed the automatic sorting system based on RFID in the logistics business processing by using a microcontroller as the controller.

As the development of the internet is so fast in the industrial era 4.0. Utilization of the Internet of Things (IoT) in several industrial sectors is mostly done, because IoT is a technology that can turn devices into something valuable, including for monitoring and analysis. Many studies relating to the internet of things have been conducted so that the data generated can be monitored remotely using the internet network, such as the implementation of IoT in monitoring home security [10], constant pressure control [11], automated object color sorting [12].

Based on the previous study, the purpose of the current study will design and implementation the RFID technology to the automatic sorting system using PLC, where the RFID tags data will be processed by Arduino into Modbus data to be sent to the PLC via Ethernet Shield. The work process of this tool can be monitored remotely using the Internet of Things (IoT).

2. Method
This study uses an experimental method by designing system hardware and software. This research method includes designing an object identification system using RFID technology, designing an automatic goods sorter system on a conveyor using a pneumatic cylinder and designing a system of monitoring the process of sorting goods remotely using the Internet of Things (IoT).

2.1. Hardware design
The hardware of the sorting system consists of RFID reader MFRC-522 as an ID Card detector, push buttons to turn on/off the system, proximity sensor to detect items right in front of each conveyor, and a conveyor belt which carries the object. The automatic controllers used in the item sorting system are Arduino Mega 2560 and Siemens PLC S7-1200 CPU 1214C. The block diagram of the control system can be seen in figure 1.

As shown in Figure 1, the signal used as input to the Arduino Mega 2560 controller is RFID tags/ID cards that are read by the RFID reader. ID cards installed on the side of the item will be read by the RFID reader and the data will be processed through Arduino. Then the ID card data in the form of hex
data will be processed into Modbus data to be sent to the Siemens S7-1200 PLC via Ethernet Shield connected to Arduino. While the signal used as input to the PLC is a push button, proximity sensor and RFID tag data that has been processed by Arduino Mega 2560. The PLC controlled output signal is a digital output which is a solenoid valve and a DC motor. Solenoid valves are used to turn pneumatic cylinders that function to push selected items to the conveyor. DC motor functions to run the conveyor. When the RFID tag data has been read and following the desired data and proximity sensors detect the presence of goods, then the goods will be pushed by a pneumatic cylinder to the desired conveyor. The design of the tool can be seen in figure 2. Meanwhile, wiring diagram and cable connection RFID reader to Arduino can be seen in figure 3.a and 3.b.

As shown in Figure 2, the system work process starts from laying items on the conveyor 1. When the start button is pressed, conveyor 1 will work with the goods. Items that have been installed with an ID card will be detected by an RFID reader. When the goods with ID # 1 are directly in front of proximity sensor 1, the goods will be moved to conveyor 2 via pneumatic cylinder 1. The conveyor 2 will stop when proximity 4 is ON. If goods with ID # 2 are directly in front of proximity sensor 2, then the goods will be moved to conveyor 3 via pneumatic cylinder 2. The conveyor 3 will stop when proximity 5 is ON. If goods with ID # 3 are located right in front of the proximity sensor 3 then the goods will be moved to conveyor 4 via pneumatic cylinder 3. The conveyor 4 will stop when proximity 6 is ON. However, if goods with ID # 99 (Goods is not registered), conveyor 1 will continue to carry the goods to the place of the box that has not been registered.

**Figure 2.** Design of item sorting system.
2.2. Software design

The first step in creating the Arduino program is to connect the Arduino Mega 2560 board and the Ethernet Shield. The programming of Arduino uses Arduino IDE software. The communication between Arduino and Ethernet Shield uses a Serial Peripheral Interface (SPI). The initial step to create a program on the Arduino IDE is to create a new sketch in the menu file. The next step is setting the board and port that we use in the tools menu. After that, make the system program as desired, and finally, upload the program to the Arduino board using a USB cable.

Arduino program is used to read RFID tags through the RFID module. Arduino will process the RFID data into Modbus data to be sent to the PLC. The Arduino data can be sent to the PLC Siemens S7-1200 via an Ethernet shield with using the settimino library. Settimino is an open-source Ethernet library for interfacing ARDUINO™/ESP8266 NodeMCU/ESP32 natively with Siemens S7™ PLCs. The CPUs 1200/1500 LOGO 0BA7 and S7200 are also supported. Settimino is an Arduino library that uses communication with the Modbus TCP/IP protocol. Arduino can communicate with PLC through the same network. In our project, we set IP address 192.168.100.4 for PLC while in Arduino, we set IP address 192.168.100.8. Then Arduino can send data to the cloud, the gateway IP address must be one network, namely 192.168.100.1. Besides IP address, we also need to enter PLC data into the Arduino program such as the rack, slot, and PLC data block used.

Meanwhile, The programming of PLC Siemens S7-1200 uses Tia Portal V14 software. PLC programming is created using OB (organization block), FC (Function Call), and DB (Data Block). The PLC program used to sort goods with # ID1 can be seen in Figure 4.

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**Figure 3.a.** Wiring RFID reader to Arduino.  
**Figure 3.b.** Connection RFID reader to Arduino.

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**Figure 4.** PLC Siemens program.
The algorithm used to allow PLC data to be sent to the IoT Cloud via Arduino connected to the Ethernet Shield is as follows:

- Create initialization program to check the IP Address, Rack, Slot, and DB of the PLC Siemens
- Try connecting to the broker. When the device is connected to the PLC, the reader will read the attached ID. If the device is not connected to the PLC (Connection Error) then the reader will not read the ID.
- Then register the ID to be sent to the PLC as a tag.
- The registered ID will send data according to the data registered and the unregistered ID will send data 99
- When the ID is read by the RFID reader the data will be sent to the PLC by the data registered and will send the data to the broker/cloud.

3. Result and discussion

The automatic item sorting system is carried out on conveyor 1 using PLC as the system controller. Conveyor 1 is turned on by pressing the start button. The consumer's goods with ID#1 will be moved to conveyor 2, and the consumer's goods with ID#2 will be moved to conveyor 3, while the consumer's goods with ID#3 will be moved to conveyor 4. For the consumer's goods with ID#99, the goods continue to run on conveyor 1 to the place of goods that have not been registered. The result of the automatic sorting system can be seen in Table 1.

| Arduino Data | PLC Data |
|--------------|----------|
| ID Input     | Output/Tagval | Data Block PLC Address | Data Block PLC Value | Input PLC (logic high) | Output PLC (logic high) |
| f5edfa69     | Modbus Data 1 | %DB1.DBB0 | 1 | %I0.0 & %Q0.1 |
| a5edfa69     | Modbus Data 2 | %DB1.DBB0 | 2 | %I0.1 & %Q0.2 & %Q0.3 |
| d5ecfa69     | Modbus Data 3 | %DB1.DBB0 | 3 | %I0.2 & %Q0.3 & %Q0.4 |
| ID not registered | Modbus Data 99 | %DB1.DBB0 | 99 |

As seen in Table 1, when the RFID tags are read by Arduino with the ID value fc5edfa69, Arduino will process the RFID data into Modbus data to be sent to the PLC, where the data will be stored in the Data Block PLC at % DB1.DBB0 with a value of 1. So, when the goods are detected by ID#1 and the goods are in front of proximity sensor 1 (% I0.0 logic "1"), the PLC will sort the goods from conveyor 1 to conveyor 2 by turning on the pneumatic cylinder 1 via solenoid valve 1 and conveyor 2 (% Q0.0 logic "1" and % Q0.1 logic "1"). Meanwhile, when the RFID tags are read by Arduino with the ID value a5edfa69, Arduino will process the RFID data into Modbus data to be sent to the PLC, where the data will be stored in the Data Block PLC at % DB1.DBB0 with a value of 2. So, when the goods are detected by ID#2 and the goods are in front of proximity sensor 2 (% I0.1 logic "1"), the PLC will sort the goods from conveyor 1 to conveyor 2 by turning on the pneumatic cylinder 2 via solenoid valve 2 and conveyor 3 (% Q0.2 logic "1" and % Q0.3 logic "1"). The work process on this sorting system can be monitored on a handphone/laptop remotely using an internet network as seen in figure 5. Data from the PLC can be sent to the cloud in the GoIoT server through Arduino using the MQTT protocol. There are several steps to use that server which are creating your account, fill the channel, add device and tags.
4. Conclusion
In this research, the Internet of Things (IoT) can be implemented to monitor the sorting systems of consumer goods production remotely via handphone/laptop that has been connected to the internet. Where the automatic sorting system can be controlled by PLC Siemens S7-1200 using RFID technology as object detection. The RFID data that has been processed into Modbus data by Arduino Mega 2560 can be sent to PLC Siemens S7-1200 via Ethernet Shield so that it can be used as an input signal to the PLC in sorting consumer goods.

Acknowledgments
This research was supported by Universitas Negeri Jakarta through faculty competitive research funds.

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