Design and Implementation of Sembako-ATM using IoT based on Microcontroller and Web Application

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Abstract. This paper describes the design of a Sembako-ATM system for staples distribution using IoT based on microcontroller and web application. The purpose of this design is to design a system that can facilitate the distribution of basic food items to the public on target using IoT technology. The research method used was experimental. The research begins with studying by literature, collecting of materials and components of research, designing of system, testing of the system, and making conclusions, sequentially. The Sembako-ATM system consists of three parts, namely ATM Machine, Registration Device, and Server. The ATM Machine consists of Arduino Mega 2560, PN532 (RFID reader) module, three Infrared Sensor modules, Wemos D1 Mini module, four push-buttons, and three LEDs. Register Device consists of NodeMCU, PN532 (RFID reader) and two LEDs. Lastly, the server part consists of web programming applications. The test results of this study show that the Sembako-ATM designed can be functioned properly. Every part of its system component has worked as expected.

1. Introduction
Staple food or Sembako (nine staple food in Indonesian) is an important thing that is needed by people, especially Indonesian because Sembako as a nutrition safety is a determinant of public health. Therefore, a study recognizes the important relationship between the four main factors of food security, namely availability, stability, utilization, and access [1,2]. To meet these needs, the government has a policy of food self-sufficiency, although, in reality, food self-sufficiency has not been able to cover the needs of all the people [3,4]. Economic events generally affect food security and nutrition, not only depending on the extreme poverty level, but also on the existence of inequalities in income distribution. Where inequality is greater, the economic slowdowns and downturns have a disproportionate effect on food security and nutrition for lower-income populations. The income and wealth inequalities are also closely associated with undernutrition [5].

The distribution of food staples is one of the activities carried out by the government in Indonesia to overcome the problem of the inadequacy of the poor in purchasing food staples. The distribution process meets the challenges of efficient and accountable implementation, this can ensure people have regular physical and economic access to sufficient food to meet nutritional needs[2,6]. However, in the process of implementation, there are several problems, including food that is distributed is not on target and sometimes the recipient of basic food needs to queue and jostle because the distribution of groceries is done in a mass and simultaneous manner. Sometimes, it can cause an accident because of the distribution of such groceries, as happened in one city in Indonesia. As a solution, the distribution of groceries uses vending machines or Automatic Teller Machine (ATM) placed in public facilities, such as village offices, Integrated Service Post or Post Pelayanan Terpadu (POSYANDU), etc. It is expected to overcome the problem of the distribution of groceries. Why a vending machine? It is because nowadays, the vending machine is like a robot maid for humans [7]. Several studies of vending machines that
manage food staples have been carried out by several studies, for example, Automatic Rice-Selling Machine [8] and Prototype Automated Instant Noodle Vending Machine [9].

This study aims to design the Sembako-ATM for the practical and automatic distribution of the food staples using IoT technology[10–12]. It used an electronic of Kartu Tanda Penduduk (e-KTP) owned by the head of the family as a means of user transactions because e-KTP has RFID which can be used as an identity to access Sembako-ATM [13,14]. This study used an experimental method that includes the study of literature, the design process, and the process of implementing and functional testing.

2. Method
2.1. Method
The experimental method used in this study. It conducted by studying literature, designing, implementing the system, and testing. The research is conducted in Digital System Laboratory. In the designing, the system design consists of hardware design, software design, and mechanical design. Each part will be described below. In the testing conducted, ten e-KTP cards used to test the ability of a system designed.

2.2. Hardware Design
The Sembako-ATM system as shown in Figure 1 consists of three parts, namely ATM Machine, Registration Device, and Server. ATM Machine consists of Arduino Mega 2560, PN532 (RFID reader) module, three Infrared Sensor modules, Wemos D1 Mini module, four push-buttons, and three LEDs. Register Device consists of NodeMCU, PN532 (RFID reader) and two LEDs. Lastly, the server part is consist of web programming application.

![Figure 1. Block Diagram of Sembako-ATM System](image-url)
Some of the components contained in the Sembako-ATM machine are as follows: (a) NFC PN532 (RFID Reader), which is a Near-Field Communication (NFC) module to read RFID tags that work at a frequency of 13.56 MHz wirelessly at close range [15–17]. The tag that is read is e-KTP, in which there is a unique code in the form of 7 bytes UIDs (Unique Identifiers) with a combination range of 14 digits; (b) three Infrared Obstacle, namely the Infrared sensor module to detect food staple 1 (rice), food staple 2 (sugar), and food staple 3 (oil). When the IR obstacle module is blocked the microcontroller orders the stepper motor to stop spinning; (c) Three Push Button to choose food staple 1, food staple 2 and food staple 3; (d) One Push Button, for validation; (e) Wemos D1 mini, functions as the data processing from Arduino Mega, controlling buttons, and LEDs. In addition, it is also a medium for wireless data transmission to send unique codes and button conditions to the web server and read JSON files from the web server; (f) Three Motor Drivers to control the rotation of stepper motors 1, 2 and 3; (g) Three LEDs for the food staples stock. (h) Three Stepper Motor, to move the food staple 1, food staple 2 and food staple 3; (i) Arduino microcontroller, based on ATMega2560 which has 54 digital input/output pins[18]. This microcontroller will control the NFC PN532 module, IR obstacle module, A4988 motor driver, and communication to Wemos D1 mini.

Register Device is used for registration of new e-KTP. It consists of PN532 module (RFID Reader), NodeMCU module, and two LEDs. PN532 is used to read data from e-KTP and sent it to NodeMCU. Then NodeMCU will transmit to the web server via wireless[19,20]. And LEDs are used for indicators. The router as Access Point is used to connect Sembako-ATM with the web server via wireless. The server has an important role in this system. This server is used by administrators to carry out processes such as the following: (1) storing the identity of the food recipient's identity; (2) see registered food staple data; (3) editing of recipient data; (4) deleting recipient data; (5) updating stock at each food staple; and (6) processes unique code data and button data pressed. Display on this server computer in the form of a website application that was built using the programming language PHP and MySQL as the database.

2.3. Software Design
The software design section describes the software design that works on the Sembako-ATM machine parts and list devices in the form of flow charts. In addition, the server section displays DCD, DFD, and interface design on the website. The design diagram of the registration device flow is made to illustrate how the system works when registering and shows how the process happens when the device is run. Figure 2 shows the registration process flow chart in the system.

Figure 2. Registration Flow Chart
When the device starts, the reading program starts (A). Next, the Admin is asked to log in to the website application (B). Admin chooses the menu added registration recipient (C). Admin enters NIK data, name, date of birth, gender, and address (D). Then, the system will check whether the NIK has been registered or not (E). Next, tap the e-KTP to get the data (unique code) (F). The system will check whether the unique code has been registered or not (G). If it does not yet exist, the system will store data (H) and send it to the database (I). Finally, the new data storage process is complete. The Data Context Diagram (DCD) on a Sembako-ATM machine consists of admin and recipient. The processes include adding data, deleting data, changing data, changing basic food stocks, viewing data and basic food stock in the system, then the system will provide confirmation of these changes. Explanation of the Data Context Diagram of the Sembako-ATM machine is shown in Figure 3.

![Data Context Diagram of Sembako-ATM Machine](image)

**Figure 3.** DCD of Sembako-ATM Machine

### 2.4. Mechanic Design

Design of mechanic is shown in Figure 4.

![Mechanic Design](image)

| No. | Information |
|-----|-------------|
| 1-3 | LED indicator for staple 1 (Rice), staple 2 (Sugar), staple 3 (Cooking oil) |
| 4-6 | Push button 1 for stapler 1, Push button 2 for stapler 2, Push button 3 for stapler 3 |
| 7   | Push button 4 for validation |
| 8   | Place for e-KTP tap |
| 9-11| Staple 1, Staple 2, Staple 3 |
| 12-14| Conveyor Staple 1, Conveyors Staple 2, Conveyors Staple 3 |
| 15  | Places to take staples |

**Figure 4.** Mechanic design
3. Results and Discussion

Tests were conducted to determine the suitability of the design of the tool that has been made, whether the results are as expected or not.

3.1. Hardware Testing

Hardware testing is conducted to test every component in the system, namely, the NFC sensor, Stepper motor, and IR obstacles.

3.1.1. NFC Testing

The PN532 NFC module is connected to the Arduino Mega2560 using SPI communication. Testing is done by running a program to read e-KTP as a passive tag that receives waves from the PN532 module and sends back unique code data to the PN532 module with a frequency of 13.56 Mhz. Tests carried out on 10 e-KTP. Each reading is displayed via a serial monitor on the Arduino IDE as shown in Figure 5.

![Figure 5. Display of the NFC module testing on the Arduino IDE Serial Monitor](image)

The test results shown in Table 1 show that the NFC PN532 module can read the unique code on the e-KTP properly.

| username  | e-KTP Unique codes (Hex) | Validation |
|-----------|-------------------------|------------|
| Raka      | 04 4c 08 d2 12 2c 80    | ✓          |
| Fauzi     | 04 13 4f 72 2e 50 80    | ✓          |
| Irfan     | 04 29 30 ca a5 56 80    | ✓          |
| Wandi     | 04 72 e8 02 bf 53 80    | ✓          |
| Yudi      | 04 48 45 b2 76 2b 80    | ✓          |
| Rakhman   | 04 44 2d f2 aa 2d 80    | ✓          |
| Andika    | 04 7f 39 7a b0 2d 80    | ✓          |
| Citra     | 04 3e 05 2a 2e 50 80    | ✓          |
| Hasan     | 04 4c 06 aa 82 05 80    | ✓          |
| Rahmatulah| 04 13 4f 72 2e 50 80    | ✓          |

3.1.2. Stepper Motor Testing

The stepper motor used is the NEMA 17 stepper motor with A4988 motor driver connected to a conveyor roller with a diameter of 3.8 cm. Stepper motor testing is conducted to determine the performance of a stepper motor using the A4988 stepper driver. This driver uses a digital pulse, which
is 1 step on the stepper motor is the same as one clock on the stepper driver. Motor testing is conducted by measuring the distance of moving objects on the conveyor and then compared with mathematical calculations. The test results on each stepper show that the difference in the movement of objects on the conveyor has a different error percentage, namely: stepper 1 has an average error of 5.64%, stepper 2 has an average error of 1.27%, and stepper 3 has an average error of 2.38%.

3.1.3. IR Obstacle Testing
Infrared testing is done to detect the presence or absence of food. If the infrared is obstructed by basic food, the status has a logical value of 0 (LOW) and vice versa, infrared is not obstructed by basic needs, therefore, the status is logical 1 (HIGH). The infrared test results are shown in Table 2.

### Table 2. IR testing

| No | Infrared | Condition | Logic | Successful |
|----|----------|-----------|-------|------------|
| 1  | Obstructed | 0         | Yes   |            |
| 2  | No obstructed | 1     | Yes   |            |
| 3  | Obstructed  | 0        | Yes   |            |
| 4  | No obstructed | 1     | Yes   |            |
| 5  | Obstructed  | 0        | Yes   |            |
| 6  | No obstructed | 1     | Yes   |            |

3.2. Software Testing
Testing on software is done via black box method. We only test the function. Table 3 is the test results on the website application.

### Table 3. Results of web application web Testing.

| No | Parameter Content | Functionality | Description |
|----|-------------------|---------------|-------------|
| 1  | Login             | ✓             | System can run login menu and enter to dashboard admin. |
| 2  | Dashboard         | ✓             | System can show all list user and stock of staple. |
| 3  | Add Data          | ✓             | System can add new user. |
| 4  | Show Data         | ✓             | System can add show all user. |
| 5  | Edit Data         | ✓             | System can edit data user. |
| 6  | Delete Data       | ✓             | System can delete user. |
| 7  | Staple Stock      | ✓             | System can update staple stock and show all stock. |

In sequence, Figures 6-10 display the sembako-ATM website menus. The followings are the displayed login, dashboard view, display add recipient, display of recipient data and display of food stocks.

![Selamat Datang Admin](image)

**Figure 6. Login page**
Figure 7. Dashboard

Figure 8. Add Recipient Data

Figure 9. Display data

Figure 10. Stock of groceries
4. Conclusion
As a conclusion, in general, the design results on the Sembako ATM machine have been successful. This is based on the following points. Firstly, the Register Device can read the unique code on the e-KTP well and send it to the database. Secondly, the Sembako ATM machine can read the unique code on the registered e-KTP and can distinguish the unique e-KTP code that is not registered. Thirdly, the Sembako ATM machine can produce groceries according to the choice on the machine. Finally, the website application is functioning properly according to the tests that have been carried out.

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