RFID as Automatic Billing System on Smart Cart Based on Wireless Sensor Network at Clothing Store

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Abstract— **The current billing system can only be done at the cashier by relying on human resources. So that it can increase the number of queues when consumers increase and purchase more than one product. Longer queues can waste time and energy so that it can reduce customer satisfaction. The billing process that can only be done at the cashier can also be an obstacle for customers in knowing the total bill when shopping. This can trigger an over budget so that customers have to increase their expenses. This research proposes an automatic billing system on a smart cart that can support the billing process, especially reading the total bill in real time. This system uses a Radio Frequency Identification (RFID) passive label attached to each product as a unique identification code. In the shopping cart there is an RFID reader that functions to read the label. The products that have been added to the cart will be displayed on the application intended for customers and the web server for the cashier. Information on the website includes product name, price per product unit, product quantity, and total bill.**

Keywords—Billing, Carts, Clothing Store, Label, RFID, Wireless Sensor Network

I. INTRODUCTION

Quoted from several stories, there have been queues at the cashier payment process at several clothing store outlets. Queues caused by discount offers and high season. As a result of the enthusiasm of the residents, some end up exhausted and irritated. From the news quoted, one of the growing queues can be triggered by a billing system that can only be done at the cashier by relying on human resources. With this system, the product identification process can only be done by the cashier to find out the total bill. So that it can increase the number of queues when consumers increase and purchase more than one product. Longer queues can waste time and energy so that it can reduce customer satisfaction [1-4].

In previous studies, researchers have not implemented the system but described the system planning [5-7]. In another study, researchers implemented a system with barcode technology. [3] As per the journal presented by Mandeep Kaur et al, researchers explain that RFID allows identification from a distance, and unlike previous barcode technologies, it does so without the need for a line of sight [8-13]. From the advantages offered by RFID technology, researchers use RFID technology in this study.

Because of these problems, a real-time automatic billing system is needed to shorten the billing process. In this research, proposed a system with the title "RFID as an Automatic Billing System on Smart Cart Based on Wireless Sensor Network in Clothing Stores". In this system there is a basket that is able to identify products when consumers do shopping activities so that it can shorten the scanning process at the cashier. In addition, with the automatic billing system, the billing process at the cashier can be assisted by the system so as to minimize queues during the billing process.

II. METHOD

A. System Block Diagram

Systematically, the workings of the tools that the system runs are made in the form of a block diagram shown in Fig. 1. below:

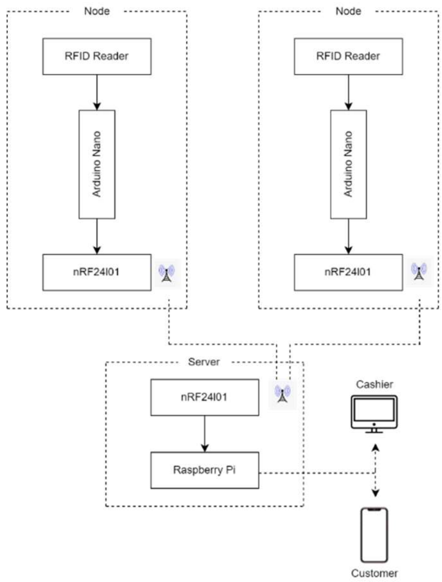


Figure 1. System block diagram

In Fig. 1 the block diagram of the system will explain the work process of the system carried out during the study the description of Fig. 1. is as follows: In this system there are two sensor nodes consisting of an RFID reader, Arduino Nano, and nRF244l01. At each sensor node there is an RFID reader sensor that is used to detect RFID labels contained in smart carts. The sensor is connected to the microcontroller to store sensor data. Then there is the nRF24l01 communication module which is connected to the microcontroller. The module is used to transmit data from the node to the server so that sensor data can be received by the server. On the server node there is an nRF24L01 communication module which is used to receive sensor data from sensor nodes. The communication module is connected to the Raspberry Pi component which is used to store and process sensor data so that product information and total invoices can be displayed by the system application and web server.

B. Customer Application Design

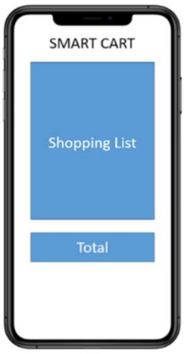


Figure 2. Customer application design

Fig. 2 is an application display design for customers. This display displays the name of the product (item), the number of products (qty), the price per product unit (@), the total price of the product (price), and the total bill in rupiah. Information on the system will be updated in real time so consumers can see the total bill before carrying out the billing process. The application can be accessed by consumers by scanning the QR Code contained in each basket.

C. Web Server Design

Figure 3. Web Server Design

Fig. 3. is a website display design for cashiers to check out products. On another page, there is a recap of products sold per day.

D. Node Sensor Hardware Design

The hardware design of this sensor node will be explained in a schematic form in Fig. 4. The hardware circuit consists of an RFID reader, microcontroller, and nRF24l01 communication module.

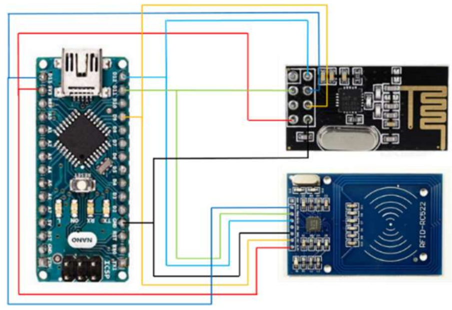


Figure 4. Node sensor hardware design

The pin connections between the above components are described in Table 1.

TABLE I
NODE SENSOR COMPONENT PIN CONNECTION

No.	Arduino Nano	RFID Reader	nRF24l01
1.	3.3 V	3.3 V	VCC
2.	Pin 9	RST	CE
3.	GND	GND	GND
4.	Pin 12	MISO	MISO
5.	Pin 11	MOSI	MOSI
6.	Pin 13	SCK	SCK
7.	Pin 10	SDA	CSN

E. Node Server Hardware Design

The hardware design of this sensor node will be explained in the schematic form in Fig. 5. The hardware circuit consists of the nRF24l01 and Raspberry Pi communication module components.

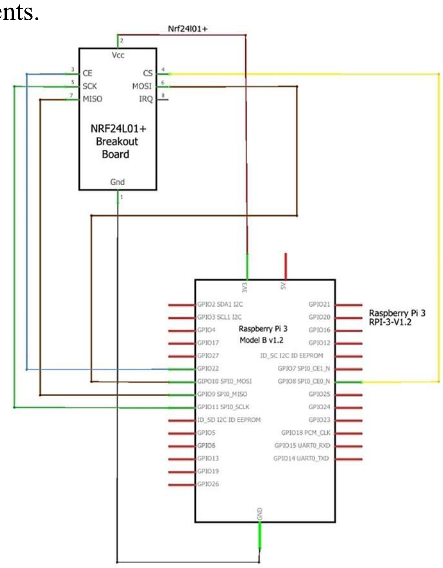


Figure 5. Node server hardware design

The pin connections between the above components are described in Table 2.

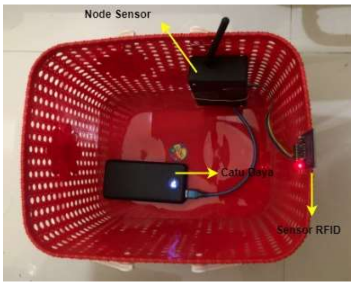
TABLE II
NODE SERVER COMPONENT PIN CONNECTION

No.	Raspberry Pi	nRF24l01
1.	15	CE
2.	24	CSN
3.	19	MOSI
4.	21	MISO
5.	23	SCK
6.	25	GND
7.	17	3.3V

III. RESULTS AND DISCUSSION

A. *Result of Product*

1. Mechanical Implementation Result



(a) Looks inside

(b) Looks Outside

Figure 6. Mechanical Implementation Result

Fig. 6 (a) is the implementation of the smart cart design looking inside and Fig. 6 (b) is the implementation of the smart cart design looking outside according to the design.

2. Hardware Implementation Result

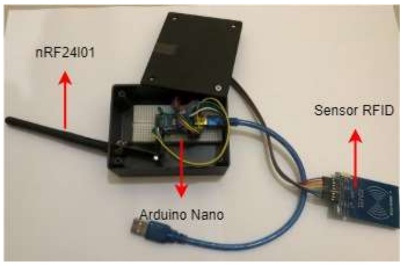


Fig. 7. Node Sensor Implementation

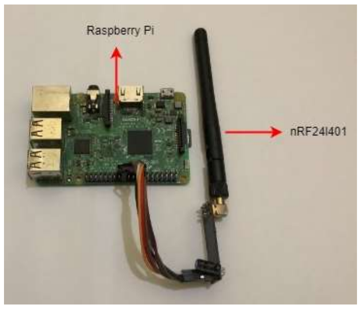
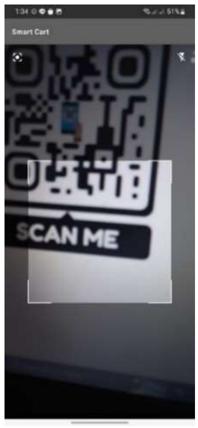


Fig. 8. Node Server Implementation

3. Software Implementation Result

(a)

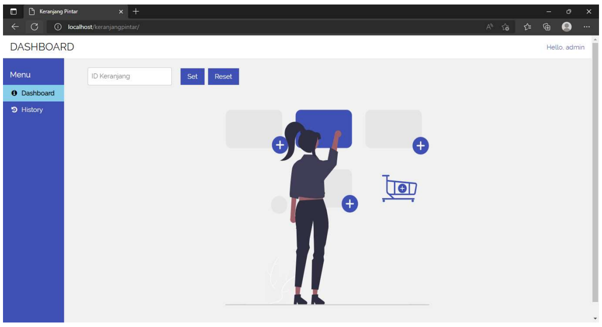


(b)

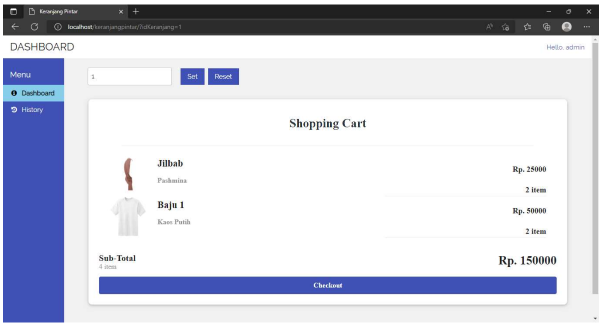
(c)

Figure 9. Customer application

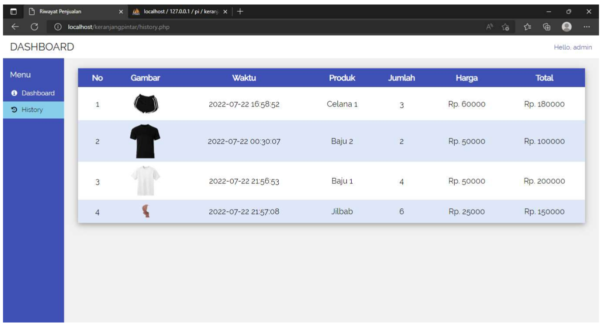
Fig. 9 is the result of application implementation for customers. Fig. 9 (a) displays the application's main page. On that page there is a yellow button at the bottom right of the page to scan the qr code. Fig. 9 (b) displays the qr code scan page for smart cart id access. Fig. 9 (c) displays a list of products that have been entered in the smart cart. In the shopping list view, there is product information including name, quantity, and price.



(a) Initial View



(b) Shopping list view



(c) History view

Figure 10. Web server

Fig. 10 (a) shows the initial appearance of the web server. At the beginning of the web view there is a form that is used to input the basket id. Then there is a set button that is used to view the shopping list in the basket that has been entered in the form section and there is a reset button to return to the start page. Fig. 10 (b) displays a shopping list in the basket. The shopping list contains product names, product descriptions, prices, and sub totals. Fig. 10 (c) displays history which shows a recap of shopping lists that have been checked out at the cashier.

B. RFID Reader Reading Distance Test

The reading distance test aims to determine the ability of the RFID reader to capture the feedback signal from the RFID label. This affects product detection. In testing the reading distance of the RFID reader, 10 different distances were determined from the ruler and 3 tests were carried out. The results of testing the reading distance of the RFID reader are shown in Table 3.

TABLE III
RFID READER READING DISTANCE TEST RESULTS

No.	**Distance (cm)**	**Test**		
		1	**2**	**3**
1.	0.5	Detected	Detected	Detected
2.	1	Detected	Detected	Detected
3.	1.5	Detected	Detected	Detected
4.	2	Detected	Detected	Detected
5.	2.5	Detected	Detected	Detected
6.	3	Detected	Detected	Detected
7.	3.5	Detected	Not Detected	Not Detected
8.	4	Not Detected	Not Detected	Not Detected
9.	4.5	Not Detected	Not Detected	Not Detected
10.	5	Not Detected	Not Detected	Not Detected

From the results of testing the reading distance of the RFID sensor, in the first test the sensor cannot detect at a distance of 4 cm. Whereas in the second and third tests the sensor readings could not detect at a distance of 3.5 cm. From these data, RFID detection is stable at a distance of 3 cm so that a maximum reading distance of 3 cm is set.

C. RFID Reader Read Accuracy Test

Testing the level of accuracy aims to determine the quality of the RFID reader in reading the number of products detected. This affects the accuracy of the number of products and total consumer bills. In testing the accuracy of the reading used a sample of clothing products that have been given an RFID label. Products are placed in the basket one by one according to a predetermined number of samples. The results of testing the accuracy of reading the RFID reader are shown in the Table 4.

TABLE IV
RFID READER READ ACCURACY TEST RESULTS

No.	**Number of Samples**	**Detected Amount**			**Status**
		1	**2**	**3**	
1.	1	1	1	1	Matched
2.	2	2	2	2	Matched
3.	3	3	3	3	Matched

No.	Number of Samples	Detected Amount			Status
		1	2	3	
4.	4	4	4	4	Matched
5.	5	5	5	5	Matched
6.	6	6	6	6	Matched
7.	7	7	7	7	Matched
8.	8	8	8	8	Matched
9.	9	9	9	9	Matched
10.	10	10	10	10	Matched

From the results of testing the accuracy of RFID reading in Table 4, it can be concluded that the success rate of the RFID reader in reading labels is 100%.

D. Sample Test

Sample type testing aims to determine the suitability of the label with the product that has been detected. This affects the accuracy of the products included in the smart cart. Prior to testing the type of sample, an RFID label is affixed to each product packaging. Sample type testing is carried out by adjusting the detected product. The test results are shown in Table 5.

TABLE V
SAMPLE TEST RESULTS

No.	Type	Reading
1.	Jilbab 1 (Pashmina)	Jilbab 1 (Pashmina)
2.	Baju 1 (Kaos Putih)	Baju 1 (Kaos Putih)
3.	Baju 2 (Kaos Hitam)	Baju 2 (Kaos Hitam)
4.	Celana 1 (Celana Sport)	Celana 1 (Celana Sport)
5.	Celana 2 (Celana Legging)	Celana 2 (Celana Legging)

From the results of the sample type test, all detected samples match the reading results. So, it can be concluded that the suitability of the sample type test results is 100%.

E. Quality of Service (QoS) Testing Result

1. Packet Loss

The packet loss test aims to determine the percentage of the total number of packets lost when sending data. Testing is carried out using the Wireshark application as shown in Fig. 9.

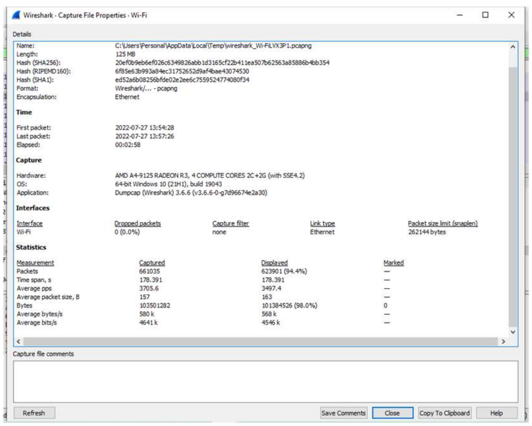


Figure 11. Example of packet lost test

Fig. 11. shows the packet loss test command with the input "ip.dst==192.168.220.1&&ssh" and data packet loss by Wireshark. From this test it can be seen that the packets sent were 661035 and the packets received were 62390. From the results of the packets received, the percentage of packets received was 94.4%. Then the packet loss obtained is 5.6%. The packet loss test is carried out 10 times. The results of packet loss test are shown in Table 6.

TABLE VI
PACKET LOSS TEST DATA RESULTS

No.	Packet Sent	Packet Received	Succeed Percentage	Error Percentage
1.	661035	623901	94.4%	5.6%
2.	647835	612156	94.5%	5.6%
3.	641835	602161	93.8%	6.2%
4.	663075	624977	94.3%	5.7%
5.	673075	634619	94.3%	5.7%
6.	737456	680263	92.2%	7.8%
7.	699133	660121	94.4%	5.6%
8.	701233	658835	94.4%	6.0%
9.	751023	724554	96.6%	3.5%
10.	750021	703109	93.7%	6.3%
Average				5.6%

Based on the test results that have been carried out 10 times, the packet loss percentage is 5.6%.

2. Delay

Delay test aims to determine the time required for data transmission from the sensor node to the server node. Testing was carried out using the Wireshark application, to get delay data, the command used was "ip.dst==192.168.220.1". The results of the sample delay data testing are shown in Table 7.

TABLE VII
DELAY TEST DATA RESULTS

No.	Source	Destination	Delay (s)
1.	192.168.220.42	192.168.220.1	0,013035
2.	192.168.220.42	192.168.220.1	0,19046
3.	192.168.220.42	192.168.220.1	0,023719
4.	192.168.220.42	192.168.220.1	0,031431
5.	192.168.220.42	192.168.220.1	0,052702
6.	192.168.220.42	192.168.220.1	0,035544
7.	192.168.220.42	192.168.220.1	0,052865
8.	192.168.220.42	192.168.220.1	0,07365
9.	192.168.220.42	192.168.220.1	0,021954
10.	192.168.220.42	192.168.220.1	0,032411
11.	192.168.220.42	192.168.220.1	0,072468
12.	192.168.220.42	192.168.220.1	0,055307
13.	192.168.220.42	192.168.220.1	0,02446
14.	192.168.220.42	192.168.220.1	0,062246
15.	192.168.220.42	192.168.220.1	0,023647
16.	192.168.220.42	192.168.220.1	0,032132

No.	Source	Destination	Delay (s)
17.	192.168.220.42	192.168.220.1	0,083621
18.	192.168.220.42	192.168.220.1	0,084258
19.	192.168.220.42	192.168.220.1	0,054929
20.	192.168.220.42	192.168.220.1	0,073513
Average			0,054718

From the results of the 20 delay data samples, an average of 54.717575 ms was obtained.

F. System Functionality Test

Functional tests carried out include testing qr code scanning to obtain basket IDs, placing products into baskets via RFID readers so that labels can be detected, sending data from sensor nodes to server nodes, displaying data on the web and applications, and product suitability.

TABLE VIII
SYSTEM FUNCTIONALLY TEST

No.	Test	Succeed	Fault
1.	Qr code scanning	✓	-
2.	Label scan by RFID reader	✓	-
3.	Sending data from sensor nodes to server nodes	✓	-
4.	Application view	✓	-
5.	Web server view	✓	-
6.	Product suitability	✓	-

Table 8 is an overall system testing table. From the tests that have been carried out, it can be seen that all tests were successful. So, it can be concluded that the implementation of the automatic billing system on the smart cart can work according to the design.

IV. CONCLUSION

From the background, problem formulation, planning, and implementation as well as discussion, it can be concluded that the average percentage of accuracy of the RFID sensor as an automatic billing system for detecting objects/products is 100%, so that the system can run according to design. The automatic billing application is intended for customers to help provide information including product name, quantity, price, and total bill. In addition, the web server is intended for cashiers to carry out the checkout process and provide product information that comes out per day. Applications and web that have been implemented as a whole in accordance with the design; and the Quality of Service (QoS) testing based on the data obtained a packet loss value of 5.6% and a delay of 54.717575 ms. From the results of the QoS test, data transmission on the system is sent and received according to real-time.

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