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Iot Based Food Court

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Abstract : The purpose of this research is to implement the internet of things (IoT) system into a food court place to reduce its service time and cost. The IoT will handle the security and the payment of this self-service food court. Thus, there will be no need for waiter and cashier employees. We created a mobile and server side application and also a food container boxes equipped with the IoT devices to handle this food court service operations. Each food container has a quick response (QR) code for its identification. These food containers only can be opened by smartphone through the food court app by scanning the container's QR code, while the IoT system will get the user identification and measure how many foods that the buyer took. Then, the payment will be handled back through the mobile application.

1. Introduction

The wide penetration of smartphone changes many businesses recently [1]. Smartphone became irreplaceable for our daily life. Today, smartphones are already connected into the 4th generation of the wireless communication system that can provide sufficient data speed and quality [2]. The computing power in the smartphone also already became closer to the personal computer power. Because of that smartphone already become more than just a communication media. In this industry 4.0 era, people are eager to do an online transaction rather than an offline or direct transaction. However, the food business is an exception that can survive online disruption [3]. Different from fashion or electronic goods, people still want to purchase food directly in the food court or restaurant.

The food court business is an inseparable part of our daily life even in this industry 4.0 era. The food courts often appear near business offices, schools, universities and community centers [4]. Food court provides instant food access in the center of the city crowded places. Thus, a long queue in the food display and cashier is inevitable. To give a better experience to the customer, a food producer need to hire more waiter and cashier employees, but it will make the operational cost for waiter and cashier employees in a food court business become larger. Even for a self-service food court, the producer still needs to employ waiters and cashiers.

Recently, the internet of things (IoT) is also a new promising method to replace human capability in many applications of works. IoT is a computing device that can connect to the internet and can be interfaced with many sensor devices. Smartphone today can be a very suitable complement for IoT. Smartphone with IoT can enable a producer to monitor and process many elements of its business anytime and anywhere. The IoT has been implemented in many fields such as agriculture, smart city, industrial and retail. In the food industry, there have been some researches for IoT application such as in the order handling and payment transaction [5,6].

This paper proposes a design of the smart food container to be put in the food court. Using this smart food container, a food producer will not need waiters or cashiers to operate a food court. We design a self-service food court where the customers will use their smartphone to open the container thus a waiter to guard the food container is unnecessary. The smart container will count how many items the customer bought and calculate the price. Moreover, the payment is done online as the customer balance will be deducted automatically. The aim of this research is to enable many people can join the food court business even with limited time and money.

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Furthermore, it also can give a better experience to the customer as the transaction can be done in seconds.

2. Literature Review

2.1. Food Court

A food court is a shopping place with many outlets that provide a variety of foods. The customer will wait in a queue, order the food, pay at the cashier and the waiters will deliver the food for the customers. The food provided is usually in the form of fast food. There are several food courts that provide e-cards as payment media for cash substitutes. This payment system from e-cards has begun to be applied to food courts located in major malls in Indonesia, but still making payments requires the cashier to calculate the amount of food purchased.

Fig. 1 Food Court Outlet

2.2. Internet of Things (IoT)

Internet of things (IoT) is a computing device that can connect into the internet. Because it is connected into the internet, the IoT devices can be used to do monitoring continuously in the real-time. It also makes the IoT devices can ease the ability to perform a collaboration between many other systems. Various sensing devices can be connected to IoT that enable it to perform many kinds of monitoring. In this paper, we use an open source IoT platform which is node MCU as the core of our IoT system. The node MCU had 12 I/O ports and already equipped with the WiFi. The CPU for this IoT node is ESP8266 processor. This processor can run on 80 to 160 MHz of clock speed. The node MCU module also has an analog to digital converter (ADC) module, thus it can directly read the data from analog sensors.

2.3. Sensors

The number of the item taken by a customer is measured by comparing the weight. This paper uses a load cell sensor to measure the weight. The load cell used in this paper is a strain gauge based load cell. The strain gauge is connected in a Wheatstone bridge in the load cell. The strain gauge will act as a resistor which value is changing according to the force applied to it. The strain gauge is connected to a metal layer where a load can be put to be measured. The load will change the resistance value in the strain gauge that also will affect the output electricity parameter of this sensor.

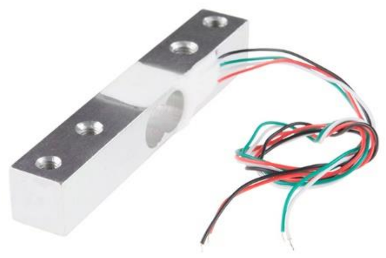

Fig. 2 Load Cell

3. System Design

The system architecture of our proposed design is shown in the figure below. The mobile application in the buyer smartphone will need to access the camera to scan the QR code in the food container. If the container ID is confirmed, then the application will contact the server to initiate the open lock mechanism at the food container. The food container is equipped with a node MCU based IoT processor. The node MCU will start the motor servo to open the locking mechanism at the food container. The node MCU at the container acts as the center of the processing processes. The node MCU will calculate how many items are taken from the container by utilizing the weight data from the load cell sensor which placed at the bottom of this container. Then, the node MCU will send the purchase data to the server. The server handles the payment process by charging the user account.

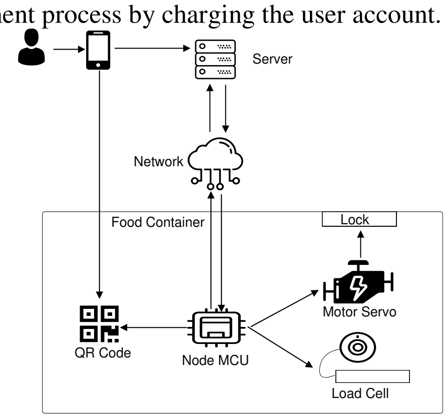

Fig. 3 Proposed System Block Diagram

The detail of the software flowchart of the proposed system can be seen at the figure below. The software here is the combination of the mobile app, server side computation and the IoT computation by the node MCU. The mobile app mainly has a function to scan the QR code and show the user data from the server database. The mobile app will initiate the transaction process of this food court service. The database at the server side stores both user data and item IDs at the food containers. The database has connections for both the mobile app and the IoT device. The calculation of the amount of the item taken is handled by the node MCU and this data is updated in real-time. The database also stores the transaction based on the data from both the mobile application and the IoT device.

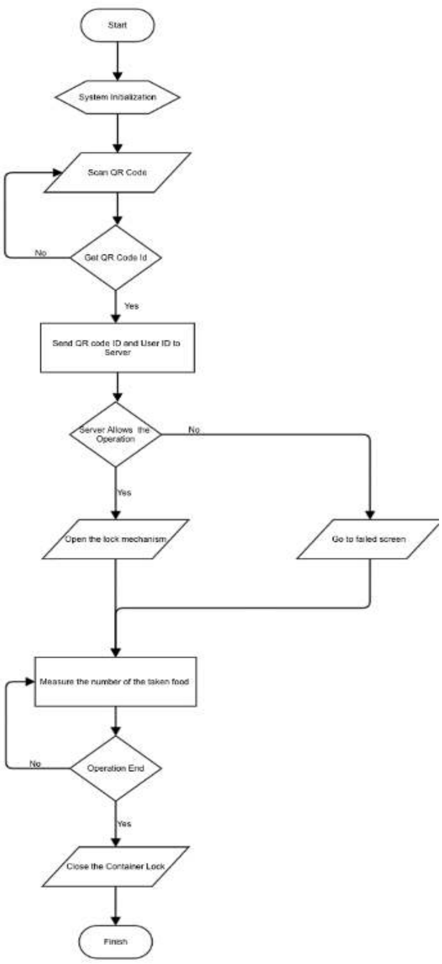

Fig. 4 Software flowchart of the proposed system

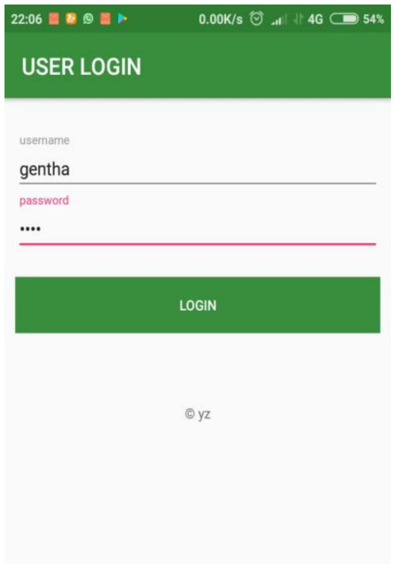

Fig. 5a Mobile application interface login page

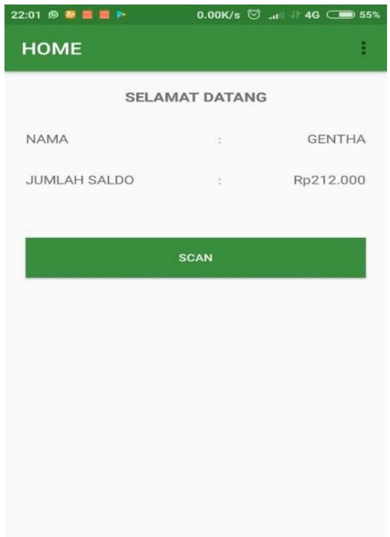

Fig. 5b Mobile application interface home page

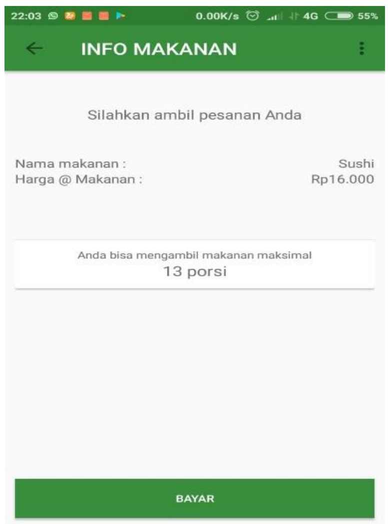

Fig. 5c Mobile application interface transaction page

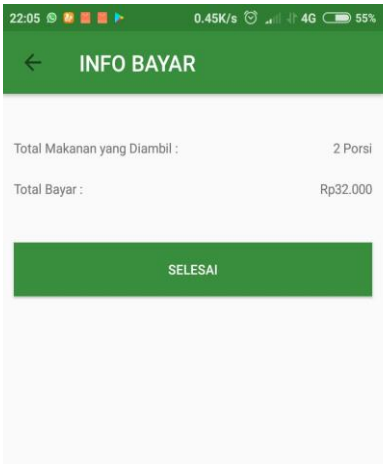

Fig. 5d Mobile application interface confirmation page

The user interface of the mobile application can be seen in the figure above. Each user will have a credential of username and password that need to be inputted at the login page as shown in Fig a. The user can see the account balance at the home page of the application as seen in Fig. b. If the user has an insufficient account balance, then the server will refuse the transaction. The transaction page at Fig. c will show the amount of the item taken at real-time. If the buyer account balance is less than the charging bill, the transaction cannot be completed. Moreover, if the buyer forced to leave the food court without paying, the mobile application will force to sound an alarm at the buyer's phone. The confirmation page in Fig. d is the last page that will authorize the transaction, the server will deduct the buyer account from the amount that been charged.

Fig. 6 Database Design

The database has four tables that consist of users, box, transaction and history tables. The users' table will hold the username and password. This table also contains a user ID that only known by the server. In this table also holds the balance that the user has. The box table has a unique ID for the box container. This table also holds the food name, price, stock and weight for each item. The status in this box table will trigger the node MCU to open or close the box container. The transaction table will hold the transaction's ID, box's ID and user's ID. This table also keeps the charging amount from each transaction. Last, the history table will keep all the transaction available from each day.

4. Testing and Results

The reliability of the proposed system is tested in three aspects which are the camera, load cell, and software. The camera was tested to get the best setting for QR code reading. The first test is to obtain the best distance of the camera and the QR code. The test results are shown in the Table I below. Here the QR code has a dimension of 8cm x 8cm. It can be seen that the distance of the camera to the QR code should be in 8cm to 19 cm.

Table I. Camera and QR code distance test

Distance from QR code	Status
1 cm	Can't read
2 cm	Can't read
3 cm	Can't read
4 cm	Can't read
5 cm	Can't read
6 cm	Can't read
7 cm	Can't read
8 cm	Success
9 cm	Success
10 cm	Success
11 cm	Success
12 cm	Success
13 cm	Success
17 cm	Success
19 cm	Success
20 cm	Can't read
22 cm	Can't read

The second test regarding QR code scanning process is the angle of the camera. As shown in the table II below. It is also can be concluded that the angle range to read the QR code correctly is from 0^0 to 30^0. The third test is the lighting test. Here we try to read the QR code in the different lighting. In this test, the phone is used in 10 cm distance and 0^0 angle. The results of this test can be seen in the Table III. In this test, the light intensity is varied from 0 lux to 45 lumens. Each of the light intensity parameter is experimented in 50 tests. From the results presented in Table III it can be seen that the required light intensity is 40 Lumens.

Table II. Camera and QR code angle test

Camera Angle from the QR Code	Status
0	Success
15	Success
20	Success
25	Success
30	Can't read
35	Can't read
40	Can't read
45	Can't read

Table III. Lighting intensity test in QR Code Scanning

Intensity (lumens)	Status
0	0 % Success
5	0 % Success
10	0 % Success
15	0 % Success
20	12% Success
25	20% Success
30	52% Success
35	80% Success
40	100% Success
45	100% Success

The load cell reliability test is to measure the difference between the real weight and the load cell reading. The results of this test are shown in the table IV. Here we try to weight a known thing with a certain weight which vary from 100 gr to 500 gr. The result in the table IV shows that almost all of the experiment will have a mean error of 5%. This data will be used in the software as an offset in the item number calculation.

Table IV. Load cell reliability test

No	Real weight (gr)	Load cell reading (gr)	Weight different (gr)	Error (%)
1	100	104.33	4.33	4.33
2	200	213.19	13.19	6.60
3	300	312.98	12.98	4.32
4	400	421.84	21.84	5.46
5	500	526.17	26.17	5.23
Mean error				5.19

The last experiment is the software profiling test. Because the proposed system is updated in the real-time, we need to make sure that the execution time of each function in this system less than the real-time deadline. In this paper, the deadline is 3 seconds to maintain that the users still have a great experience. The result of the profiling test can be seen in the Table V below. The table shows that the total execution time for one transaction is 2.88 seconds. It also can be concluded that the proposed system has met the soft real-time deadline.

Table V. Software Profiling

Function	Execution Time
login	1.23 s
Send Id	0.54 s
Measure Item amount	0.32s
Update Transaction Data	0.45 s
Finish Transaction	0.34 s
Total	**2.88 s**

5. Conclusions

This paper has proposed a solution for a self-service food court system based on IoT. Using this system, the owner of the food court can focus only on preparing the food in the smart food container. The IoT based food container will handle the transaction with the customer from securing the food itself, measuring the amount of item taken, calculating the cost and to handling the payment. The proposed system can assure that the customers will only have to wait less than 3 seconds in each of transaction. The implementation of the proposed system can cut the cost of food court implementation greatly and improve the security in the self-service food court.

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