Application of Internet of Things (IoT) in Coin Counting, Notifying, and Reporting System of Coin-Operated Washing Machines via Mobile Application

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Abstract : This research aims to apply Internet of Things devices to coin-operated machines, which can install in washing machines. Typical coin-operated machines allow you to count the coins that have been dropped in and receive notifications of problems. The developed system can send data, including checking the value of a currency, amount of coins and notifications through the Internet of Things devices to the cloud storage. The developed mobile application enables the owner to check the amount or quantity of coins in the washing machines and alert the machine of problems as a notification message through the application on mobile devices. Besides, the users conducted business activities, which measured the effectiveness of detecting the coins dropped into the cabinet to classify the value and count the number, a total of 150 times, of which 450 coins were measured with 100 per cent accuracy. In addition, measuring the effectiveness of the notification button press a total of 30 times were carried out with 100 per cent accuracy. Finally, conducted the interoperability test between the coin counting system and notification to store on a cloud system. Besides, data retrieval is reported in mobile applications, including the results of the coin value checked and wrote in Mobile Application are 100 per cent accurate. The coin counting, performance measurement, and interoperability are accurate in 98 per cent. According to research and development of the application of the Internet of Things in the coin counting system, notifications and reporting of coin-operated laundry machines through mobile applications. It found that such a system can be applied, practical and accurate in business processes. It can also gather data to generate information for supporting decision-making in the actual operation of the business.

Keywords: coin counting system; Internet of Things; coin-operated laundry machines; mobile applications

Introduction

The Internet of Things or IoT refers to items connected as a network of data transfers to exchange, process, or control the operation of various things. The items mentioned earlier are referred to as "Things/Devices", such as office supplies, agricultural tools or machinery, machinery in the robotic industry, robot arms for indoor equipment including residential items, everyday appliances such as watches, cars, refrigerators, alarm devices, etc. The mentioned has sensors that perceive the environment. There is a network system to communicate with each device (machine-to-machine communication) as if the devices were able to communicate with each other by virtue of protocols and network systems, etc. [1]. Recently, they are increasingly popular for use. They can assemble finished products into systems to work with different approaches and benefit entrepreneurs in various fields, such as CCTV systems that monitor individuals' faces, check the nature of things or animals, and talk in real-time.

However, another popular business is a form of coin-operated laundry machine that is gaining popularity called a laundromat [2]. In comparison, Internet of things can be applied to the service of such coin-operated laundry machines, as mentioned earlier. Besides, regular coin-operated laundry machines in community areas or dormitory buildings. Shop owners need to come to collect money from coin-operated machines regularly. While they do not know how much money is in that closet. There is no indication of the number of coins flowing into the cabinet to verify the accuracy of the amount collected, and whether the machine has been working correctly. In contrast, when the coin-

operated machine has a problem, the owner may take a long time until the coin-operated machine has to be open to collect money. It leads to a loss of business opportunities and a lack of value to go to collect money from such coin-operated machines.

The researchers then proposed to develop a coin-counting system for notifications and reporting through a mobile application for coin-operated laundry machines. By applying the Internet of Things for counting coins and then calculating the amount at that time. Besides, receiving notifications if the coin-operated machine has problems directly from customers, including reporting the number of coins of each value to facilitate the effective monitoring and management of the coin-operated machine. Also, reporting the number and value of cash contained in the coin-operated machine to the owners. They can use the data for a decision to go to the location of the coin-operated washing machine.

The developed system includes an idea that allows users to install it in conjunction with existing coin-operated machines without damaging the existing system or requiring further modifications. Also, it is cheap, and individuals can procure, assemble and install the work on their own. It is partly to encourage the knowledge and understanding of digital literacy, awareness of digital technology and innovation, and lifelong learning [3]. It was then encouraging the people in the country to have the opportunity to learn and develop themselves in digital technology sustainably.

Objectives

1. To apply Internet of things devices in a regular coin-operated washing machine to be connected via mobile devices.
2. To develop mobile applications connecting to Internet of things devices in a regular coin-operated washing machine.
3. To measure the performance of the coin counting system, notifications and performance reporting with Internet of Things devices via mobile application.

Literature reviews

1. Arduino

Arduino is an AVR family of microcontrollers that can work with various IC microcontrollers or sensors under the C programming language. To control, operate in conjunction with other sensors. It has the hallmarks of being easy to access. Affordable price. Supports working on a wide range of platforms Developed under open software and Creative Common licensed hardware. Can be customizes or modifies functionality. Various are easy to use for beginners studying microcontrollers who have no experience or who want to get started. Microcontrollers by commonly used Arduino boards include Arduino Uno Rev3, NodeMCU ESP8266, etc. [5].

2. Android Operating System (Android OS)

Android OS is an operating system on mobiles such as smartphone, and tablets. Initially developed by Android Inc., then financed by Google and further developed by Android. It was later developed on behalf of the Open Handset Alliance. Google has enabled developers to edit code in Java and control devices through the Java libraries developed by Google. It was formed in 2007 by Android and Google and has collaborated with more than 30 leading companies to develop the system [4].

3. Related works

Kiruthika and Dhandapani studied smart washing machines by using an Advanced Risc Machine (ARM) board to communicate with sensors by using the IoT concept. They created a monitor and controller through a web server that was developed by PHP [5]. Menachery and Johnson presented an IoT automation system of laundry machine status updates via smartphone by IoT technology. The smartphone was set up to the back of the laundry machine remotely to record in the magnetic field [6]. Shakya et al. developed Laundry Monitoring Service (LMS) using IoT for washing machines. LMS was connected to the network system via a chip (SOC) capable of Wi-Fi. The LMS was connected remotely to the status and notification by enabling users [7]. Homeowner monitoring was constructed by Mendoza et.al. They used the concept of IoT to develop three modules: dust monitoring, house lighting activation and gas sensors sent remotely through mobile devices [8]. Sahuji et al. proposed designing the Automatic Vending Machine as an IoT technique to help customers to order chocolate. The machine was provided in a coin-based vending machine using a microcontroller [9]. Yamunathagam et al. studied using IoT in smart care in washing machines via smartphone of customers that analysed the current state [10]. Setthawong and team developed the smart coin of an existing washing machine using IoT. It was explored by three sensors including brightness sensor, vibration sensor and current flow sensors [11].

Methodology

3.1 Designing the workflow of counting coins and notifications device.

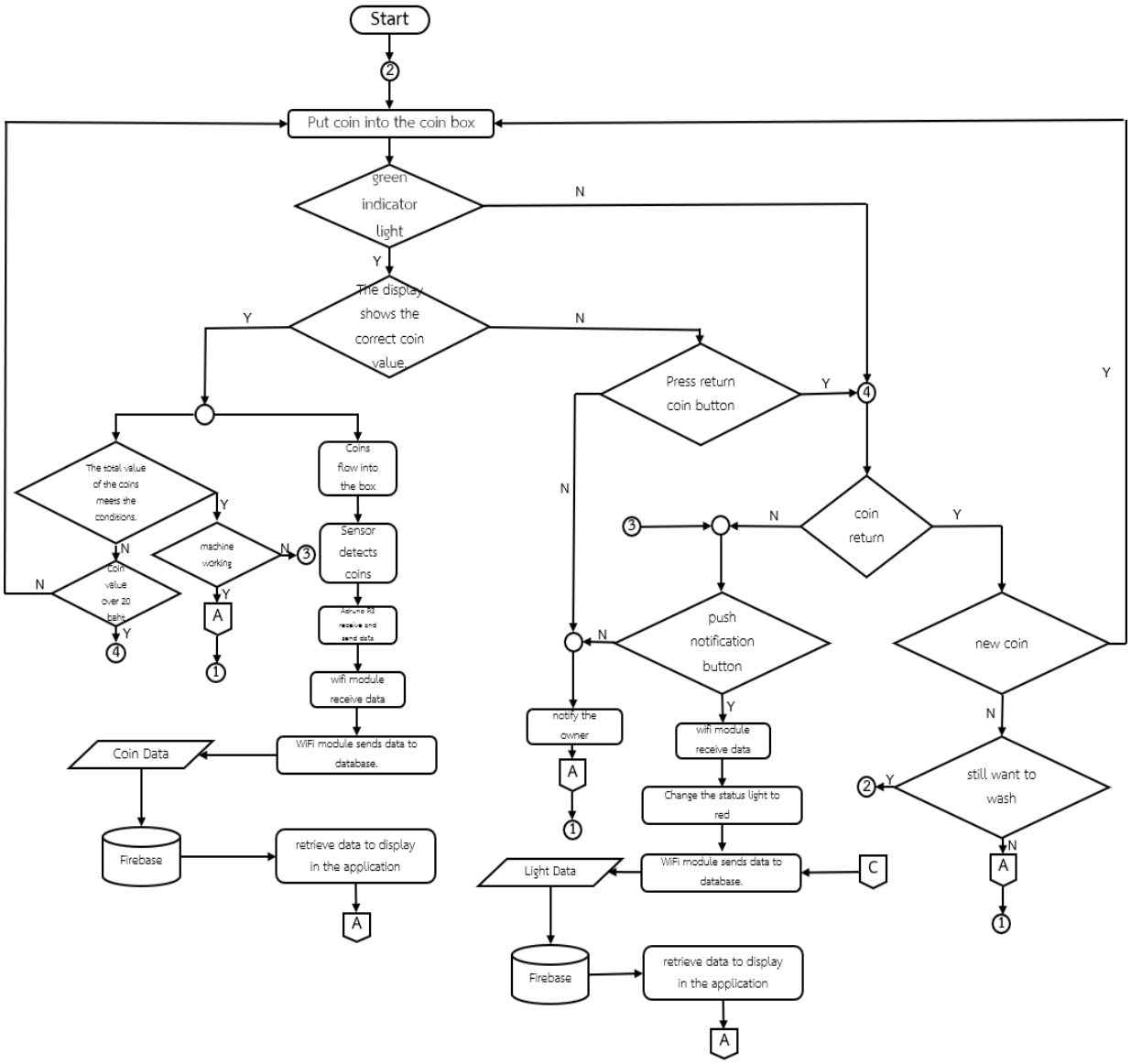

Figure 1: workflows of counting coins and notifications device.

When a coin is dropped into a box, it flows into a coin-operated rail with a sensor that detects the size of the coin. Then send the counting data of the cash to the Arduino UNO R3 board and forwards the data to NodeMCU V2 ESP8266 via a Flammable signal, which can be recorded into the Firebase database. Lastly, the application retrieved to display the coin counting result. Suppose a problem occurs with the washing machine or coin-operated, and it does not work. Users can press the notification button to update the machine's status on the application as unavailable.

3.2 Designing the workflow of the application.

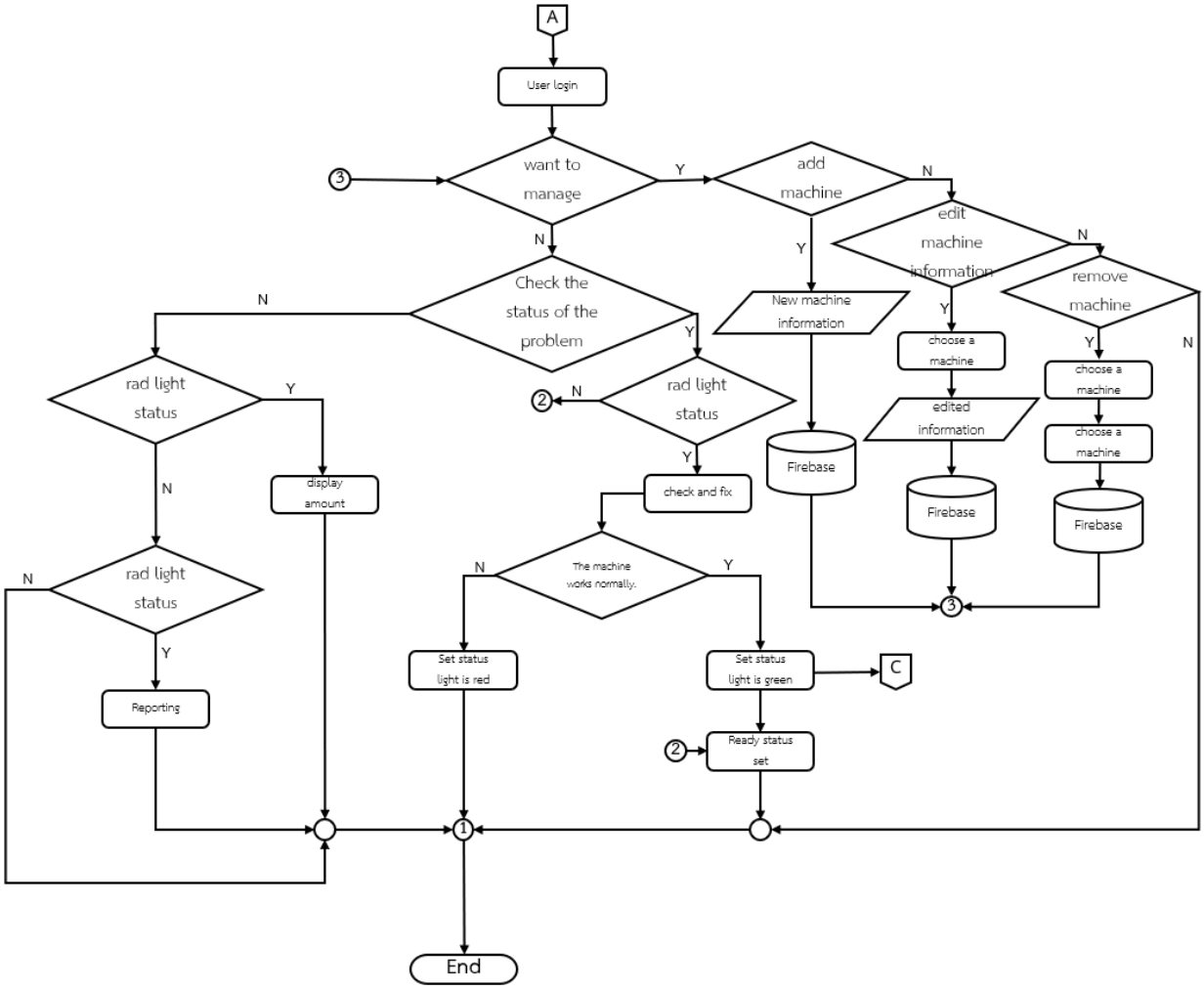

Figure 2. the workflow of the application.

Figure 2, users can manage the data on the application as follows:

- Managing device information, users can add, delete, and edit the information. All data is saved to the Firebase database.

- Checking the status of problem notifications, users can check the notification status of the washing machine on the application to see if it is available. If the device has a red light or the application is not ready for the user. When monitoring the alert situation, If the light is red, there is a problem with the machine. Once the corrective action has been successfully performed, the device is back to regular operation. Users can press the reset button, and then the status change to ready and the green lamp display.

- Checking the number of coins, users can check the number of coins counted on the machine by the application. Result of the cash counting is the number of five baht and ten baht coins.

3.3 Connection of the device and sensor.

The experiment will use three kits, each consisting of one Arduino Uno R3, one NodeMCU V2 ESP8266, two Counter Sensors, one Breadboard 400 points, one Push button module, one RGB LED, and three resistors.

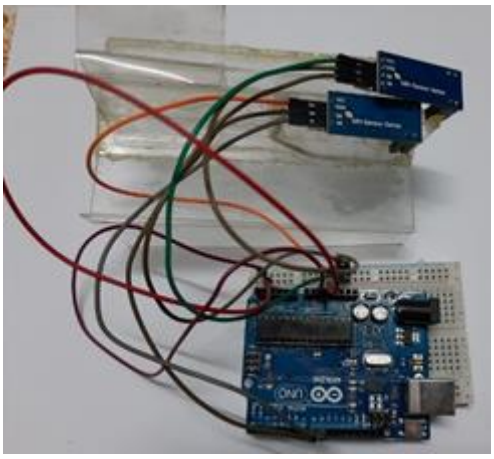

Figure 3. Connection of the Counter Sensor to the Arduino Uno R3 and the Coin Sorting Rail.

Figure 3, a counter sensor for counting five baht coins is attached to the board, connecting the Vcc pin to the breadboard on a pin+, connecting the Gnd pin to the breadboard on a pin -, and connecting a D0 pin to the Arduino Uno R3 board on pin 9. Next, attach a counter sensor for counting ten baht coins to the board by connecting the Vcc pin to the breadboard on a pin +, connect the Gnd pin to the breadboard on a pin -, and join a D0 pin to the Arduino Uno R3 board on a pin 8.

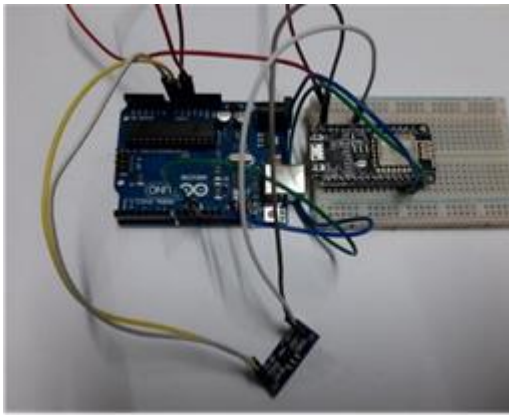

Figure 4. Connection of the NodeMCU V2 ESP8266 and Regulator to Arduino Uno R3.

Figure 4, NodeMCU V2 ESP8266 is connected to the breadboard by attaching the Vin pin to the VIN + pin of the regulator. Besides, connecting the Gnd - pin of the regulator, then joining the VOUT + pin of the regulator to the VIN pin of Arduino Uno R3 and connecting the Gnd - pin of the regulator to the Gnd pin of Arduino Uno R3. Then connect the D1 and D2 pins of nodeMCU V2 ESP8266 to the 10 and 11 pins of the Arduino Uno R3, respectively.

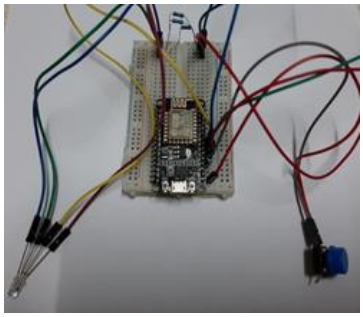

Figure 5. Connecting keypad modules and RGB LEDs to NodeMCU V2 ESP8266.

Figure 5, the Vcc pin of RGB LED is connected to the 3V3 pin of NodeMCU V2 ESP8266. Connect the R pin to the resistor of the D5 pin. The G pin is connected to the resistor of the D6 pin, and a B pin is connected to the resistor of the D7 pin. The push button module is connected to the D8 pin, and the other connects to the Gnd pin of nodeMCU V2 ESP8266. The connection of all three devices is shown in Figure 6.

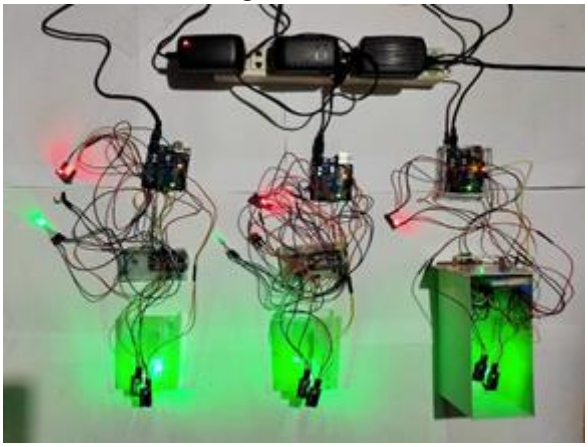

Figure 6. The connection of three devices.

Figure 7. Installation of a device into a coin-operated laundry machine.

After connecting the device to all three sensors, attach all equipment to the coin box of the washing machine.

3.4 Application display screen

Figure 8 Application home page

The main page of the application consists of 3 main functions: the detail function. Report output function and password correction function

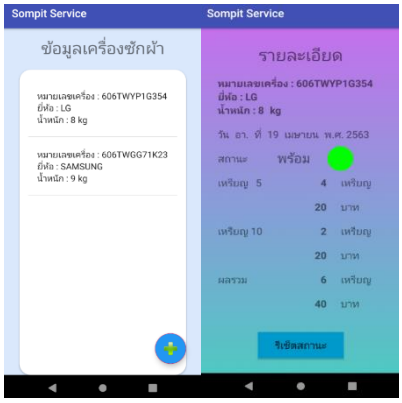

Figure 9 Application Detail Function

The detail function manages the washing machine that is already equipped with the device into the coin-operated laundry machine. It can check the status of the machine and the number of coins that are in it. If the status light is green, the washing machine can be used normally. If the status light is red This indicates that the washing machine has problems working. Once the problem is resolved, you can press the Reset Status button to return to its ready-to-use status.

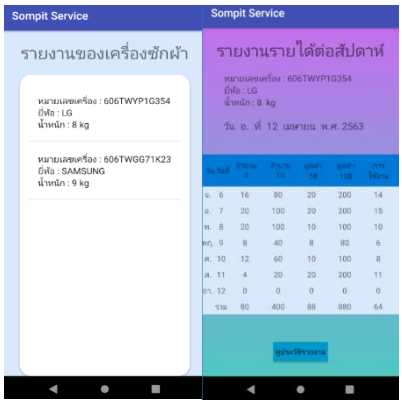

Figure 10 Reports earnings per week

Report function It is responsible for browsing the coin count history of each washing machine, displaying the number of coins, the countable value, and the number of use of the washing machine.

Results

Table 1 Testing the effectiveness of coin counting

Test pattern	Number of coins	Number of detected coins	Per cent detected by a sensor
Only 5 baht coins	200	200	100
Only 10 baht coins	100	100	100
Coin Drop includes two of 5 baht and one 10 baht coins.	150	150	100

Note: One coin drop is 20 baht.

Table 1 shows the results of the performance test of the coin count will be performed in three patterns of coin drops: four 5-baht coins, two 10-baht coins, besides one 10-baht and two 5-baht coins. The test results showed that a total of 50 times, all three patterns could count the coins with the sensor at 100 per cent.

Table 2. The performance test of the notification button.

Duration time (second)	Number of times										Accuracy (%)
	1	2	3	4	5	6	7	8	9	10	
0.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100

Table 2 shows the performance test of the notification button. The notification button will press to turn LED into red in three patterns: press and hold for 0.5 seconds, and press and hold for 2 seconds. All three patterns are testing for ten times.

Table 3. The performance test of counting coins in a week duration.

Display	Number of coins : Accuracy (Per cent)					
	Machine 1		Machine 2		Machine 3	
	5 baht coin	10 baht coin	5 baht coin	10 baht coin	5 baht coin	10 baht coin
Box	12	36	14	31	22	27
Application	12	36	13	31	21	27
Accuracy	100 %	100 %	93 %	100 %	95 %	100 %

Note: One coin drop is 20 baht, and space is one hour at a time.

Table 3 shows the performance test results of three coin counting in a week, which counts the coins in the box, compared to counting by the coin counting devices. The results showed that machine 1 counted coins from the box and obtained 12 of 5 baht and 36 of 10 baht coins; when the application displayed the counting of 12 of 5 baht and 36 of 10 baht coins, with the accuracy of counting the two types of coins at 100 per cent. Machine 2 counted coins from the box, and obtained 14 of 5 baht and 31 of 10 baht coins, while the application displayed the counting of 13 of 5 baht and 31 of 10 baht coins, with an accuracy of counting 5 baht coins of 93 per cent, besides 10 baht coins of 100 per cent. Whereas machine 3 counted coins from the box, and obtained 22 of 5 baht and 27 of 10 baht coins, the application showed the counting 21 of 5 baht and 27 of 10 baht coins, with an accuracy of counting 5 baht and 10 baht coins of 95 and 100 per cent, respectively.

Conclusion and discussion.

Based on the performance tests of the coin counting system, notification button, and mobile applications, the results were as follows:

1. The performance test results of the coin counting have tested patterns of coin drop with a total value of the one-time service fee of 20 baht. Three patterns of coin drop, including all 5 baht coins, all 10 baht coins, and 5 baht coins for ten baht, together with 10 baht coin for ten baht, a total of twenty baht. By conducting 50 tests for each pattern total of 150 times. Besides a total of 450 coins used, the sensor could check every coin and verify the correct value of all 450 coins, representing an accuracy of 100 per cent.
2. The performance test of the notification button from the front of the unit to the mobile application to determine whether the status and washing machine number are correct. The test was conducted in terms of the time distance of pressing the notification button in three duration times, 0.5 seconds, 1 second and 2 seconds, with the spacing range of ten times, a total correct result of 30 times. It obtained 30 accurate results, concluding that the effectiveness of the notification button was one hundred per cent accurate.
3. Results of the performance of the compatibility between the coin counting system and the display of the number and type of coins in the Mobile Application that was tested on three washing machines at different locations. It takes a total of one-week duration to test, and there is no less than an hour between each round. The results of the coin value check and report in the Mobile Application are one hundred per cent accurate. Regarding the number of coins counting, it found two inaccuracies of 5 baht coins, which occurred with machines 2 and 3, one coin each out of 14 and 22 coins, respectively. In conclusion, the interoperability performance is accurate at 98 per cent.

According to the research and development of a coin-counting system and notifications through mobile applications for coin-operated laundry machines, by applying the Internet of Things. It found that such a system can be applied, accurate and precisely for business operations. It is possible to gather information to create information for supporting decisions in the actual process of the businesses.

However, the researchers suggest that such a system could be applied to future businesses under Cyber-Physical System in another way.

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