IoT-Based Sales Reporting Devices

Noppon Manop, Kanyuma Kamata, and Surachai Suksakulchai

***Abstract*—Vending machines play an important role in selling goods because they do not require a salesperson to service or track sales and can sell indefinitely until the goods run out. To report the number of items sold and left in the vending machine, it is important to make the trip to the machine and print the report, and it is inconvenient for the vending machine administrator. Therefore, the present study makes use of IoT technologies to track inventory and sales data. The system used ESP32 microcontroller as a main controller and UC-15 module was used as the Internet connection. The system was tested for seven days with ten vending machines that had IoT-based sales reporting devices installed. Throughout the test, all data was transferred to a central server every two minutes, totaling 720 times each day. From the results of the experiment, it was found that the data can be sent to the server with a success rate of 98.04%. Twenty employees of Asia Vending Machine Operations Thailand were selected for the satisfaction study, and they were extremely satisfied with the sales report device.**

***IndexTerms*—IoT, reporting device, vending device.**

I. Introduction

Nowadays, vending machines are increasingly important in Thailand. There are vending machines that creates new investment opportunities for efficient product sales. There is no need for additional personnel. Vending machines can sell a wide range of products and generate higher returns on investment. Buyers have the options to purchase products at any time. They can also pay by coin or banknotes and receive the desired product. However, in order to check the selling report, the vending machine operator would have to bring the printer to the vending machine in order to check the data and send it to the company, which is inconvenient for the vending machine manager.

The Internet of Things (IoT) is a type of Internet technology that allows computers to connect and control devices. IoT is a system that connects and interacts with electrical equipment over the Internet, allowing humans to control things in their homes and offices from anywhere at any time [1]-[3].

In addition to Internet connectivity, IoT technology will enable enterprises and individuals to gain insights and control over the data generated by objects and their surroundings. IoT technology may also be used by organizations and individuals to stay connected to the outside world and their surroundings in order to work or function more effectively and fluently. Today, vending machines have been digitalized, allowing them to track information and sales at all times and aiding in sales management. ESP32 is the name of a microcontroller board with built-in WIFI and Bluetooth capabilities. The ESP32 includes the following detailed information: Its CPU has a dual-core architecture, a 240MHz clock, 512KB of built-in RAM, external ROM support up to 16MB, and 802.11b/g/n standard WIFI that supports both station softAP and Wi-Fi direct modes. It includes Bluetooth 2.0 and 4.0 BLE modes built in, with an operational voltage range of 2.3V to 3.6V [4], [5]. In this research, all functionalities in this study were controlled by the NodeMCU ESP32, which connected to the internet through the QUECTEL 3G Module [6]. In order to access the internet service provider, this module requires the usage of a SIM card. The purpose of this study was to develop a technique for communicating vending machine data, e.g., remaining commodities, to a central server via an IoT system rather than the traditional approach of printing on paper [7].

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Noppon Manop, Kanyuma Kamatam, and Surachai Suksakulchai are with King Mongkut's University of Technology Thonburi, Thailand (e-mail: noppon.mano@kmutt.ac.th, kanyuma.j@mail.kmutt.ac.th, surachai.suk@kmutt.ac.th).

II. Concept and Approach

Developing an IoT system makes it easier for vending machine administrators to read data from machines. The former vending machine method required the machine administrator to print the receipt from the machine. Therefore, the researcher offered a novel concept for constructing an IoT-based sales reporting device that would interface with the vending machine to receive data and send it to the server. Furthermore, the management system enables machine administrators to examine the sales system and stock information within vending machines in real time, allowing them to manage the sales of goods [8]. Fig. 1 shows the concept of reporting the sales using IoT technology. The device, which consists of a microcontroller ESP32 [9], and ET-3G UC15 [10] reads data from the vending machine and sends it to a server. The information may then be displayed on the website and tracked by users via both mobile phones and computers.

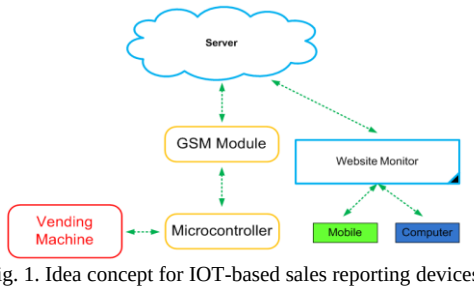

Fig. 1. Idea concept for IOT-based sales reporting devices.

III. Hardware

A. Hardware Diagram

Fig. 2 depicts the design of a hardware part. The first section (number 1) is power supply circuits, which supplies

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power to the circuit (KIA278R33 and MIC29032) by receiving 8VDC from a vending machine. The KIA278R33 supplies 3.3VDC to the ESP32 microcontroller and MIC29032 would supply 3.88VDC to the GMS module. The second component (number 2) is the Buffer circuit, which is needed to transform the signal from the vending machine to ESP32 format. The third part (number 3) is the processing unit. All of the IoT-based sales reporting devices are controlled by the ESP32, and the data is then delivered to the server through GMS via the internet provider service [11]. The reading intervals is also shown and may be changed via the server.

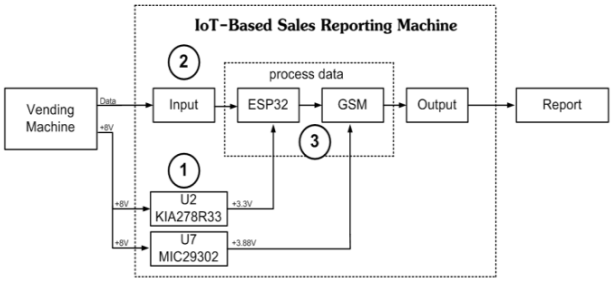

Fig. 2. Diagram IoT-based sales reporting devices.

B. Component IoT-Based Sales Reporting Devices

The hardware used to develop the machine is PVC because the machine must be installed in the vending machine. Non-conductive objects are therefore suitable in design. The components of IoT-Based Sales Reporting Devices demonstrated in Fig 3 include 1) GSM Antenna, 2) SIM Card Socket, 3) Led status for IoT-Based Sales Reporting Devices, 4) Connector data Vending Machine, 5) USB connector programming, and 6) Magnetic screw and Nuts, size 95×210×30 mm.

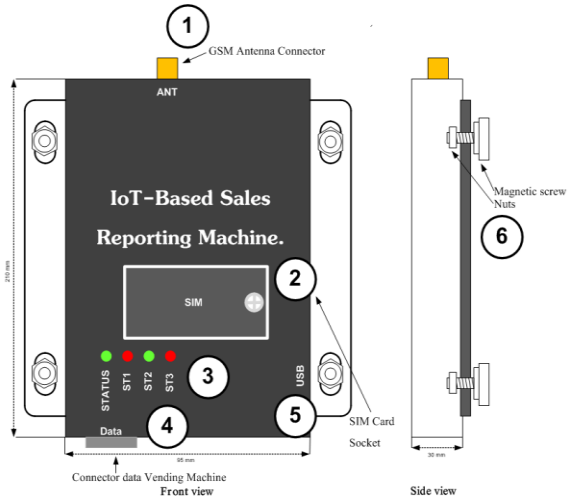

Fig. 3. IoT-based sales reporting devices.

C. Internet Communication Use ET-3G UC15 Modules

ET-3G UC15 [10], [12] is a development kit for the telecommunication system by cell phone that mainly uses Module UMTS/HSDPA #UC15-T of QUECTEL; this UC15 [11], [13] device is the Module Communication UMTS/HSPA that supports GSM System with the Frequency of 850/900/1800/1900 MHz and UMTS(3G) with the Frequency of 850/2100 MHz. It uses AT Command to command the Module UC15 via PORT RS232. In IoT-Based Sales Reporting, Devices use ET-3G UC15 to send data to the server in connecting protocol HTTP [14], [15]. Microcontroller ESP32 controls the module power on/off and the module to be rebooted. The use of this module necessitates the use of a SIM card in order to access the service provider's Internet signal, as shown in Fig. 4.

Fig. 4. ET-3G UC15 modules [10].

D. Voltage Regulator KIA28R33

KIA278R3 was used to design the power 3.3 V. The regulator has multi-function, such as over current protection, overheat protection, and Max current 2.0A TO-220 was selected because of a large structure used to disperse heat of system well [16]. The circuit is demonstrated in Fig. 5.

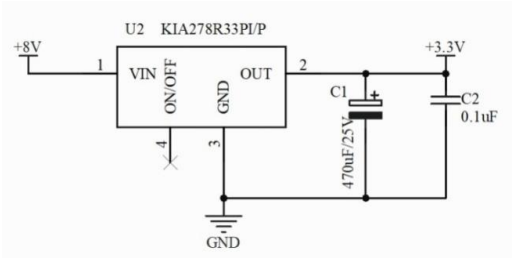

Fig. 5. Regulator KIA28R33.

E. Voltage RegulatorMIC29302

MIC29302 was used to design the voltage regulator GSM UC15 [17]. The regulator has a maximum output current of 3A. The regulator's input voltage can be between 3V to 16V, and the output voltage can be configured between 1.24V to 15V by using a couple of resistors. The equation (1) was used to calculate. VBAT or power supply voltage of GSM UC-15 The value of calculation showed R37 = 100K, R36 = 47K Voltage, VBAT = 3.88V. The circuit is shown in Fig. 6.

$$VBAT = 1.242((100K)/47K)+1)$$
$$VBAT = 3.88V \quad (1)$$

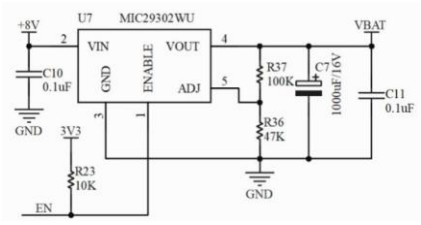

Fig. 6. Regulator MIC29302.

F. Microcontroller NODEMCU-ESP32

Microcontroller ESP32 was used to control for IoT-Based Sales Reporting Devices. Designing software parts on ESP32 used the Arduino IDE. The program using Arduino IDE connected with two devices contacting with the vending machine using IO NODEMCU-ESP32 [9], [18], [19]

contacting with the GSM UC-15, using USART TX2, RX2 to communicate to each other. NODEMCU-ESP32 [20] send AT Command to command the Module GSM UC-15 UC15 as designed by the program and has IO pin ON/OFF control to reboot module GSM UC-15 as shown in Fig. 7.

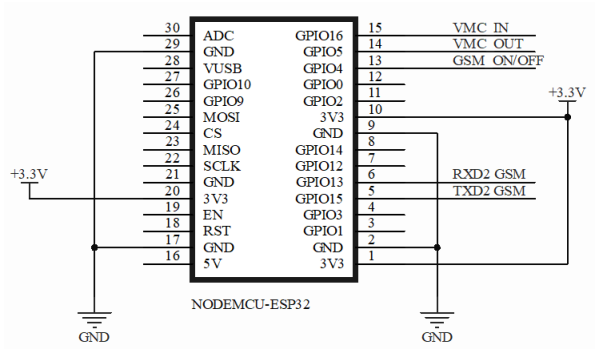

Fig. 7. NODEMCU-ESP32 modules.

Fig. 8 shows the IoT-Based Sales Reporting Devices that has been successfully created.

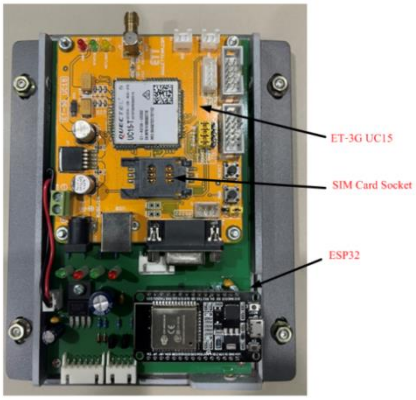

Fig. 8. The IoT-based sales reporting devices.

IV. Software

A. Software Design

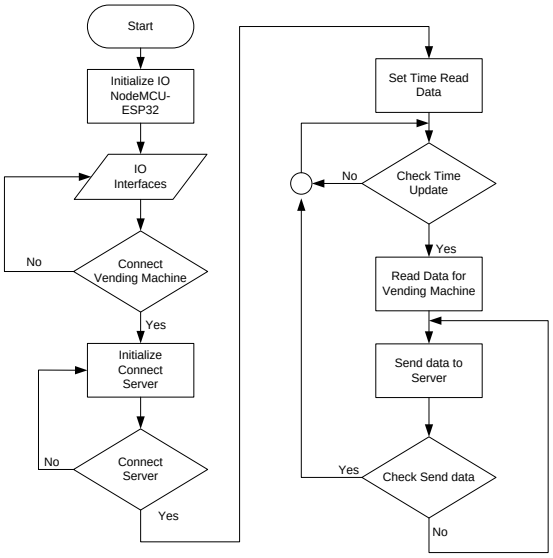

Fig. 9. Flowchart software.

The Arduino IDE [21] an open-source application, will be used to write operating codes and it operates as a bridge between computers and the ESP32 board in order to write to a program to microcontroller. The Arduino IDE begins by setting the NodeMCU-ESP32's IO so that it can work properly. After that, the program will then connect to the vending machine. The next step is to initialize the server via HTTP and wait for it to reply. The server was reacting by sending current day and time to the ESP32. The device sends the current state of the vending machine, including the reading intervals, to the server. The program will execute according to the time specified by the set loop as shown in Fig. 9

B. User Interface

In part of the web monitor, the website can display the current status of the vending machine. Fig. 10 depicts a portion of the receipt read from the IoT sales report machine and viewed via the web [21]-[25].

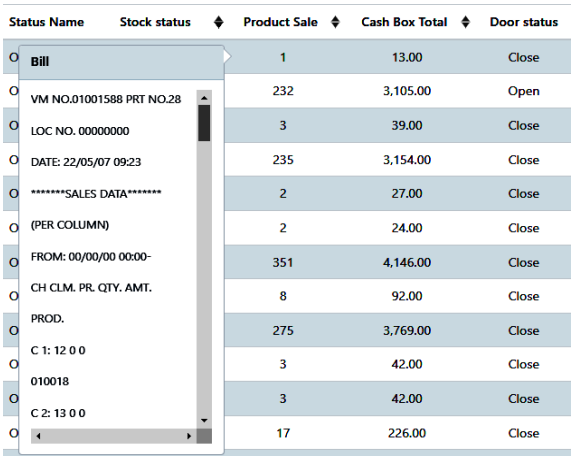

Fig. 10. Web monitor show sales report.

Fig. 11 shows overall sales and the amount of money in the vending machine. The first column reflects the status of the vending machine, which is green while online and red when offline. The second column is the VM No., and the third column is the Name, which is the vending machine's description. Product Sale is the number of products that can be sold, and Case Box Total is the total amount of money for the product sold.

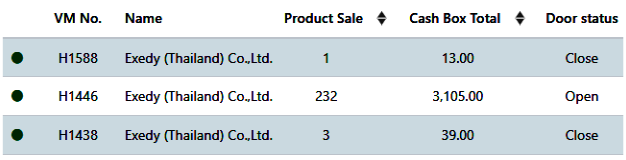

Fig. 11. Web monitor show sales total report.

The web monitor on the mobile phone is shown in Fig. 12. The total number of items sold, and the total sum are displayed.

Fig. 12. Sales report on the web monitor.

V. Experiments

A. Voltage Measurement Test for MIC29302 and KIA278R33

The FLUKE114 meter was used to evaluate the output voltage of the MIC29302 and KIA278R33, which required five days and was tested every 30 minutes from 8:00 a.m. to 5:00 p.m. The average output voltages of MIC29302 and KIA278R33 are shown in Table I.

TABLE I: Voltage MIC29302 and KIA278R33

Day	MIC29302	KIA278R33
1	3.30 V	3.85 V
2	3.31 V	3.88 V
3	3.29 V	3.87 V
4	3.31 V	3.90 V
5	3.30 V	3.74 V
Avg.	**3.30 V**	**3.79 V**

B. Vending Machine Reading Interval Test

Reading intervals testing is a measure of time used to read data the from a vending machine, started from the initial reading to the end of the reading process. The test of vending machine's reading data took five days, and each day would test to send the data 720 times. Table II shows the example of reading interval test results.

TABLE II: Reading Intervals of Vending Machine

Day	1st	2nd	3rd	4th	5th	Avg.
5	1:43m	1:45 m	1:48 m	1:42 m	1:40 m	**1.43 m**

C. Data Transmission Speed Tests

To measure data transmission speed, the time spent from start to end of data transfer is recorded. Table III show examples of the average data transmission time for 5 days of testing, with 720 data transfers done each day.

TABLE III: Time Transmitting Data to Server

Day	1st	2nd	3rd	4th	5th	Avg.
5	10s	11s	8s	12s	10s	**10.2s**

D. The Device's Data Transmission Test

The performance of the IoT-Based Sales Reporting Devices is determined by the transmission efficiency and accuracy. The devices were installed on 10 vending machines owned by the target company in Thailand, and the test last 7 days. The data was transmitted 720 times a day at a rate of two minutes per transmission. The results of analyzing the data from the experiment revealed that the lowest percentage of data transmission in the fifth and tenth vending machines was 95.77% and 97.2%, respectively. This is because the fifth and tenth machines were placed within the production facility, causing the percentage of accuracy lower than other vending machines due to the signal strength of the signal being lower than other machines. The data transmission accuracy was highest on the eighth and ninth devices (99.21%). This is because the two vending machines are positioned outside the facility, therefore the signal strength is adequate. The efficiency of each machine in data transmission is shown in Fig. 13.

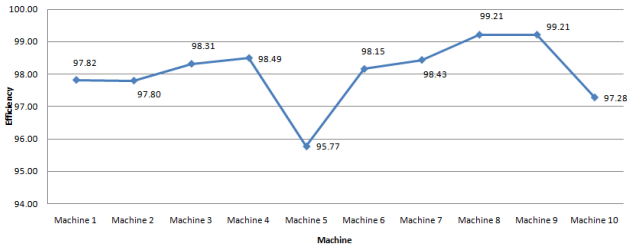

Fig. 13. The efficiency of the machine in transmitting data.

Fig. 14 depicts the percentage of data transmission for each time period, divided into three-hour intervals of ten vending machines throughout a seven-day period. The data was sent 90 times in each period. The period with the lowest percentage of transmission succeeded was 6:00-8:59, with the lowest value of 96.97%. This is Because numerous employees accessed the network at that time. Due to low network utilization, the time period with the highest proportion of successful transmissions was 21:00-11:59, resulting in 98.67% accuracy.

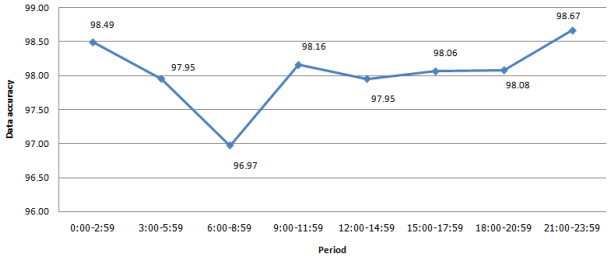

Fig. 14. Data accuracy by time interval.

E. Users' Satisfaction

The sample consisted of 20 employees from Asia Vending Machine Operations Limited's product preparation department who were asked about their satisfaction with utilizing the devices. The sample was chosen by the purposive method. The satisfaction survey consisted of 11 items, shown in Fig.15. The findings revealed that users had the highest satisfaction with the accuracy of the total money and the accuracy of opening and closing the door, which showed 75% of high satisfaction.

The findings revealed that users were the most satisfaction with the accuracy of total money and the accuracy of opening and closing the door, with 75% of strongly satisfied. The item with the lowest percentage of satisfaction was the manual's clarity. This is due to users do not understand the manual thoroughly.

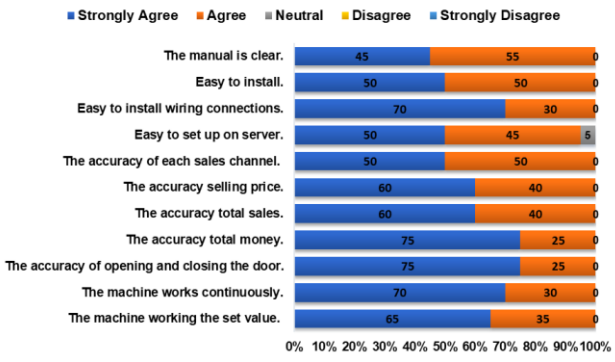

Fig. 15. The customer satisfaction.

VI. Conclusion

In this study, the ESP32 microcontroller was used to control all processes in the creation of an IoT-Based Sales Reporting devices using IoT system with the ET-3G UC15 as a communication interface with the internet network. It is a non-conductive device in the design of the exterior structure, and it magnetically connects the box to the cabinet for convenient installation between the vending machine and the IoT-Based Sales Reporting device's body. The accuracy of data transmission received every two minutes, for a total of 720 data a day, was used to evaluate the functioning of the IoT-Based Sales Reporting devices. The average percentage of data transmission of ten vending machines is 98.04 The lowest transmission rate for the test was 96.97 percent between 6:00 and 8:59 a.m. The accuracy of the total money and the accuracy of opening and closing the door received the highest ratings from users of the IoT-Based Sales Reporting devices.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Noppon Manop developed the IoT-Based Sales Reporting Devices and collected data, Surachai Suksakulchai analyzed the data and Kanyama Kamata designed methodology. However, the three researchers conducted the research and wrote the article together.

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Noppon Manop is 2nd year master student at the Electrical Technology Education Department, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi, Thailand.

His research was related to electronics and the development of programs using a microcontroller.

Kanyuma Kamata is a lecturer at Electrical Technology Education Department, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi, Thailand.

Her research relates to teaching and learning in the area of electronic, electrical, and robotics.

Surachai Suksakulchai is an associate professor at the Electrical Technology Education Department, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi, Thailand. He received his bachelor's degree in Electrical Technology Education in 1985 and Electrical Engineering in 1987 from King Mongkut's University of Technology Thonburi, Thailand. He also received master's and doctoral degrees in Electrical Engineering at Vanderbilt University, USA. His current research includes robotics, electrical education, and robot-based education.