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Development of an electronic payment system using the Internet of things

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ABSTRACT

Smartphone has become more widely used than ever and become necessary to develop electronic payment systems using the internet of things (IoT) techniques with the smartphone. Payment solution is one of the most important issues in the IoT. It is the future to make life easier and better through the new relationships will be commercial, requiring payment for services and products. This paper develops a prototype of a payment system consisting of a network from several interconnecting devices such as radio frequency identification (RFID) reader, RFID card tag, equipped with microprocessors NodeMCU, and corresponding software represented by an interactive website for making process of purchase, a database (MySQL) for store data of payments. Focusing on the side of protecting the payment system, a security model for a simplistic payment system based on the IoT is represented by using biometric authentication in the sensor of smartphones like fingerprint authentication and face detection to make sure the identification of the user before making the payment process in the system.

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1. INTRODUCTION

In many sectors, the development of information and communication technology (ICT) in the second part of the twentieth century has transformed the way they do business. Communication services and the banking sector expanded fast as a result of technological advancements, whereas the customer electronics business would have been impossible to imagine without these successes [1], without requiring physical resources at hand.

Electronic payment systems are restricted to a few institutions that are strategically located, but after the COVID-19 pandemic, it has altered the way to interact with electronic payments [2]. Different services and apps are used. Since then, the Internet of things (IoT) has proven to be highly influential and has become the quickest developing technology, as seen by the fact that IoT devices are expected to reach 21 billion by 2025 [3], [4]. Service providers are attempting to keep up with the rising technological development and the deployment of modern technology in a variety of fields, such as electronic payment, which allows clients to make all transaction payments electronically [5]. In the same way, manual and traditional processes are continuously used by some banks and payment processes. Every transaction requires the application of numerous documents and can be a lengthy process [6]. Therefore, the electronic payment system is the backbone and one of the most important aspects of e-commerce. It is a payment service that uses information and communication technologies such as embedded system (microprocessor) cards, encryption, and communication infrastructure [7].

Payment gateways, which operate as a point of entry to many financial institutions, handle each online transaction. These payment gateways confirm payment data between multiple parties and banking organizations [8]. Electronic payment networks connected to internet devices are currently limiting, some people may find them difficult to deal with and prefer to use cash rather than bank accounts, resulting in a financial liquidity shortage. As a result of the reduced investment in new projects, the national economy may suffer. Furthermore, paper transactions are performing in delays and the use of human resources.

As a result, the goal is to develop a general electronic payment mechanism for smart devices that is simple to use for everyday people, as well as to address the issues mentioned earlier. Therefore, this paper presents an electronic payment system based on the IoT and looks at the aspects of system protection issues and the modern methods used recently, such as fingerprint or face print.

2. RELATED WORK

This section introduced the related work about the electronic payment system (ESP), focused on the methods and components that are used in the system for each paper. Husni and Hidayat [9] designed a payment system that uses SMS gateway and Line API to cover the entire area where the people can employ this system to accomplish any transaction, which includes sales, buys, top-up balances, and cashback. Noer *et al.* [10] discussed how radio frequency identification (RFID) can be used for authentication and offline intelligent payment in public transit. This authentication is complete without a contact smart card that serves as an e-ticket and an identity card, using Raspberry Pi 3 Model B, MFRC522, and LCD Waveshare 3.5 as the basis of the system.

Lee *et al.* [11] demonstrated a straightforward payment mechanism using OneM2M and an IoT gateway. Users can order menus from a shop using a smart device via the system, and the store management can check the business's menu and order status via the IoT gateway. Aigbe and Akpojaro [12] discussed electronic payment system security risks. Each payment option includes advantages and disadvantages for both clients and shops. The importance of analyzing security levels concerning fraud vulnerability is stressed, and they assess how this relationship affects user confidence. Ramzan *et al.* [13] explained the improving of the traditional cash-based payment system, which has many flaws and risks, a secure payment system in the vending machine using radio frequency identification technology has been developed. Passive RFID identification cards and readers, an Arduino Mega microcontroller, an SPI protocol for RFID and Arduino interfacing, a keypad for authentication, a liquid crystal display (LCD) for displaying the user's name and current balance, and a GSM modem for sending SMS notifications are all included in this system. DC motors driven by relays in the vending machine's mechanical structure support spiral coil architecture and Actuators are provided by relays in mechanical structures.

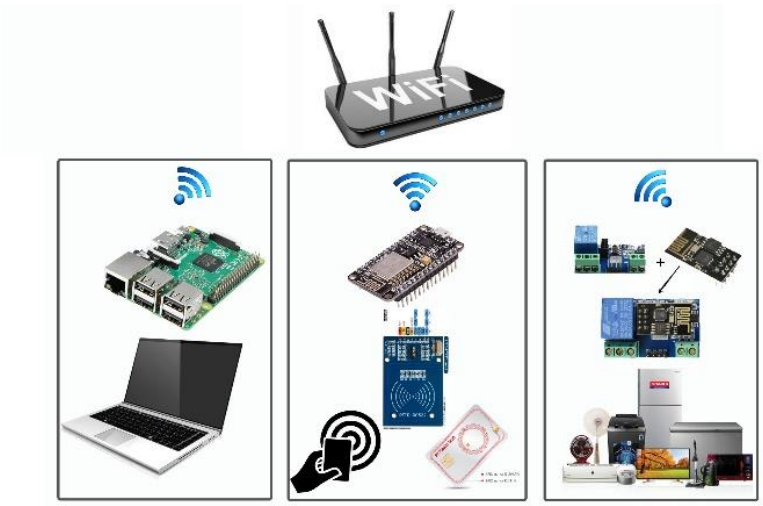
3. MATERIALS AND METHODS (METHODOLOGY)

Different sides and components make up the suggested information management system. As a result, it has been separated into sections to make it easier to read.

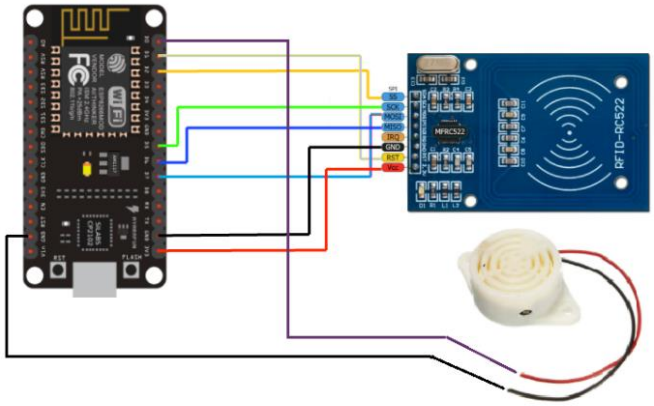
3.1. System structure

The system is subdivided into three major parts made up of different hardware and software that are linked together through the local network or public network based on the IoT techniques such as cloud, IFTTT services, and database (MySQL). The three major components are represented in Figure 1(a).

- The first component is a local server (Raspberry Pi) and a web server (cloud): this part has a database, and the website's host may control the system through it; all the system's key processes occur there, and all the customers' purchase logs are stored there.
- The second components are a microcontroller (NodeMCU) and a card reader with an RFID (tag) system designed to receive input data from the customer [14], can connect between them through pins as shown in Table 1. Clients can check in with the database using their unique ID discovered on the card; hence, these devices assist us in verifying the identity of customers with the seller [15]. It can represent the physical connection between them through Figure 1(b).
- The third component includes a Wi-Fi relay as well as any electric devices: it created a system to enable services such as park gate opening, hall reservation, sports club (gym), hotel booking, bus ticket, and so on. These services may necessitate the use of a relay to control the operation of electrical systems in real-time [16].



(a)



(b)

Figure 1. Proposed system structure: (a) main components and (b) connection between NodeMCU and RFID reader

Table 1. The pin connection of NodeMCU with RFID Reader

Node MCU Pins	RFID Reader Pins
D2	SDA/SS
D5	SCK
D7	MOSI
D6	MISO
GND	GND
D1	RST
3V/3V3	3.3V

3.2. System architecture

This part explains the block diagram of the process when a customer uses an RFID card in the payment system. First initializing microcontroller Node MCU and RFID reader when clients use his RFID tag contain unique identity (UID) as the input to check if exist in the database if happen any fail try again else pass to next step is check from biometric authentication in proposed system use the sensor in the smartphone to check from identity at the database. Lastly, check out the items in the cart or pay for some of the services you wanted and receive the message to inform the customer success of the purchase, this message can through SMS to a phone number or his email by using the services of IoT cloud such as IFTTT [17]. All that can be illustrated in Figure 2.

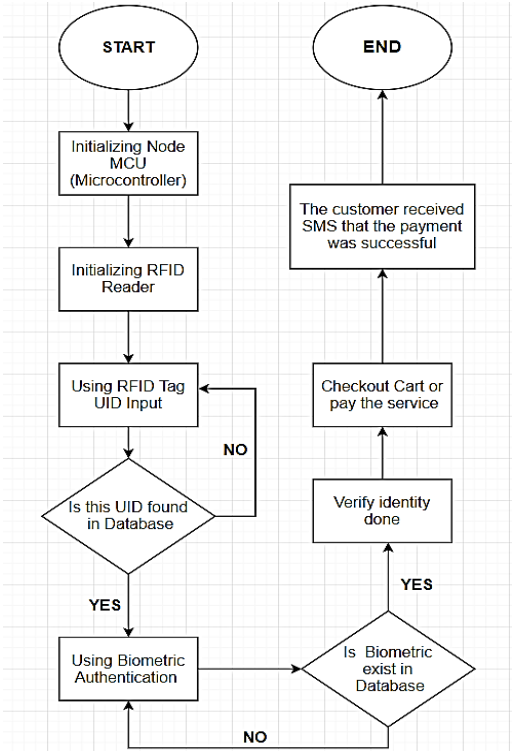


Figure 2. Block diagram of system architecture for a customer verification method

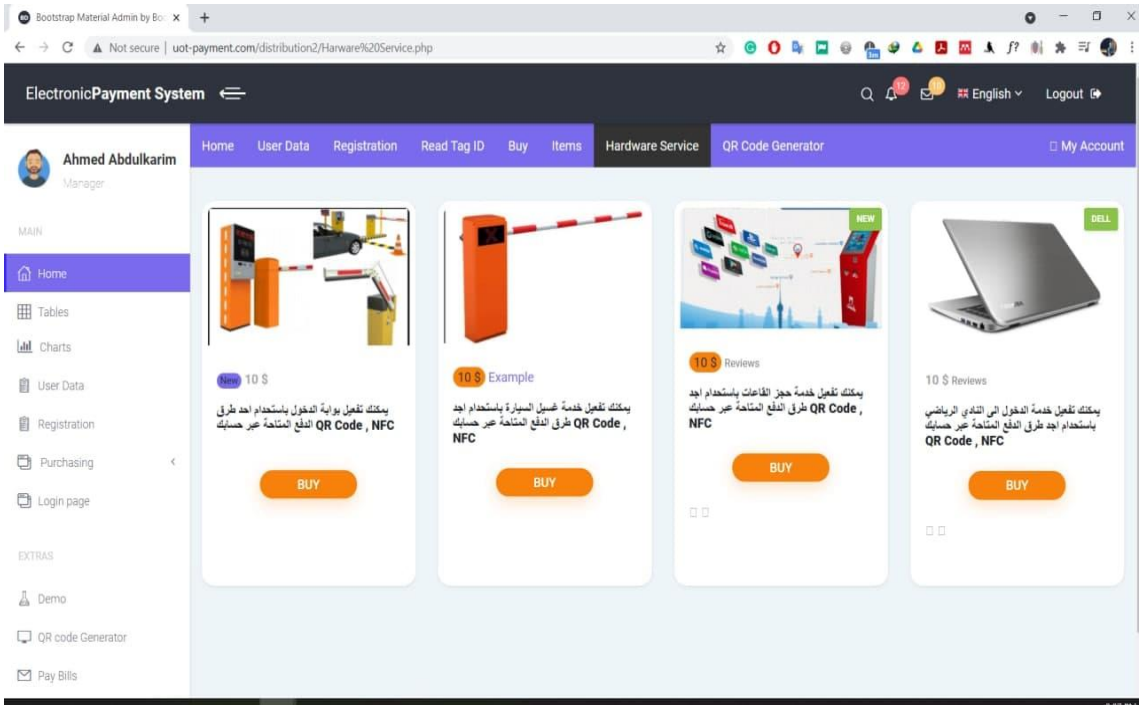
4. DESIGN THE PAYMENT SYSTEM

In this section, we will explain a prototype of the electronic payment system.

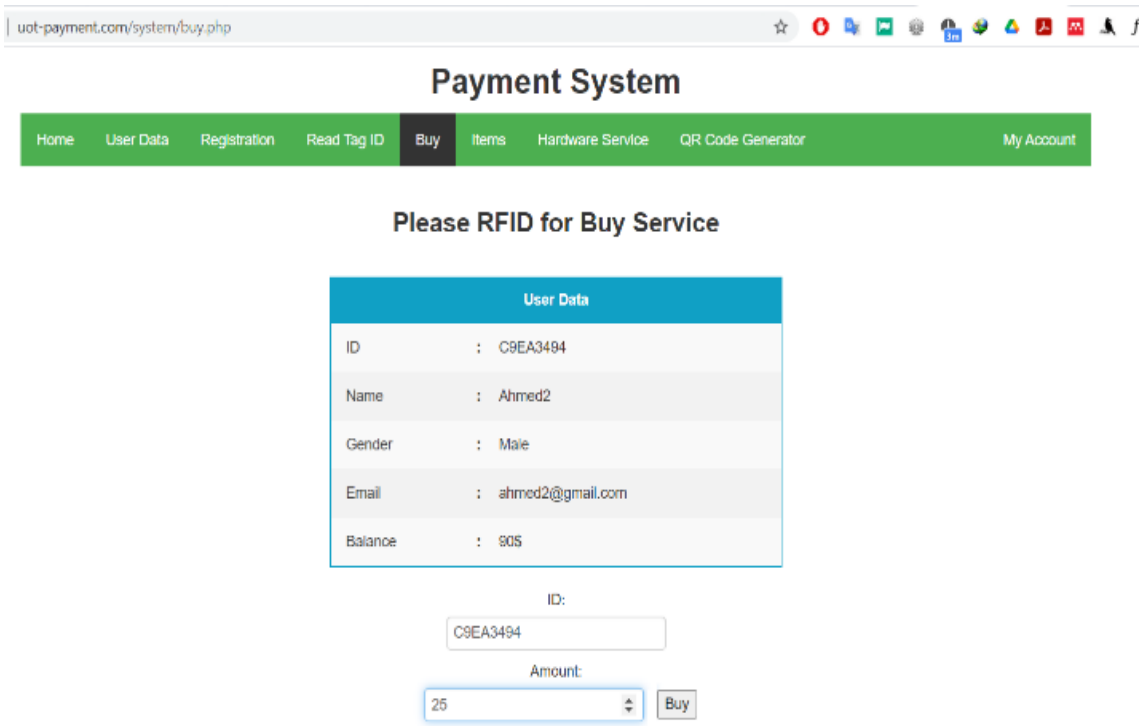
4.1. Interactive website

The site consists of several pages organized in hierarchical structure. The first page contains a description of the system and the login panel as shown in Figure 3, then select the items you want to pay for it or would be the services get it and through the RFID card pass on the reader the UID send to the website of the electronic payment system by using a webhook technique after that compare with database to verify this purchase [18]. The store's items can be shown in Figure 4(a) while Figure 4(b) represents the balance and other details of the RFID card.

Figure 3. The main page in electronic payment website



(a)



(b)

Figure 4. Payment page on the website (a) select items and (b) get RFID for the customer

The website is one of the content management systems (CMS) by using a database (MySQL) to store all recodes of the transaction and the personal information of customers such as table contains name, email, gender, and UID to making confirmation if this account exists in the database [19], as shown in Figure 5.

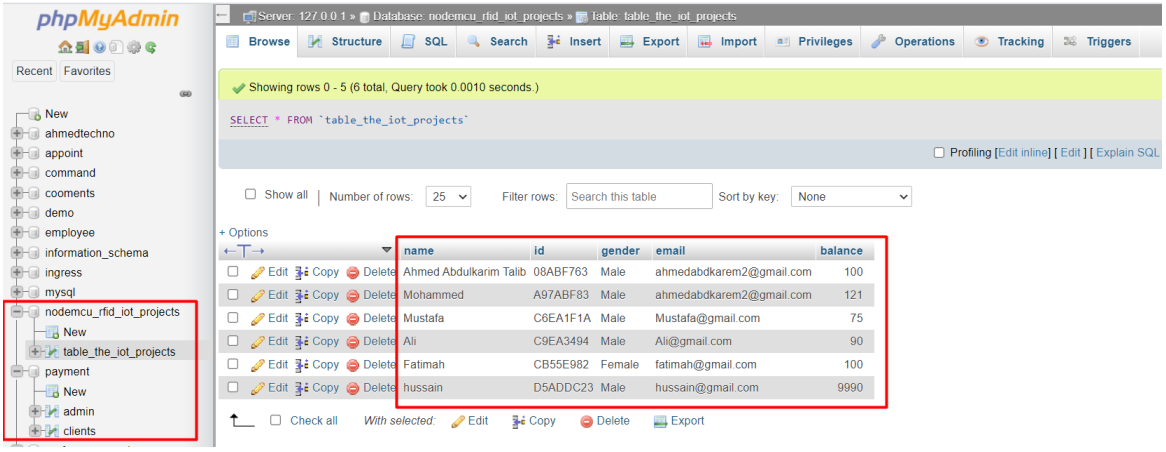


Figure 5. MySQL database of the electronic payment website

4.2. Application for smartphone

A smartphone application is developed using the sensors in the phone, represented by the fingerprint and the face detection in this application to verify the identity of the user. Nowadays, the smartphone has become more and more popular with its ease and flexibility of use [20]. The application consists of several fragments, the first interface is the main interface of the login interface by using the fingerprint of the client, after that the second interface contains to select the payment method, as well as the website can be accessed through a WebView of the phone application [21], all that illustrated in Figure 6.

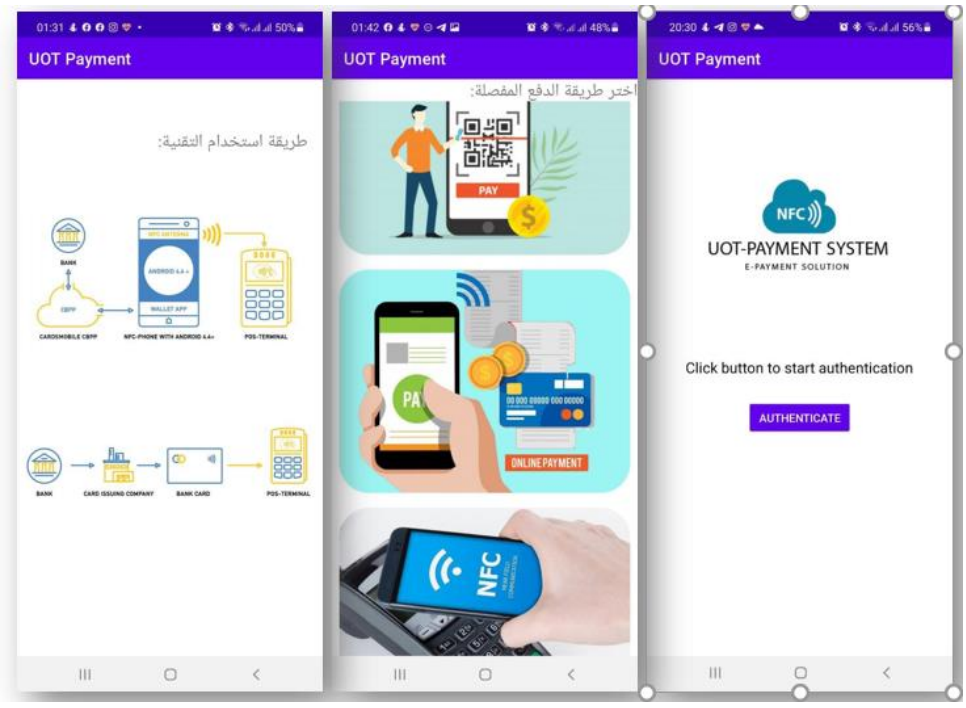


Figure 6. Interfaces of the payment system application

The site has been designed to be responsive with smartphones, where we can browse the site and choose the items, we want to purchase through a mobile phone without using a computer, where we can easily modify personal information and make sure that there is enough balance to purchase any service we want or choose goods through the stores available in the application as shown in Figure 7.

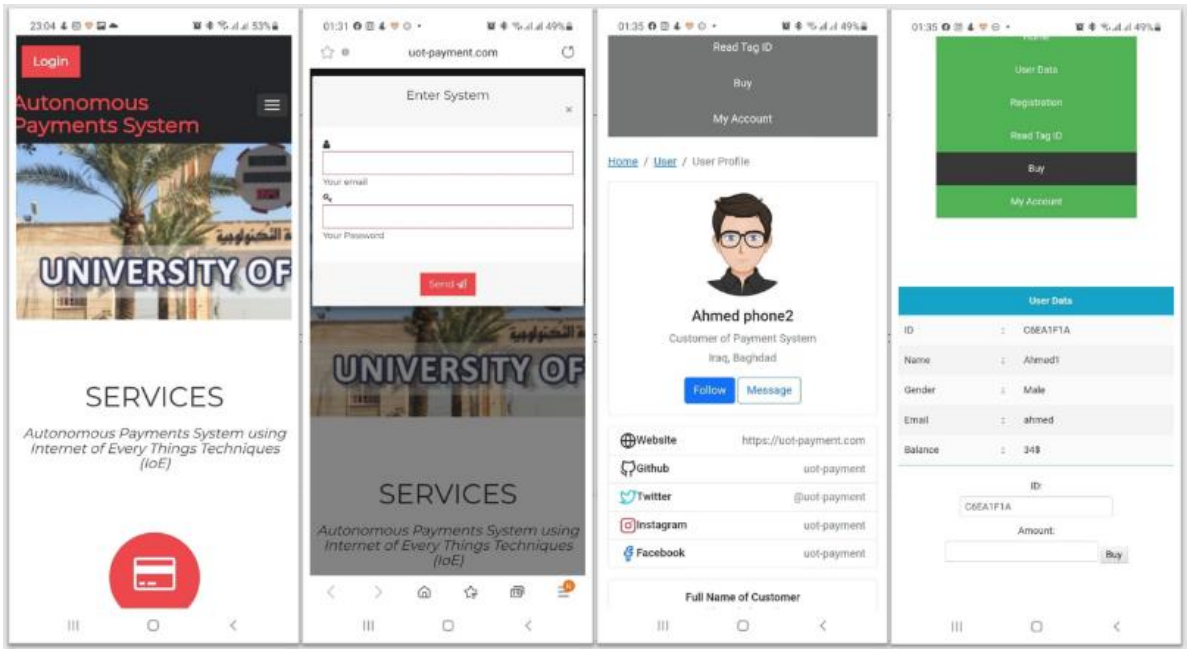


Figure 7. Interfaces of the payment system application

5. RESULTS AND DISCUSSION

A prototype was designed in the electronic payment system consisting of multiple devices connected with three-level authentication to complete the purchase process, as shown in Figure 8. This prototype can simulate the proposed protection systems before making the payment. The proposed model has created three stages to confirm the payment process, the first stage using RFID card, the second stage by entering the password via the keyboard, the third stage using a fingerprint. It can be applied to the three steps of the authentication level or only one step according to the place and need, as shown in Figure 9.

Figure 8. Hardware system connection

The results represent a message (SMS, email) is sent to the client after success purchasing, using an IFTTT cloud, the term meaning (IF This Then That) is widely used in works of IoT systems and can integrate it with Arduino Software (IDE) in Node MCU by code this process happen through using application programming interfaces (APIs) enable users to interact with anyone, as shown in Figure 10.

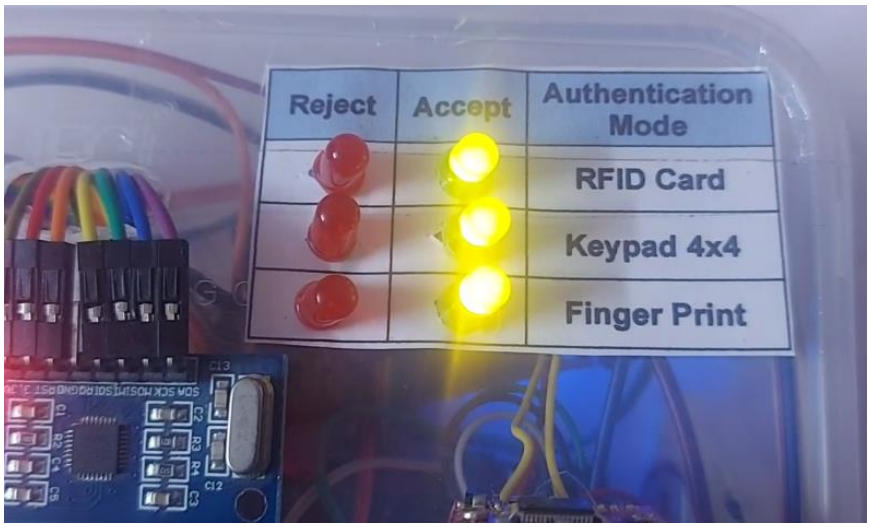


Figure 9. Hardware system connection

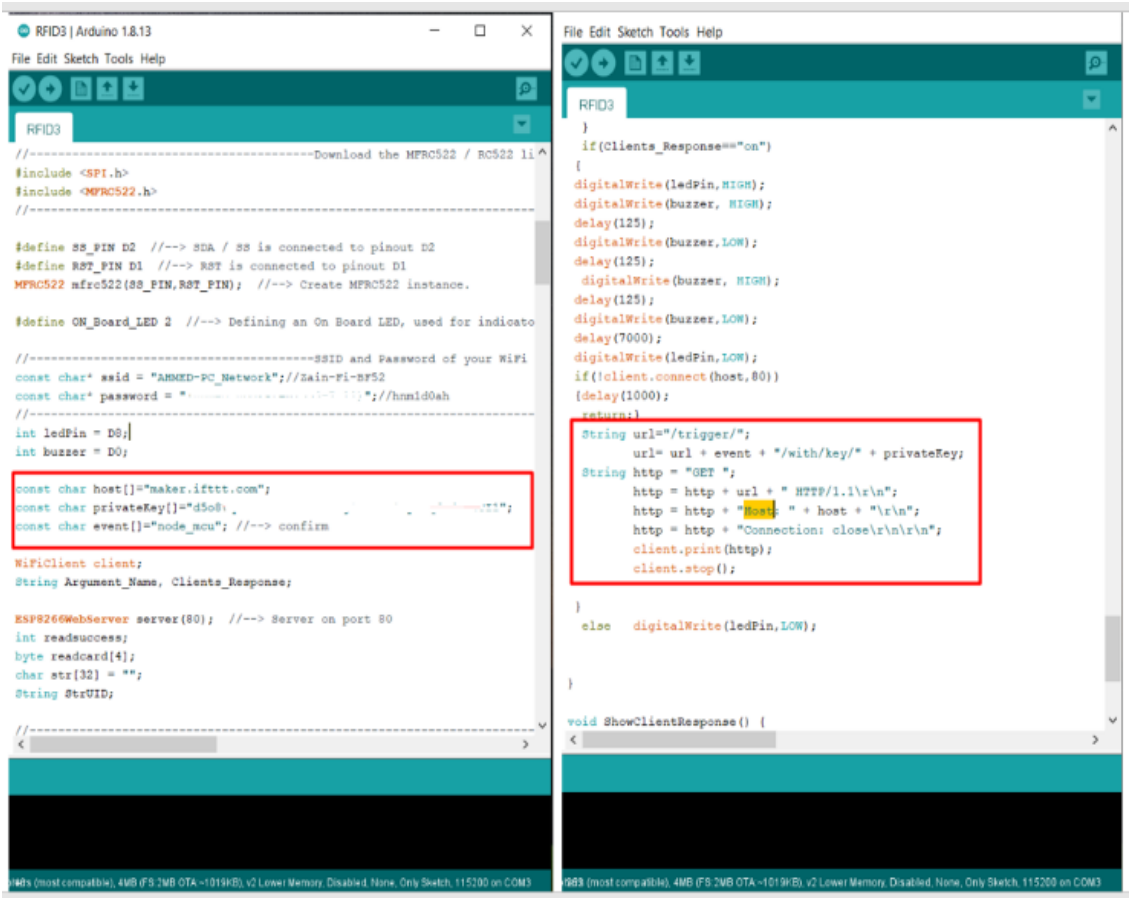


Figure 10. The code of IFTTT integration in Arduino IDE

After purchasing from the website, we make the payment process, to ensure the success of the payment process. We use the webhook technique through receiving a trigger from the system by a transaction that happens from a bought process. This data is sent to the IFTTT cloud to enable send message to the client for informing it about purchasing, then a message will be received on your email or mobile phone, confirming that the payment was successful, as shown in Figure 11.

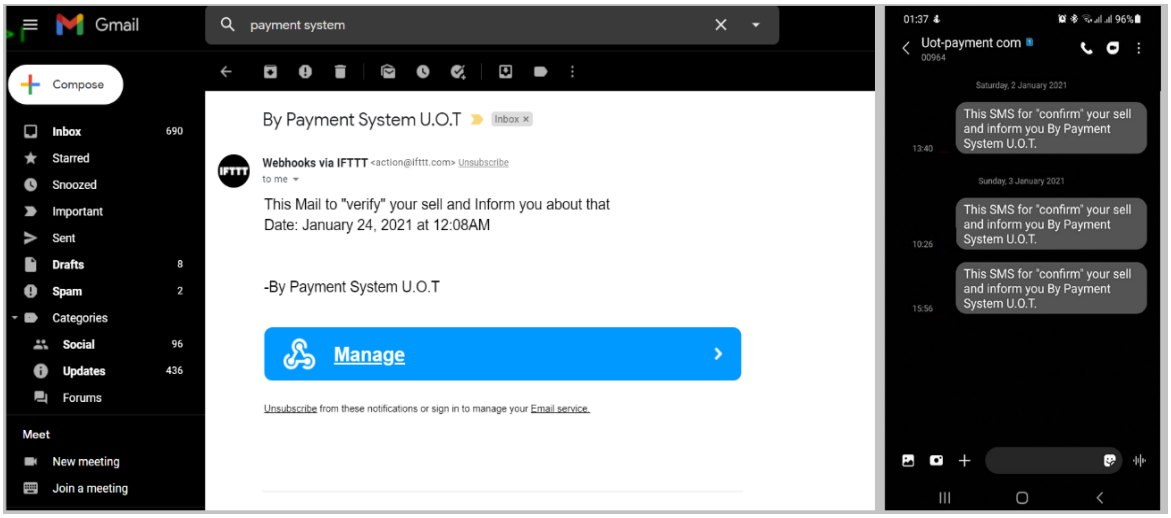


Figure 11. The resulting message (email, SMS)

6. CONCLUSION

Plan to provide a futuristic vision of how fintech (financial and technology) might impact our daily lives and how electronic payment systems with IoT cloud computing can improve financial services in the future. In this paper, the prototype of the payment system is used to describe and demonstrate the concept. The chapter's key contribution is its inclusion of previously unimagined topics in which the researcher could focus, which will serve as a watershed moment for the research community. There are also areas that require a great deal of investigation that have yet to be answered. As a result, the system will be useful in determining the user's budget represented by electricity, water, shopping, and other outgoings, thus helping to improve his budget management.

The prototype of this system can be used in various aspects of e-commerce. These purchases may be software or hardware, such as a service provided to the customer, for example, using the payment to open an electronic gate to enter a club, paying bus fare, paying hotel fare, and other tangible services. It does not only achieve new economic growth by providing financial liquidity but also provides a competitive element for e-commerce, which our current era has become highly dependent on for its ease without human mistake. Even while IoT technology is still in its early stages of adoption, the relevant technology is beginning to mature. The current research should focus on a mobile payment system in order to obtain a considerable advantage from IoT technology. Only in this way will innovative IoT technologies be put to good use, giving a huge boost to the development of mobile payment systems. A flexible mobile payment system and modern payment methods are provided in this study because the smartphone is more common in use among Individuals, easier to use, and available to the people of the modern generation.

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