DESIGNING DISPENSER ISI ULANG (DISILANG) BASED ON INTERET OF THING (IOT) USING V-MODEL SOFTWARE DEVELOPMENT

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Abstract

The Internet of Thing (IoT) is a concept in which several objects are connected in a network and communicated to each other. This concept enables the objects to transfer and exchange data without human intervention. Nowadays, this technology has been implemented in various aspects of human life such as industry, agriculture, transportation, etc. Furthermore, this technology able to be integrated with other technology such as cashless based payment technology. This integration seems has great potential in Indonesia if looked at the increasing of transaction volume and nominal each year. Looking at the increasing use of electronic money and as research advances on IoT research, making a cashless-based IoT system is expected to help human life, especially in Indonesia. One of the problems which Indonesia faces is waste problem, especially plastic waste. Indonesia produces 65.2 million tons of waste per year which 10 million of it is came from plastic waste in 2016, as this situation goes, there are many solutions which came up from government or the people like program called "One million tumbler" that initiated by the Ministry of Communication and Information of the Republic of Indonesia. Therefore, for helping this movement to reduce the plastic waste usage and to take advantage of integration between IoT and cashless based payment, an idea comes out to integrate dispenser with IoT. Afterward, in developing this system V-model software development will be carried out for helping the developing process.

Keywords: Internet of Thing, Android, User Interface, V-model

1. Introduction

The Internet of Thing (IoT) is a concept in which several objects are connected in a network and communicated to each other via cable or wireless which enable the objects to transfer and exchange data without human intervention [1]. This concept was introduced by Kevin Ashton, the initial implementation was conducted to devices identification and tracking then stored its information [2]. Now the implementation of IoT has expanded to various aspects of human life, such as in the field of industry with the 4.0 industrial revolution and then in the field of agriculture with smart agriculture and in various smart concepts that are developing now such as smart home, smart city, etc.

Moreover, other benefits of IoT implementation is when the IoT system connected to internet banking or financial tech (fintech). It has the potential at how the volume and nominal growth of transactions using electronic money, especially in Indonesia. In figure 1.1, it shows in 2014 the volume of transactions using e-money was 203 million transactions and increased each year to 4.2 billion transactions [3]. Looking at the increasing use of electronic money and as research advances on IoT research, making a cashless-based IoT system is expected to help human life, especially in Indonesia.

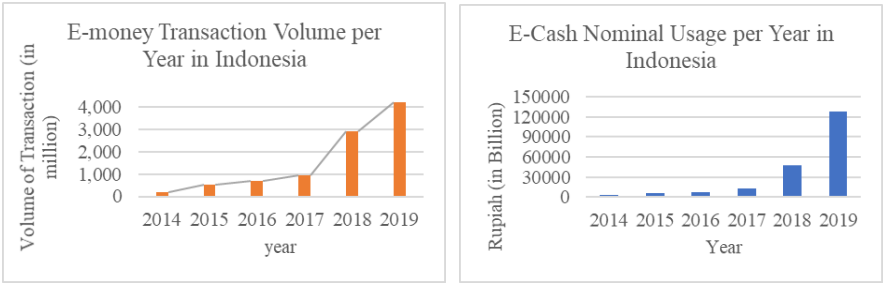

Figure 1(a) cashless transaction volume in Indonesia per year, Figure 1(b) cashless transaction nominal in Indonesia per year

There are various kinds of problems in Indonesia that need attention, one of which is the problem of garbage, especially plastic waste. Indonesia produces 65.2 million tons of waste per year which 10 million of it is came from plastic waste in 2016. Additionally, Indonesia also become the second highest plastic waste contributor to the ocean which contributes 3.22 million tons of plastic waste per year into the ocean. Therefore, based on Ministry of Maritime and Investment websites, Indonesia plans to reduce the plastic waste up to 70% in 2025 (2019). In order to achieve that, there are many programs hold up by government or society to reduce the plastic usage. One of the programs is a

movement to reduce disposal water bottle usage and replace it with reusable bottle like tumbler. This movement supported by the government which proved by a program called "One million tumbler" that initiated by the Ministry of Communication and Information of the Republic of Indonesia in several cities in Indonesia, they are Jakarta, Lampung, Medan, Surabaya, Semarang, Yogyakarta, Pontianak, Makassar, West Papua and many more [5]. Besides the movement that initiated by government, there are many movements held by academics and society. Institut Teknologi Sepuluh November (ITS) recommends their whole staffs and students to bring tumbler instead of buying disposal bottle [6] and the 1000 tumbler movement held by people in Jogjakarta [7]. However, despite having good response by the people, there are several obstacles in order to sustain and develop this movement such as the support facilities like dispenser or vending machine which provide refill water for the people.

That statement can be proved by looking at some public facility area or campus in Indonesia. The example of this situation can be observed in Telkom University in Bandung especially in building of Industrial Engineering faculty which has no dispenser or vending machine which provide refill water. Therefore, in order to reduce plastic waste by helping the tumbler movement, the IoT system for dispenser will be developed also it will provide cashless payment which make it easier to use and monitor.

Afterward, the methodology used for building the proposed IoT system is V-Model approach. The reason for using this methodology is the urgency for the processes to be done step by step and this methodology accommodate this urgency by its feature, those are structured, systematic, progresses on an individual and separate phase, and easy to understand [8]. This methodology proved to be a good approach for building several IoT systems such as autonomous vehicle [9], real time diagnostics for automotive industry [10], and smart traffic density control [8]. Thereafter, an IoT system will be built in dispenser by using V-model approach for accommodating the reduce plastic movement by using tumbler

2. Literature Review

2.1 Internet of Thing (IoT)

Internet of things was firstly introduced in 1999 with the appearance of radio frequency identification (RFID) network system proposed by Massachusetts Institute of Technology (MIT) Auto-ID Labs [2]. Then, by a couple of decades, IoT has developed to not only using RFID but also another newer device such as wireless sensor network (WSN), intelligent sensing, barcodes, cloud computing and so on depends on the purpose of the implementation of IoT system [11].

Those devices are connecting to each other through a connection via cable or wireless system without any interaction with human [1]. So, it will allow each device to send or receive data from one to another and resulted with ability to real-time reporting, analyzing, and visualizing data for helping human to solve their problem in various aspects of their life. First example is the impact in industrial aspects which using IoT as one of the components of the succession of Industrial Revolution 4.0 [12]. Another example IoT impacts on human aspects is in human daily life in the city which manifested by idea of smart city that based on [13]and many more aspects such as healthcare, market, traffic, agriculture, smart home and so on. [14].

2.2 V-Model Software Development

The V-model is a software development approach which can be stated as the extension of waterfall model which firstly introduced in 1980 by Paul Rook [15]. The V-model shows the relationships between each development phase in the process with its associated testing phase. The V-model is different compared to waterfall which moving down linear way, the V-model are moving upward after the coding phase then will form a V shape [16]. In Figure II.2 it can be seen the whole phases of V-model development process.

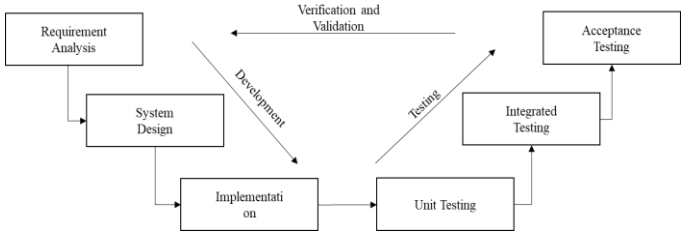

Figure 1. V-Model software development life cycle

V-model software development consists of 9 phases from requirement analysis until the acceptance testing. Based on [17] the phases in V-model development process are:

1. Requirement analysis, in this phase the system requirements will be collected by analyzing user requirements based on literature review.
2. System Design, in this phase the system architecture will be defined which will be the "blue print" of the developed system. The defined architecture will consist of every function of the system also the hardware and software required for every function.

3. Implementation, this phase will use the output or "blue print" of the system design will be implemented. The system will be implemented function by function based on the blue print and using the required software and hardware based on functions.
4. Unit testing, in this phase every function will be tested start from hardware, software.
5. Integration testing, in this phase the communication between every function including hardware and software communication will be tested.
6. Acceptance testing, in this phase the developed system will be tested by user.

3. Discussion

3.1 Research Flow

In this research, problem solving systematic divided into five phases. The whole phases are shown in the figure 2 which describes all phases for solving the problem of this research. The first part is initiation and problem identification phases. Next is the designing phase and continue with the implementation phase. After the design and implementation phase the testing phase will be brought up then finished up with analysis and conclusion phase.

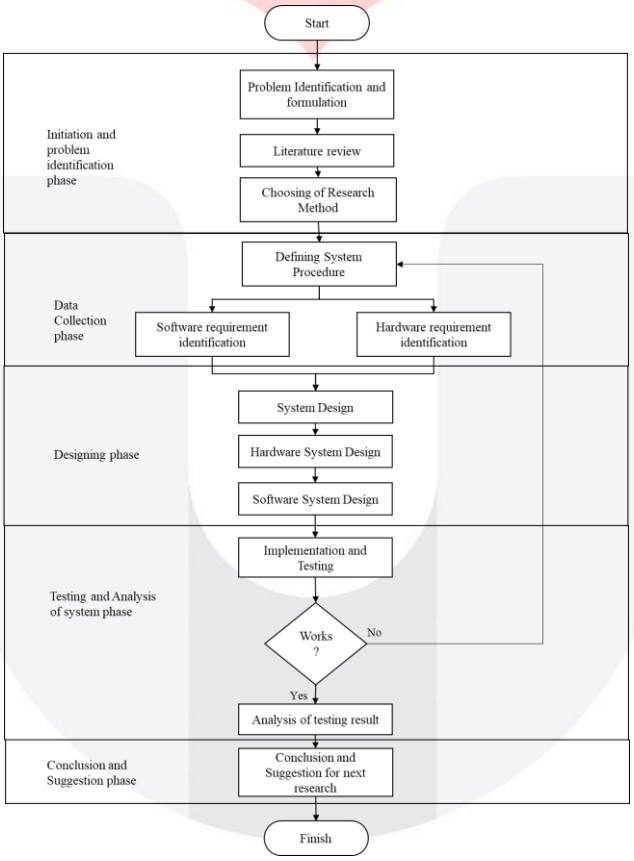

Figure 2. Research Flow of Disilang System

3.2 Designing Dispenser Isi Ulang (Disilang) System

Disilang is a dispenser based on Iot that is used to facilitate drinking water refill using the cashless method. The IoT system implementation aims to control dispensers and monitor purchases from dispensers through the database. The Internet of Thing (IoT) system in dispenser will be built using chosen method which is V-model approach. The research begins with defining system function identification for the IoT system, then continue with the data collection for the hardware and software requirement and then designing both the hardware and the software.

Disilang system has several functions, there are storing purchasing data, showing historical data, controlling process, purchasing process, login and logout process and scan QR code or barcode process. Those functions are supported by specific hardware and software. The hardware devices used in Disilang system are ESP32 micro-controller, power supply 12 V, relay, solenoid valve, and brushless water pump. Then, the software used in Disilang system are Arduino IDE for ESP32 micro-controller, Android Studio, and Firebase. For Firebase, there are three services which used in this research, there are Firebase Authentication, Firebase Real-time Database, Firebase Authentication. Those hardware and software will be integrated to build the Disilang system. Then, in integrating the hardware devices and software, the architecture of the system will be designed in order to make the developing process easier. The architecture design of the Disilang system is shown in Figure 3.

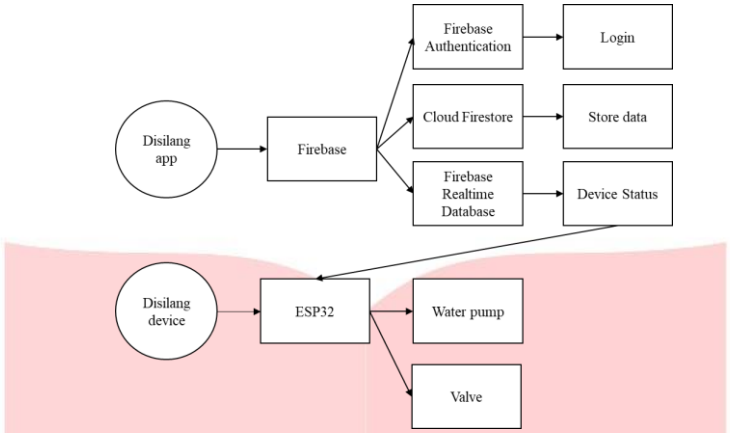

Figure 3. Disilang hardware system overview

Disilang system consists of two sub-system, there are Disilang application and Disilang devices. Disilang application will handle the firebase system which consists of three functions, there are store data function which handled by Cloud Firestore, all the purchase data, dispenser data, and product data will be store there the device status which handled by Firebase Realtime Database, and the last is login system which handled by Firebase Authentication. The device status information which stored in firebase real-time database. Then, it will be used by ESP32 micro-controller that already connected to Internet via Wi-Fi to operate the actuator within Disilang system.

The overview of Disilang hardware is shown in Figure 4. Based on figure 4, brushless water pump and solenoid valve are located inside of the dispenser and the rest of the hardware devices are located outside of the dispenser.

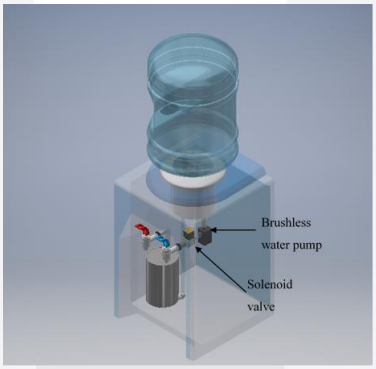

Figure 4. Disilang hardware system overview

Then, the interconnection of Disilang system is shown in figure 5. In this figure ESP32 micro-controller connects to relay which use to control solenoid valve and brushless water pump. Then, for providing 12V to solenoid valve and brushless water pump, power supply 12V is connected to the relay to supply the current.

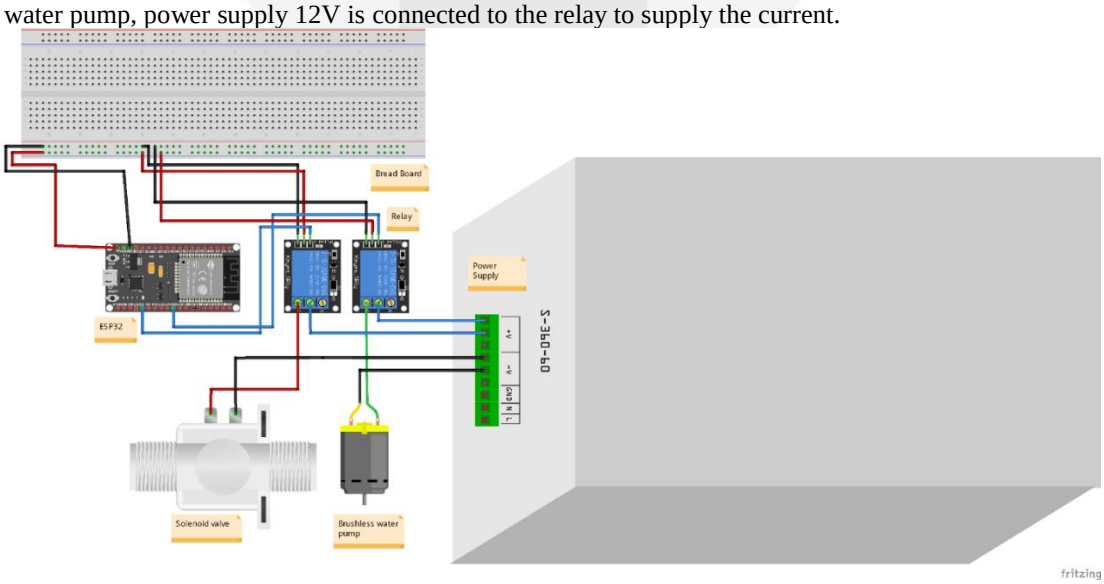

Figure 5. Disilang hardware system overview

After the hardware system has been defined, next is software system design. Software system design consists of three steps, there are user interface design which use android studio to make both the interface and the back-end application. Next is database design which prepared for the software and hardware connection and the last is ESP32 micro-controller programming process which use Arduino IDE platform to program it.

First, in software design process, the interface of Disilang application will be made, there are seven interfaces used in the application. First is Disilang login interface, scanning interface, outlet interface, confirmation interface,

after purchase interface, profile interface, voucher interface and purchase history interface. These whole interfaces are shown in figure 6(a)-(h) respectively.

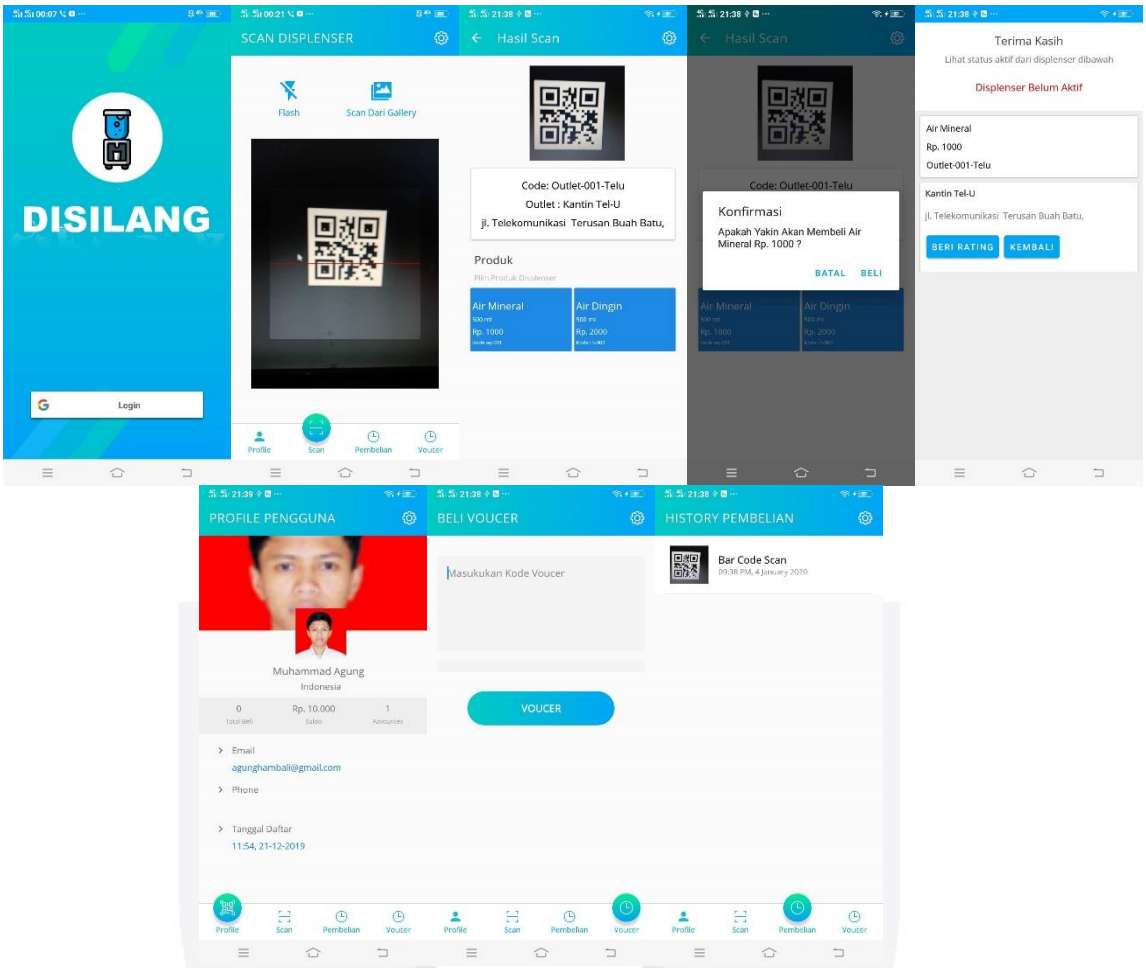

Figure 6(a)-(h) Disilang application Interface

After Disilang interfaces have been made, next is the database design which use Firebase platform and its service to run it. There are three Firebase services which used in this research, there are Cloud Firestore which used to store transactional data, outlet data and the product data. The Cloud Firestore used in Disilang system is described in figure 7.

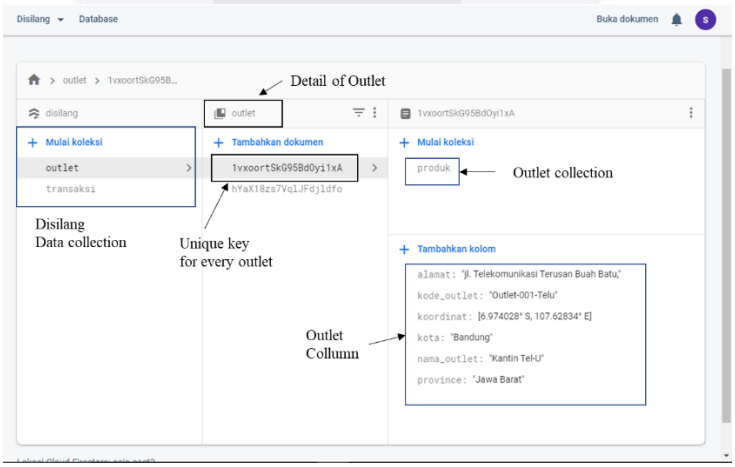

Figure 7. Cloud Firestore in Disilang system

Next is Firebase Real-time database which used for exchanging status information between software system and hardware system. Firebase Real-time database itself is a JSON tree which consists of data that can be monitored and controlled in real-time. Furthermore, for login and logout system, Firebase platform provide a service called Firebase authentication which enables user to login into application with various ways such as Google account, Facebook, Twitter or something personal such as phone number. These two services are described in figure 8 and 9.

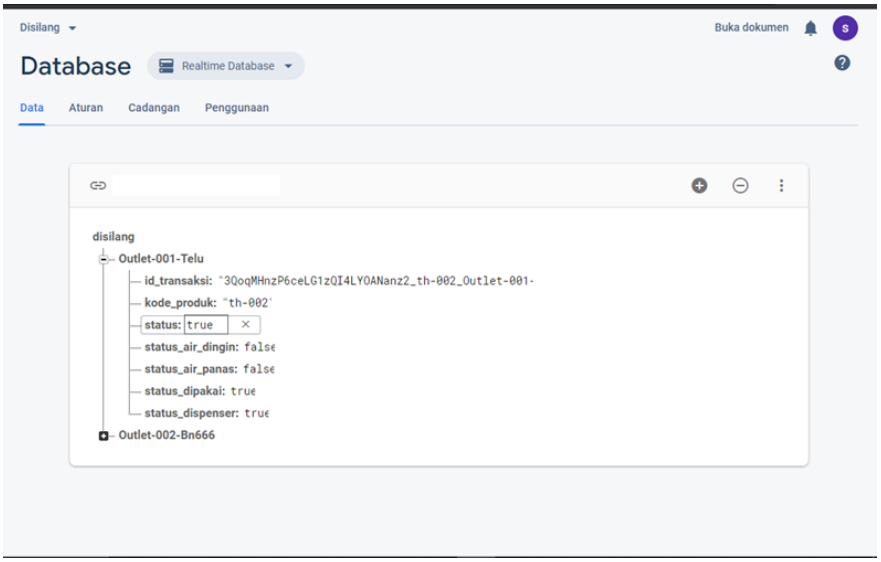

Figure 8. Firebase Realtime Database in Disilang system

In Firebase Realtime Database, there are several statuses which used to exchange status with ESP32 micro-controller, those statuses are detailed in table below.

Table 1. Firebase Realtime Database Status in Disilang system.

No	Status	Description
1	Id_transaksi	Transaction ID is used to record the current transaction ID which generated by firebase in Cloud Firestore
2	Kode_produk	Kode Produk is used to record the current transaction product code which its data stored in Cloud Firestore
3	Status	Status is used for stating the condition or status of the connection between user and the dispenser
4	Status_air_dingin	Status_air_dingin is used for switching on the water pump and relay for normal temperature water
5	Status_air_panas	Status_air_panas is used for switching on the water pump and relay for hot temperature water
6	Status_dipakai	Status_dipakai is used for informing the user that their session is over, it will be shown in disilang application interface
7	Status_dispenser	Status_dispenser is used for informing the user that the dispenser is ready to use, it will be shown in disilang application interface

Next is authentication process in Disilang system. This process is supported by Firebase Authentication which described can authenticate user with the application through several ways like media social and private information such as phone number. In figure X, Firebase Authentication lists the whole users and login method they used to authenticate with the application, this enables the monitoring and controlling process easier.

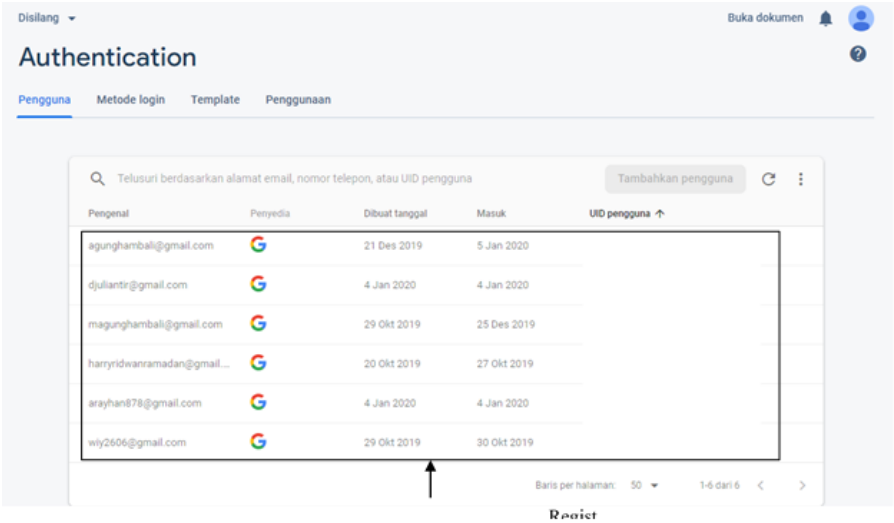

Figure 9. Firebase Authentication

3.2 Designing Dispenser Isi Ulang (Disilang) System

After designing the hardware and the software of Disilang system and integrate the whole systems based on architecture and functions. Next is the testing and analysis of Disilang system. The testing will be carried out for both hardware and software system and the result will be analyzed. First testing to be analyzed is software testing

Table 2. Software testing

No	Process	Desired Result	Status
1	Login	User success to login into Disilang application using google account	Success
2	Logout	User success to logout into Disilang application using google account	Success
3	Retrieve user data	The data retrieved in profile interface fit the information in google account.	Success
4	QR Code scan from camera	Barcode scanning process can retrieve the data within the QR Code using camera.	Success
5	QR Code scan from gallery	Barcode scanning process can retrieve the data within the QR Code from gallery.	Success
7	Retrieve product data	Retrieve available product in specific outlet.	Success
8	Camera Flash	Camera Flash enabled or disabled during scanning process based on application control.	Success
9	Storing purchase data	The purchase history is stored to Cloud Firestore.	Success
10	Voucher	User can redeem voucher to get discount.	Success
11	Purchase history	The purchase history is displayed in purchase history interface	Success
12	Control Firebase Realtime Database status	Read and write data to id_transaksi in Firebase Realtime Database	Success
		Read and write data to kode_produk in Firebase Realtime Database	Success
		Read and write data to status in Firebase Realtime Database	Success
		Read and write data to status_air_dingin in Firebase Realtime Database	Success
		Read and write data to status_air_panas in Firebase Realtime Database	Success
		Read and write data to status_dipakai in Firebase Realtime Database	Success
		Read and write data to status_dispenser in Firebase Realtime Database	Success

Based on the testing result, there are several problems in software system like redeem voucher process and storing purchasing data into Cloud Firestore. However, the rest of the software system are working properly. After that is Hardware system testing

Table 3. Hardware testing

No	Process	Desired Result	Status
1	ESP32 Wi-Fi Connection	ESP32 is connected with Wi-Fi with specific SSID and password	Success
2	Connection between ESP32 and Firebase	Read and write data to id_transaksi in Firebase Realtime Database	Success
		Read and write data to kode_produk in Firebase Realtime Database	Success
		Read and write data to status in Firebase Realtime Database	Success
		Read and write data to status_air_dingin in Firebase Realtime Database	Success
		Read and write data to status_air_panas in Firebase Realtime Database	Success
		Read and write data to status_dipakai in Firebase Realtime Database	Success
		Read and write data to status_air_panas in Firebase Realtime Database	Success
		Read and write data to status_dipakai in Firebase Realtime Database	Success
		Read and write data to status_dispenser in Firebase Realtime Database	Success

Table 3. Hardware testing (cont'd)

No	Process	Desired Result	Status
	Transaction Process	Giving time for the user to prepare before turned on	Success, but the delay is unpredictable. The mean of the delay is 15.12 seconds from 30 experiments
	Transaction Process	Water pump is switched on after delay	Success

In table 5.2 almost all of the testing results successfully without any obstacles. However, there is a problem in transaction process which the given time for the customer is not same, from 30 times experiment the delay mean is 15.12 second. Therefore, the Wi-Fi connection or the programming approach have to be reviewed.

4. Conclusion

Based on the results of the design, testing and analysis that has been done, conclusions can be drawn regarding the development of a Dispenser Isi Ulang (Disilang) based on IoT system. From the results of testing the functionality of the software and hardware on the Disilang system it can be concluded that all software and hardware systems work according to their functions. From the test results it can be seen that there is a Wi-Fi connection problem which makes the delay longer than it should be. The rest, the functions that exist in Disilang system are functioning properly.

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