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CARDIOSYS: HUMAN CARDIOLOGY MEASUREMENT SYSTEM BASED ON INTERNET OF THINGS

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ABSTRACT

Indonesia as an archipelago requires a technology-based health data collection system that can be a reference in the distribution of health services for its citizens. Internet of Things (IoT) is currently a global concern because of its ability as an ecosystem that is built from many hardware connected via the internet that is connected via the internet. CardioSys development, consisting of health gauges integrated with IoT-based software applications, is an option to help collect disease data in the cardiovascular system. IoT allows CardioSys devices to interact with the outside environment or with their internal circumstances. CardioSys hardware is integrated with the CardioSys application using the internet so that medical staff/doctors do not need to record measurement results and record measurement data manually. CardioSys measurement and recording results can be accessed on the android application features. Measures in the form of blood pressure, heart rate, and body temperature are automatically and realtime sent by the CardioSys hardware to the Firebase realtime database. Cardiology devices and human body temperature gauges are designed using ESP8266 wireless module as a microcontroller connected to three sensors, namely the MPX4250AP sensor, heart rate sensor, and DS18B20 sensor that allows users to monitor blood pressure, heart rate and body temperature displayed in applications that have been displayed created using Android Studio software, so this application can store measurement results for many users. Based on the results of this test, the percentage of errors for blood pressure in the form of systole is 7% and diastole is 17%, heart rate is 15%, and body temperature is 3%. Also, based on a questionnaire from several respondents showing that 80% said they agreed on the application of monitoring cardiology and body temperature following the user's needs.

Keywords: *Cardiovascular, IoT, ESP8266, MPX4250AP, Firebase, Android*

1. INTRODUCTION

Every year the highest mortality rate in the world is caused by diseases of the cardiovascular system. Hypertension is a cause of disruption in the cardiovascular system. Referring to data from WHO in 2015, hypertension sufferers in the world ranged from 1.13 billion people. This number continues to increase and in 2025 it is estimated that around 1.5 billion people suffer from hypertension and the possibility of dying each year from hypertension and complications as many as 9.4 million people [1]. In addition, based on data from Indonesia's basic health research (Riskesdas) in 2018 an increase in hypertension prevalence results of 8.3% from 2013 data [2].

According to data from the Bojongsoang Health Center in Bandung Indonesia in September 2017, Hypertension ranked second in 10 chronic diseases in Bojongsoang. There were 247 cases in 2017 while in 2018 there were 4961 cases. This can be caused by the difficulty of measuring blood pressure for the layman, because measuring blood pressure usually must be done by medical personnel, for example in hospitals and health centers, so that hypertension cannot be detected as early as possible, while periodic blood pressure measurement is very important to be able to immediately prevented. Based on 2016 data by the National Health Indicators Survey (Sirkesnas), around 32.4% of the population aged 18 years and over will experience a prevalence of hypertension [1].

Based on the latest developments, research [3] has created an Arduino-Based Digital Tensimeter which has a feature in blood pressure measurement. Then in research [4] has created a Heart Rate and Body Temperature Monitoring System which outputs from the measurement results are displayed on a normal 16 x 2 LCD. The two studies have not been integrated with applications to facilitate data collection and monitoring records of patient health measurements.

Other studies related to health measuring devices that are integrated with applications have been carried out in research [5] but have not yet maximized the process of monitoring health measurements in many patients.

Indonesia is an archipelago, the problem of health data in Indonesia makes it difficult for the government to map the health conditions of its citizens. A system that is able to integrate health equipment with the existing health information system is needed. The system must be user-friendly because not all medical staff have mastered the technology. This problem is the reason for this research to create an integrated system between cardiology measurement tools and patient health record applications.

According to [6], the Internet of Things (IoT) is currently a worldwide concern because of its ability as an ecosystem that is built from a lot of hardware connected via the internet-connected via the internet. IoT allows us to interact with many devices while also being able to perform maintenance and monitoring for data centers in the cloud infrastructure.

Cardio-Sys based on IoT consists of integrated hardware and software. The hardware part is a measurement of the cardiology system and temperature in humans to anticipate the occurrence of hypertension, where this tool can measure systolic diastole, heart rate, and temperature in humans. Whereas the software part is an android application that will automatically save the measurement results from hardware and can be monitored easily by patients, medical officers/doctors or hospitals. The measurement results will always be recorded so that the user can monitor the measurement results periodically. It is hoped that this tool can be useful for diagnosing hypertension as early as possible.

2. MATERIAL AND METHOD

2.1 The Cardiovascular System

The cardiovascular system is a system that regulates the work of the heart. The cardiovascular system basically consists of the heart, blood vessels, and lymphatic ducts. This system functions to carry oxygen and other substances to be distributed throughout the body and to carry metabolic waste materials to be removed from the body.

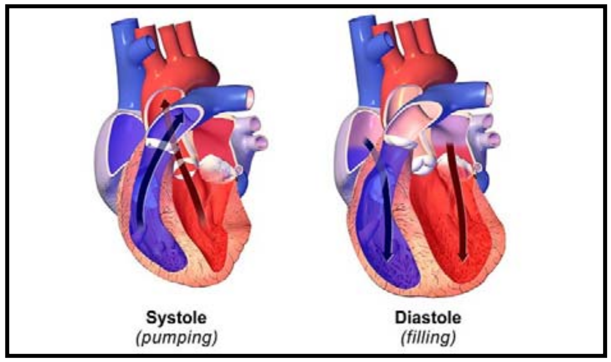

Figure 1. Systole and Diastole[7]

The cardiac cycle can be seen in figure 1 that the cardiac cycle consists of two types namely systole and diastole. Systole is a condition when the heart contracts and when the heart pumps blood to the lungs and throughout the body. While diastole is a condition when the heart relaxes and the heart fills blood in the chambers. Systole and distro values used when measuring blood pressure [8].

2.2 Blood Pressure

Blood pressure is the driving force of blood pumped by the heart against the artery wall. Blood pressure plays a role in flowing oxygenated blood and nutrients throughout the body. The blood pressure unit is mmHg (millimeter of mercury), which is one of the official pressure units used in physics and chemistry and consists of blood pressure systole and diastolic blood pressure. The average normal blood pressure in adults is 120/80 mmHg. Meanwhile, blood pressure which is at 140/90 or more is called hypertension while under 90/60 is called hypotension [9]. The difference in systolic and diastolic blood pressure can be seen in Table 1 below.

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Table 1. Differences in Systolic and Diastolic[9]

	Systole	Diastole
Definition	Blood pressure that occurs when the heart muscle contracts to pump blood through the arteries throughout the body.	Blood pressure in the arteries when the heart is resting (relaxed).
Range Normal	90-120 mmHg	60-80 mmHg
Hypertension	Equal to or above 140 mmHg.	Equal to or above 90 mmHg.
Hypotension	Below 90 mmHg.	Below 60 mmHg.
Determination	When the manset cuff is deflated, the first pulse heard through a stethoscope is systolic blood pressure	When the sound of the beat disappears, the blood pressure heard through the stetoscope is diastole blood pressure.
Writing	Upper blood pressure.	Lower blood pressure.

One of the causes of disorders of the cardiovascular system is hypertension. Hypertension is a condition in which blood pressure is higher than 140/90 millimeters of mercury (mmHg). The figure of 140 mmHg is the value of systolic pressure when the heart contracts and pumps blood throughout the body. Meanwhile, the 90 mmHg number is diastole, when the heart is in a state of relaxation and refilling its chambers with blood [3] [10]. Following the classification of hypertension contained in table 2 as follows.

Table 2. Classification of Hypertension[11]

Blood Pressure Classification	Systole (mmHg)	Diastole (mmHg)
Normal	< 120	< 80
Prehypertension	120 – 139	80 – 89
Hypertension Stage 1	140 – 159	90 – 99
Hypertension Stage 2	>= 160	>= 100

2.3 Heart Rate

Heart rate is one of the most important parameters in the human cardiovascular system. Each person has a heart rate that varies depending on fitness, age, and genetics. When the heart rate is irregular, it can be a critical sign. Several methods can be done to measure the heart rate, such as an electrocardiogram (ECG), phonocardiogram (PCG) and Auscultation [12].

Heart rate is measured in units of time expressed in beats per minute (bpm). A normal adult heart rate ranges from 60 to 100 bpm. Heart rate abnormalities can occur when the rate is less than 60 bpm, known as bradycardia. Besides, heart rate abnormalities can also occur when the speed exceeds 100 bpm, known as tachycardia.

2.4 Human Body Temperature

Temperature is a quantity that expresses the heat or cold of an object. Heat is thermal energy that flows from one object to another because of the temperature difference [4]. Body temperature is the difference between the amount of heat produced by body processes and the amount of heat lost to the outside environment. Surface temperature fluctuates depending on blood flow to the lower surface of the skin and the amount of heat lost to the outside environment. These acceptable surface temperature fluctuations range from 36 o C or 38 o C [5].

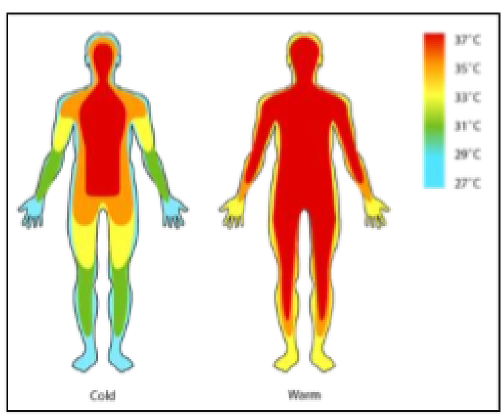

Figure 2. Human Body Temperature Hotspots[11]

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In Figure 2 above there are differences in temperature at each point of the human body. Size of normal body temperature based on age group:
• Normal baby temperature: 36.1 - 37.7 o C
• The child's normal temperature: 36.3 - 37.7 o C
• Normal adult temperature: 36.5 - 37.5 o C

2.5 NodeMCU

NodeMCU ESP 8266 is an open source IoT platform [13]. NodeMCU was developed using the Lua programming language to assist in making prototypes of the Internet of Things (IoT) product or it could be by using a sketch with ArduinoIDE. ESP 8266 functions to upload the results of sensor calculations, and also becomes a server during the monitoring process.

2.6 Android Studio

Android is an application that offers a different environment for developers. Android does not distinguish between core applications and third party applications. Application Programming Interface (API) provided offers access to hardware, as well as mobile data, or the system data itself [14].

Android Studio is an Integrates Development Environment (IDE) for developing Android applications. This software offers many features to increase productivity when creating Android applications, for example [15]:

a. Flexible Gradle-based version system.
b. Fast and feature-rich emulator.
c. A unified environment for development for all Android devices.
d. Instant Run to push changes to running applications without creating a new APK.
e. Code templates and GitHub integration to create the same application features and import sample code.
f. Extensive testing tools and framework.
g. Lint tools to improve performance, usability, version compatibility, and other problems

2.7 Firebase

Firebase is a combination of various Google services on the Cloud, including instant messaging, user authentication, real-time database, storage, hosting, and so on. This system uses user authentication and a real-time database [16]. Firebase Authentication provides backend services, an easy-to-use SDK, and a ready-to-use UI library to authenticate users to your application. Firebase Authentication supports authentication using passwords, telephone numbers, popular joint identity providers, such as Google, Facebook, and Twitter, and others [17]. There are several main capabilities of firebase authentication as follows.

a. Email-based authentication and password.
b. Authentication with Facebook, Twitter, Google, and so on.
c. Integration of identity providers combined.
d. Integration of special authentication systems.
e. Anonymous authentication.

Besides, there are also features of the Firebase Realtime Database which is a database hosted on the cloud. Data is stored as JSON and synchronized in realtime to each connected client. When you create cross-platform applications with the Android SDK, iOS, and JavaScript, all clients will share a Realtime Database instance and receive the latest data updates automatically [18].

2.8 Android

Android is a Linux-based operating system designed for touch screen cellular devices such as smartphones and tablet computers [19]. Android is also open source because Android provides an open platform for developers to create their applications that can be used by various devices [20].

2.9 Internet of Things

Internet of Things is a platform where everyday tools become smarter, every day processing becomes smart, and daily communication becomes informative [21]. IoT also connects the physical world and the world of information, processing data obtained from electronic devices through an interface between users and IoT devices aimed at making the internet more expanding and expanding, enabling easy access and interaction with various tools such as household appliances, cameras CCTV, monitoring sensors, actuators, displays, vehicles, and so on [22].

3. CARDIO-SYS COMPONENT

The CardioSys hardware is integrated with the CardioSys application by using the internet so that medical staff/doctors do not need to record the measurement results and record the measurement data manually. CardioSys measurement and recording results can be accessed on the android application features. Measures in the form of blood pressure, heart rate, and body temperature are automatically and realtime sent by CardioSys hardware to the realtime database firebase. In Figure 3 the following shows a complete use case diagram of CardioSys hardware and software.

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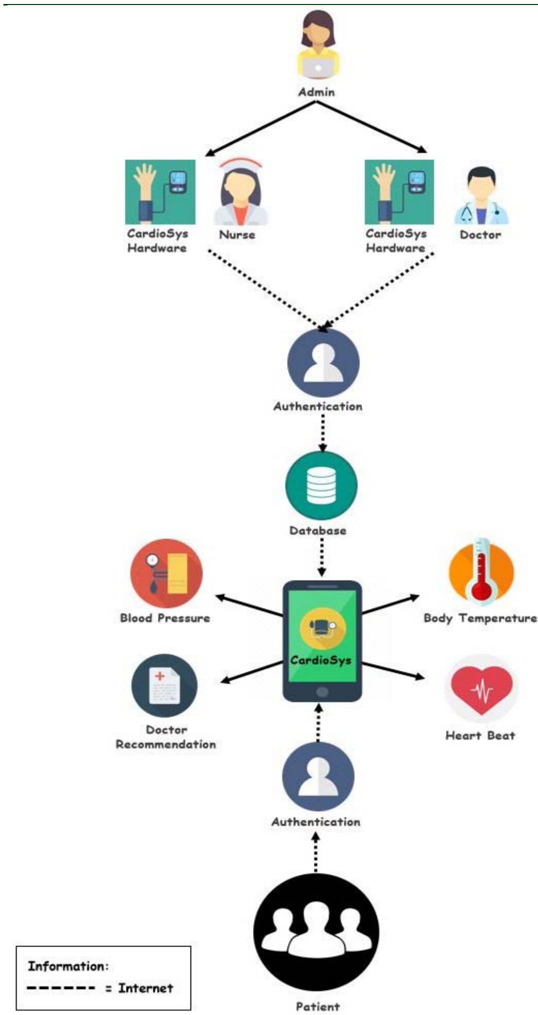

Figure 3. Usecase Diagram

The process of creating a doctor or medical officer account is done by the Admin to avoid misuse of the account. Cardiology measurements in patients are performed by Doctors / Medical Officers using the CardiosSys tool, then the measurement results from the device are sent to the Firebase realtime database integrated into the CardioSys application. Therefore patients can see the measurement results along with the recapitulation of data displayed on the application.

3.1 Determination Of Component Specifications

The first stage in designing is determining the component specifications used, namely, MPX4250AP Sensor, Pulse Heart, DS18B20, and NodeMCU as a microcontroller and data transfer, and OLED to display the measurement results.

3.2 System Design

There are three features that can be displayed on OLED and applications that are integrated with Firebase. There are features of blood pressure, heart rate, and temperature. The value is processed by a microcontroller, the calculation results are displayed on OLED and applications that have been integrated on the tool. Data displayed on OLED and application in the form of blood pressure are systole and diastole with mmHg units, heart rate with bpm units, and temperature in Celsius units. But in the application, there are measurement charts following the number of measurements that have been made.

3.2.1 Blok diagram

The results of measurements of blood pressure, heart rate, and body temperature are processed by a microcontroller, the measurement results are displayed on OLED and application. The measurement results on OLED will be displayed after the microcontroller gets the final measurement results, after that at the same time the measurement results data will be sent to the Firebase realtime database. The overall system block diagram is shown in Figure 4 as follows.

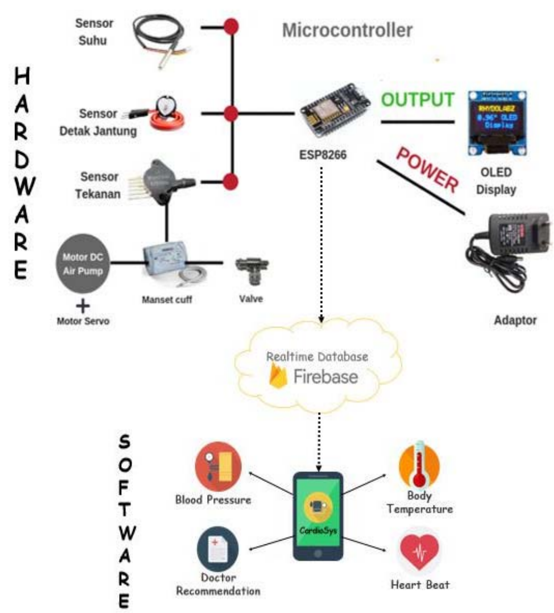

Figure 4. Block System Diagram

Also, the measurement results can also be displayed on the android application following the features being accessed by the user in the form of history and graphics. The measurement results are taken from the Firebase realtime database. Measurement data is taken from Firebase and then

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displayed on the application along with a graphical display of each measurement result.

3.2.2 Planning

There are two designs namely hardware design and software design, which are described as follows.

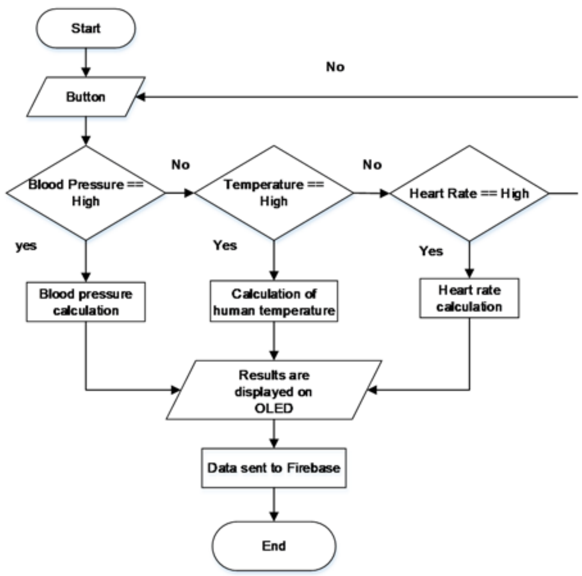

Figure 5. Flowchart Tool

In Figure 5 it can be seen that the system on the device works based on keystrokes, three buttons have different functions. This function is used to measure blood pressure, heart rate, and temperature. When one button is pressed then the tool will work, after that, the hardware will do the calculation to get the results and displayed on the OLED Display. Then the calculation results will be displayed on OLED and sent to Firebase.

The application system flowchart describes the activities that can be carried out by patients and doctors when using the application presented in Figure 6 as follows:

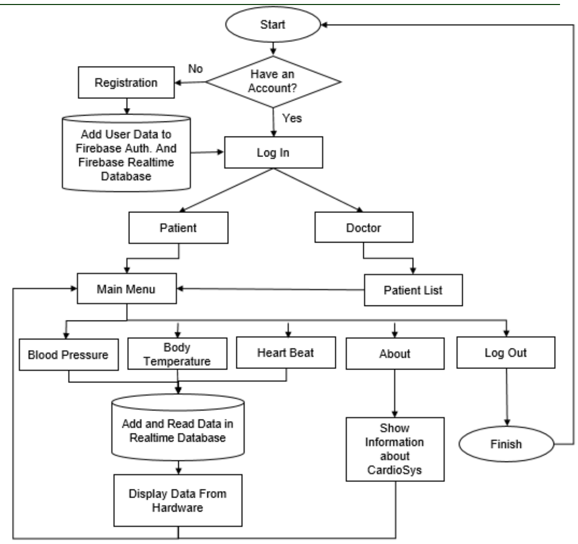

Figure 6. Flowchart Application System

When starting the application the user is faced with two conditions namely having an account or not. If the user has an account, he can directly log in, if the user does not have an account, the user is required to register, at the time of registration the user data will enter the realtime database while the email and password will be stored in Firebase authentication, as well as the registration of the registered doctor by admin. After registration, a login can be done, both logins as a doctor and patient to enter the main page.

On the doctor's account, you will see a list of patients who have taken measurements that if pressed will go to the main page of the patient. On the main page, we can access features such as blood pressure, heart rate, body temperature, about page, suggestion page, and log out button. When features are accessed, the measurement data from the hardware will be added to the realtime history database, then read and displayed in the Android application. Likewise with the suggestion page, where doctors can provide advice to patients and the advice can be seen on each patient's account. The log out button is used to log out of the user's account.

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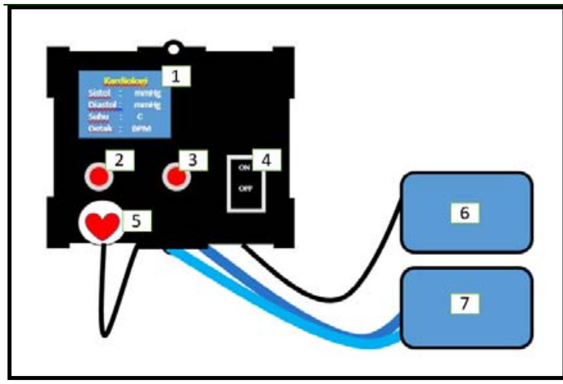

Figure 7. Hardware Design

Figure 7 is a device design, number 1 is an OLED screen to display the results of measurements in the form of blood pressure (systole, diastole), heart rate, and body temperature. There are two pushbuttons and one switch, number 2 push button to start the heart rate program, number 3 push button for blood pressure program, number 4 there is a switch for body temperature program. Then in number 5, there are sensors for heart rate. Number 6 is a temperature sensor. Number 7 is a manset cuff that is connected to two tubes, the first hose is connected to the blood pressure sensor, and the other hose is connected to the valve and the dc motor.

The workings of the heart rate sensor using the method of photoplethysmography (PPG), which utilizes low-intensity infrared light (IR) to detect land flow that moves due to heart rate. The voltage signal from PPG calculates the amount of blood and the time difference that flows through blood vessels to obtain the number of heartbeats per minute. Heart rate measurement by placing the index finger on the sensor, then pressing the push button, then after 9 times the sample calculation results will be displayed on the OLED.

```
rate[9] = IBI;
runningTotal += rate[9];
runningTotal /= 10;
BPM = 30000 / runningTotal;
```

The input of the MPX4250AP is the air pressure in units of Kpa (Kilopascal) which will be converted to a unit of blood pressure (mmHg) obtained in the following equation.

$$1 \text{ Kpa} = 7{,}50062 \text{ mmHg} \quad (1)$$

The design of blood pressure begins with the calibration of MPX4250AP to aneroid tensimeter. The following table 3 is a calibration results table.

Table 3. MPX4250AP Sensor Calibration

Bit Mpx	Manometer Aneroid (mmHg)
321	0
329	20
334	30
339	40
344	50
350	60
355	70
360	80
366	90
371	100
376	110
381	120
389	130
394	140
399	150
404	160
409	170
414	180

Based on the table above, an offset value of 321. is obtained from normal blood pressure which has a diastolic systole value of 120/80 mmHg, the following equation is obtained.

```
mux1 = mux.readADC_SingleEnded(1);
Bit = map(mux1, 3, 17636, 1, 975);
pressure = (Bit  - offsetBP) * 2;
```

```
systole = pressure;
diastole = systole - 40;
servo.write(0);
```

$$\text{Blood Pressure (mmHg)} = (\text{Bit-Offset})*2 \quad (2)$$

To read pressure, begin with reading pin A0 on ADS1115. Then the reading results are converted into the value format at the time of MPX4250AP sensor calibration. Therefore the pressure value can be obtained by the equation formula (2).

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Blood pressure by attaching the manset cuff to the upper arm, then pressing push the blood pressure than the dc motor will pump the manset cuff until it reads 180 mmHg then the servo will open the valve then the air on the manset cuff out and at the same time the systole and diastole values are obtained which will be sent to the Firebase realtime database and displayed on OLED.

```
JsonObject& timestampobject =
BloodPressure.createNestedObject("t
imestamp");

BloodPressure ["Sistol"] = sistole;

BloodPressure ["Diastol"] =
diastole;

timestampobject[".sv"] =
"timestamp";

Firebase.push("/Hardware/
BloodPressure ", Blood Pressure);
```

Temperature measurement by attaching the temperature sensor to the armpit or by holding it by hand, the output of the temperature sensor is in the form of degrees celsius [23].

The hardwares and materials needed for software design are laptops, smartphones, android studios, real-time database firebase, and firebase authentication. Mobile specifications used in this design are mobile phones with a minimum API of 21, namely the Android 5.1 Lollipop version.

A system diagram of the design of a cardiology and body temperature monitoring application is shown in the figure below.

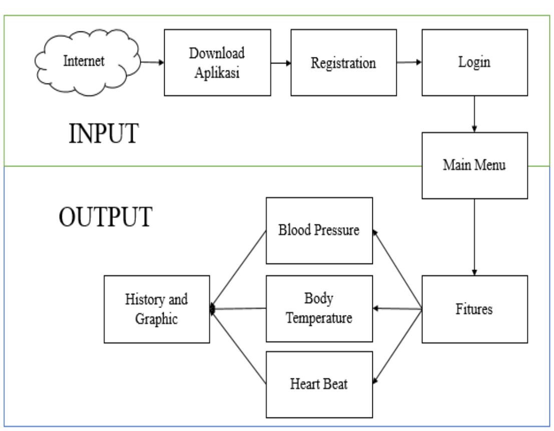

Figure 8. System Diagram

In Figure 8, there are two parts in the application working system, namely input, and output, in the input the user downloads the application, logs in, and registers. The user can run the application according to the commands the user wants. At the output data that has been processed will be displayed in the form of the value of the measurement sensor and measurement history in the form of a listview that is converted also into a chart. The design stage consists of making mock-up applications in the form of splash screen interface, log in and registration interface, main page interface, blood pressure feature interface, heart rate, and body temperature, interface about, doctor page interface, admin page interface.

3.2.3 Wiring diagram

All sensors are connected to NodeMCU. Other components namely ADS1115 and OLED are connected with SCA and SDL on NodeMCU. The analog output MPX4250AP pin as a blood pressure sensor is connected to pin A1 of ADS1115. The input pins of the DC air pump and servo motors are pins D3 and D4 from NodeMCU. The heart sensor pulse output pin is connected to the heart pulse circuit on pin A0 of ADS1115. The DS18B20 output pin is connected to pin D5 of NodeMCU. In Figure 9 the following is a wiring diagram of the hardware.

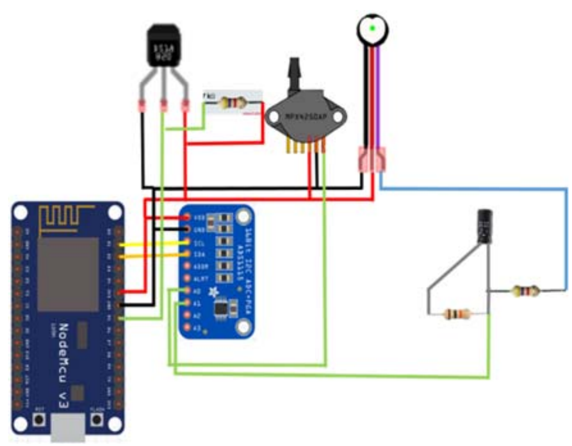

Figure 9. Wiring Diagram

4. RESULTS AND DISCUSSION

CardioSys research results are compared with existing tools to determine the functionality of the research results made.

4.1 Hardware Design Results

The sensor that has been installed is then validated before testing. Sensor validation is done to ensure that the measurement results are following the size of the design. Following the results of the

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design of the hardware contained in Figure 10 as follows.

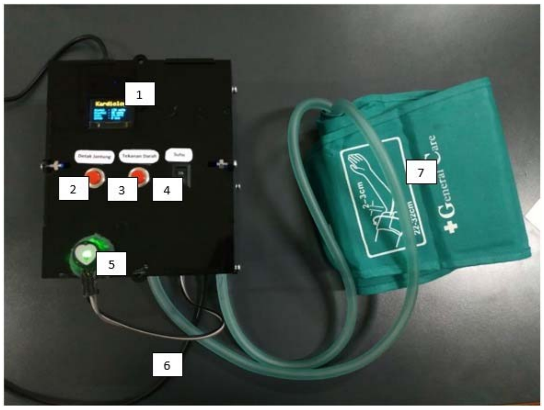

Figure 10. Hardware Design Results

Number 1 there is an OLED display to display the measurement results. For the measurement of heart rate found in number 2 in the form of a button, after the button is pressed then the hardware will process then the measurement results will be displayed on OLED and sent to the realtime database firebase that has been integrated into the application. While blood pressure measurement is at number 3, and body temperature is at number 4. Number 5 is a pulse heart sensor for heart rate measurement. Number 6 is a temperature sensor and number 7 is a manset cuff that is attached to the patient when measuring blood pressure.

$$\text{Error Percentage} = \frac{True\ Value - Measurement\ Value}{True\ Value} \text{ x } 100\ \% \quad (3)$$

The Calculation of error percentage is the process of calculating the percentage of errors from a device or system with an existing tool or system as a comparison error. So that the accuracy value obtained from the hardware [24]. The following calculation of the error percentage is in the equation below.

4.2 Application Design Results

The android application is connected to the firebase authentication and firebase realtime database through an internet connection. In the firebase realtime database, there are measurement values from each user, while the patient and doctor user data are stored in firebase authentication. This application has previously been tested for functionality on every component in the application.

To use this application, patients only need to create an account using a verified email, after which they can log in to access the features on the main page of the application as in Figure 11 below.

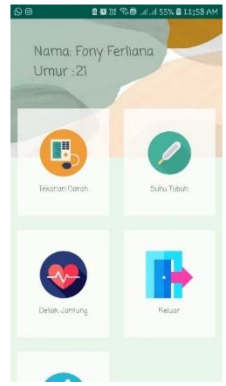

Figure 11. The main page of the patient

Patients can see the value of the measurement results when opening one of the features. When the feature is open then the medical officer or doctor must take measurements of the feature on the device so that the value of the measurement results can be stored in a database according to the condition of which patients are accessing the feature.

Figure 12. Feature page

Figure 12 is a display of overall measurement results. In the text view section, it functions to display the measurement results in realtime, as shown in Figure 13 as follows.

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Figure 13. Textview

In the history section, there are two views, graph, and listview. History consists of the value of the measurement results as well as the date and time when the measurements were made which are calculated into a graph to make it clearer the increase and decrease of measurement results for each feature, as shown in Figure 14 as follows.

Figure 14. History

While the Admin can log in using the username and password that has been predetermined in the source code so that this admin account can only be used by one person. Besides, the admin has the authority to add a doctor's account and delete all user accounts that are not used. When a user account is deleted, then the data contained in the database will also be deleted, and vice versa when the admin adds a doctor's account, it will be recorded in Firebase authentication. The following picture 15 is a view of the admin main page.

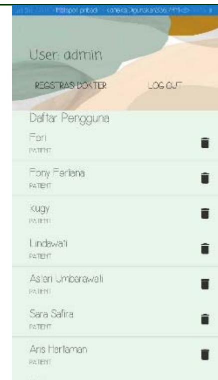

Figure 15. Admin Main Page

The doctor's account can be seen in Figure 16 below, that doctors can access all patient data in full can also add suggestions.

Figure 16. The main page of the doctor

4.3 Blood Preassure Accuracy Testing

Blood Pressure Measurement Tests are carried out to determine the comparison of blood pressure measurement results in the form of systole and diastole with existing tools, blood pressure measuring devices used to take measurements are Digital Omron HPB 1300 Tensimeter. The following results of measurements can be seen in Table 4 as follows.

Table 4. Blood Pressure Test Results

No	Name	Age	Hardware		Comparison Hardware		Difference		Error Percentage	
			Systole	Diastole	Systole	Diastole	Systole	Diastole	Systole	Diastole
1	Hasna	26	116	76	108	62	8	14	7%	18%
2	Upik	27	90	50	98	65	8	15	9%	30%
3	Lindawati	55	154	114	149	95	5	19	3%	17%
4	Nani	54	128	88	105	64	23	24	18%	27%
5	Wulan	32	92	52	103	65	11	13	12%	25%
6	Sara	32	108	68	103	57	5	11	5%	16%
7	Arni	24	102	62	106	56	4	6	4%	10%
8	Lita	28	134	94	121	76	13	18	10%	19%
9	Adibah	22	112	72	107	75	5	3	4%	4%
10	Astari	22	96	56	98	58	2	2	2%	4%
Amount of Difference							84	125		
Average							8.4	12.5	7%	17%
Accuracy									93%	83%

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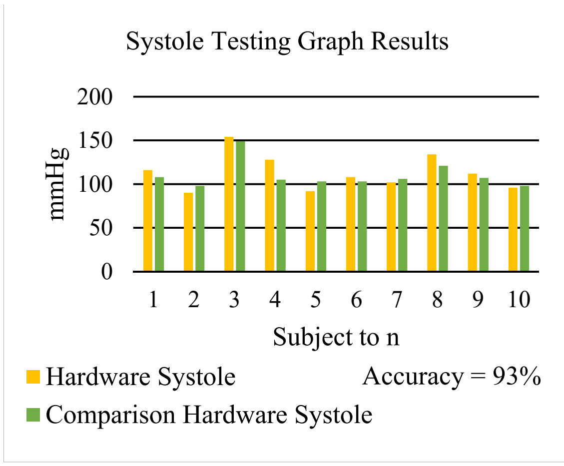
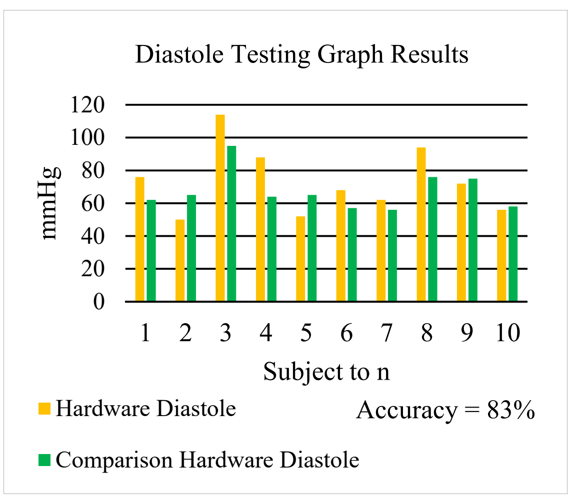
After testing, the difference between the average and the difference obtained from the test is obtained. The percentage of error from systole was 7% and diastole was 17%, while the percentage of accuracy of systole was 93% and diastole was 83%. This shows that the error percentage is quite large due to the calibration of the MPX4250AP sensor. The measurement results in the form of a percentage are presented in graph 1 as follows.



Graph 1. Systole Measurement Results

The diastole measurement results are presented in graph 2 as follows.



Graph 2. Diastole Measurement Results

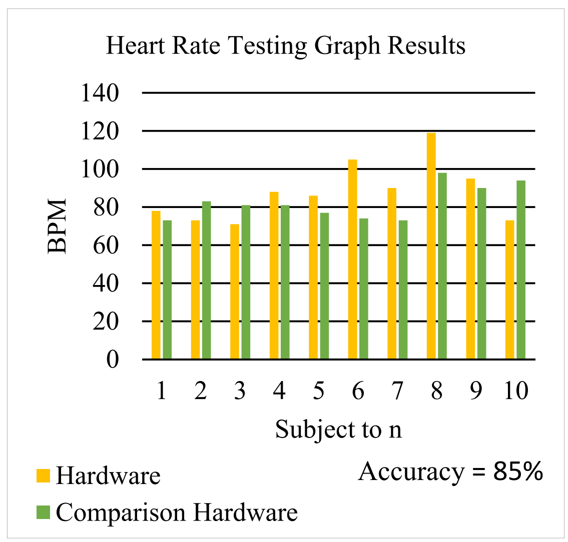
4.4 Heart Rate Accuracy Testing

Testing heart rate measurements to determine the comparison of heart rate measurement results with existing tools and using the Digital Omron HPB 1300 Tensimeter as a comparison hardware.

Table 5. Heart Rate Test Results

No	Name	Age	Hardware	Comparison Hardware	Difference	Error Percentage
1	Hasna	26	78	73	5	6%
2	Upik	27	73	83	10	14%
3	Lindawati	55	71	81	10	14%
4	Nani	54	88	81	7	8%
5	Wulan	32	86	77	9	10%
6	Sara	32	105	74	31	30%
7	Arni	24	90	73	17	19%
8	Lita	28	119	98	21	18%
9	Adibah	22	95	90	5	5%
10	Astari	22	73	94	21	29%
Amount of Difference					136	-
Average					13.6	15%
Accuracy						85%

Based on table 5 above, the heart rate calculation is 15%, while the accuracy percentage of the heart rate calculation is 85%. It can be concluded that in the calculation of heart rate there is a big error because the sensor used is very sensitive so that it results in an error in reading the results of measurements that have been made. The results of heart rate measurements in graphical form are presented in graph 3 as follows.



Graph 3. Heart Rate Measurement Results

4.5 Body Temperature Accuracy Testing

Testing body temperature measurements to determine the comparison of body temperature measurements with a digital thermometer. The results of temperature testing with a comparator are an error percentage of 3% and an accuracy percentage of 97%. The following results from measurements can be seen in Table 6 as follows.

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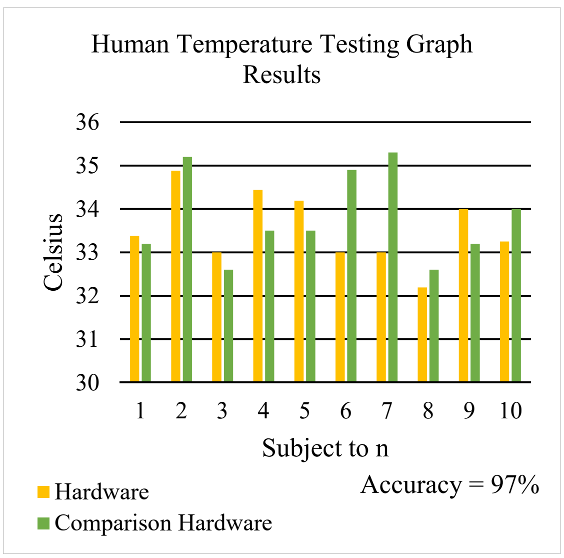
Table 6. Body Temperature Test Results

No	Name	Age	Hardware	Comparison Hardware	Difference	Error Percentage
1	Yusriyyah	20	33.38	33.2	0.18	1%
2	Nandy	21	34.88	35.2	0.32	1%
3	Fiqhi	21	33	32.6	0.4	1%
4	Dhea	21	34.44	33.5	0.94	3%
5	Febriyyanti	20	34.19	33.5	0.69	2%
6	Khafabi	20	33	34.9	1.9	6%
7	Yoshi	21	33	35.3	2.3	7%
8	Tika	20	32.19	32.6	0.41	1%
9	Chelsia	20	34	33.2	0.8	2%
10	Asril	20	33.25	34	0.75	2%
Amount of Difference					8.69	
Average					0.869	3%
Accuracy						97%

So it can be concluded that the measurement results have met the standards of existing comparison tools. The results of body temperature measurements in graphical form are presented in graph 4 as follows.



Graph 4. Body Temperature Measurement Results

4.6 Delay Testing

Delay testing is done to find out the time needed when sending data from the device to the website. Delay testing is done five times. There are two conditions in this delay test, namely by using a data network and using wifi which has a higher speed.

Tests conducted using WiFi found an average delay of 0.67 seconds on blood pressure, 0.62 seconds on heart rate, and 0.68 seconds on body temperature. While using the data network obtained an average delay of 1.85 seconds on blood pressure, 1.52 seconds on heart rate, and 1.37 seconds on body temperature. The results of delay testing with WiFi are shown in table 7 as follows.

Table 7. Testing Delay with WiFi

Blood Pressure		Heart Beat		Body Temperature	
Test -	Delay (second)	Test -	Delay (second)	Test -	Delay (second)
1	0.65	1	0.62	1	0.61
2	0.69	2	0.53	2	0.57
3	0.64	3	0.54	3	0.88
4	0.71	4	0.66	4	0.61
5	0.67	5	0.76	5	0.76
Mean	**0.67**	**Mean**	**0.62**	**Mean**	**0.68**

The Delay Test Results with Data Network are shown in table 8 as follows.

Table 8. Testing Delay with Data Networks

Blood Pressure		Heart Beat		Body Temperature	
Test -	Delay (second)	Test -	Delay (second)	Test -	Delay (second)
1	02.13	1	02.07	1	01.67
2	02.40	2	01.42	2	00.68
3	00.67	3	01.03	3	01.80
4	01.96	4	01.81	4	00.77
5	02.13	5	01.31	5	01.93
Mean	**1.87**	**Mean**	**1.52**	**Mean**	**1.37**

4.7 Subjectivity Testing

This test is carried out to find out whether the application is following what is needed by the user or not. This test is done by distributing questionnaires to several respondents who have used the application.

Table 9. Testing Subjectivity

No	Question	Answer				
		SS	S	KS	TS	STS
1	Is Application easy to use?	30%	70%			
2	Is the Android application that has been created in accordance with the needs of users?	20%	80%	-	-	-
3	Does the application look quite interesting?	-	90%	10%	-	-
4	Does the measurement result value in the hardware already match the value shown in the application?	100%	-	-	-	-

Can be seen from Table 9 above, that respondents think this application is easy to use (30% strongly agree and 70% agree), respondents think this application has been made according to user needs (20% strongly agree and 80% agree), this application also it is quite interesting for respondents (90% agree and 10% disagree), besides that the respondents also think that the value of the measurement results on the hardwares and applications are 100% appropriate.

4.8 Data Testing

This data test is done to find out how much data is needed to take the measurement results of each sensor. This test uses the internet speed meter application as shown in Figure 17 as follows.

Figure 17. Internet Speed Meter

It can be seen based on table 10 that the data needed to retrieve the measurement results in the database.

Table 10. Testing Data

Blood Pressure		Heart Beat		Body Temperature	
Test-	Data (kb)	Test-	Data (kb)	Test-	Data (kb)
1	4.14	1	3.90	1	4.48
2	4.57	2	3.61	2	5.28
3	5.71	3	6.91	3	9.19
4	9.46	4	3.02	4	3.10
5	4.29	5	3.59	5	4.57
Mean	**5.63**	**Mean**	**4.20**	**Mean**	**5.32**

In blood pressure, an average data of 5.63 kb is needed, an average heart rate of 4.20 kb is required, and in body temperature, an average data of 5.32 kb is required.

5. CONCLUSION

The objective of this study was to understand the results of measurements on the device, realtime database firebase, and applications 100% the same, this proves that the integration between hardware and software works well. The investigation has concluded that delay at the time of receiving data from the measurement results of hardware to the software database is still safe because it is under the ITU-T standard of 150 ms. Then from the results of subjective tests on CardioSys users, it can be concluded that the application is following what they need.

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