Designing IoT-Based Independent Pulse Oximetry Kit as an Early Detection Tool for Covid-19 Symptoms

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***Abstract*— The increasing positive confirmed patients Covid-19 in Indonesia especially in Banyuwangi showed how serious the outbreak of this virus. Based on data obtained from news, mass media, and surveys in health facilities (Faskes) in Banyuwangi, most hospitals appointed to treat patients with symptoms Covid-19 have not been able to provide adequate rapid test equipment for early detection independently to the patient. Similarly, a person who is conducting quarantine from the Covid-19 is either quarantined in the hospital as a patient in supervision, a positive patient, or a self-imposed quarantine in the home as a supervising person who, because it has just traveled from the red zone area Covid-19 requires an infectious risk assessment Not all people infected with Covid-19 show their symptoms within a few days, can also be felt after 10-14 days or even more, or even show no symptoms at all. However, a person who does not experience the symptoms of Covid-19 is at risk of being a carrier that can transmit to another person. The symptoms for a person who is indicative of Covid-19 one of them is shortness of breath, abnormal heartbeat, and abnormalities in lung function similar to the symptoms of pneumonia. Indications of the symptoms shown indicate that the soluble O_2 levels in the blood in the person's body are abnormal. The O_2 level in the normal blood vessel is 75-100 mmHg, which means if the O_2 level is below normal indicating a person needs additional O_2, and if it exceeds it will damage the cells of the lungs. In the case of Covid-19, a person will exhibit symptoms similar to health disorders especially similar to asthma and pneumonia. So, in this study, the main focus was on the development of tools used to measure the level of dissolved O_2 in the blood carried out with the help of the medical personnel and carried out independently. The implementation of the Pulse Oximetry Kit has been developed and used extensively in the health world. However, the latest Pulse Oximetry Kit does not yet have a system that can be monitored in real time and record the measurement results according to the needs of management of Covid-19 patients. Therefore, this research will be focused on the development of pulse oximetry kits by utilizing the Internet of Things (IoT) technology as tools that can be used to perform remote monitoring of covid-19 patients through smartphones with regard to physical and social distancing protocols. The design and development of portable pulse oximetry kit products that are equipped with GPS and its integration with IoT technology that is mass production is the main focus on this research**

Keywords—pulse oximetry kit, iot, covid-19, smartphone

I. INTRODUCTION

The growing positive patients confirmed the novel coronavirus disease (Covid-19) in Indonesia especially in Banyuwangi showed how serious the outbreak of this virus. Based on the current data development of the Covid-19 pandemic in Banyuwangi [1] showing the trend of the number of people at risk, supervised persons, supervised patients showed a slow rise but certainly from day to day to date has not shown an indication of the decline in Banyuwangi regency from the yellow zone to the Green Zone. The problems faced by health facilities (faskes) both hospitals and Puskesmas in Banyuwangi based on surveys conducted [2] showed that the facility have not been able to facilitate many people to do rapid test and swab test to patients who showed the symptoms of Covid-19 because of the limitations of equipment that have considerable cost if done independently.

Symptoms are caused for a person who is indicative of Covid-19 [3], one of which is shortness of breath, abnormal heartbeat, and abnormalities of lung function similar to the symptoms of pneumonia. Indications of the symptoms showed that the saturation or O_2 levels dissolved in the blood in the body of the person is not normal. The O_2 level in the normal blood vessel is 75-100 mmHg which means if the dissolved O_2 level is below normal, then a person needs an additional O_2, and if the O_2 levels exceed normal, then the cells in the lungs will experience malfunction or damage.

The Pulse Oximetry (SpO_2) method [4] is widely used as a standard in measuring the health level of the human body, namely by measuring O_2 dissolved in the blood. Abnormal dissolved O_2 levels are found in health abnormalities in patients such as pneumonia, cardiovascular disorders, asthma, and are even used to measure possible abnormalities in newborn babies.

However, the latest Pulse Oximetry Kit does not yet have a system that can be monitored in real time and record the measurement results according to the needs of management of Covid-19 patients. Therefore, this research will be focused on the development of pulse oximetry kits by utilizing the Internet of Things (IoT) technology as tools that can be used to perform remote monitoring of covid-19 patients through smartphones/PC with regard to physical and social distancing protocols [12].

II. LITERATURE REVIEW

A. Covid-19, Symptoms, and Prevention

The Novel coronavirus disease 2019 or known as Covid-19 is one of the pathogens that attack the human respiratory system. Today, the Covid-19 outbreak has become a major threat to people all over the world. Covid-19 was part of a previous outbreak in the 2000s, Middle East Respiratory Syndrome (MERS)-CoV and Severe Acute Respiratory Syndrome (SARS)-CoV.

Covid-19 was first discovered in December 2019 in Wuhan City, province, China [5]-[6] where a number of patients were found hospitalized with early diagnosis of pneumonia. Early allegations of these patients had an epidemiological relationship with animal and seafood markets before eventually progressed into such a terrible plague.

Zhao S, Lin Q [7], conducted a study in December 2019 by performing a calculation of the Covid-19 (Ro) reproductive rate using exponential growth methods, obtained the average Ro estimate of COVID19 was 2.24 to 3.58 with an increase of 8 folds. That is, if Ro is more than 1, then Covid-19 predicted to cause a pandemic because of its rapid development.

The first case of a person infected with Covid-19 occurred on 18 December 2019, where within 10 days had plundered 5 patients with acute respiratory distress, and 1 person was declared dead [8]. By the beginning of January 2020, patients were infected with a covid-19, 41 people, where half of the patients had congenital diseases, especially cardiovascular, hypertension, and diabetes. Some feel symptoms-6 symptoms such as asthma and pneumonia, convulsions, dry cough, and body temperature around 38-39 degrees Celsius [9].

Originally Covid-19 was found in Wuhan, indicating that this virus is very contagious which is easily transmitted through the air because of contact with an infected person. The Media is the most widely transmitted through saliva fluid, air, and objects around the human being affected by droplet or splashes of corona viruses that are transmitted by a person infected with a virus. The very massive spread of Covid-19 today has plunder almost every country in the world. Until the last data compiled from the World Health Organization (WHO) [10]-[11] on April 24, 2020 showed the current United States became the country's highest infection rate of 898,974 cases and the number of dies approaching 50 thousand people, and the healing rate reaches 85,000 people. The 2nd rank was followed by Spain and Italy with each infection rate reaching more than 200 thousand cases and 189 thousand cases with a mortality rate of each reaching 10% and 11%, and the cure rate reached 45% and 25%. While China as the country of origin of the Covid-19 outbreak was considered successful in suppressing the rate of infection and was in position 9 under Iran, and above Russia. China's infection rate reaches 82 thousand cases with a cure rate of about 50% and a death of 5%. While Indonesia itself became the country number in southeast Asia under Singapore with an infection rate of 7,700 cases with a mortality rate reaches 9%. The new distribution Data for the Covid-19 case is shown in Fig. 1.

Fig. 1. Worldwide Data Covid-19 Infographics.

Based on the data in Fig. 1, almost all countries do prevention of pandemic distribution with the government policy of each state. In China, from 23 January to the present, quarantine in some areas of the city are infected such as Wuhan and surrounding cities. In Indonesia, the government seeks to limit the spread of viruses and communities affected by the Covid-19 through large-scale social restrictions (PSBB) and Lockdown policy enforcement to areas located in the Covid-19 red zone. In addition, some things are done for the prevention of transmission in the practice of daily life in accordance with the recommendations imposed by the Indonesian Government, namely: 1) Wash your hands with soap and water for at least 20 seconds. 2) Use an alcohol-based hand sanitizer that contains at least 60% alcohol, if water and soap are not available. 3) Avoid touching the eyes, nose and mouth with unwashed hands. 4) As much as possible avoid contact with people who are sick. 5) When you are sick use a medical mask. Stay in the house when you are sick or immediately to the appropriate health facilities, do not have much activity outside. 6) Cover your mouth and nose when coughing or sneezing with tissue 7) Discard the tissues in the designated place. 8) Clean and disinfected regularly surfaces and objects that are often touched.

B. Pulse Oximetry Kit BLE

Pulse Oximetry Kit BLE is a tool for measuring the oxygen saturation in the blood. This tool is also often called saturation monitor. Pulse Oximetry is widely used by doctors or nurses to check the health of patients, especially those who suffer from respiratory tract disease [13]. The growing technology now Pulse Oximetry Kit has undergone a change that used to use cables to monitor now already equipped BLE (Bluetooth Low Energy) and small LCD display to see the monitoring results shown in Fig. 2.

Fig. 2. Pulse Oximtery Kit BLE

C. ESPDUINO-32

ESPDUINO-32 is a microcontroller that serves as an electronic network controller equipped with Wi-Fi and Bluetooth Low Energy (BLE) devices. So we can connect the ESPDUINO-32 device with other Bluetooth Low Energy based devices shown in Fig. 3.

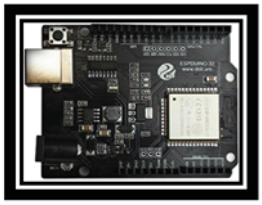

Fig. 3. Espduino-32

D. NodeMCU

NodeMCU is an open source IoT platform. The device is a microcontroller and chip esp8266 so that it can be integrated with the Internet indicated by Fig. 4.

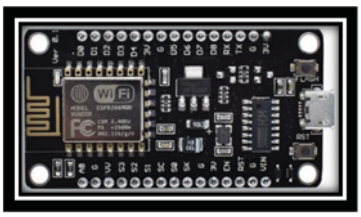

Fig. 4. NodeMCU

E. Finger Print

The function of this fingerprint is to validate the identity data by recording the Figure of the fingerprint and then stored in the database. The fingerprint Sensor is a type of AS608, which can be seen below. Its communication using the 4-pin Serial TTL is used when connected to the Arduino or other controllers such as VCC, GND, TX and RX, as Fig. 5 shows.

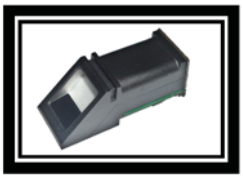

Fig. 5. *Finger Print*

F. GPS NEO-6M

The NEO-6M GPS is a GPS module that acts as tracking or determines the location of something based on Latitude and Longitude coordinates that will be shown in Fig. 6.

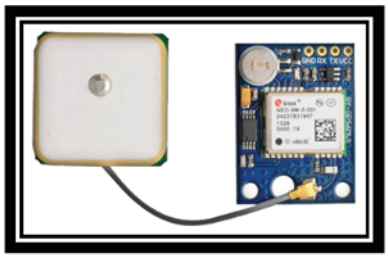

Fig. 6. *GPS NEO-6M*

G. HMI LCD TFT

Liquid Crystal Display or commonly called LCD is a type of media viewer that uses liquid crystals as the media of its main viewer. The LCD function is very important because it serves to display the working status on one tool. The Inter integrated Circuit, often called I2C, is a two-way serial communication standard that uses two channels and is specifically designed to accept or transmit data. The systems contained in the module consist of an SCL (Serial Clock) channel and an SDA (data serial) that sends information in the form of Data between the module and its control. To be shown in Fig. 7.

Fig. 7. HMI LCD TFT

H. Cloud Databases Server

IoT is a concept in which, certain objects have the ability to transfer data over a network. Without requiring interaction from human to human, or from human to computer devices. The Cloud world and the Internet of Things (IoT) have evolved into today's superior information technology. There are a lot of advantages resulting from the integration between Cloud Computing and the Internet of Things (IoT) identified in the literature. The incorporation between the Cloud and the Internet of Things (IoT) or we can also refer to as Cloud-IoT is a paradigm that relates to one another. In the field of cloud, the database server is used as a measurement data storage media and 11 patient diagnoses virtually. The IoT system plays a role in remote control and monitoring. As shown in Fig. 8.

Fig. 8. *IoT and Cloud Database Configurarion*

III. RESEARCH METHOD

A. Research Method

Related to the research conducted as well as the guidance of development of monitoring system discussed in this proposal, the author uses research methods Research and development (R&D). The R&D research method is a research method used to produce a specific product, and to test the effectiveness of the product. This method will lead the authors to through a series of processes or steps to develop a new product or to narrow the existing product to be accounted for.

B. Stage of Research

The R&D method is divided into 4 phases of the research phase, namely: Planning, Product Research Processing, Product Development, and Launching. Here is the explanation of each research phase:

1. Phase 1: Planning

Planning is part of the initiation of research activities consisting of the Literature Review and Project Scope. The Literature Review was conducted to obtain valid information and data on the symptoms of Covid-19 and the needs of the tools needed in the treatment and care of patients. Meanwhile,

Project scope is created to limit the implementation of research which is limited by cost, schedule, and human resource, as well as hardware requirement planning. The planning phase begins with the research assignment from the director of Poliwangi to the team that has been appointed through a summary assessment of the study proposed by the research team. The research team comprises of Poliwangi lecturers, lecturers of Polinema Partners, and Faskes Kabat conducted a study of the problem identification, project initiation, and research proposal equipped with a cooperation agreement in the form of a Memorandum of Agreement (MoA) between the three parties who joined the study team.

2. Phase 2: Product Research Processing.

Product Research Processing or implementation of product research is a stage of research activity consisting of project execution 13 and Project Process Quality Management. Project Execution is carried out from the analysis phase and the translation of the problem into the needs of hardware and software needed in the process of conducting research until the monitoring and evaluation of each stage of its activities. While Project Process Quality Management is done to maintain the quality of implementation activities related to the administration of the implementation of research related to progress report and research control according to the research scope (cost, schedule, human resource, and progress documents). At the stage of product research processing, Poliwangi as the chairman of the research is responsible as a host of research activities ranging from planning to closure, preparing a place or laboratory as a place to work and testing tools by the research team, and ensure the quality of implementation of the study. Polyorem as an expert in providing advice and input about the tools being developed. Faskes Kabat is involved in providing the appropriate data and information related to the IoT-based Pulse Oximetry Kit that is being developed, calibration, and validation of tool measurement results.

3. Phase 3: Product Development

Product development is an important step of research activities consisting of tool prototyping and project closure management. Prototyping is done after testing of the network integration of hardware and software of the equipment is complete and successfully calibrated according to the function of Pulse Oximetry Kit. The prototyping process carried out re-packaging the product kit which is Laik industrial and ready to be mass produced. Project closure is characterized by the achievement of all indicators of external achievement of research, namely: international publication, prototype, and portfolio or research product Blueprint.

4. Phase 4: Launching

Launching is part of the official release of Triple Helix research product which is a collaboration between 3 institutions, namely Poliwangi, Polinema, and Faskes Kabat. An external product in this launching is the IoT-Based Independent Pulse Oximetry Kit which is used for monitoring patients with the symptoms of covid-19 and or someone who is undergoing quarantine independently.

C. Observed/Measured Variables

In transmissive application mode, the sensor device is placed on a thin part of the patient's body, usually the fingertip or the earpiece, or in the case of a baby, over the leg. The device passes through two wavelengths of light through the body to a photodetector. This will measure the change in the absorption of each wavelength which allows it to determine the absorption of the arteries that are only pulsed, excluding vein, skin, muscle, or bone blood. About 89% of blood carries oxygen. This percentage indicates the rate of oxygen saturation. Oxygen saturation levels play a role in keeping cells, body and health. In healthy patients, oxygen saturation levels range from 95% while 92% will indicate potential patients with hypoxia or lack of oxygen that reaches the tissues in the body. This percentage will be used as reference in the early detection of patients exposed to Covid-19. This variable will be observed in the success testing tool that is comparison of oxygen saturation of healthy patients and pneumonia patients (wet lung). Early detection of Covid-19 patients had almost the same characteristics as pneumonia sufferers, but to determine whether the patient was exposed to Covid-19 they were obliged to perform a series of tests such as X-Ray, CT-Scan, Swab to ensure that they were infected. So, the variables to be taken are shown in Table I.

TABLE I. MEASURED VARIABLE

No	Item	Healthy Patients (90-95%)	Risk Patients (<90%)
1	*Percentage of oxygen saturation levels in the blood*	80 – 99 % SpO2	<80% SpO2

IV. DESIGN SYSTEM

The system works by relying on ESPDUINO-32 as a receiver or Bluetooth Low energy receiver that will be connected with Pulse Oximetry BLE. ESPDUINO-32 and NEO-6M GPS are connected with *Node MCU* serially to Server Databases to be monitored in real-time. Fingerprints are used as ID or identity of the patient using this tool. Figure to show the system design will be displayed on Fig. 9, and Fig. 10.

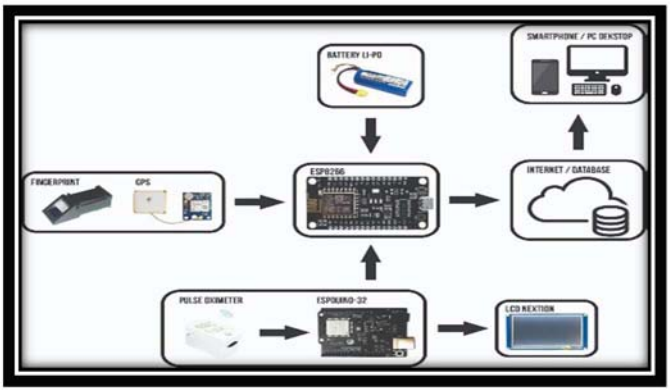

Fig. 9. Design System

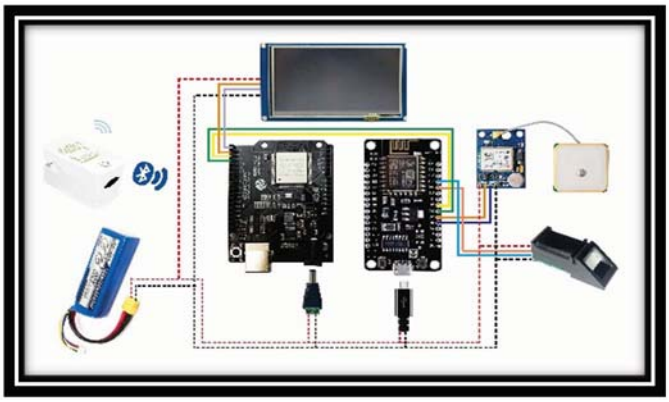

Fig. 10. Cabling System and Wireless on Device.

V. Result and Discussion

In this research tool Pulse Oximetry Kit based on the Internet of Things is designed using a Pulse Oximetry BLE sensor that complies with existing health standards. Pulse Oximetry BLE is connected by ESPDUINO-32 via Bluetooth which is already integrated on both devices. After the data is received by ESPDUINO-32 It is then sent to *NodeMCU* serially. The Data that has been received by *NodeMCU* is sent to the Database Server over the Wi-Fi network connected on the device.

A. Oximetry BLE Pulse Sensor Testing

The Oximetry BLE Pulse Sensor uses the fingers as a medium to measure the dissolved O2 levels in the blood [14]. Measured O2 levels are the result of a direct measurement. That will be shown in Fig. 11.

Fig. 11. Oximetry BLE Pulse Sensor Testing.

B. Testing Sensors with ESPDUINO-32

The Pulse Oximetry Kit Sensor is associated with the ESPDUINO-32 via Bluetooth which deprogram on the Arduino IDE using the C programming language. The following views of the program have been created for this study as shown in Fig. 12, Fig. 13, and Fig. 14.

Fig. 12. Program View *ESPDUINO-32 BLE*.

Fig. 13. View Program Upload Results.

C. Test Monitoring Results with Applications

The results of the measurements that have been completed will be processed by *Node MCU* and then sent to the Database Server and directly in access by the application that has been created. That will be shown in Fig. 14.

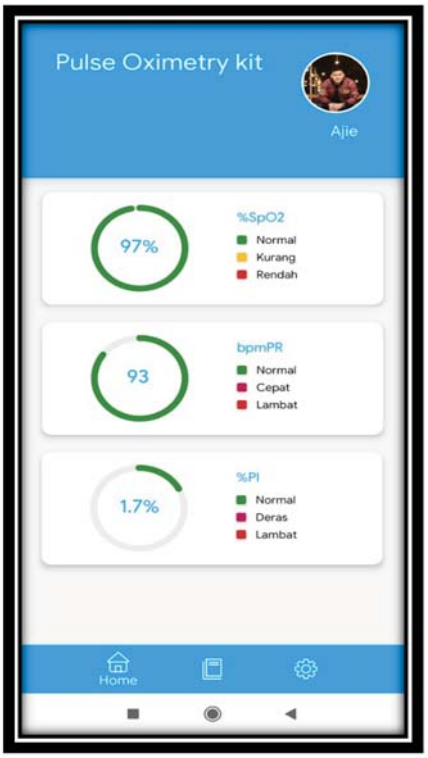

Fig. 14. Monitoring Application by User

VI. Conclusion

The results of this research can be concluded:

1. Tool Pulse Oximetry Kit based on this Internet of Things uses a Pulse Oximetry BLE Sensor to measure the dissolved O2 levels in the blood which then the data is in process by ESPDUINO-32 and sent to the Database Server by *NodeMCU*.
2. Determination of the minimum limit of dissolved O2 levels in the blood that has been done research and trial stage.

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