Advances in Social Science, Education and Humanities Research, volume 651
Proceedings of the 4th International Conference on Innovation in Engineering and Vocational Education (ICIEVE 2021)

Design and Implementation of Multiple Vaccine Monitor System Using IoT and Android Application

Ali Taufan
Department of Forensics and Medicolegal, Faculty of Medicine
Universitas Jenderal Achmad Yani
Cimahi, Indonesia

Dede Irawan Saputra*
Department of Electrical Engineering, Faculty of Engineering
Universitas Jenderal Achmad Yani
Cimahi, Indonesia
*dedeirawan.saputra@lecture.unjani.ac.id

Siska Telly Pratiwi, Eka Noneng Nawangsih
Department of Microbiology, Faculty of Medicine
Universitas Jenderal Achmad Yani
Cimahi, Indonesia

***Abstract*—The need for safe distribution of Covid-19 vaccines is indispensable for all parties to minimize the risk of distribution. Vaccine monitoring systems has advantage that officers or supervisors can continuously monitor multiple device such as the temperature, shock and cold box position during the distribution process. When the cold box temperature is outside the specified temperature range, the system will give warnings in the form of notifications through the android smartphone application and can also be accessed via the website so that vaccine carrier can condition the cold box by increasing or decreasing ice packs so that the quality of the vaccine can be maintained. Equipped with a location tracking system using GPS, it can provide information on the presence of vaccines to supervisors in real time. This system consists of a DS18B20 temperature sensor, a shock sensor using MPU6050 and a GPS sensor using UBLOX NEO-6M GPS module. The sensors are connected to a microcontroller ATMega 2560 chip in a single printed board along with a battery power supply. The notification feature is very helpful for vaccine carrier and supervisors when an abnormal event occurs in the cold box so that it can facilitate the decision-making process.**

Keywords—Covid-19, vaccine, monitoring, IoT, Android

I. INTRODUCTION

The Coronavirus which has spread since December 2019 has been declared a pandemic [1]. The Government of the Republic of Indonesia has established an emergency response status through Decree no. 7 of 2020 issued on March 17, 2020 [2]. Various health protocols have been implemented to suppress the spread of the Covid-19 virus, such as using masks, maintaining distance, and washing hands with soap [3]. Another effort that is being carried out by the government is the distribution of vaccines [4]. There are various challenges in the vaccine distribution process, one of which is the distribution monitoring process. The process of monitoring the vaccine can go through several things, including the maintained temperature.

Vaccine storage requires special attention because vaccines are biological preparations that are susceptible to changes in environmental temperature [5]. In the Minister of Health Regulation Number 12 of 2017 concerning the Implementation of Immunization, it is stated that vaccines are biological products so they must be stored at a certain temperature, namely at a temperature of 2ºC to 8ºC for vaccines sensitive to freezing. Meanwhile, heat-sensitive vaccines can be placed at a temperature of -15ºC to -25ºC [6]. The entire vaccine distribution process to the service level must be able to maintain high vaccine quality, the distribution process must use a cold box accompanied by a cold pack or other means of transportation following the type of Covid-19 vaccine [7]. Each cold box can be accompanied by a temperature monitor. However, the need for a real-time temperature monitoring process equipped with warnings and position detection when abnormal occurs is very necessary. In addition, features that can detect shocks should also be needed to identify behavior in vaccine distribution.

The need for safe vaccine distribution is very necessary for all parties, innovation, and engineering can be done to simplify and minimize risks. Vaccine monitoring systems placed in good logistics infrastructure can also have a good impact in terms of management such as being able to monitor temperature [8], shocks [9], and position [10,11]. The monitoring process can use the concept of the Internet of Things (IoT) [12–14]. The main advantage of this system is that officers can continuously monitor the temperature, shock, and cold box position. When the cold box temperature is outside the optimal temperature range, the system will give warnings in the form of notifications and alarms through the smartphone application and can also be accessed through the website so that officers can condition the cold box temperature by increasing or decreasing the number of ice packs so that the quality of the vaccine can be maintained.

II. Research Methodology

In making and designing this system, an approach using the V-Model method and referring to VDI 2206 can be used for the manufacture of a mechatronic device and cyber-physical system. At this stage, it can be divided into several phases, namely Phase 1: Literature Study. Phase 2: Production Concept, Phase 3: Prototypical Realization.

After studying the literature in the first phase, the next step is to carry out the concept of production or analysis of specifications and architecture. In realizing this, a list of requirements for both basic and advanced systems is needed. The following is a list of the requirements of the system.

- The system can read the temperature on the cold box device and can provide notifications if an abnormal or failure occurs in the colding process.
- The system can provide information on the position or location of the cold box delivery.
- The system can read shocks and provide notifications if an abnormal event occurs or gets a severe shock.
- The system has recorded data and is connected to the internet.
- The system can observe the delivery speed of the cold box when it is on its way to the desired place/destination.
- The system is equipped with an Android mobile application so that it can be accessed via a smartphone.
- Applications on smartphones can be integrated with multi-device cold boxes.

A. System Architecture

The first step in designing a system is to describe it in several forms as shown in Figure 1. The figure shows the data flow that occurs in the cold box system. The entities of the system are sensors, microcontrollers, cloud storage, and Android applications. The beginning of the data flow in the system is when the sensor receives energy from the outside so that it can read and provide data in the form of sensor readings which will be processed on the microcontroller part. Furthermore, the sensor reading data will be processed into raw data and then forwarded to cloud storage along with the device identity. Next, the Android application will display a dashboard in the form of data from sensor readings and device channels that can be accessed.

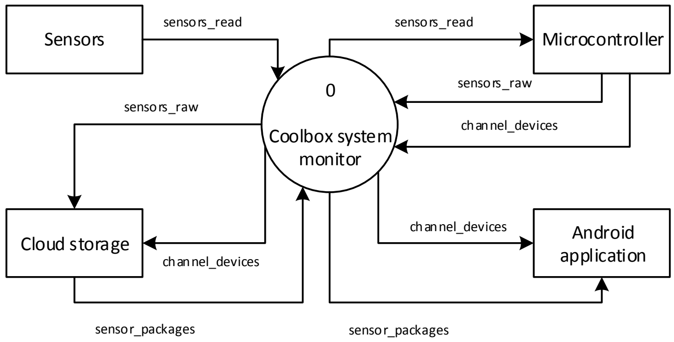

Fig. 1. DFD level 0 cold box monitor system.

A more complete data flow can be shown in Figure 2 in the form of a level 1 data diagram. In the diagram, it can be seen that there is some data stored by cloud storage. At first, the data read by the sensor is then processed by the microcontroller, then the microcontroller sends the data using the internet with the HTTP protocol to cloud storage. The microcontroller sends data by the Post method. The Android application that will be connected can retrieve the required data by accessing cloud storage using the Get method. In Figure 2, it can be seen that the data stored by cloud storage is data on temperature, longitude, latitude, altitude, speed, and shock.

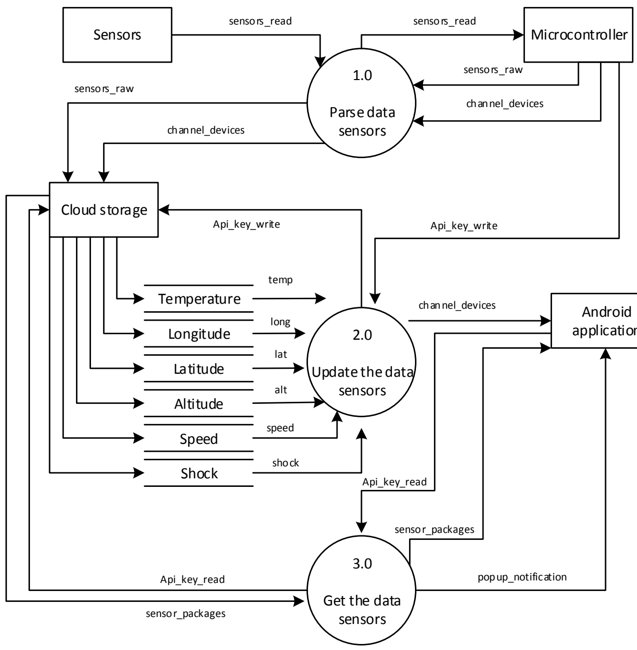

Fig. 2. DFD level 1 cold box monitor system.

B. Flowchart of Microcontroller Programming

Microcontroller programming in research has been determined based on needs and specifications. In Figure 3 at first, the microcontroller can initialize input and output. Furthermore, in order to communicate properly, the microcontroller must be able to directly communicate with the main devices such as GPS modules, GSM modules, SD card modules, and OLED modules. The system will continue to repeat until all the modules are connected. If it is connected then the microcontroller must be able to read all input from the sensor. The data processed by the microcontroller is then grouped into one package so that it will be easier to send it to cloud storage. The microcontroller must also display some pre-defined conditions as abnormal conditions, such as a very drastic drop in temperature, a drastic increase in temperature, and a drastic shock. The evaluation results can then be recorded on the connected SD card.

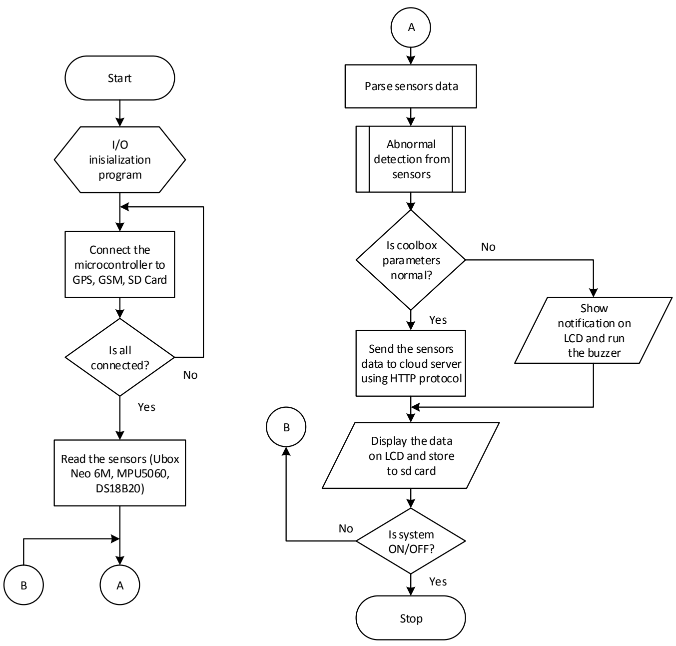

Fig. 3. Flowchart of microcontroller programming.

When the senor functionality and data processing on the microcontroller is complete. Data that has been compiled and will be sent to cloud storage using the HTTP communication protocol. The microcontroller connected to the GSM module can activate the internet feature on the GPRS network so there is no need to communicate using wifi. The packaged data will then be sent at certain time intervals, once every 10 seconds. After the data packet is sent to the cloud storage, the task of the microcontroller is complete. The program will continue to repeat until the system is turned off.

C. Design of Electronic Hardware

The hardware used in the system as shown in Figure 4 includes GPS Ublox Neo 6M which is a position sensor used to retrieve data on longitude, latitude, altitude, speed, and time. Next MPU6050 is an accelerometer sensor that can be used to detect changes in acceleration that occur in the sensor. The sensor has 3D characteristics. The data obtained from each axis can be generated and converted in various values, one of which is slope. The next sensor is the DS18B20 which is a temperature sensor that can make direct contact with the object whose temperature is to be measured. The sensor has high accuracy so it is very suitable for detecting objects such as the cold level of an ice gel or ice pack on a cold box. Next SIM800L is a communication device or module that can be connected to a microcontroller. This device has several features like the function of a mobile phone. This device can be used to access the internet and send messages. All these devices are integrated on an ATmega2560 microcontroller.

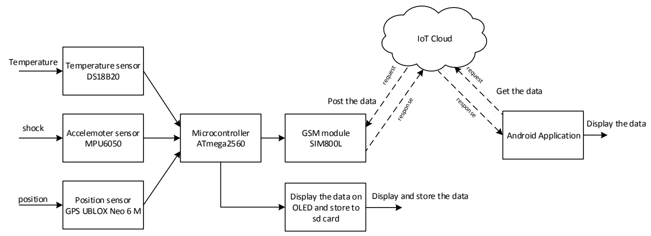

Fig. 4. Block diagram of signal processing.

III. Results and Discussion

A. IoT Integration and Implementation

The website used to collect all channel device data and sensor data using the cloud from Thingspeak. Thingspeak is an IoT platform that can be accessed for free by complete features. 4 channel devices can be integrated with Thingspeak cloud storage in this research. To collect data from the cold box, it requires six fields, each field is filled with sensor readings, namely, longitude, latitude, altitude, temperature, shock, and speed. The following configuration is carried out on the Thingspeak website which is shown in Figure 5. Two API keys can be accessed and used on each channel, namely the WRITE API KEY to perform the writing process and the READ API KEY which can be used for the data retrieval process or data reading.

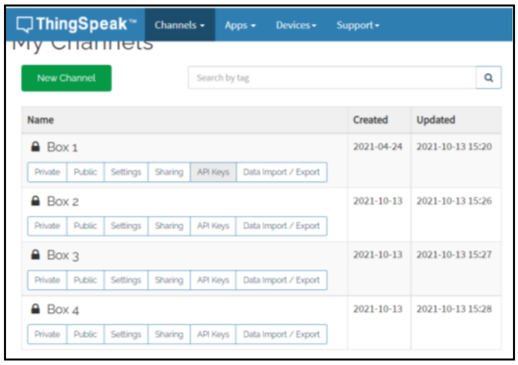

Fig. 5. Cold box channel in Thingspeak.

B. Android Application

Because the microcontroller is a sensor node, in the process of sending data obtained from the sensor, have to use the WRITE API KEY to send the measured data on the cold box to the Thingspeak cloud server. The cold box system that can already be integrated with the Thingspeak will make it easier to retrieve data and send it to other platforms such as the Android application. The application can be made using the MIT App Inventor application. The application created can be operated on all smartphone devices with the Android operating system as shown in figure 6.

Fig. 6. Android application development using MIT App Inventor.

To communicate with the Thingspeak cloud server, Android application as a display or interface, use READ API KEY. There is a variable that serves to accommodate the condition of the button selected by the admin. If the box1 button is pressed, the variable will be 1 and will determine the READ API KEY for box 1. And so on for the next channel. The data from the Thingspeak server is JSON and requires parsing in the Android app to display. So the Android application creates a variable to accommodate the JSON data parsed results. then the variables that have been created are used for the process of displaying data on the Android application. The data is retrieved from the Thingspeak cloud server using the GET method of the HTTP protocol.

IV. Conclusion

The system has been realized using the VDI 2206 model for cyber-physical systems. From a perspective, the VDI 2206 is very useful to guide the design process of the vaccine cold box system. The verification process of each system component can be easily traced both in terms of software, hardware, mechanics, and IoT. The main advantage of this system is that officers can continuously monitor the temperature, shock, and cold box position. When the cold box temperature is outside the optimal temperature range, the system will give warnings in the form of notifications and alarms through the smartphone application and can also be accessed through the website so that officers can condition the cold box temperature by increasing or decreasing the number of ice packs so that the quality of the vaccine can be maintained. Utilization of the free Thingspeak cloud storage website can accommodate 4 channel cold boxes. Each channel can be accessed by the Android application by distinguishing the API that has been provided by Thingspeak. The results of the readings of each sensor work well so that cloud storage can communicate with each other with the microcontroller and with the Android application.

Acknowledgment

The authors thank the Universitas Jenderal Achmad Yani for supporting the research.

References

[1] I. Wahidah, R. Athallah, N.F.S. Hartono, M.C.A. Rafqie, and M.A. Septiadi, “Pandemik COVID-19: Analisis Perencanaan Pemerintah dan Masyarakat dalam Berbagai Upaya Pencegahan,” J Manaj Dan Organ, vol. 11, pp. 179–88, 2020.

[2] A. Rohman, “Dasar Pembentukan Peraturan Daerah Dan Peran Kepala Daerah Terhadap Upaya Pencegahan Penyebaran Covid-19,” ADIL J Huk, vol. 11, 2020.

[3] A. Nurrahman, “Peran Pemerintah Daerah Dalam Memelihara Ketenteraman Dan Ketertiban Umum (Studi Pada Penanganan Penyebaran Virus Covid 19 Di Provinsi Dki Jakarta),” J Tatapamong, vol. 2, pp. 1–16, 2020.

[4] N.P.E.D. Yanti, I.M.A.D.P. Nugraha, G.A. Wisnawa, N.P.D. Agustina, and N.P.A. Diantari, “Public Knowledge about Covid-19 and Public Behavior During the Covid-19 Pandemic,” J Keperawatan Jiwa, vol. 8, p. 491, 2020.

[5] P. Hietaharju, M. Ruusunen, and K. Leivisk, “A Dynamic Model for Indoor Temperature Prediction in Buildings,” Energies, vol. 11, 2018.

[6] Prevention C for DC and. COVID-19 Vaccination Program Interim Playbook Program for Vaccination Jurisdiction Operations Interim Operational Guidance for Jurisdictions Centers for Disease Control and Prevention (CDC). 2020.

[7] H. Lundbeck, B. Hakansson, J.S. Lloyd, S.K. Litvinov, F. Assad, “A cold box for the transport and storage of vaccines,” Bull World Health Organ, vol. 56, pp. 427–32, 1978.

[8] M. Zola, L. Cahyadi, and A.T. Alamsyah, “Cooler box dengan thermoelectric cooler dengan monitoring suhu berbasis labview dan IoT,” Jurnal Poli-Teknologi, vol. 17, no. (2), pp. 145–54, 2018.

[9] S. Devrani, S. Pandey, S. Chaturvedi, K. Sankar, S. Patil, and K. Sridhar, "Design and analysis of an efficient vaccine cold chain box," ASME Int Mech Eng Congr Expo Proc, vol. 50534, 2016.

[10] P. Karthikeyan, C. Ashwin, R.S. Vishnu, and N. Ravi, "Electronic Vaccine Monitoring System," Int J Recent Technol Eng, vol. 8, pp. 3963–8, 2020.

[11] C.M. Li, C.C. Nien, J.L. Liao, and Y.C. Tseng, "Development of Wireless Sensor Module and network For Temperature Monitoring In Cold Chain Logistics," 2012 IEEE Int. Conf. Wirel. Inf. Technol. Syst. ICWITS 2012, 2012.

[12] D.I. Saputra, G.M. Karmel, Y.B. Zainal, "Perancangan dan Implementasi Rapid Temperaturw Screening Contactless Dam Jumlah Oorang Berbasis IoT Dengan Protokol MQTT," JEEE, vol. 2, pp. 20–30, 2020.

[13] D.I. Saputra, A. Rohmat, A. Najmurrokhman, and Z. Fakhri, "Implementation of fuzzy Inference System Algorithm In Brooding System Simulator With The Concept of IoT and Wireless Nodes," ICIEVE 2019, IOP Conference Series: Materials Science and Engineering, pp. 1–6, 2020.

[14] P. Fulzele, A. Kumbhare, A. Mangde, A. Gaidhane, P. Palsodkar, A. Narkhede, et al. "An IoT Enabled Convenient Vaccine Cold Box for Biomedical Use," Eur J Mol Clin Med, vol. 7, pp. 1615–24, 2020.