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Alarm System and Suitcase Tracker with Arduino Microcontroller Based on the Internet of Things

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ABSTRACT

Suitcases are prone to criminal crimes, because suitcases are a place to store valuables, especially when traveling. It is difficult to track the availability of suitcases because there are too many of the same suitcases. Research on the manufacture of alarm tools and suitcase trackers is intended to design and build a luggage tracking system using GPS, SIM 800L, Buzzer, Li-Ion 18650 Battery, and Arduino Nano which can provide alerts through smartphones connected to IoT. To find out how the system works well, testing is carried out by measuring the length of time it takes for alarm devices and suitcase trackers to track and the time it takes for the alarm to sound. The successful design of an alarm and suitcase tracker using GPS, SIM 800L, Buzzer, IoT, Li-Ion 18650 Battery, and Arduino Nano. GPS devices can lock signals with an accuracy of 98.53% for operator one and by 35.59% for operator two in a closed room state, by 97.71% for operator one, and by 62.85% for operator two in an open room state. The phone delay time with buzzer has an average delay time value of 14 seconds for operator one and 16.4 seconds for operator two and an accuracy value of 98.78%. Thus using operator one is more efficient than operator two.

1. Introduction

The fundamental needs of every human being consist of biological needs as well as social needs. Social needs such as social status, social role, actualization of and a sense of security [1]. Currently it can be said that a sense of security is one of the basic human needs to carry out daily activities [2]. Common aspects of running security vary. Such as maintaining the physical security of the assets that we have.

In this study, the object of research was suitcases [3]. A suitcase is one of the things that is usually called very important as a storage of goods. Usually, suitcases are used when traveling by their owners and are used as a place to store valuables that are considered special [4]. Suitcases are usually prone to crime, because many important items are stored in suitcases [5].

As recently, there have been several cases of crime of theft of luggage at the airport taken from several sources, namely the incident experienced by Titi Yusnawati, wife of Head of Unit I of the West Kalimantan Regional Police Narcotics Directorate, Adjunct Senior Commissioner of Police Prasetyono. At that time, Titi was using the Lion Air airline with flight number JT 715, from Supadio Airport to Soekarno Hatta Airport. The plane took off at around 16.00 WIB and landed at Soekarno-Hatta Airport around 18.30 WIB. When Titi was about to pick up her luggage in the luggage waiting room, she saw the padlock was broken. Titi then opened her suitcase. Jewelry in the form of necklaces, rings and 4 bracelets of considerable value were missing. This incident was also reported to the Soekarno-Hatta Airport police [6][7]. The same incident also occurred at Soekarno Hatta airport on Saturday January 2 2017, based on the results of the investigation the officers found systematic and organized theft of luggage involving private security officers who were identified through the CCTV of the airport manager, PT Angkasa Pura II [8].

Based on the description above a research was carried out regarding the manufacture of a tool that can be given a warning to the user and a sound when the suitcase is carried by another person. So, if the suitcase is lost, the user and the alarm will remind the owner in the form of a tracking display on the smartphone application [9]. The system controller with the Ublox NEO-6MV2 GPS module is useful as a location detector obtained from the 800L SIM by utilizing network services and then from the Ublox NEO-6MV2 GPS data and 800L SIM will be processed on the Arduino Nano. The system is designed to create conditions where we want the suitcase to be in the area we want [7][5].

2. Research Method

2.1. System Design

In designing this system, a system design is used with two design stages, namely hardware and software design. The first step in system design is to make a hardware block diagram, then proceed with making an IoT control system as a bait and GPS as a motion detector whereabouts [10]. The second step is to create software or commands that are used to operate the system [11].

2.1.1. Hardware Design

Based on the block diagram in Fig. 1, on the transmitter side there is a cellphone as a system controller where the Ublox NEO-6MV2 GPS module is useful as a location detector obtained from SIM 800L by utilizing network services and then from Ublox NEO-6MV2 GPS data and SIM 800L will be processed on Arduino Nano where the output will be obtained in the form of a buzzer (sound as a sign of the presence of the suitcase) in this study the alarm only indicates the location when the owner calls whereas if the suitcase is forced open the buzzer cannot function automatically, SIM 800L and IoT send data previously obtained from processing which will be sent to the smartphone. While on the receiver side there is a smartphone that functions as a receiver of information from the transmitter side, while turning on the alarm can be done on the receiver side.

In the work of detecting the luggage security system, when the owner wants to know the whereabouts of the suitcase clearly, this can be done by opening the invertor tracking alarm app. In this application the owner can carry out tracking automatically with the condition that the alarm device must have a SIM card installed to get an internet network as feedback, then after the data is obtained the owner is not satisfied about the location point of the suitcase or suitcase which on average has the same appearance, then can a telephone call is made to the number attached to the luggage tracking device in order to turn on the buzzer or alarm.

The design of an IoT-Based Suitcase Tracking Alarm tool uses Arduino Nano as a data processor that is read by the Ublox NEO-6MU2 GPS, functions as a presence detector and the SIM800L Module functions as a smartphone link with IoT, which is then sent to users wirelessly [12][13].

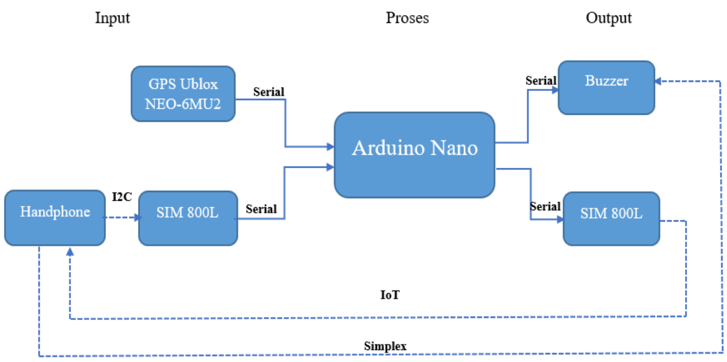

Fig. 1. System design block diagram

Hardware assembly is the process of connecting all devices so that they can read the whereabouts of the suitcase. The overall circuit of the system can be seen in Fig. 2, and for Input/Output is shown in Table 1.

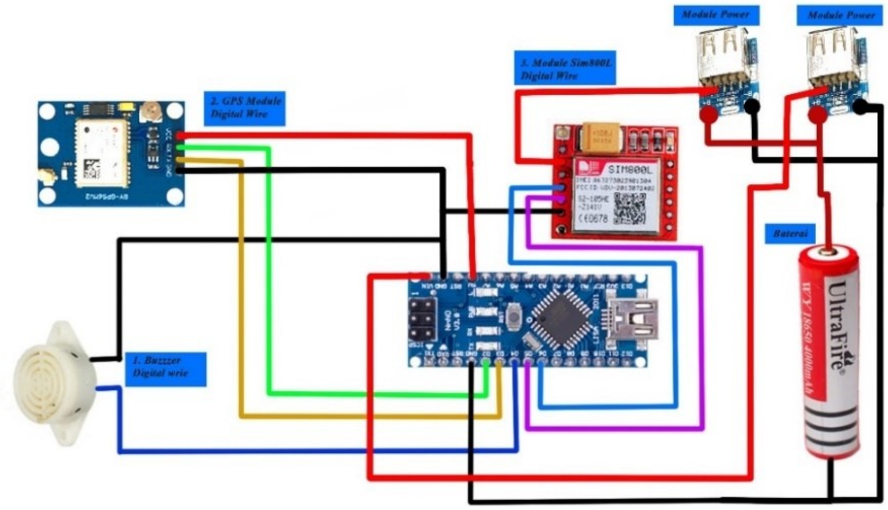

Fig. 2. Overall system wiring diagram

Table 1. Tabel Input Output

Pin NodeMCU	Sensors / Actuators
A7, D2, D3	GPS Ublox NEO-6MU2
D4	Buzzer
D5, D6	SIM800L
VCC, GND	Battery

2.1.2. 3D Design

From the entire series of systems that have been made, you can see the external design of the tool in Fig. 3. It is equipped with the components used, including GPS Ublox NEO-6MU2, Arduino Nano, Buzzer, SIM 800L.

Fig. 3. 3D Design

2.1.3. Software Design

Software design is the process of designing programs for microcontrollers. The program will be created through the Arduino IDE application and downloaded using a USB cable to the Arduino board. Arduino IDE is programming software for Arduino boards using C language [14]. The flow chart for the security alarm and luggage tracker design program can be seen in Fig. 4.

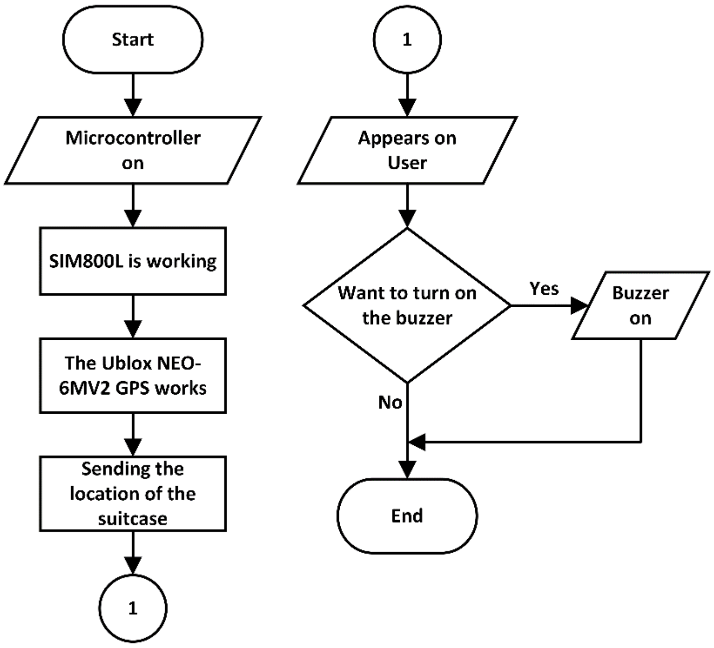

Fig. 4. Flowchart of the process of reading and sending data

From Fig. 4 it is explained that if the microcontroller is on, the Ublox NEO-6MV2 GPS module will start tracking by asking a location request, after the location of the suitcase is detected, the buzzer will automatically sound and the microcontroller will continue to process it to get accurate data. After the data is detected accurately and the buzzer continues to sound, the microcontroller sends information to the owner via IoT [5].

2.2. Research Flow Chart

In this research, the problem identification process was carried out on the suitcase tracking alarm. The problem factor is knowing the existence and safety of the suitcase [2]. Then a supporting literacy study is carried out to further design the appropriate hardware. After the hardware design is complete, then testing the tool whether it works properly, here the tool being tested experiences problems so it needs to be repaired, then data collection from the tool being tested and data analysis will be carried out from the results of data collection [15]. The research flowchart can be seen in Fig. 5.

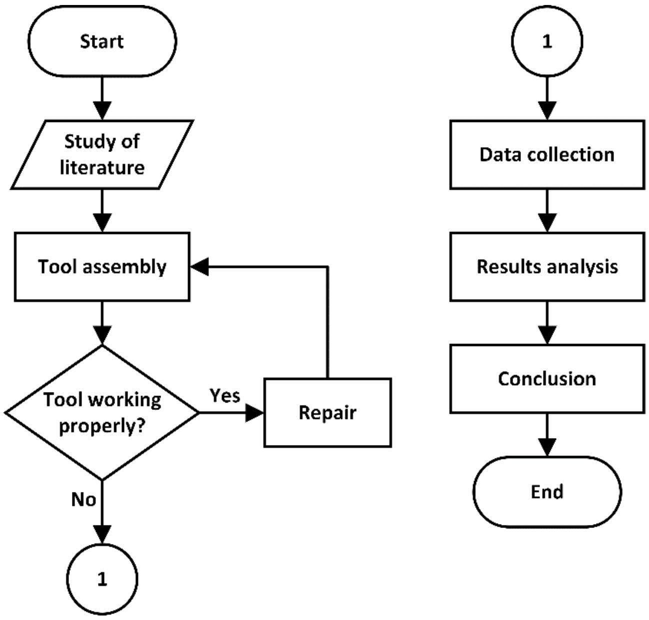

Fig. 5. Research flowchart

3. Results and Discussion

3.1. GPS Sensor Testing Results

Data testing is carried out by pairing sensor outputs in accordance with the provisions, then taking sensor distance measurement data with several sensor readings, the results will be compared with one another between predetermined distances. The wireless tracking test itself is carried out by collecting data while the system is running, so that the data sent via the Arduino Nano will be read on the smartphone. In order to be able to send data to a smartphone, it is necessary to make a connection between Arduino and wi-fi (800L SIM module), the process of tracking or sending data is done wirelessly.

Based on Table 2, sensor testing is carried out by collecting GPS sensor data by calibrating the CPUZ application. The resulting data from the test will be calculated by the value of the difference between the manual measurement value and the result value obtained from the sensor value. After obtaining the value of the difference results, the error value will also be known which can be known by the equation shown in (1) and (2).

$$Difference = Reference\ Value - Percentage\ Error \tag{1}$$

$$Sensor\ Value = \frac{|Difference|}{|Reference\ Value|} \times 100 \tag{2}$$

Table 2 can be seen in the measurement of the GPS sensor, the calculation of the GPS sensor with five trials, in the 1st experiment it has a difference in latitude of 0.33, longitude of 0.17, while the error value of lattice is 4.42, longitude is 0.16, in the 2nd experiment it has a latitude difference value of 0.33, a longitude of 0.17, while for a latitude error value of 4.42, a longitude of 0.16, in the 3rd experiment it has a latitude difference value of 0.33, longitude is 0.17, while the error value for latitude is 4.42, longitude is 0.16, in the 4th experiment it has a difference in latitude of 0.33, longitude is 0.17, while for the error value latitude was 4.42, longitude was 0.16, in the 5th experiment it had a difference in latitude of 0.33, longitude was 0.17, while the error value for lattice was 4.42, longitude was 0.16, in the experiment 6th has in the difference in latitude is 0.33, the longitude is 0.17, while the error value for latitude is 4.42, the longitude is 0.16, in the 7th experiment it has a difference in latitude of 0.33, the longitude is 0.17, while the latitudinal error value is 4.42, the longitude is 0.16, in the 8th experiment it has a difference in latitude of 0.33, the longitude is 0.17, while the lattice error is 4.42, the longitude is 0, 16, in the 9th experiment it has a latitude difference value of 0.33, a longitude of 0.17, while for a latitude error value of 4.42, a longitude of 0.16, in the 10th experiment it has a latitude difference value of 0, 33, the longitude is 0.17, while the latitude error value is 4.42, the longitude is 0.16. In the sensor calculation data with five trials, it can be seen that there are no different values or all the result data are the same.

Table 2. Proximity sensor testing

Experiment to-	Measurement using Sensors		Measurement using CPUZ		Difference	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
1	-7.8066630	110.4035000	-7.482374832	110.241234148	0.33	0.17
2	-7.8066854	110.4034300	-7.482373756	110.241233545	0.33	0.17
3	-7.8066630	110.4035000	-7.482374234	110.241236261	0.33	0.17
4	-7.8065929	110.4034700	-7.482374354	110.241232096	0.33	0.17
5	-7.8064990	110.4034300	-7.482370767	110.241236079	0.33	0.17
6	-7.8066163	110.4034500	-7.482372919	110.241235234	0.33	0.17
7	-7.8066630	110.4035000	-7.482375191	110.241236441	0.33	0.17
8	-7.8065929	110.4033700	-7.482376506	110.241234752	0.33	0.17
9	-7.8066196	110.4044500	-7.482376148	110.241234269	0.33	0.17
10	-7.8067613	110.4044000	-7.482376506	110.241233545	0.33	0.17

3.2. GPS Test Data Retrieval

The measurement data taken is the time needed by the GPS to determine the location of the suitcase, which is carried out within a day with a time range of 07.00-09.00, 11.00-13.00, 15.00-17.00, 20.00-22.00, each data collection is subject to a 10-minute delay. Testing of GPS signal locking is carried out using Telkomsel services (service one) and XL services (service two). The results can be seen in Table 3 and Table 4.

Table 3. The results of testing the GPS signal lock using Telkomsel services in open spaces

Data to- (n)	Time taken for signal locking(s)				Difference (x)	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$
	07.00-09.00	11.00-13.00	15.00-17.00	20.00-22.00			
1	330	442	678	369	5.55	-45.01	2.02
2	366	11	405	09	87.7	37.10	1.37
3	09	13	09	46	9.33	-41.23	1.69
4	03	454	12	05	34.3	-16.24	263.73
5	06	05	15	03	116	65.44	4.28
∑	714	1.016	1.114	403	253.8	6	27.309
Average	1428	203.2	222.8	86.4	50.56	1.2	5.4618

The standard deviation value is

$$\sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{27.309}{4}} = 2.61$$

The absolute error value is

$$\frac{Standard\ Deviation}{\sqrt{n}} = \frac{2.61}{\sqrt{5}} = 1.16$$

Relative error

$$\frac{Absolute\ error}{\bar{X}} \times 100\% = \frac{1.16}{50.56} \times 100\% = 2.29\%$$

The value of the accuracy of the tool is

$$100\% - Relative\ error = 100\% - 2.29\% = 97.71\%$$

Based on Table 3, there is an average value of the largest signal locking in the morning of 142.8 seconds, during the day at 203.2 seconds, during the afternoon at 222.8 seconds, and at night at 86.4 seconds. Based on the calculated data, the largest time difference is 116 seconds, while the smallest difference is 5.55 seconds and the average difference in GPS signal locking is 50.56 seconds. Thus, knowing the average difference, you can also know the standard deviation value, which is equal to 2.61 with an error value in each sample of 1.16, so it is known that the accuracy value is 97.71%.

In Fig. 6 it can be seen for the experiment 07.00-09.00 the first data is known for 330 seconds and then rises to a value point of 366 seconds after obtaining the highest value from the morning experiment then the graph will decrease with a known value of 46 seconds and then the value began to stabilize that is equal to 3 seconds, 6 seconds, and 9 seconds. The experimental data at 11.00-13.00 experienced a very clear change where in the first experiment it was found that the highest value was 442 seconds and then decreased to 11 seconds and stabilized at a value of 13 seconds then the value would increase significantly to be at the highest peak value of 454 seconds and finally the value will decrease drastically with a value point of 5 seconds as the smallest value in the daytime trial, therefore if you look at the graph the experimental data from 11.00-13.00 looks like a valley and a hill. While the data from 15.00-17.00 and 20.00-22.00 experienced the same graphical form where in the first experiment it was found that the highest value was 678 seconds for data at 15.00-17.00 and 678 for data at 20.00-22.00 by 369 seconds then after being at the second highest value the graph will decrease continuously and stabilize at the lowest value point.

Based on Table 4, there is an average value of the largest signal locking in the morning of 153.8 seconds, during the day it is 273.8 seconds, in the afternoon it is 205.2 seconds, and at night it is 92.2 seconds. The difference in the value of the difference is caused by several factors that result in a delay in the sending time of the GPS signal from the satellite.

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Table 4. GPS signal locking test results using XL services in open spaces

Data to- (n)	Time taken for signal locking(s)				Difference (x)	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$
	07.00-09.00	11.00-13.00	15.00-17.00	20.00-22.00			
1	20	740	615	429	2.18	- 19.17	367.48
2	06	484	378	07	1.24	- 20.11	404.41
3	731	10	12	16	92.40	71.05	5.04
4	04	06	16	06	6.40	- 14.95	223.5
5	08	129	05	04	4.56	- 16.76	280.89
∑	769	1.369	1.026	462	106.78	6	1.281.32
Average	153.8	273.8	205.2	92.2	21.35	1.2	256.264

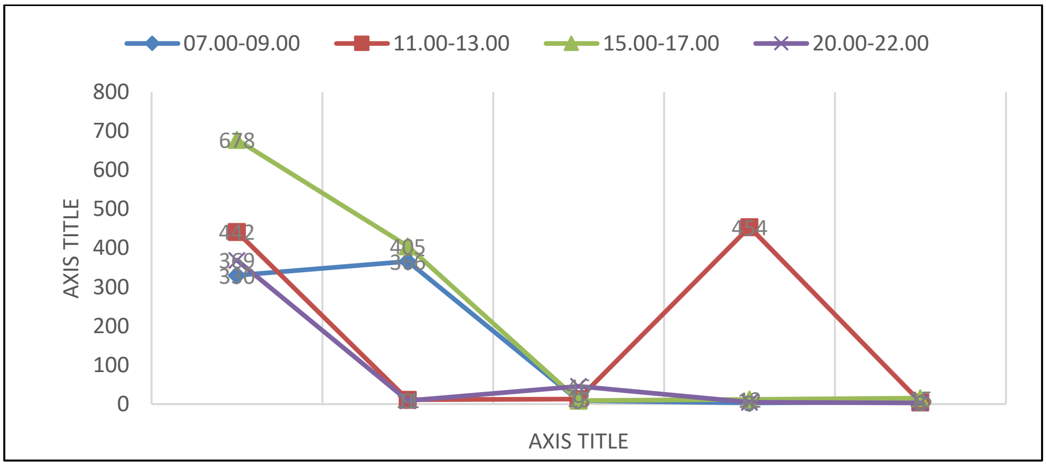

Fig. 6. GPS measurement chart using Telkomsel services in an open room

The standard deviation value is

$$\sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{128182}{4}} = 17.89$$

The absolute error value is

$$\frac{Standard\ Deviation}{\sqrt{n}} = \frac{17.89}{\sqrt{5}} = 8.00$$

Relative error

$$\frac{Absolute\ error}{\bar{X}} \times 100\% = \frac{8.00}{21.35} \times 100\% = 37.15\%$$

The value of the accuracy of the tool is

$$100\% - Relative\ error = 100\% - 37.15\% = 62.85\%$$

Based on the calculated data, the largest time difference is 92.40 seconds while the smallest difference is 2.18 seconds and the average difference in GPS signal locking is 21.35 seconds. Thus knowing the average difference, you can also know the standard deviation value, which is 17.89 with an error value for each sample of 8.00, so it is known that the accuracy value is 62.85%.

In Fig. 7 it can be observed that the shape of the graph is not much different. In the experimental data at 07.00-09.00 it is known that the first value is 20 seconds and then decreases to 6 seconds, after experiencing a decrease that is not too significant then the data will increase drastically with a peak value of 731 seconds and then will decrease again and continue to be stable at the value for 4 seconds and 8 seconds, therefore the shape of the graphic of the experiment 07.00-09.00 is in the form of a mountain or hill. As for data at 11.00-13.00, 15.00-17.00, 20.00-22.00 it has the same graphic form where in the first experiment it was found that the highest value was 740 seconds respectively for data at 11.00-13.00, 615 seconds for data at 15.00-17.00, and 429 seconds at 20.00-22.00 after knowing the highest value of each experiment then all graphs will decrease towards a stable number at the lowest point value of 4 seconds, 5 seconds, 6 seconds and 7 seconds.

3.3. GPS and Alarm Test Results at a Certain Distance

In testing GPS and alarms at certain distances, the researchers tested only using Telkomsel services with certain distance samples, namely 600 m, 1000 m. Where at that distance a measurement of the delay time is then carried out to find out the presence of a luggage tracking alarm device with a description of whether the alarm is functioning or not.

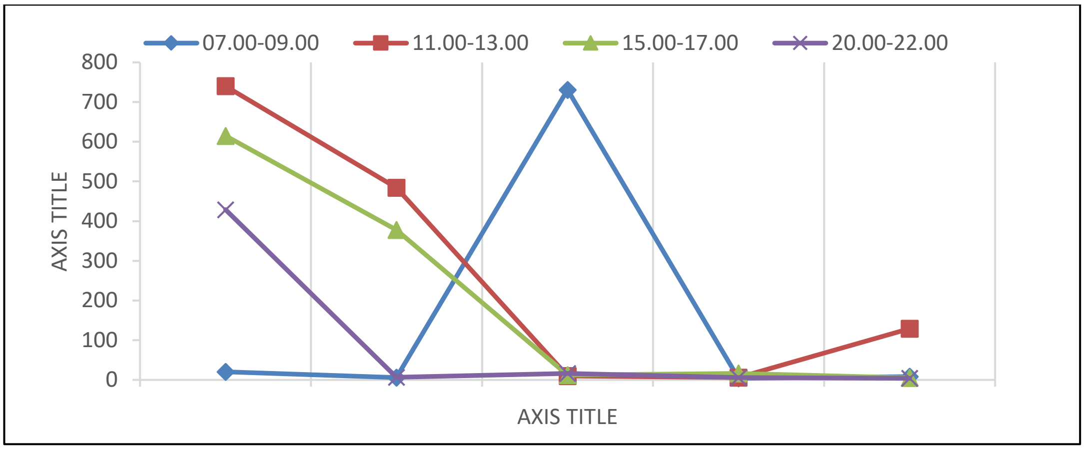

Fig. 7. GPS measurement graphs using Telkomsel services in closed spaces

3.3.1. 600 Meter Distance Testing

The test is located at Gembira Loka Zoo which is approximately 600 meters away, shown in Fig. 8, and the display for the tracker is in Fig. 9. Then the results of the test located at Gembira Loka Zoo can be seen in Table 5. The signal locking time delay is averaged -an average of 115.3 seconds, while for longitude and latitude experienced insignificant changes. And for the alarm it works fine

Table 5. Test results located at Gembira Loka Zoo

Experiment to-	Time(s)	Latitude	Longitude	Alarm Conditions
1	15.82	-7.7985663	110.4071300	Function
2	320	-7.7985158	110.4071300	Function
3	11.57	-7.7985263	110.4071400	Function
∑	346	-233.956.084	3.312.214.000	
Average	115.3	-77.985.361	1.104.071.333	

Fig. 8. Position of the suitcase tracking alarm device at Gembira Loka Zoo

Fig. 9. Display on the user when detecting a location

From the tests shown in Table 5, the signal locking time delay was obtained with an average of 115.3 seconds, while the longitude and longitude experienced insignificant changes. And for the alarm it works fine.

3.3.2. 1000 Meter Distance Testing

The test is located at Grahatama Pustaka which is approximately 1000 meters away, shown in Fig. 10, and the display for the tracker is in Fig. 11. The results of the test at a distance of approximately 1000 meters obtained results as shown in Table 6.

Table 6. The test results are located at Grahatama Pustaka

Experiment to-	Time(s)	Latitude	Longitude	Alarm Conditions
1	129	-7.7985663	110.4071300	Function
2	10.36	-77985158	110.4071300	Function
3	13.57	-7.7985263	110.4071400	Function
∑	152	-233.956.084	3.312.214.000	
Average	50.66	-77.985.361	1.104.071.333	

The test results show that the signal locking time delay is obtained with an average of 50.66 seconds, while the longitude and longitude experience insignificant changes. And the alarm function works fine.

Fig. 10. The position of the alarm device and luggage tracker at Grahatama Pustaka

Fig. 11. Display on the user when detecting a location

3.4. Set of tools

The series of tools in question is the entire set of tools that have been put together, as can be seen in Fig. 12 for the set of tools that have been made. It can be explained where there is a switch that is connected to the Arduino Nano, the MT3608 DC Step UP Module, the SIM800L Module, and the power supply, if the switch is turned ON then all systems will work with the LED light marked on, the SIM 800L Module functions as an information seeker which becomes feedback by the Ublox NEO-6MV2 GPS to find out the location of the suitcase, Buzzer keys connected directly to the Arduino Nano are used as an alarm that will sound when on the phone, there is storage on the SIM800L Module to store energy and there is a Step UP MT360 DC which also functions as a voltage boost which is installed near the current input source, the incoming current will later be stored in the 18650 Li-Ion battery, all of this circuit is done with the system contained in the Arduino Nano which can be called the brain of a program. After all the components are assembled in such a way, the Android Smartphone application that is connected to IoT is used to control the device.

Fig. 12. Series of tools

4. Conclusion

In the results obtained in the test, the sensor used can run well but is less accurate. The comparison of latitude and longitude obtained from the GPS and CPUZ sensors has clear differences even though the data collection is carried out at the same place. The distance between the user and the buyer who has the tracking device installed does not affect the delivery time of the information. Telkomsel services tend to be quicker to detect the whereabouts of the buyer's location than XL services. The average is 142.8 seconds in the morning, 203.2 seconds during the day, 222.8 seconds in the afternoon, and 86.4 seconds at night using one service. 143.8 seconds in the morning, 273.8 seconds during the day, 205.2 seconds in the afternoon, and 92.2 seconds at night using service two. The system that has been created has several drawbacks, including this application system that can function only on Android systems, not on IOS, and Windows. In testing the system in an open room, the tool takes a long time to detect the location of the presence.

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