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IoT-Based Tracking System of Transceiver Location

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***Abstract*—Object mapping based on location tracking methods has been widely used in various types of applications. Most tracking systems recently use existing technology and infrastructure such as satellite, cellular and wireless (RF) technology. These existing technologies are high-cost technology that needs authorized permission to be integrated to the novel technology. This research proposed a cheap point to point device technology to track a location of a transceiver using GPS in a portable infrastructure using Line of sight radio communication. The tracking system is connected to the IoT system in order to be more accessible, anytime and anywhere. The proposed system uses GPS as an identifier of the transceiver coordinate location and 433MHz radio module as communication media between transmitter and receiver. The use of a 433MHz radio frequency module which is free-license adds value to the system since its frequency will easily be accessed. The design of portable and internet-based devices also gives a positive value in which the system does not have to depend on existing infrastructure and the system can also be reached even if it is placed in remote areas. The system test results show that the system can be well accessed up to a distance of 6.8 km.**

Keywords: ***tracking and mapping system, IoT, transmitter tracking, transmitter mapping, gps,uhf transceiver***

***Abstrak*—Pemetaan objek berdasarkan metode pelacakan lokasi telah banyak digunakan dalam berbagai jenis aplikasi. Sistem pelacakan saat ini banyak menggunakan teknologi dan infrastruktur yang telah ada seperti teknologi satelit, seluler dan nirkabel (RF). Teknologi yang ada saat ini adalah teknologi berbiaya tinggi yang membutuhkan izin resmi untuk diintegrasikan ke teknologi baru. Penelitian ini mengusulkan teknologi perangkat point to point yang relatif murah untuk melacak lokasi transceiver menggunakan GPS dalam infrastruktur portabel menggunakan komunikasi radio Line-of-sight. Sistem pelacakan dihubungkan ke sistem IoT agar lebih mudah diakses kapan saja dan dimana saja. Sistem yang diusulkan menggunakan GPS sebagai pengenal lokasi koordinat transceiver dan modul radio 433MHz sebagai media komunikasi antara pemancar dan penerima. Penggunaan modul frekuensi radio 433MHz yang merupakan frekuensi bebas lisensi menambah nilai pada sistem dikarenakan frekuensinya akan mudah untuk diakses. Desain perangkat yang portabel dan berbasis internet juga memberikan nilai positif di mana sistem tidak harus bergantung pada infrastruktur yang ada dan sistem juga dapat dicapai bahkan jika ditempatkan di daerah terpencil. Hasil uji sistem menunjukkan bahwa sistem dapat diakses dengan baik hingga jarak 6,8 km.**

Kata Kunci: ***sistem pelacakan dan pemetaan, IoT, pelacakan lokasi pemancar, pemetaan posisi pemancar, gps, pemancar/penerima uhf***

I. Introduction

Mapping systems have been widely applied to various devices with the aim of tracking and monitoring objects both for objects that can be reached and those that are difficult to reach. This mapping system technology has continually developed, especially in the development of system performance by increasing its efficiency and accuracy [1]. One of the industries that use this mapping technology is the shipping industry that applies Automatic Identification System (AIS) technology for tracking ship locations [2]. Besides being used to track the location of ships in the form of latitude and longitude, the existing system is also used to transmit detailed vessel data required such as unique identification data, position, speed and other information. In addition, other research also applies this mapping technology to ground transportation, especially public transportation [3]. Besides a tracking purpose, this technology is also implemented to manage traffic scheduling of public vehicles, and other functions.

A mapping system technology that has been applied in various applications uses several types of communication technology, including satellite communication technology, Global System for Mobile Communications (GSM), wireless, and RF. Satellite communication technology is commonly used for mapping the earth through remote

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imaging, where this technology is categorized as a high-cost technology especially in the infrastructure aspect. Meanwhile GSM communication technology utilizes mobile technology infrastructure to track cellular devices and can only be reached as long as the infrastructure is available [4]. For applications in areas that are somewhat difficult to reach where GSM infrastructure is not available, several studies have applied RF technology that works in the Ultra High Frequency (UHF) frequency band, although the coverage is small but the cost is quite cheap [1].

Free-license RF module 433MHz has been implemented in several applications both indoor and outdoor (open space). Although this radio communication technology does not perform better compared to other technologies, especially if it is implemented in Non-line-of-sight (NLOS) communication (indoor) [5], it is useful when applied in Line-of-sight (LOS) communication [6]. This performance makes this technology suitable for low-cost communication technology instead of using GSM or satellite infrastructure that are categorized as high cost technology.

Combining AIS technology concept for tracking or mapping location and RF communication technology which does not need fixed and expensive infrastructure such as GSM or satellite networks, this research proposed the tracking system design using a transceiver module that works at a frequency of 433MHz for tracking the position of the transceiver device. The device is located in the hinterland and the monitoring system is connected to the Internet for access flexibility. Therefore, this research can be an alternative solution for tracking as well as mapping devices especially in remote areas where GSM infrastructure is not available.

II. An Overview: Used Components and Technologies

A. Global Positioning System (GPS)

Global Positioning System (GPS) is a connection of several satellites that are incorporated in a system and continuously disseminating encrypted information to users. Each satellite that is connected provides information that allows users to obtain a location on Earth by measuring the distance from each satellite. GPS is also able to disseminate position information, navigation and time information for all users in the world [7].

GPS technology involves at least three important parts, namely satellites in orbit, ground control stations, and users (GPS modules) [8] [9]. The information, sent in the form of coordinate data, wind speed, time, has been widely used especially to obtain an accurate position of an object based on satellite data.

The GPS module communicates with satellites using the National Marine Electronics Association (NMEA) protocol. The data received by a GPS module before being parsed is in the NMEA form (NMEA sentences) which then being processed to get further information such as position data (latitude, longitude), speed, and time. Many GPS modules produced lately have their own standards to translate NMEA sentences from the manufacturer. NMEA sentences contain sentences starting with the character '$' and each sentence consists of only one line separated by commas. These sentences continue to be sent sequentially until the limit that can be received by the GPS module [2].

This study uses the uBlox Neo-6M GPS module (GY-GPS6MV2) combined with a microcontrollers, Arduino Nano, as a data processor. This GPS module has a pretty good level of accuracy compared to other modules after having the same test for tracking and distances measuring so that it is suitable for applying on mobile platforms [10]. The specification of uBlox Neo-6M GPS module and Arduino Nano used are defined as shown in Table 1.

B. UHF Transceiver Module

UHF is a most important frequency band, especially for the development of modern wireless communication technology recently. UHF has a band frequency range between 300 MHz to 3 GHz and has many sub-frequency bands, each of which is aimed to specific applications. Some technology applications that work on the UHF band include GPS, navigation systems, Wi-Fi, Bluetooth, television broadcasting, GSM, Code-division Multiple Access (CDMA) and Long-Term Evolution (LTE) technology. In addition, many technologies use UHF as a data transmission medium such as Radio-frequency identification (RFID) [11]. In this study 3DR Radio Module working on a frequency of 433MHz is used to transmit coordinate data obtained from GPS to the receiver module and a computer as a data processor. The following are the features of 3DR radio module:

1. Operating frequency: 915MHz or 433MHz
2. Receiving sensitivity: -121 dBm
3. Transmit power: up to 20 dBm (100 mW)
4. Transparent serial link
5. Air data rates up to 250 kbps
6. Modulation: Adaptive Time Division Multiplexing (TDM)

Table 1. The specifications of ublox Neo-6M GPS module and Arduino nano

Module	Features/Specifications
uBlox Neo-6M GPS module	• Receiver type: 50 Channels • Sensitivity: Tracking & Navigation -161 dBm • Horizontal position accuracy: 2.5 m • Velocity accuracy: 0.1m/s • Protocol: NMEA → Input/output, ASCII
Arduino nano	• Operating/Input Voltage: 5V/7-12V • Analog Input Pins: 6 (A0 – A5) • Digital I/O Pins: 14 (Out of which 6 provide PWM output) • Frequency (Clock Speed): 16 MHz • Flash Memory/EEPROM/SRAM: 32KB/1KB / 2KB

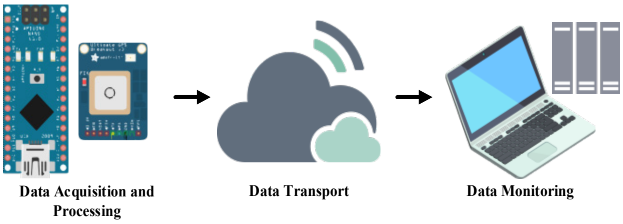

Figure 1. Simple architecture of Internet of Things

C. *Internet of Things (IoT)*

Computer and communication technology has now encountered changes to enable many objects communicate through the Internet. The application of IoT itself has penetrated various objects such as sensors, actuators, mobile devices and others that are connected simultaneously to certain purposes, including positioning, identification, communication, tracking and data sharing [10].

Similar to that described in research that has been conducted by several researchers [12], this study describes the simple architecture of IoT with three main layers as represented in Figure 1. It is started with the lowest layer, namely the data acquisition and processing layer, with the GPS module as a coordinate data receiver and a microcontroller as a data processor. Data from this GPS will require data transmission media that work on the second layer (transport layer). The Transport Layer can be wired or wireless communication supported by the use of UHF, GPRS and internet modules. The top layer of the system built is the front view of data monitoring, display and storage.

III. Design and Implementation

A. *Proposed System Design and Methodology*

In general, the block diagrams constructed in this study are represented in Figure 2. It can be seen that transceiver coordinate data obtained from the GPS module will be parsed by a microcontroller, Arduino Nano, and then the segmented data is sent via a transceiver radio module

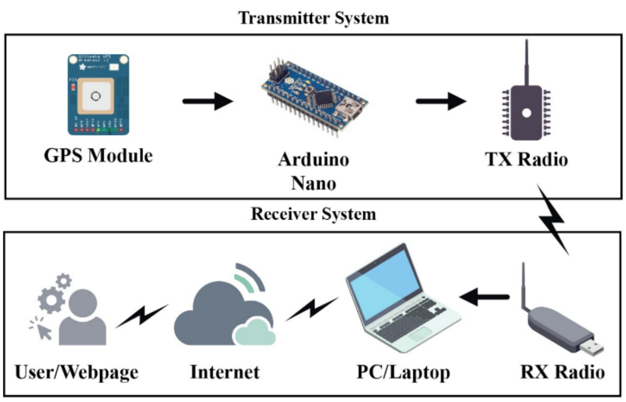

Figure 2. The entire block diagram of tracking system design of transceiver location

Table 2. RMC code format and its definition

Code	Definition
$	The initial sentence of 'NMEA Sentence'
GPRMC	Global Positioning Recommended Minimum Coordinates
103020	Current time according to UTC - 10:30:20
A	Status
3723.2475	Latitude : 37 degree and 23.2475' (ddmm.mmmm)
N	Indicator; N = North or S = South
12158.000	Longitude : 121 degree and 58.000' (dddmm.mmmm)
E	Indicator; E = East or W = West
022.4	Speed in knots
084.4	Angle in degrees
300719	Date Information
003.1, W	Magnetic Variation
*6A	Checksum data

(transmitter/receiver) to a PC or Laptop. After that the data will be processed using middleware (C # programming) to finally be sent to the database server via the Internet.

Data received on GPS will be encoded to the form of NMEA data. The data consist of numbers which usually starts with the character '$', which is followed by other data. The coordinate data in the form of longitude and latitude data will then be processed by a microcontroller (Arduino Nano) and converted to the RMC data form which has the following structure:

```
$GPRMC, hhmmss, status, latitude, N, longitude, E, spd, cog, ddmmyy, mv, mvE, mode*cs<CR><LF>
```

Example of the RMC code sent:

```
$GPRMC, 103020, A, 3723.2475, N, 12158.000, E,022.4, 084.4, 300719, 003.1, W*6A
```

Code definitions are given in Table 2.

This RMC data is then sent through the radio module and repeater to get to the gateway. The data received will be stored in the plain text (.txt) file and arranged in a database so that it is more easily accessed and displayed on the website. The parsing process of GPS data until it is sent to the transmitter module is represented in the flowchart Figure 3.

B. *IoT System Implementation*

In the receiver segment, data processing and infrastructure are designed so that data can be accessed via the Internet by buffering data on a database server as shown in Figure 4.

Figure 4 represented the data processing started from retrieving coordinate date via radio module until saving the data in the database. Data from radio modules that the computer has received is first partitioned and then uploaded by a middleware application built with Microsoft Visual C #. This application can connect to the MySQL database by adding the MySQL Connector (MySQL Data.dll) to the

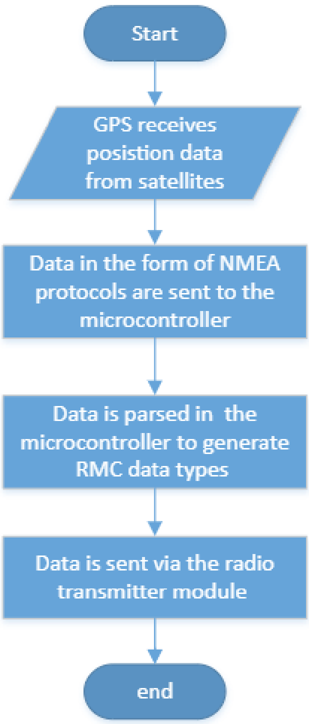

Figure 3. Flowchart of GPS data processing including retrieving, parsing and transmitting data in microcontroller

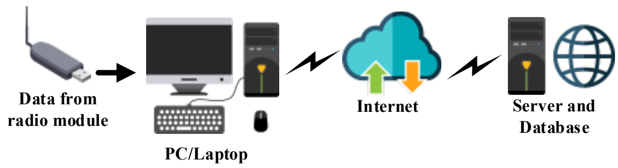

Figure 4. Block diagram of receiver station started from retrieving coordinate data until saving it in database

'reference' as shown in Figure 5.

After the coordinate data is sent to the database through the middleware application, it takes several pre-processor hypertext programming (.php) files to display the data in a website. The required files are separated into several files namely file connection, map and save data as shown in

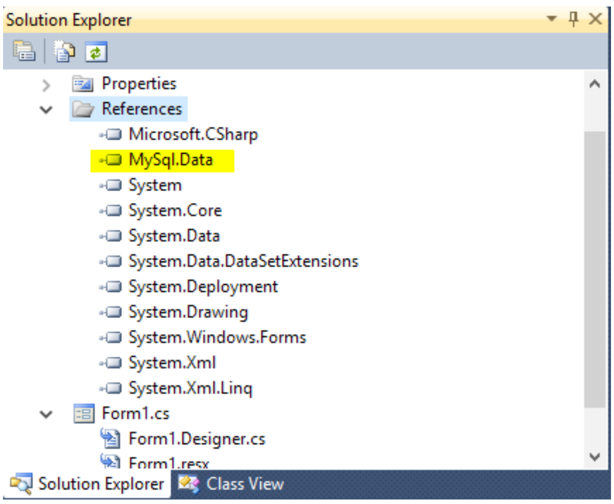

Figure 5. MySQL Data.dll inserted on reference

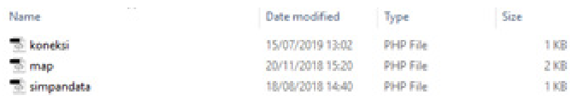

Figure 6. Document of .php extension file existed on website server

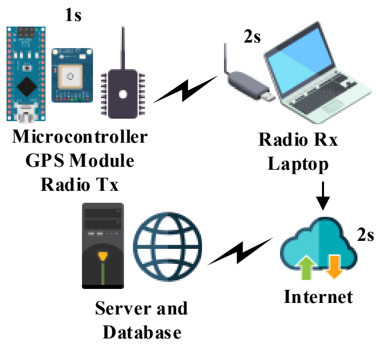

Figure 7. Detailed data sending time lag

Figure 6. All of these documents must be stored on the website server because they will be used when the user accesses the website.

The 'koneksi.php' document is a document containing the database identity used such as the identity of the server's IP address, database username, password, and database name. The 'map.php' document contains the Google Maps map format displayed on the website and the 'simpandata.php' document functions to save coordinate data to the database.

IV. Result and Discussion

Data collection is conducted by connecting the radio transceiver module to the laptop to receive and process the coordinate data. The data sent is the latitude and longitude coordinates of the transmitter position. The coordinates are then sent to the database which is then displayed on the website. Transmission of transmitter coordinate data to the database is repeatedly retrieved every 5 seconds, therefore if there is a change in position, it will be immediately visible in the marker position on the website display. This transmission delay data is the average total time needed starting from GPS data retrieval, then transmit it through radio modules, until save it to the database as shown in Figure 7.

In detail, the time interval for sending data of 5 seconds is shown in Figure 7. The time interval for retrieving GPS data is 1 second, then data processing by the radio Rx module is 2 seconds. In normal conditions, sending data to a database via the internet takes 2 seconds. The optimal time to send data from payload to the database is 5s, where there will be no truncated and overlapped data. Before parsing process, the GPS data will look like Figure 8.

Before the data is sent by radio Tx and received by the receiver (Radio Rx), the GPS data has been parsed into the RMC format ($GPRMC) and only the position value (latitude, longitude) is used. In the next process the parsed data will be sent to the database as shown in Figure 9 and Table 3.

To ensure that no data is corrupted during transmission,

```
...
...
$GPGSV,1,4,13,19,040,33,24,57,087,32,24,251,31,29,14,087,32,24,251,187,27*7F
$GPGSV,4,4,13,32,37,308,25*42
$GPGLL,5133.81,N,00042.25,W*75
$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A
$GPVTG,360.0,T,348.7,M,000.0,N,000.0,K*43
$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47
$GPGSA,A,3,19,28,14,18,27,22,31,39,,,,,1.7,1.0,1.3*35
...
```

Figure 8. GPS data before the parsing process

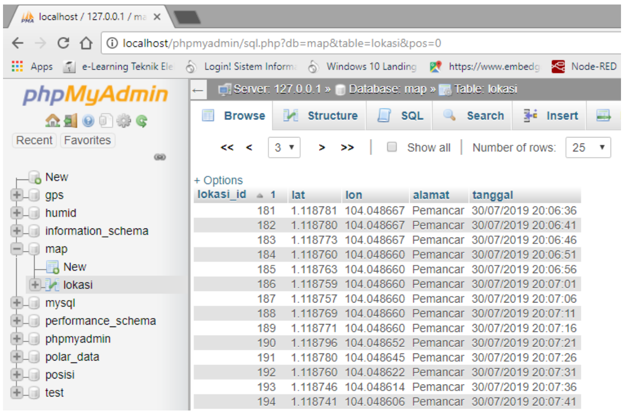

Figure 9. Database structure for GPS data (latitude, longitude, maps)

the microcontroller is set to transmit only 19 characters of latitude and longitude in the single transmission process. From the receiver side, applications that has been created using Microsoft Visual C # as middleware will be recalculated the number of characters from the data received to verify that the received data has been

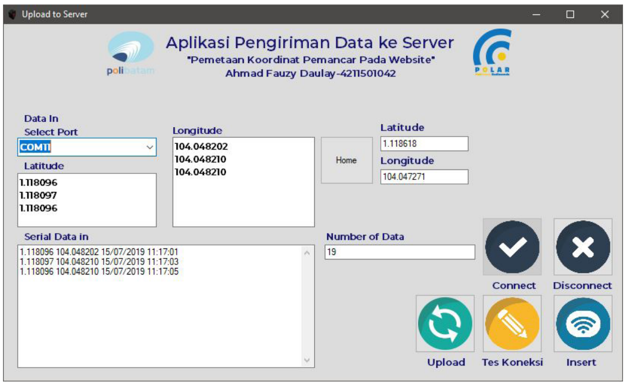

Figure 10. The number of data received by the middleware

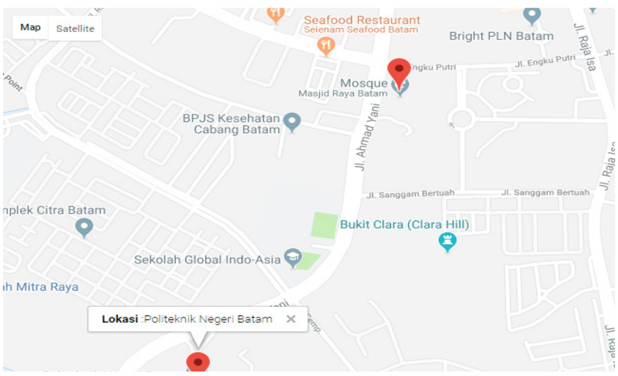

Figure 11. Two coordinates of transceivers showed on the map

Table 3. Detail record of GPS data (langitude and longitude) on database

No	Latitude	Longitude	Time
1	1.118836	104.048690	30/07/2019 20:06:11
2	1.118821	104.048683	30/07/2019 20:06:16
3	1.118808	104.048667	30/07/2019 20:06:21
4	1.118791	104.048667	30/07/2019 20:06:26
5	1.118788	104.048667	30/07/2019 20:06:31
6	1.118781	104.048667	30/07/2019 20:06:36
7	1.118780	104.048667	30/07/2019 20:06:41
8	1.118773	104.048667	30/07/2019 20:06:46
9	1.118760	104.048660	30/07/2019 20:06:51
10	1.118763	104.048660	30/07/2019 20:06:56
11	1.118759	104.048660	30/07/2019 20:07:01
12	1.118757	104.048660	30/07/2019 20:07:06
13	1.118769	104.048660	30/07/2019 20:07:11
14	1.118771	104.048660	30/07/2019 20:07:16
15	1.118796	104.048652	30/07/2019 20:07:21
16	1.118780	104.048645	30/07/2019 20:07:26
17	1.118760	104.048622	30/07/2019 20:07:31
18	1.118746	104.048614	30/07/2019 20:07:36
19	1.118741	104.048606	30/07/2019 20:07:41
20	1.118739	104.048599	30/07/2019 20:07:46
21	1.118736	104.048591	30/07/2019 20:07:51
22	1.118736	104.048583	30/07/2019 20:07:56
23	1.118731	104.048576	30/07/2019 20:08:01
24	1.118725	104.048576	30/07/2019 20:08:06
25	1.118722	104.048568	30/07/2019 20:08:11
26	1.118723	104.048561	30/07/2019 20:08:16
27	1.118727	104.048553	30/07/2019 20:08:21
28	1.118746	104.048538	30/07/2019 20:08:26
29	1.118755	104.048530	30/07/2019 20:08:31
30	1.118758	104.048522	30/07/2019 20:08:36
31	1.118760	104.048522	30/07/2019 20:08:41
32	1.118764	104.048515	30/07/2019 20:08:46
33	1.118766	104.048515	30/07/2019 20:08:51
34	1.118763	104.048507	30/07/2019 20:08:56
35	1.118762	104.048507	30/07/2019 20:09:01
36	1.118771	104.048500	30/07/2019 20:09:06
37	1.118768	104.048492	30/07/2019 20:09:11

completed, as shown in Figure 10.

Transmitter location coordinate data sent to the database will be displayed on the website page. An example of the display of the location of two transmitters on a map is shown in Figure 11.

Tests were also carried out several times on the Politeknik Negeri Batam campus, but still within a relatively close distance to observe the movement of the payload as shown in Figure 12. The test is carried out for about 3 minutes and the payload is brought in motion by continuously sending coordinate data. The time delay for sending data to the database is 5 seconds. There are several

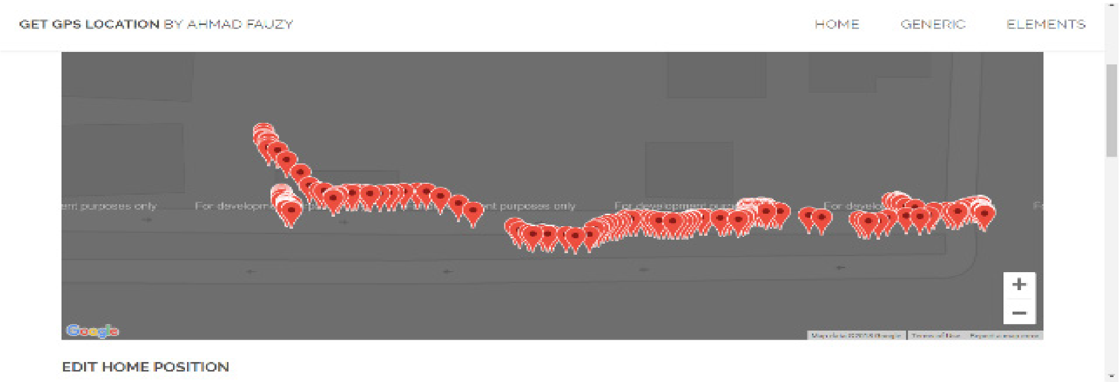

Figure 12. Payload position had spotted on maps for every 5s data retrieval

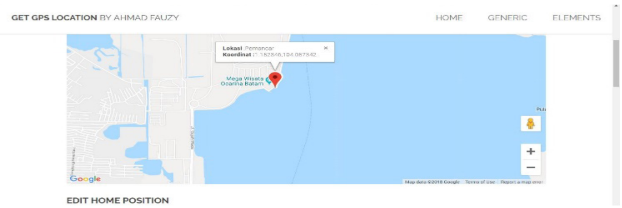

Figure 13. A view of transceiver location in a distance of 4km apart from home position on website

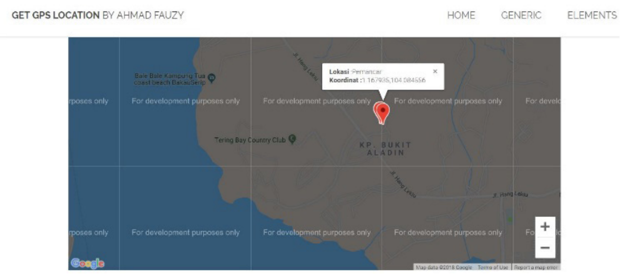

Figure 14. A view of transceiver location in Nongsa Area, 6.8km apart from home position, on website

gaps that are empty for some time from Figure 12, which there is a loss of coordinate data during transmission so that it does not appear on the website. The complete data that were received is shown in Table 3.

Next tests were carried out in the tourist area of Batam Ocarina with the transmitter distance from the initial position being 4 km, as shown in Figure 13. The initial position (home position) of the observation is the Tower A Building of Politeknik Negeri Batam.

The next test was carried out in the Nongsa region with the distance from the starting point of observation (home position) was 6.8 km. The appearance on the website is shown in Figure 14.

Based on several observations made, it can be concluded that the system created has been able to transmit transceiver coordinate data and display it on the website. As mentioned earlier, the advantage of this method is its ability to transmit coordinate data on a stand-alone infrastructure so that it does not depend on available infrastructure such as cellular networks, and it is also portable. Another advantage obtained is in terms of cost incurred. While the deficiencies of the chosen method are the time delay needed to be able to display the transmitter coordinates on the website that cannot be shortened. Coordinate data sending to the website also depends on the speed of the internet connection used.

V. Conclusion

Based on the results and discussion, it can be concluded that the chosen method can transmit transceiver coordinate data up to a distance of 6.8 km and be able to display it in the form of a map on the website with a time interval of 5 seconds for each data transmission to the website. The process of data sending on this system is divided into 2 parts, namely sending data from the transmitter to the receiver module, and from the receiver module to the website server. Internet network speed greatly affects the transmitting of coordinate data to the website server. Overall, the design chosen can be used as an alternative to reduce costs when compared to the method of sending data using cellular networks.

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