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TRACKING SYSTEM USING GPS AND SMART CARD AUTHENTIFICATION BASED ON ESP 32 MCU

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ABSTRACT

Logistics distribution is a series of activities that are interconnected in each process. Therefore, an information system is necessary to record, report conditions, and display the current location of items directly. An Android-based application system is vulnerable to spoofing, such as fake GPS. The application is used to falsify the coordinates of digital map locations. This research aims to develop a common tracking system and prevent Fake GPS by employing the System Development Life Cycle method, consisting of several stages, i.e., planning, analysis, design, implementation, testing, and maintenance. In this research, a prototype of the tracker tool and its information system were made. It used an RFID Smart Card for courier identity authentication and a GPS module to track position information on a digital map. RFID and GPS were controlled using the ESP32. Furthermore, the Website served as an information system to read and create a QR Code to identify the goods carried. It received data from the RFID Smart Card and GPS, stored it in the Database, and displayed it online. The test results indicated that the tracker prototype succeeded in sending location data throughout the test and gained an average distance of 6.82 meters, which was different from a commercial GPS device. It had a delay of 268.5 seconds when the location was first read. The tracker prototype had an average power consumption of 1.5 watts, an average battery life of 2 hours, 28 minutes, and 40 seconds, as well as an average battery deficiency of 36.79%. In conclusion, the system test was successful.

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1. INTRODUCTION

Rapid developments in the world of expeditions have influenced the development of delivery service providers or expedition services. This requires starting to carry out several system developments to simplify the distribution process. Distribution of goods is a series of activities that are organized and interconnected in each process. In its implementation, a good control system is needed. In running this system, validated sender data is needed that can be tracked and supports the tracking application distribution process or what is usually called location parameter tracking [1].

Use of GPS module [2] can provide extremely accurate location information for mobile objects and people. However, behind this technology there are vulnerabilities in the Android-based application system, one of which is a weakness in detecting spoofing, including GPS spoofing [3]. One example of spoofing is using the Fake GPS application[4]. This application itself is used to deceive the current position or location by falsifying location-data-enabled[5] or coordinate data.

To overcome this annoying problem that can occur in the process of delivering goods by couriers, an external tracking device is needed that cannot be manipulated by the Fake GPS application[6] by adding authentication to the user of the tracking device, namely by entering the courier's identity via smart card ID[7], which has been recorded in the system database. Where you can report and display the current location conditions of a goods delivery destination, directly. This tracking device will only be operated by couriers when they are on duty to deliver packages.

2. RESEARCH METHODS

In this study using an experimental design approach in carrying out the research process. With the system we have developed, the following benefits are obtained, namely a logistics system with multiple authentications, namely the position of the courier's location, and courier data using a smart ID, accompanied by a unique token key that is generated by the system specifically for the courier on duty, so that the system can monitor movements the courier and the exact identity of the courier. reduce the risk of fraud and falsifying the identity of the courier on duty, as well as the position of goods delivery, with a direct GPS system for more accuracy. The stages of the system are as follows. starting from system requirements, planning, design, software creation, testing, and deployment[8][9], In the tool work test phase, the entire system is tested using stages in figure 1, in the initial phase it starts with initializing the tool, getting the location coordinates via the Neo U-Blox[10], GPS module [2]from the courier, the information is repetitive, so that he can authenticate via login, and the courier gets a user ID. (UID) which locks the application to the user. The Smart Card is used as UID data and generate the token number, with an RFID Reader [11] module to read the card code. The main data processing component is on the ESP32 Microcontroller[12], with a smart card reader sensor using MFRC-522 RFID Reader[13], location pin point access using GPS Neo 6M, status display using a 0.96" OLED display, and the circuit power supply using a 1500 mAh. Lithium-Ion battery, equipped TP-4056 module for battery charger, on-off switch as power breaker.

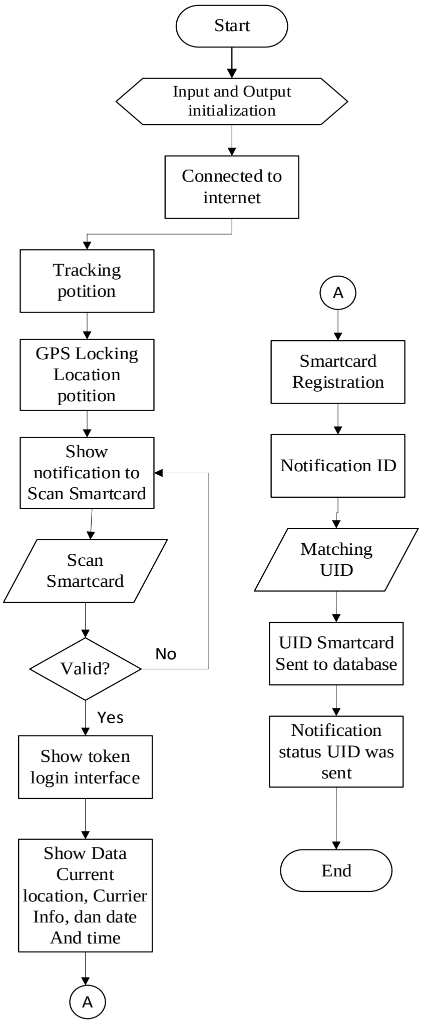

Figure 1. Experimental design of the system

The stages of the system are as follows. On **Figure 1** the process begins with initializing the system requirements, then establishing a connection to the internet, after connecting, start activating the GPS tracking system to determine the position of the courier's location, then after the GPS position of the courier is successfully locked, the courier logs in by authenticating using a smartcard ID, the system will generate a token for the smartcard ID To lock the account of the courier on duty, the system will display the latest location data, time and date, smart card ID number, then this data, called UID, will be given to the data center at the system operator.

2.1 Coordinate measurement

Euclidean is a mathematical equation for calculating the radius of two points**[14] [15]**which is intended to study the relationship between angles and distances. In research to compare the distance between prototype courier tracking devices and commercial GPS, the equations are as follows:

$$\text{Distance} = \left(\sqrt{(LAT1 - LAT2)^2 + (LNG1 - LNG2)^2}\right) x\ 111{,}319 \quad (1)$$

Information:

LAT1 = Latitude data from Commercial GPS.
LAT2 = Latitude data from GPS Prototype Tool.
LNG1 = Longitude data from Commercial GPS.
LNG2 = Longitude data from GPS Prototype Tool.
111.319 = Conversion constant of 1 degree on earth into kilometers.

In this equation, the distance results that will be obtained are still in kilometers. To convert it into meters it needs to be multiplied by 1000. And also, the constant 111.319 is the result of converting 1 degree on Earth into kilometers **[16]**

2.2 Power consumption

The energy in batteries certainly has different battery storage capacities [17] according to their specifications. The electrical energy storage capacity [18][19] of a battery is in Ampere-hour (Ah) units, so a battery can supply power to a circuit and has a time limit, if the battery is continuously used as a power supply source [20]. The power of a device or circuit can be determined using the following formula:

$$P = VI \tag{2}$$

Where, P is Power (watts), V is Voltage (Volts), and I is Current (Ampere)

And the length of battery usage time can be determined using the following equation.

$$LB = \frac{PB}{PP} \tag{3}$$

Where, LB is battery Lifetime; PB is the power in the battery (Watt); PP is Power required for the prototype device (Watts).

To calculate lithium battery charging using the state of charge equation (SOC) [21][22]is calculated by assessing the current capacity divided by the nominal capacity, which is expressed in the following equation[23]

$$SOC = SOC_0 - \frac{1}{C_n}\int i\,\eta \mathrm{dt} \tag{4}$$

where state of charge on lithium battery is the estimated value[24], SOC_0 is the reference value, C_n is the nominal capacity, η is the coulombic efficiency, while i and t denote the battery charging or discharging current and duration,[25] [26]respectively

3. RESULTS AND DISCUSSION

3.1 Hardware

The following is the prototype device developed in this research, with two clients for two delivery couriers.

(a) **(b)**

Figure 2. **(a) Tracker Tool Prototype; (b) GPS tracking status information display**

On Figure 2 (a) are 2 prototype devices brought by different couriers. The device will read the user's couriers identity via Smart Card reading which uses an RFID Card system implementation. After the device is connected to the internet network and the user has been successfully identified, a UID token will be generated, then the device will start tracking the current location based on the latitude and longitude coordinates obtained via the Neo U-Blox 6 GPS device. After that, the numeric information from the current location point on digital map system[27] using google map API, will be sent to the database server. When the device is working, power usage is measured using a multimeter. It is known that the current consumption required by the tracker prototype system when working is around 0.30 A. The battery has a power of 5.88 Wh Equation (2), while the power consumption for each prototype tracker tool is 1.5 W Equation (3), Using a Li-Po battery labeled 1500mAh-3.7 V, the charging process takes around 1.5 hours to be full. Equation (4), the battery life time used as a system resource for the tool prototype tracker is around life of 2 hours 28 minutes 40 seconds.

3.2 Software develops with user interface

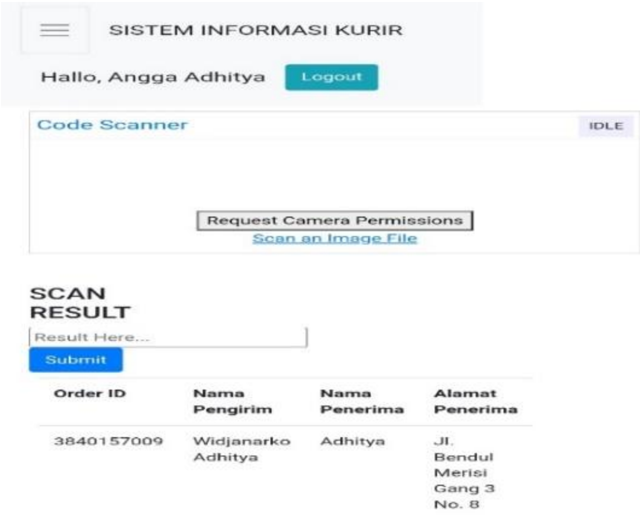

Figure 3. Landing Page Dashboard of Courier User Interface

On **Figure 3** is the dashboard display, a page like, the image will appear. There is significant information due on that UI showing the name of the courier, barcode scanner for goods, and input for pickup goods. On this page, the courier carries out the input process for picking up goods or the process of bringing goods by scanning the QR Code already on the goods.

3.3 Tracking and pin point position

Numerical data on longitude and latitude information obtained from the Neo Blox GPS module is translated and converted into features provided by the Google Map API, utilizing the Reverse Geocoding feature from the Google Maps API which is connected to the information system website. If you want to see the location in the form of a digital map below.

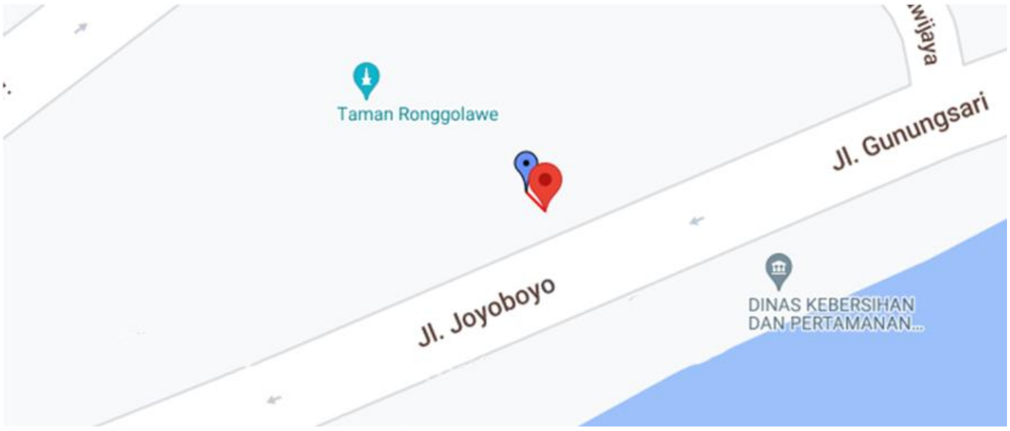

Figure 4. Latest Location Map when Tracking Connected with G-map API

On **Figure 4**, a new tab will open in the browser which will display a Google Maps map. Then wait a few seconds, a marker point will appear along with a description of the name of the street or location. Marker points (blue dot) and location information will change automatically according to the movement of goods sent by couriers who are equipped with tracking devices (red dot). Where in real time the tracking tool will send location data and websites that are connected to the Google API will translate the data in the form of a digital map.

3.4 Calibration and Data Acquisition

The following is a test for matching user data (UID) to the database token. The test is carried out by reading all RFID cards that have been registered in the database. The reading is done in a random pattern as shown in **Table 1**.

Table 1. Results of Testing the Consistency of RFID Reader and Token Readings Produced by the System

Experiment no.	*UID*	Status	Token
1	1151166546	Matching with data Base	852145
2	1151166546	Matching with data Base	164646
3	7413616323	Matching with data Base	306139
4	1151166546	Matching with data Base	195605
5	7413616323	Matching with data Base	720212
6	7413616323	Matching with data Base	447675
7	1151166546	Matching with data Base	604126
8	7413616323	Matching with data Base	835162
9	1151166546	Matching with data Base	20899
10	7413616323	Matching with data Base	138435

In **Table 1**, it can be seen that from all the experiments carried out using the RFID Reader it was able to read consistently and the tokens produced by the system were also varied and no identical tokens appeared during testing.

The next test is measuring the difference from the acquisition of data readings from GPS, where here the data obtained from commercial GPS is compared with the GPS resulting from the design of the tracking system, as follows on **Table 2**.

Table 2. Comparison of GPS Distance Differences for Commercial Devices and Prototype Devices

Street Name or Location	Coordinates of the commercial device		Coordinates of the Prototype device		Error margin (meter)
	Latitude	*Longitude*	*Latitude*	*Longitude*	
Bendul Merisi Gang 3	-7,306273	112,743854	-7,306315	112,743797	7,80
RSI Jemursari	-7,321721	112,739924	-7,321698	112,740018	10,70
Taman Ronggolawe	-7,299800	112,731386	-7,299818	112,731405	2,90
Kampus ITATS	-7,290279	112,779173	-7,290399	112,779201	13,70
ITATS Plaza	-7,291591	112,779968	-7,291610	112,779910	6,70
Kantor DP3AK Surabaya	-7,305988	112,759236	-7,305964	112,759283	5,87
Klaska Residence	-7,301913	112,743943	-7,301936	112,743911	4,38
RSAL Dr. Ramelan	-7,307695	112,737454	-7,307697	112,737517	7,01
Puskesmas Jagir	-7,305925	112,737909	-7,305892	112,737909	3,67
Kantor Kelurahan Jagir	-7,305929	112,741146	-7,305900	112,741116	4,64
Average error distance in meter					**6,74**

And based on **Table 2** above, the following is a graph comparing the coordinate points between the coordinate points produced by the commercial tool and the prototype tracker tool in **Figure 5** below.

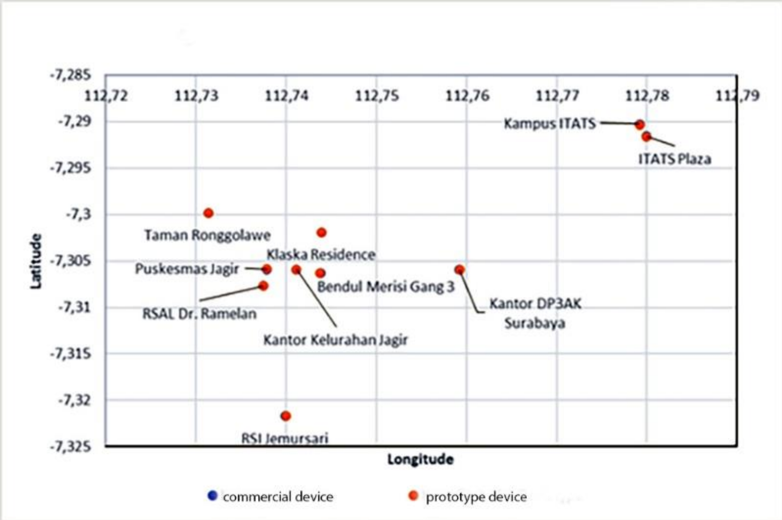

Figure 5. Comparison of Coordinate Points between commercial devices and prototypes devices

On **Figure 5**, During data acquisition testing of location points with GPS, the tracker was able to connect to satellites and obtain latitude and longitude location data. In table 2, by entering the latitude and longitude of the two types of equipment, the distance difference results are obtained according to those in the table. It can be seen that the difference in the closest distance or lowest error is in Ronggolawe Park, namely 2.9 meters. And the furthest distance difference or highest error is at the ITATS Campus testing location with a distance difference of 13.7 meters, and the average distance difference was found to be 6.74 meters. And if it is displayed in the form of a coordinate point comparison graph like the one in Figure 4, it can be seen that the coordinate points produced by the prototype tool are very close in position to the coordinate points produced by the commercial tracker tool, so that the difference in distance between them can be seen. the real world is still very close to an acceptable distance.

4. CONCLUSIONS

Based on the results of testing and data collection, the prototype courier tracker device is used as a component of an internet-based location tracking system that can be accessed via a web browser. First, it can be concluded that this device is successful in fulfilling its purpose and uses the U-blox Neo-6M GPS Module as a courier GPS tracker module. Second, the OLED screen is used as a status display medium, the RFID RC-522 is used as user authentication, and the ESP32 module as a microcontroller. Third, the smart Cards that use RC522-based RFID applications can function well. In this system, courier user data storage uses the UID Smart Card as the authentication key for each courier data. Overall, the device successfully sent data to the database via the HTTPS protocol, and also had an average battery life of 2 hours 28 minutes 40 seconds. The use of the U-blox Neo-6M GPS module as a GPS on the tracker prototype can work well, from the test results it has a difference in pin point location, on average with commercial GPS of 6.82 meters and also has an average time lag when first receiving location point for 268.5 seconds.

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