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# Embedded response technology and service cloud platform for vehicle information tracking

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ABSTRACT

Based on the Indonesia national police crime database, it is reported that vehicle theft cases have increased during the Covid-19 pandemic. The database reported an increasing trend of vehicle theft, 4,065 cases from January 2019 to January 2020 in the province and regency region. Therefore, to help police officers work and minimize the criminal cases of vehicle theft, an effective strategy is needed to reduce these threats. This study proposes implementing SMS and QRcode technology embedded in the vehicle for validation information. Cloud computing capabilities can offer real-time network access to technology resources that can be physically located anywhere geographically based on business needs. This technology can rapidly search and show detailed information regarding the specific vehicle, including the vehicle owner, the vehicle registration number, and the validation of the driver's license. To implement and examine the effectiveness of the proposed technology, this study was conducted an experimental study in a real-world setting from January 2021 until April 2021 in Makassar city, Indonesia. This study concluded that the proposed technology could successfully be implemented and effectively show detailed information regarding the specific vehicle based on the experimental results. This study concluded the potential use of the proposed technology in the real world as an alternative solution to minimize the criminal cases of vehicle theft. It can be used as an alternative solution to reduce the increase in criminal cases of inter-island private vehicle theft syndicates.



## INTRODUCTION

Paper Economic disparities during the Covid-19 pandemic have caused various problems in society in Indonesia. Many people do not have jobs, and the difficulty of fulfilling their daily needs causes a person to take various ways to survive, including committing the crime of theft. One form of theft crime that often occurs is the crime of private vehicle theft. Based on the provincial and district-level police data in Indonesia, private vehicle theft during the Covid-19

pandemic has increased; there have been 4065 cases from January 2019 to January 2020, out of a total of 136,542,034 private vehicles scattered in Indonesia [1].

The number of vehicle theft cases has increased sharply. However, the cases of theft of private vehicles occur in cars and appear in motorcycles. In previous studies, a method to distinguish thieves and vehicle owners could be done using sensors embedded in cars[2]. On the other hand, certain parties can only embed sensors on vehicles so that its application cannot be applied as a whole to vehicle owners. Cloud computing capabilities can offer real-time network access to technology resources that can be physically located anywhere geographically based on business needs. The ability of fast reading methods on QRcode and those applied to cloud computing technology can create a cost-effective and good quality service[3]. Quick Response Code(QRcode) is designed for information storage and high-speed reading applications[4]. The use of QRcode technology has been proposed to support real-time tracking of vehicles in terminals and processing time recording in each service[5]. Nowadays, the QRcode scanning process can be done through an application installed on a smartphone device so that the camera that has been embedded in a smartphone device can be used as a scanning tool. However, the scanning process uses a webcam device to require additional devices in its application.

The development of information technology-based services has been the driving force behind various services in various industries, making them more efficient, accessible and convenient for people to use[6]. Previous studies have carried out research related to incorporating information technology-based services. The concept of Embedded technology has been widely applied to a service, but it is still found that each has advantages and disadvantages. Vehicular Cloud Computing (VCC) has become an attractive solution supporting vehicle computing and storing vehicle data service requests [7]. However, the implementation at the application layer still uses traditional cryptographic algorithms, making the built system easy to infiltrate. Subsequent research presented the design of an IoT-based Storm detection system with the provision to display messages on Android mobiles using Cloud Computing technology, where the entire embedded chip system is built to be able to help monitor online data about identified locations[8]. The next research is a methodology for tracking stolen laptops by implementing GPS, GSM, Motion Sensor, and Cloud Services embedded in laptops via the cloud[9].

Research related to vehicle security is through the ability to detect various vehicle attacks, where the mechanism for detecting conditions in vehicles is based on in-depth learning and the set of an experience knowledge structure, which is a knowledge representation structure[10]. Previous research builds a unique brand-based vehicle start framework with a perspective to reduce vehicle theft and prevent unauthorized clients, which this research utilizes IoT technology for fingerprint applications[11]. Subsequent research related to security in technology-based vehicles is the implementation of a low-cost and reliable Anti-Theft Vehicle Tracking System based on IoT services with a microcontroller to track vehicles in real-time consisting of embedded systems including GPS, GSM, GPRS, relays, and microcontrollers, which are placed in-vehicle, and web applications[12]. Previous research implemented the use of Open CV Face Detection Subsystem (FDS) technology and Arduino by identifying driver photos in the database[13]. The research gap is the obstacle found is the risk of subsystem detection failures that can occur due to Arduino devices, besides that it requires additional costs to implement the system as a whole.

This study proposes a method to reduce the increase in vehicle theft cases through the use of cloud computing technology and the use of QRcode and SMS as vehicle data validation devices, and the application involves collaboration between security officers or police and vehicle owners so that the authenticity of the data can always be maintained. It is maintained to support the acceleration of confirmation of validity applied to the delivery of the current location.


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## METHODOLOGY

This research involves the analysis and integration of qualitative and quantitative data and a mixed methods approach as part of the research procedure, where the mixed methods approach is consistent with the need to understand the preferences of government organizations in the use of cloud computing technology, and to test and evaluate the effectiveness of various strategies that can improve outcomes the expected implementation of the framework.

### 1. Sort Message Service(SMS)

Result in Cellular telephone communication devices have a function to support sending and receiving short messages called Short Message Service (SMS) base of text via wireless devices[14]. SMS (Short Message Service) technology on cell phones has been widely applied in various studies. Sending text messages (SMS) can remind users of a condition[15]. There are many benefits of using SMS reminders, including ease of use, relatively cheapness, and fast and automated message delivery[16]. In recent years short message services (SMS) have become an essential security infrastructure component, assisting with tasks including identity verification and authentication[17].

Basically in Figure 1. While viewed as existing solely within cellular networks, the modern SMS ecosystem includes various non-traditional carriers, ESME gateways and resellers, and OTT services[18]. The emergence of smartphones that provide SMS and voice services through data networks, including the internet allows third parties to create information technology services through SMS and cloud computing.

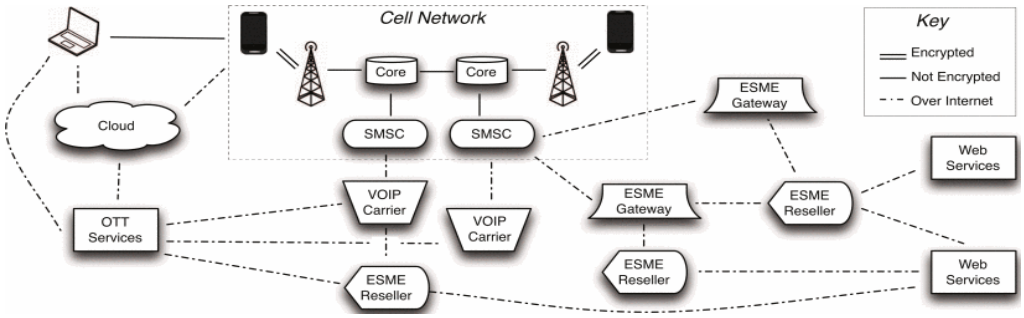


Figure 1. Modern SMS ecosystem [18]

### 2. Geolocation

GPS, which was launched in 1978 under the original name NAVSTAR specifically intended for the needs of the US military, however in 1994, GPS services are fully available for technological needs around the world. They are designated as the de-facto GNSS standard because they have a wide range of acceptance, global adoption[19]. There are three main domains in the GPS namely the Space segment, Control segment, and User segment, as shown in figure 2.

Geolocation is a collection of elements of digital location, techniques, and digital positioning practices that intersect with proliferation, popularization, and commercialization, which results in the collaboration of hardware, software, and data which will then be spatially active[20].

The Global System for Mobile(GSM) communication technology that emerged in the late 1970 was used to enable higher data transmission rates with the Global Packet Radio Service (GPRS) technology[21].The proliferation of mobile networks allows users through various positioning tools to track location based on real-time location information retrieved from mobile phones[22]. GPS can be used to obtain coordinates to detect a device's location using the geolocation feature[23]. From an operational point of view, Geolocation only identifies the vehicle's state regarding positioning and navigation. From a management point of view,

Geolocation can infer the vehicle's state[24]. The basic concept of Geolocation is an ISP (internet service provider) or GSM, which transmits internet connection signals connected to GPS and telecom satellites. All existing data will be stored on the server. Then the user accesses the location search via a smartphone connected to the GPS. This GPS serves to determine the longitude and latitude of a location. Geolocation technology is an API from HTML5 for Location-Based Services (LBS) to support user systems in knowing their location based on latitude and longitude; Geolocation tracks the presence of the device we are using and concludes by utilizing RFID, WiFi, and Bluetooth MAC addresses, and GSM / CDMA cell I.D., as well as user input. Additional services available on Google Maps include Street View, a route planner for driving, public transit, walking and cycling, and business locations.

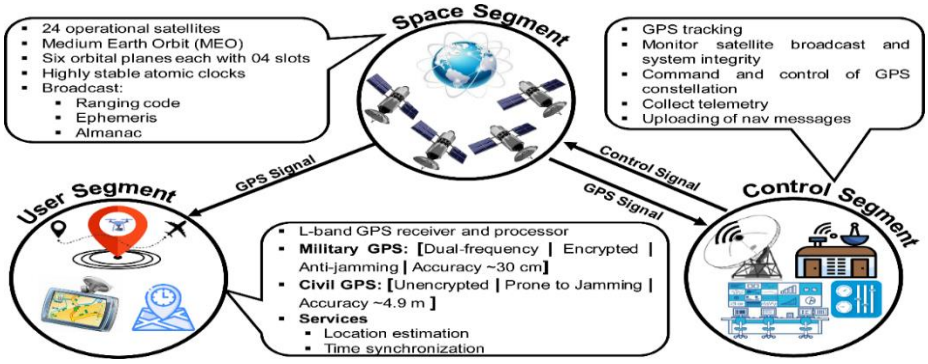


Figure 2. Global positioning system segments [25]

## 3. Cloud Computing

Cloud computing is the latest technology that is an essential service for efficiently managing applications over the Internet[26], so that a cloud service supports the occurrence of a data communication process without using a physical computer. Although the existence of cloud computing is a solution to the problem of the ability of users to provide physical computers, cloud computing requires collaboration between devices so that the services provided can meet user needs[26]. Therefore, in this research, several elements are collaborated to create a dynamic and automatic system. The critical role of Services in cloud computing requires federated management of computing and network resources to enable maximum service delivery[27]. An API service into one composite service of user requirements into a cloud-enabled services approach to support on-demand service composition has been proposed[28].

## 4. Quick Response Code(QRCode)

The elements contained in the QRcode consist of a two-dimensional code, similar to a barcode, through encoding messages with limited character length[5]. Quick Response QRcode technology is a two-dimensional matrix sketch that contains specific information data. QRcode technology evolved from Barcode, consisting of a black-and-white line arrangement of bars containing specific information data; when scanned, it will return information stored therein. In coding data, all forms of data, be it alphabetic data, numeric or numeric data, kanji, hiragana, symbols, binary codes, and others, can be stored in QRcode form.

The QRcode display is also smaller when compared to the barcode model. Because barcodes only contain horizontal data, QRcode contains horizontal and vertical forms (matrix). One of the other advantages of QRcode is that it has a damage tolerance of up to 30%. So that if a small part of the QRcode is damaged or defective, the data is still stored and can be read. QRcode has a unique structure for geometric correction and high-speed decoding. Three-position tags are used for Q.R. code detection and orientation correction. One or more alignment patterns are used for the deformation adjustment code. The time pattern sets the module coordinates. Next, the format information area contains error correction levels and mask patterns. The code version and error correction bits are stored in the version information area.


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## 5. Research Steps

The Algorithm is illustrated through flowcharts and system architecture drawings; this is considered very important because an information system built with detailed analysis is beneficial for organizational needs, and decisions are taken for each level (level) of management.

In figure 3. the process of the flowchart is explained as follows:

Step 1: The service system works in mobile applications and online website
Step 2: In the input process, the administrator or user can input their vehicle information, vehicle owner information, and permission permit for using the vehicle
Step 3: If there is no input process, then vehicle information checking through scanning process of QRcode, which is installed on the vehicle
Step 4: The results of QRcode scanning will be a key for searching data in server
Step 5: If the status is valid, it will show the vehicle information, vehicle owner information, and permission permit for using the vehicle
Step 6: Sending the checkpoint place for checking the vehicle through SMS message to the handphone number of the vehicle owner.
Step 7: If not valid, then it will show the warning message from the system
Step 8: Sending the checkpoint place for checking the vehicle through SMS message to the handphone number of the vehicle owner.
Step 9: The user will accept the notification from the checking vehicle
Step 10: Police officers will confirm and check the vehicle in detail.

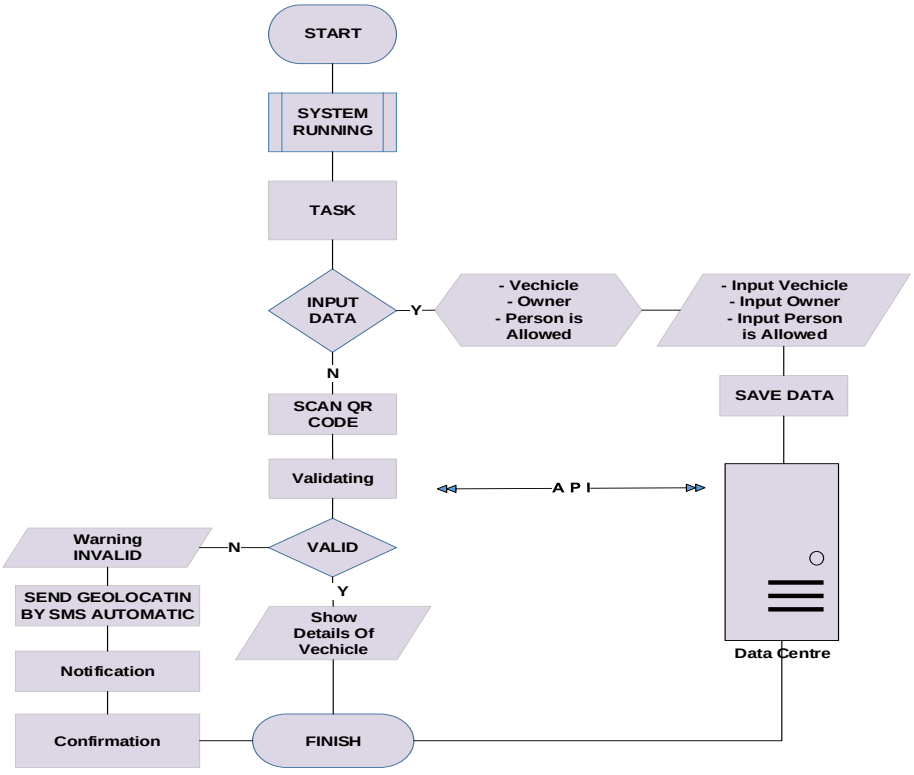


Figure 3. Design flowchart data communication

## 6. Design Research

This research illustrates that the user community category can be divided into web clients and mobile clients. Users can request information by entering the web application's tracking and vehicle-specific code string or scanning a QRCode image via the mobile application. The

structure of the web and mobile-based systems differ only in the presentation and logic of each layer.

Based on the illustration shown in Figure 4. the explanation for each layer is:

**Application Layer.**

The application layer is a GUI access user interface. All types of users can access via web based website or Mobile.

**Forwarding Layer**

The forwarding layer forms the clustering of application deployments through hardware and software processing. By dynamically managing backup and recovery services provided by the system to users so that existing resources no longer limit them, users can continue to use service resources at any time. Static resources CDN acceleration refers to distributing data and information to the server, thereby increasing access speed.

**Control Layer**

The control layer is used to process business related to the access interface, and a series of modern technologies are adopted to ensure that all services on the system can still operate efficiently and stably in high concurrent access status. Asynchronous is done to protect the system by simultaneously limiting the rate and locking access or data requests. Restful API achieves front and back-end separation, reduces system traffic, optimizes server performance, and prevents security issues such as attack injection.

**Business Layer**

The Business Layer consists of Service logic and unified control components involving multiple management functions referring to the realization of unified authority control, unified log and audit management, unified system backup and restore unified exception handling and alarm management, and secure operation of system data and provide conditions for the expansion of system functionality. Cloud technology services support perfect backup and data recovery schemes and avoid data loss caused by sudden failure, system poisoning, or human error.

**Data Layer**

The data layer provides storage for structured and unstructured information stored in Oracle databases combined with implementing cloud computing technologies to achieve significant cost savings, business agility, and high scalability. Users can access databases on the cloud personally or through a cloud provider because the data is stored systematically so that whenever the user wants to retrieve data for processing, the data will always be ready and easily accessible.

## RESULTS AND DISCUSSION

### 1. Mobile Application

This study has built a vehicle prototype that includes data input, vehicle owner and use permits, and features of the validation process using a QRcode. The system is built using two platforms, namely the web on the admin side and the android application on the user side, where Figure 5 shows the implementation of the system. The mobile application used by the public or officers to track vehicle information through a QRcode string, as shown in Figure 5.

### 2. Tracking Location

The smartphone application on the Android platform implements location sensing as a background process and phone-based localization method using Global Systems for Mobile (GSM) and Universal Mobile Telecommunication Systems (UMTS)[22]. In the built system, there is an automatic SMS sending feature to vehicle owners if there is no similarity between the


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QRcode scanning data and the documents submitted to the officer. The interface results are shown in Figure 6.

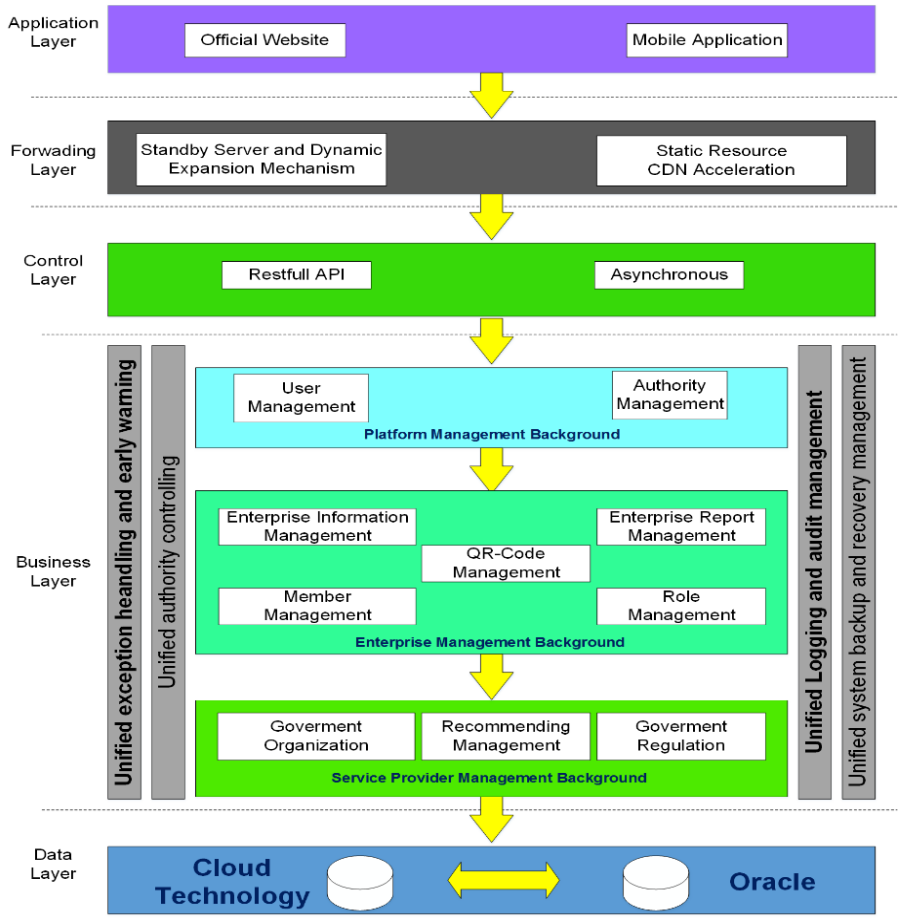



Figure 4. Example of hybrid map view with typical traffic information

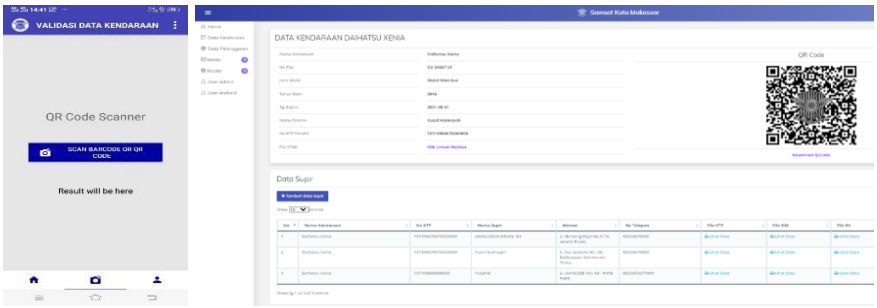
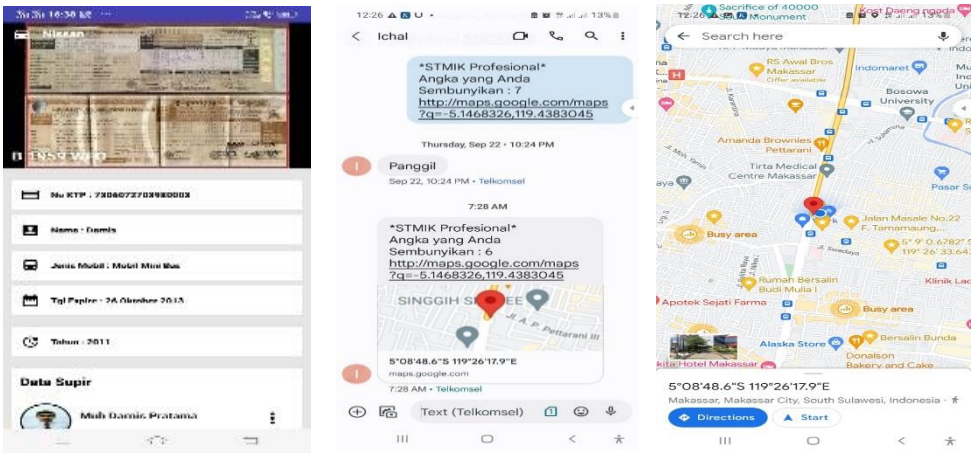



Figure 5. The interface on the mobile application

When vehicle thieves target vehicles in a particular place, they will assess the environmental conditions and measures to prevent criminal acts, such as police patrols or surveillance cameras[31]. The illustration in Figure 6. shows the system implementation, which is described through several processes, including:

- The owner of the vehicle registers the vehicle number certificate.
- The officer enters the vehicle and owner data.
- Simultaneously with the vehicle number certificate issuance, the police officer provides a QRcode sticker to the vehicle.

- The vehicle registration certificate is also printed as a unique code on the vehicle registration certificate.
- All data on vehicles and their owners are stored in the data center.
- Through the android mobile device application that has been provided, the vehicle owner makes changes to the data and then reports the list of people who are allowed to use a vehicle, including family or people who have close relationships.
- When checking vehicles on the highway, police officers scan the QRcode or the vehicle number certificate through an application made explicitly for police officers.
- Suppose the validation process displays the name of the person who is currently using the vehicle being inspected. In that case, the data is declared valid, and the driver is welcome to continue the journey.
- Suppose the QRcode scanning results display vehicle data that does not match the driver's data. In that case, the application will automatically send the coordinates of the inspection location via SMS to the actual vehicle owner.
- Vehicle owners receive notifications and track vehicle inspection locations.
- Police officers confirm by matching the actual vehicle owner with the driver.
- If an indication of vehicle theft is found, the officer shall arrest the perpetrator of the crime




A B C

Figure 6. Applications in part **a**: QRcode scan results, **b**: automatic sms, **c**: vehicle position

## 3. Response Time of Testing

A popular pictorial encoding format, QRcode, can auto-fill detailed data, freeing the user from manual typing [15]. Although the concept of QRcode technology is rarely applied, when properly implemented, the characteristics of QRcode that are easy to use, fast, and convenient can significantly increase the benefits of service management. Table 1 shows the results of recording the QRcode scanning time for each vehicle inspected by the officer.

Table 1. QRcode scanning time

| No | Vehicle Number | TS | VD | TR |
|---|---|---|---|---|
| 1 | DD 1248 TQ | 15:31:18 | 15:31:19 | 1 |
| 2 | DD 1602 SR | 15:32:12 | 15:33:13 | 1 |
| 3 | DD 1786 TQ | 15:32:52 | 15:32:53 | 1 |
| 4 | DD 1651 YR | 15:33:30 | 15:34:32 | 2 |
| 5 | DD 1571 SE | 15:34:20 | 15:34:21 | 1 |
| 6 | DD 1048 TQ | 15:35:10 | 15:35:11 | 1 |
| 7 | DD 1369 M | 15:35:50 | 15:35:51 | 1 |
| 8 | DD 1189 SE | 15:36:20 | 15:37:22 | 2 |
| 9 | DD 1702 YU | 15:37:01 | 15:37:02 | 1 |
| 10 | DD 1691 QY | 15:37:30 | 15:37:31 | 1 |
| **Average of Success** | | | | **1.2** |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In Table 1, the scanning process results are displayed on each vehicle. The scanning time column displays the start time of the QRcode scanning process; the View Details column displays the time when the scanning process succeeded in displaying detailed information on a vehicle, the response time column displays the total time required to validate vehicle data, written in the formula:

TS = Time Scanning QRCode.
VD = View Detail of Vehicle Information.
TR = Total Response Time.
TR = (VD) – (TS) (1).

The success rate and speed of the QRcode scanning process on each vehicle being inspected are speedy, reaching 1.2 seconds.

One study stated that 93.4% of mobile device users who have mobile phones expressed interest in receiving SMS[32]. Table 2 shows the recording of the time of sending automatic SMS to the vehicle owner, which contains the vehicle inspection location points.

Table 2. SMS delivery time

| No | Vehicle Number | ST | RS | TSS |
|---|---|---|---|---|
| 1 | DD 1248 TQ | 15:31:18 | 15:31:20 | 2 |
| 2 | DD 1602 SR | 15:32:12 | 15:33:15 | 3 |
| 3 | DD 1786 TQ | 15:32:52 | 15:32:54 | 2 |
| 4 | DD 1651 YR | 15:34:30 | 15:34:32 | 2 |
| 5 | DD 1571 SE | 15:34:20 | 15:34:21 | 1 |
| 6 | DD 1048 TQ | 15:35:10 | 15:35:11 | 1 |
| 7 | DD 1369 M | 15:35:50 | 15:35:51 | 1 |
| 8 | DD 1189 SE | 15:37:20 | 15:37:24 | 1 |
| 9 | DD 1702 YU | 15:37:01 | 15:37:02 | 1 |
| 10 | DD 1691 QY | 15:37:30 | 15:37:31 | 1 |
| **Average of Success** | | | | **1,5** |

The SMS-Sent column displays the start time of automatic SMS sending, the SMS-Received column displays the time when the vehicle owner received the SMS process, the Delivery-Time column displays the total time required to send Automatic SMS, written in the formula :

S.S. = Sending of Automatic SMS.
R.S. = Recieve of Atumatic SMS.
TSS = Total Time for Atumatic SMS Process.
TSS =(RS)–(SS) (2)

Automatic SMS sending time occurs after the QRcode scanning process is successful. Therefore the sending time follows the detailed view data in table 1. The success rate and speed of the automatic SMS-sending process to vehicle owners are speedy, reaching 1.5 seconds.
The process of checking the vehicle until confirmation is recorded as the confirmation time; the goal is to determine how long it takes for each process as a whole. Table 2. shows the results of recording the confirmation time of each vehicle.

Table 3. Confirmation time

| No | Vehicle | TI | TC | AT | R |
|---|---|---|---|---|---|
| 1 | DD 1248 TQ | 2.5 | 10.3 | 5.8 | Confirmed |
| 2 | DD 1602 SR | 2.4 | 11.7 | 13.11 | Confirmed |
| 3 | DD 1786 TQ | 4.5 | 12.5 | 16.10 | Unconfirmed |
| 4 | DD 1651 YR | 3.5 | 7.0 | 10.00 | Confirmed |
| 5 | DD 1571 SE | 3.7 | 7.2 | 10.9 | Confirmed |
| 6 | DD 1048 TQ | 4.0 | 11.1 | 15.1 | Confirmed |
| 7 | DD 1369 MD | 4.1 | 11 | 5.2 | Confirmed |
| 8 | DD 1189 SE | 3.8 | 7.5 | 10.13 | Confirmed |
| 9 | DD 1702 YU | 5.0 | 15 | 20.0 | Unconfirmed |
| 10 | DD 1691 QY | 4.6 | 14.9 | 18.15 | Confirmed |
| Average of Success | | | | 12.45 | |

The T.I. column displays the total time used during the vehicle data validation. T.C. displays the time used between the driver and the vehicle owner during the confirmation process. The AT column shows the total time required from the QRcode scanning process until the confirmation status is decided. The status column displays the results Matching information between the driver and the owner of the vehicle and written in the formula:

T.I. = Time spent during the vehicle inspection process in units (minutes)
T.C. = Time used during the confirmation process in units (minutes)
AT = Total time overall in the process in units (minutes)
AT = TI + TC (3)
R = The result of confirmation between the driver and the vehicle owner. If there is a similarity of information, then the decision is confirmed. Otherwise, it is non-confirmed.

In Table 3, it can be seen that the average time used for each inspection process is 12.45 minutes, from 10 samples recorded vehicles No. 3 and 9 with Non-confirmation status, which shows that there is no similarity of information between the actual owner of the vehicle and the driver being examined so that it was said there were indications of vehicle theft. Officers conducted a more detailed examination of the driver.

In Figure 7. the data recorded during the inspection process that occurs by each rider is displayed. Note that the scanning process QRcode (T.R.) and automatic SMS (TSS) delivery typically run when viewed based on the graph. At the same time, the confirmation time (AT) looks fluctuating, which explains that every final decision of the confirmation process between the vehicle owner and the driver can only be declared complete when found similarity of information so that the time used varies. Based on the test results, new knowledge was obtained about using technology through the collaboration of several cloud computing-based technologies to help overcome criminal problems regarding vehicle theft.

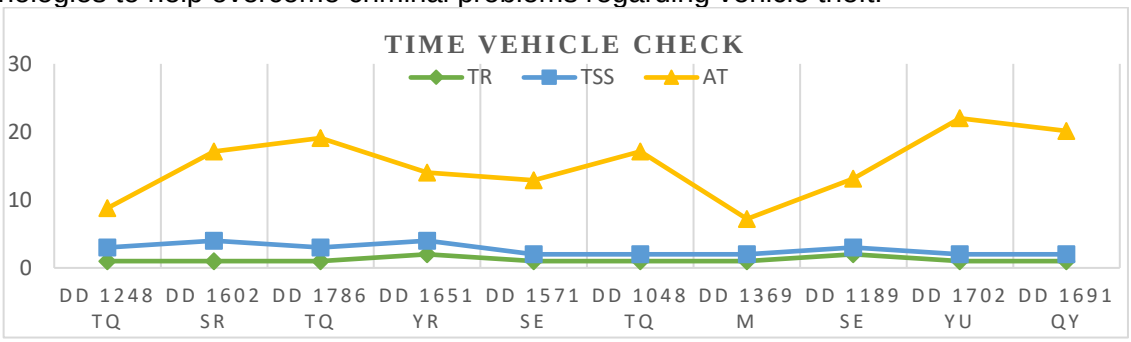


Figure 7. Vehicle checking graph

In this study, recording and comparison was carried out on implementing non-technical community reports and using technology regarding the activities needed, shown in Table 4.

Table 4. Comparison crime-handling sevices

| No | Variable | Non-Technology | Use-Technology |
|---|---|---|---|
| 1 | Reporting | Yes | Yes |
| 2 | Validation | Yes | Yes |
| 3 | Cost | Hight | Low |
| 4 | Confirmation | 10 Hours | 2 Hours |

Table 4 shows data regarding recording community activities in handling criminal cases. It can be seen that crime-handling services are better using technology, as seen from the cost variable; namely, the costs required in handling cases are lower, and the confirmation time is faster because the community can go directly to the location where the vehicle was found without having to go to the police station first. This research implies that security forces will be assisted in tracking criminal vehicle cases to maximize the response to public complaints.

Previous research as support for this research stated that the GPS provides latitude and longitude positions that can accurately pinpoint the vehicle in any climate as a satellite-based navigation system [29]. Secondly, GSM/SMS technology integration into the Driver and Vehicle


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Licensing Authority Registration Database, making it easily accessible to the Security Service for quick and easy verification of driver's license or vehicle status and authenticity concerning ownership [30].

## CONCLUSION

It is concluded that the cloud computing-based system that has been built can be used to support the vehicle data validation process by using a combination of QRcode, SMS and Geolocation technologies. The advantages obtained from this research include First, the embedded system that is applied to smartphone devices eliminates dependence on using modems in case studies related to SMS. Second, it is possible to develop services on a virtual system without the required hardware through cloud computing technology. Finally, the results of this study can be used as an alternative solution to reduce the increase in criminal cases of inter-island private vehicle theft syndicates. However, the limitation of this study is the system built has not been able to record real-time vehicle positions. In future research, it is recommended to apply more sophisticated information technology through innovations that support real-time position recording based on cloud computing services that can be used to reduce the crime of private vehicle theft so the technology can be present in realizing security for the community.

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