Research Article

Smart Dumpster: Design Of Tracking Dump Truck And Monitoring Of Waste Places To Support Effectiveness Of Waste Transportation In Bandung City

Muhammad Benny Chaniago[1], Muhamad Aldy Fauzy[2]

[1,2]Information System Department, Widyatama University,Jl. Cikutra No.204A, Sukapada, Cibeunying Kidul, Kota Bandung, Jawa Barat 40125
[1]benny.chaniago@widyatama.ac.id, [2]muhamad.aldy.f@gmail.com

Article History: Received: 10 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 20 April 2021

Abstract: The waste problem is a problem that has not been appropriately resolved, especially in various regions in Indonesia, with the increasing number of people in big cities, which is directly proportional to the production of waste produced. If the community does not handle the waste transportation process correctly, it will cause waste accumulation, especially at the TPA. Waste management must pay more attention to waste management, especially regarding cost efficiency and environmental quality. With the development of technology, it is necessary to change and develop waste better by utilizing information technology. Mobile applications are an option so that a system can be accessed anywhere and anytime. The community hopes that this mobile-based system can help waste transporters get information quickly and accurately. Therefore, in this research, the Smart Dumpster application will be carried out.Researchers built this smart dumpster application using the waterfall methodology, where the process starts from defining needs, designing software, implementing to the system testing process. This application uses a mobile application and the Android platform by utilizing Google Maps technology. This technology is integrated with a trash can detection system by providing information about the waste height status when the trash is filled.The results obtained to create a smart dumpster system make it easier for waste transporters to determine which Garbage dump to visit for the transportation process without visiting all Garbage dump one by one.

Keyword: Garbage Dump, Waste Management, Smart Dumpster

1. Introduction

The development of urban development in Indonesia is increasing rapidly, followed by the increasing rural populations' movement to cities to obtain a better life. The increase in the number of urban residents will be directly proportional to the rise in waste generated. If the city does not provide adequate facilities and infrastructure, it will reduce the environment's quality, especially in terms of waste transportation. The issue of trash is a common problem commonly faced in Indonesia, especially in big cities. According to data obtained, Indonesia's waste reaches 175,000 tons per day or 0.7 kilograms per person, even according to research published in the journal Science in 2013. 2015, it is said that Indonesia is the second-largest contributor of waste after China, especially plastic waste.

Waste management must pay more attention to waste management, especially regarding cost efficiency and environmental quality. Garbage transportation is a sub-system of solid waste that has the role of transporting waste from a transitional site or source of destruction to a final processing site (TPA), referring to Government Regulation Number 81 of 2012 concerning Household Waste Management. The process of transporting waste is the activity of transporting waste from the source or Temporary Piling Place (TPS) to the Integrated Waste Management (TPST) or Final Processing Site (TPA) by motorized or non-motorized vehicles. So planning, route selection, and efficient waste collection schedules are essential to improve the waste collection system [1].

Environmental issues related to waste transportation are a significant concern for waste management actors, the community, and the government. Sound waste or domestic waste transportation system services with optimal routes can reduce these activities' negative impact (waste transportation) on the environment.

According to the Regulation of the Minister of Public Works of the Republic of Indonesia Number 03 / PRT / M / 2013, the city government carries out the transportation of waste in Indonesia, including Bandung City, in several ways type garbage. One approach uses the lift container method, Hauled Container System (HCS), where garbage trucks carry out garbage collection by bringing empty containers to the boxes' contents and then exchanging them with filled containers and getting them to the TPA [2]. It is done by visiting all existing trash cans without knowing whether the place is filled or not.

Bandung is a city with problems in waste management with a waste management system that is not optimal. There is still much waste that has not been transported, resulting in heaps of garbage detrimental to the environment. There is still no use of information technology in the existing waste transportation process, and the process of reporting the waste collection transaction is not documented. With the development of technology, it is necessary to better change and develop the waste collection process by utilizing information technology.

Based on the above problems, the city government needs a system that can optimize waste transportation, especially the provision of trustworthy waste status information to be more effective in collecting waste based on waste quality and minimizing waste accumulation, directly impacting the public health environmental beauty. So it is proposed a "Development of a transportation tracking system for transporting garbage and monitoring trash bins" in the city of Bandung.

2. Literature review

The following will describe a literature review related to this research and a review of previous research.

II.1 Smart Dumpster

It is an era where information technology is increasing. The development of technology can be optimized to create a system that can automate and provide information on an operation. One of the benefits is in waste transportation operations, where microcontroller technology integrates mobile applications into the smart dumpster system. A smart dumpster is a system that can monitor trash bins so that information about the height of garbage can be accessed by trash collectors using a mobile application.

II.2 Android Mobile Application

Android is an information system for Linux-based mobile devices, which includes OS, middleware, and applications. Many developers are starting to pursue Android because Android provides an application framework that allows developers to build applications or games on mobile devices using the Java programming language in open source. Developers can customize the platform without paying royalties [12,17].

In this study, researchers will build an android mobile application using Android Studio as an Integrated Development Environment (IDE) and use an SQLite Database to support local data storage required by the application.

II.3 Google Maps Service

Google Map Service is a free virtual global map service provided by the google company and accessed online. Google Maps also offers a search for places and travel routes. Google provides an API that developers can use to take advantage of the Google Maps feature, from now on, referred to as the Google Maps API.

Google Maps API is a service provided by Google to users to take advantage of Google Maps in developing applications. Google Maps API offers several features for manipulating maps and adding content through various services it has [16].

In this study, Google Maps Service is used to display information in maps and location markers from each existing trash can and other information such as distance, travel time, and altitude level. Figure 1 shows the use of Google Maps Service in a mobile application.

Figure 1 An overview of the Google Map API's implementation on the Mobile App[14]

II.4 GPS. Tracker

GPS (Global Positioning System) is a system that provides positioning and navigation services. The system consists of 3 segments: the control segment, the space segment, and the user segment. The control segment serves to update location data. The segment serves to determine the position and the user segment functions as a data receiver. [15].

In this application, the mobile client is used to receive data from the GPS contained in the Google Maps service so that the device's position can be tracked.

II.5 Firebase

Firebase is a BaaS (Back-end as a Service) currently owned by Google. Firebase is a solution offered by Google to simplify the work of a Mobile Apps Developer. Many of Firebase's services, including real-time database and Firebase cloud messaging, where Firebase can provide real-time notifications [13].

In this research, Firebase cloud messaging sends messages from the server to the mobile application in real-time.

II.6 State of the Art

Table 1 Review of Previous Research

No	Title	Technology	Research Result	Comparison with Current Penalitian
1	*Solid Waste Monitoring System Integration based on RFID, GPS, and Camera* (Maher Arebey, M A Hannan, Hassan Basri, R A Begum, & Huda Abdullah, 2010)[3].	*Desktop Application,* RFID *& Camera, Google Maps.*	The monitoring system developed can detect the quantity and volume of waste to carry out planning related to the distribution of waste transportation in real-time locations according to the filled status.	In this research, the technology used is RFID and a Camera to detect the trash volume and use a desktop-based application for the management interface for monitoring the trash can.
2	*Efficient Waste Collection System* (Saurabh Dugdhe, Pooja Shelar, Sajuli Jire, and Anuja Apte, 2010)[4].	*Web-Based Application, Ultrasonic sensor, Google Maps.*	The monitoring system developed can detect the height of the waste using ultrasonic sensors and display web interface monitoring.	In this study, the application developed is based on a web interface without using a mobile application.
3	*Smart Solutions for Smart Cities: Using Wireless Sensor Network for Smart Dumpster Management* (Sahar Idwan, 2016)[5].	*Web-Based Application, Wireless Ultrasonic sensor, Google Maps.*	This dumpster management system can detect the trash level using an ultrasonic sensor and display all the trash status with a web-based application.	In this study, all dumpster management is carried out on a web application, from monitoring to the dump truck's division of tasks itself. The use of mobile applications is not applied in this study, compared to the system to be built using Android mobile technology.
4	*Arduino-based Smart Garbage Monitoring System Analysis Requirement and Implementation* (Namakambo Muyunda, Muhammad Ibrahim, 2017)[6].	*Web-Based Application, Ultrasonic Sensor, Google Maps.*	The process of monitoring and transporting waste by utilizing ultrasonic sensors as an altitude detector and web-based apps as an interface for the system.	In this study, the concept applied is the same as the system to be built, but in this research application, does not use a mobile native application such as Android but uses a web browser on the mobile device used.

No	Title	Technology	Research Result	Comparison with Current Penalitian
5	(Student Presence Using RFID and Telegram Messenger Application, Muhammad Benny Chaniago, Apri Junaidi, Widyatama University, 2016)[11].	*RFID, Telegram*	Application of an attendance system using RFID is integrated directly with Telegram to provide information now with students' parents.	The concept of this research is the same, but the tools and techniques used are different. In the study carried out using RFID technology and integrated with Telegram as a notification to the user, the research carried out using ultrasonic sensor technology and NodeMCU as a tool and integrated with Firebase to notify users.
6	*Volunteer GIS (VGIS) Based Waste Management A conceptual design and use of Web 2.0 for Smart Waste Management in Dhaka City* (S M Labib, 2017)[7].	*Web-Based Application*	The citizen determines the process of transporting garbage with a collection point. It can be said that the city functions as a sensor to resolve the problem and the issues of collection. The application interface uses web-based apps.	In this research, the technology used is different because it only uses a web-based application. The concept for collecting the waste itself is far different, where the trash can is not determined by mastering the database. Still, citizens do manual input on the web provided.
7	*Smart city initiative: traffic and waste management* (Ankitha S, Nayana KB, Shravya SR, Smt. Lovee Jain, 2017)[8].	*Ultrasonic Sensor,* GSM *Module.*	The monitoring process of waste transportation uses an ultrasonic sensor to determine the height of the trash. It is sent via a short message by the GSM module to the control room, where the message is displayed on the LCD.	In this study, the technology used is different, where only the ultrasonic sensor and GSM Module are used without any android apps. The concept is different where the dump truck will only operate when there is a signal from the trash can and send a short message to the control room where the trash needs to be done garbage transport.
8	*IoT Based Solid Waste Management System A conceptual approach with an architectural solution as a smart city application* (Abhay Shankar Bharadwaj, Rainer Rego, 2016)[9].	*Web-Based Application, Mobile Application, Infrared sensor,* MQTT *protocol, LoRa transceiver module, Google Maps.*	The trash monitoring process utilizes an infrared sensor as a detector for the height of the trash, which is then sent to the server using the MQTT protocol, and the data is displayed on the web and mobile-based app.	In this study, the concept used is the same as the system to be built, but the technology used is different, namely by using an infrared sensor as a detector for the level of waist height, and the MQTT protocol for the interaction process and sending data from the sensor to the server.
9	*Intellectual Trash Management using Internet of Things* (Sathish. A, Prakash.M, Jainulabudeen S.A.K, Sathishkumar R, 2017)[10].	*Android Mobile Application, Ultrasonic Sensor, Google Maps.*	The process of monitoring the trash by utilizing ultrasonic sensor technology to detect the garbage's height and using the mobile app as an interface to find out the trash.	In this study, the technology used is the same, but the concept applied is slightly different, where garbage can only appear around the dump truck location based on the specified radius. The system to be built provides information on the area of the trash found on its functional site.

3. Analysis and Design

At this stage, the researcher will analyze the ongoing system, analyze the system to be built or proposed, and the system design that will be made. Analysis of the current system is carried out to determine what processes are contained in the waste transportation operation, be further developed into an application, and obtain the needs needed in carrying out application development.

III.1 Current System Analysis

Analysis of the ongoing system shows that the general process flow of waste transportation operations is explained one by one based on the operational area, without knowing the TPS has been filled with waste or not, commonly referred to as the SCM transportation method. Transactions are also carried out by taking pictures of these activities, without any definite history recording.

The following are some of the procedures performed when transporting waste:

1. The truck leaves the landfill with an empty container. The user has been assigned based on the operational area. The user is given a means of transporting a garbage truck to carry waste transport. At the start of each operation, the user brings a truck with empty containers from a predetermined pool based on the functional area.
2. Trucks to TPS, which are determined based on operational area Users, bring empty container trucks to the TPS based on the TPS's functional area. In Bandung city itself, there are four functional areas: West Bandung, East Bandung, North Bandung, and South Bandung.
3. They are carrying out waste transportation. The user moves the waste from the filled container to the empty container carried by truck.
4. Take evidence. During the activity, taking pictures to prove the transportation process has been carried out (optional).
5. The waste TPS transportation process is complete. The waste transportation process is whole, but the truck will go to the next TPS as long as the truck container is still not filled.

From the analysis results carried out on the current system, results are obtained regarding the flow of the waste transportation process in general.

Figure 2 shows a business process that describes the current flow of waste hauling processes.

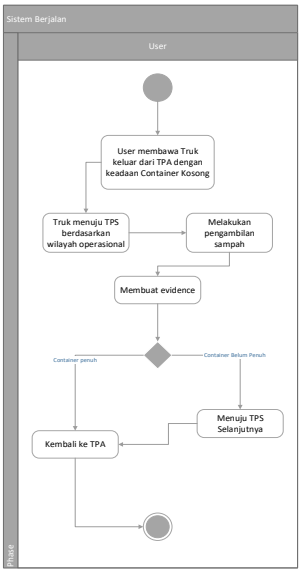


Figure 2 Business process system running

III.2 Proposed System Analysis

From the analysis of the ongoing system, it is necessary to conduct an evaluation. It is known that the waste collection process is currently being carried out by visiting each TPS without knowing the status of the trash bin filled or not. We need a system function that can provide information about the quality of waste when it is filled. Then there is a process of proving and recording less documented waste transportation transactions, so we need a system that can store a history of the waste collection process.

The proposed system will use a mobile-based application with an android platform to obtain information anywhere. The version uses the minimum Android Marshmallow SDK. It integrates a trash height detection tool using ultrasonic sensors and NodeMCU. It adds several services ranging from Pusher and Firebase notifications, google maps service, Google geolocation API service, RESTful web service using Laravel, and SQL lite database as a local device database.

Using a mobile application, the garbage collection user can directly monitor the trash through SmartDumpster, where the application will display the application location and the trashed status. The user can select the TPS where the waste transport process will be carried out.

In transporting the waste, the user will be given a recommended path or route to the TPS location. The user must check in a radius of 100 meters from the TPS to provide evidence that the user is transporting waste at the TPS and checkout when the waste transport process is complete. Later, the transaction process will be generated a waste transportation transaction history.

Using Pusher and Firebase notification, users can get real-time information about the status of a filled trash can, sent by the server using the web service via the Firebase notification to the mobile application.

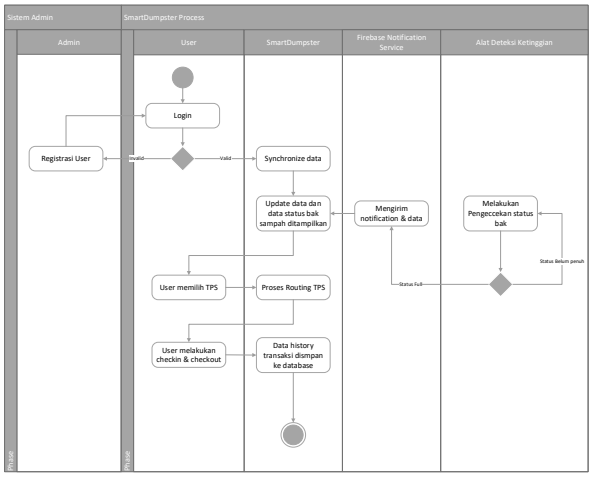


Figure 3 The system business process to be built

III.3 System Overview

The application to be developed in this study is integrated with the trash can detection system researched by Muhammad Benny Chaniago and Mohammad Natsir. The Smart Dumpster application will be built on the android platform. The application can perform GET and POST data against the server using web services as a back-end built using Laravel. The framework, to get real-time data, the application will use the Firebase service to send real-time notifications when the tool detects that the trash can is full. An overview of this system can be seen in Figure 4.

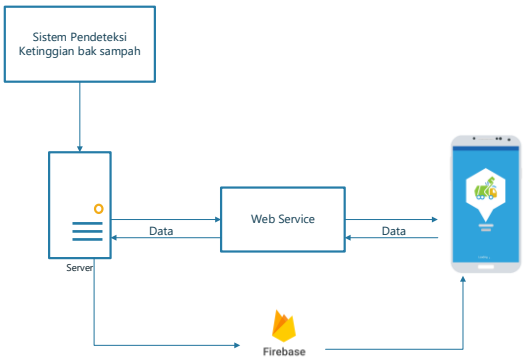


Figure 4 Overview of the system

III.5 Design

A. Application Behavior Design

In the application behavior design, it is explained about the actors and activities that exist in the SmartDumpster practical application. Designing application behavior is described using the use case diagram in Figure 5.

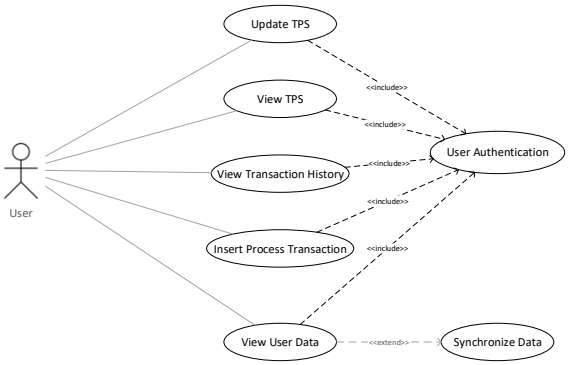


Figure 5 Use Case Smart Dumpster

B. Class Design

Class planning will be illustrated with a class diagram. Class diagrams describe the system's structure in defining the classes that will be made to build the system. The class diagram in the Smart Dumpster application that describes the local android database can be seen in Figure 6. The results of the analysis carried out by the author. Several steps are designed, starting from system design, hardware design, database design, and program design.

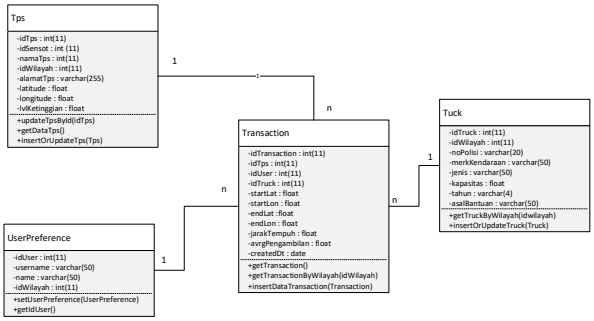
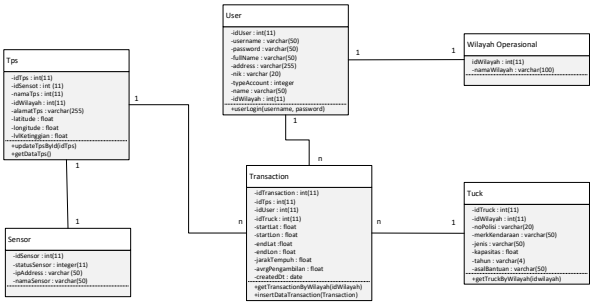


Figure 6 Class diagram of the Smart Dumpster mobile application

The class diagram that describes the database server can be seen in Figure 7.



The class diagram that describes the database server can be seen in Figure 7

4. System Application

This section describes the results of the implementation that has been designed.

IV.1 *Start of Day*

Start of Day is initiating garbage collection in carrying out the waste transportation process. The Start of Day is carried out to determine the initial kilometers, initial fuel, and the vehicle to be used. It is done at the beginning of the day. This process is carried out for the need for data recording of transportation transactions done by the user.

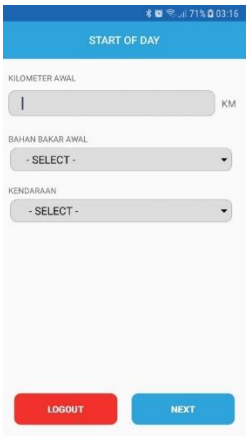


Figure 8 Start of Day Screen

IV.2 Monitoring

Monitoring is a screen that contains information regarding which trash cans are filled or whose status is still not full, marked by a red trash can icon that informs that the TPS has the status of trash cans that are full and ready to be taken. Trash cans not filled marked with a green trash icon. On this screen, the user can select the TPS for the retrieval process.

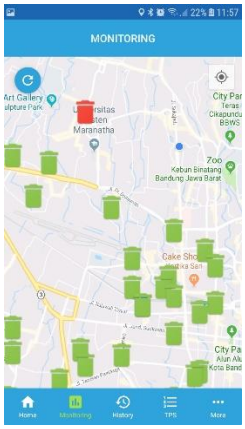


Figure 9 Monitoring Screen

IV.3 Process

The process screen is a process for recording and tracking waste transport, where users can find out recommended routes that have information on distance and time estimates.

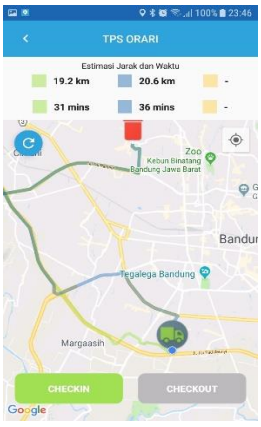


Figure 10 Process Screen

IV.4 View History

Screen History is data or information that is obtained after the user transports waste. The history contains data on kilometers traveled, TPS visited, vehicles used, and also the number of garbage transports made. This history is displayed based on the user ID who logged in

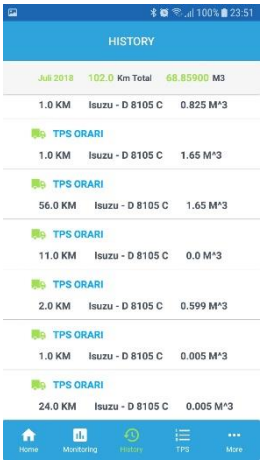


Figure 11 History Screen

IV.5 Logout and End of Day

The logout process is carried out when the garbage collection user has finished carrying out waste transport activities. The user will input the final kilometer and the final fuel to record the mileage and the fuel used during the waste transport activity.

Figure 12 End of Day Screen

5. Conclusion

From the process of developing this system, here are the conclusions that the authors can describe, including:

1. The application of technology using a mobile application allows the actors to carry the waste to choose or determine which TPS to visit, from seeing the trash cans' status. The actors who bring destruction do not have to go to each TPS one by one.
2. With the SmartDumpster system that uses a mobile application, garbage collectors can get real-time information on the trash height when the altitude status is full.
3. Using the SmartDumpster system, garbage collectors can monitor the trash's status from the mobile application to become a consideration for the TPS to be visited.

References

1. Bank, A. J. Dubanowitz, S. Roshifanni, Dkk, A. Dina, R. H, N. Zubaedah, R. Yenny, M. Woodhall, A. Purwanti, D. M. Pratomo, F. Hadi, M. Sc, S. Dwi, L. Pratiwi, Y. Trihadiningrum, R. Nasrudin, F. Muhammad, U. Gunadarma, P. R. Indonesia, U. K. Government, P. Ferry, and Agus, "PERATURAN

PEMERINTAH REPUBLIK INDONESIA NOMOR 81 TAHUN 2012 TENTANG PENGELOLAAN SAMPAH RUMAH TANGGA DAN SAMPAH SEJENIS SAMPAH RUMAH TANGGA," *Republika*, no. April, pp. 699–725, 2012.

2. M. Pekerjaan and U. Republik, "PERATURAN MENTERI PEKERJAAN UMUM REPUBLIK INDONESIA NOMOR 03/PRT/M/2013 TENTANG," 2013.
3. M. Arebey, M. A. Hannan, H. Basri, R. A. Begum, and H. Abdullah, "Solid waste monitoring system integration based on RFID, GPS, and camera," *2010 Int. Conf. Intell. Adv. Syst. ICIAS 2010*, pp. 1–5, 2010.
4. S. Dugdhe, P. Shelar, S. Jire, and A. Apte, "Efficient waste collection system," 2016 Int. Conf. Internet Things Appl. IOTA 2016, pp. 143–147, 2016.
5. Jabarullah, N. H., Geetha, E., Arun, M., & Vakhnina, V. (2020). Design, analysis, and implementation of a new high step-up DC–DC converter with low input current ripple and ultra-high-voltage conversion ratio. IET Power Electronics, 13(15), 3243-3253.
6. M. Ibrahim, "Arduino-based Smart Garbage Monitoring System," pp. 28–32, 2017.
7. S. M. Labib, "Volunteer GIS (VGIS) Based Waste Management," pp. 137–141, 2017.
8. Science, N. Mysore, C. Science, N. Mysore, C. Science, N. Mysore, C. Science, and N. Mysore, "Smart City Initiative : Traffic and Waste Management," 2017.
9. K. Nirde, P. S. Mulay, and U. M. Chaskar, "IoT based solid waste management system for smart city," pp. 666–669, 2017.
10. S. A, P. M, J. SAK, and S. R, "Intellectual Trash Management using Internet of Things," pp. 53–57, 2017.
11. M. B. Chaniago and A. Junaidi, "Student Presence Using Rfid and Telegram Messenger Application," pp. 1–5, 2016.
12. M. Lewandowski, N. Co-investigator, and C. M. Lewandowski, "Android development for dummies," Eff. Br. mindfulness Interv. Acute pain Exp. An Exam. Individ. Differ., vol. 1, pp. 1689–1699, 2015.
13. Y. Alhomsi, A. Alsalemi, M. Aldisi, I. Ahmed, F. Bensaali, A. Amira, and G. Alinier, "Real-Time Communication Network Using Firebase Cloud IoT Platform for ECMO Simulation," Proc. - 2017 IEEE Int. Conf. Internet Things, IEEE Green Comput. Commun. IEEE Cyber, Phys. Soc. Comput. IEEE Smart Data, iThings-GreenCom-CPSCom-SmartData 2017, vol. 2018–January, pp. 178–182, 2018.
14. P. Soepomo, "PEMANFAATAN GOOGLE MAPS API UNTUK PEMBANGUNAN PASCA BENCANA ALAM BERBASIS MOBILE WEB (Studi Kasus : Badan Penanggulangan Bencana Daerah Kota Yogyakarta)," vol. 1, pp. 162–171, 2013.
15. M. Kadibagil, "Position Detection and Tracking System," IRACST -International J. Comput. Sci. Inf. Technol. Secur., vol. 4, no. 3, pp. 67–73, 2014.
16. [16] Google Maps APIs. https://developers.google.com/maps/documentation/, Accessed on Agustus 22, 2017.
17. Kopar, R. (2018). Resource Nationalism in International Investment Law by Sangwani Patrick Ng'ambi. Croatian International Relations Review, 24(83), 125-128.