

WasteZap: Environmental Management System based on Crowdsorce Architecture

Satrio Yudho ^{a,1*}

^a Faculty of Energy Telematics, Institut Teknologi PLN, Jl. Lingkar Luar Barat, Jakarta, Indonesia

e-mail: ¹satrio@itpln.ac.id

*Corresponding author

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Abstract

The Waste management is a persistent challenge in urban areas. Indonesia is a country with a vast and diverse population of large cities, tourist destinations, and industrial areas. According to data from the National Research Agency, more than 35% of total waste in Indonesia, or approximately 11 million metric tons by 2025, falls into the unmanaged category, ultimately polluting rivers, ravines, and even main roads and drainage channels. This research was conducted by exploring studies related to waste problems and solutions from a social aspect, the novelty of information technology and mobile-based systems as well as government regulations related to waste management policies. This research proposes a system design called WasteZap. This system encourages collaboration from all parties to care about cleanliness and waste. The WasteZap architecture consists of an End User Layer, Data Process and Storage, and a Communication Layer. The user participation model is implemented in the form of crowdsourcing to achieve participant scalability.

Keywords: Trash Problem; Public Awareness; Crowdsourcing; WasteZap

1. Introduction

The waste problem is an classical challenge which many countries has to solve, including Indonesia, the complexity of this waste problem brings Indonesia in fourth place for countries that have complexities to overcome it[1]. being ranked fourth as previously mentioned is not a good achievement for a country that is currently trying to keep moving towards realizing a program called smart city. the Indonesian government with its 100 smart city movement aims to form a country that can achieve sustainability for the next generation.

Smart environment is one of the important indicators in the smart city framework[2], and what is meant by a smart environment is a clean environment, technology-based hygiene management and the development of renewable energy sources[3]. Garbage is not a phenomenon that just appears in the environment, this garbage problem arises due to the lack of active participation of residents in the environment in concern for disposing of waste in the proper location[4].

One of the information that came from the environmental service stated that community participation tends to throw garbage anywhere even though TPS 3R has been provided[5]. Therefore this problem is emphasized in making a mobile-based application system so that it can be used by all ages of society with the aim of forming the character[4]of a community who cares about cleanliness.

The method we use in this study is a qualitative approach to produce an appropriate system pattern to provide the addressed problems.

2. Research Methodology

To gain significant results in this research work, we arranged three main activities as shown in Figure 1 below

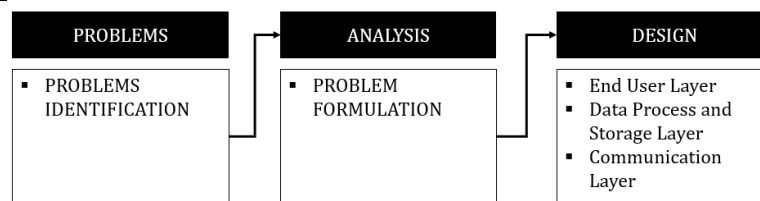


Figure 1. Methodology

The first step is to identify the problem, as we have said in the introduction that the focus of the problem is on the characteristics of residents towards waste, therefore, matters related to population density, living areas and all that are relevant to the community need to be mapped in the form parameter.

then, the second part is done by applying the analysis to improvise from the problems that have been identified. In this section this research work yields significant value to previous related research.

and the final step is the formation of a system structure in the form of a mobile application to accommodate community participation in keeping the environment clean.

3. Result and Discussion

a. Problem Identification

Waste does not form by itself, in a study conducted by Sutinah[6], it shows that there are two main elements in society to increase awareness. in 2025, the Indonesian government displays information about sources of waste from various areas as shown in Figure 2 as shown here.

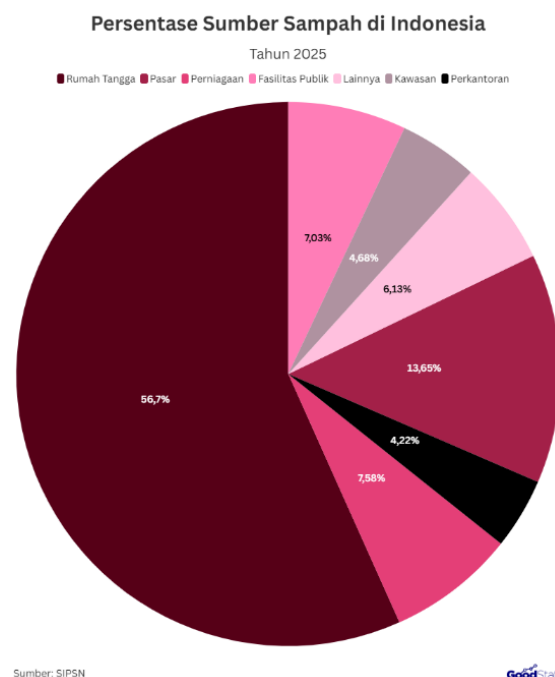


Figure 2. Waste Composition from its source [7]

according to the records of the Environment Service (DLH) which reported in Indonesia statistical bureau [8] in one of the cities in Indonesia in 2025 the volume of waste in one day will reach 71 million Tons which is recorded through transportation by garbage collection vehicles, however, the distribution of waste that is not collected in an orderly manner is scattered on the side of the road , on vacant land or in other locations that are not intended for waste disposal is classified as a high percentage. Based on this information, the main problem is the lack of community participation[9] triggered by a lack of knowledge of the 3R principles, namely Reuse, Recycle and Reduce. The problem of participation and volume of waste can be identified with the following parameters:

Table 1. Participation Level		
Parameter	Total	Scale
Level of community Participation in socialization	99%	HIGH/ MEDIUM/ LOW
level of Community Participation in Implementation	99%	HIGH/ MEDIUM/ LOW
level of Community Participation in Maintenance	99%	HIGH/ MEDIUM/ LOW

The parameters shown in table 1 above are a simple approach to being able to take measurements using a Likert scale based on the form of answer data obtained by asking using limited questions 1 to 5. Thus, grouping can be done with low, medium, and high categories.

meanwhile to get the input value from the Likert scale, the technique used is proportional random sampling with the following formula:

$$n_i = \frac{N_i}{N} n$$

where n_i is the number of samples in stratum i and N_i is the number of populations in stratum i and N is the total population.

and one of the efforts to trigger community interest in participating is to provide prizes or awards for people who have an active role in the three parameters mentioned in table 1.

Research findings should be presented in a clear and concise manner. The results should provide a summary of the scientific findings rather than presenting highly specific data. Clarify the differences between your findings and those of prior studies by other researchers. The discussion should focus on the significance of your work. Include citations from previous studies that can support the outcomes of your research.

b. Planned Behavior theory

Changing people's behavior [10]to become more environmentally conscious is one of the expected goals towards a sustainable healthy environment. and the effort to get that success is to take a behavioral approach as shown in Figure 3 below.

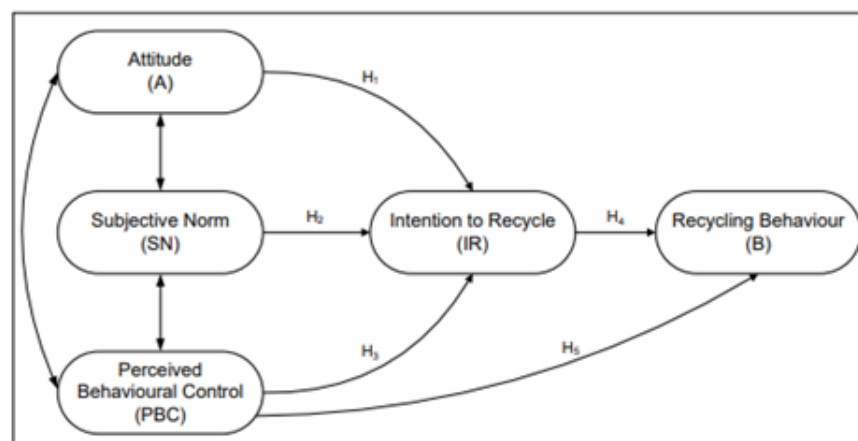


Figure 3. Theory of Planned Behavior

From the results of research conducted by Hariyani [11], the description for the parameters of the theory of planned behavior is as follows, see table 2.

Table 2. Parameters of Planned behavior

P	Term	$\bar{x}$	percentile						
			0.5	0.10	0.25	0.50	0.75	0.90	0.95
B	Recycling Behavior	0	0	0	0	0	0	0	0
IR	Intention to Recycle	0	0	0	0	0	0	0	0
A	Attitude	0	0	0	0	0	0	0	0
SN	Subjective Norm	0	0	0	0	0	0	0	0
PB	Perceived Behavioral Control	0	0	0	0	0	0	0	0

P is the name of the parameter in behavioral theory, while $\bar{x}$ is the rank of the population group from the total population sampled, and percentiles are the detailed composition of the total score on x assuming the lowest score is 1 and the highest score is 7.

In the introductory and problem identification sections it has been mentioned that one of the supporters to be able to increase caring behavior towards waste is by utilizing technology. as we already know, the development of information and communication technology is now at the stage of smart devices capable of processing data in various forms in devices that can be held in the hand, or in other words, smartphones. Smartphone is a disruptive technology that is almost owned by most people, because this technology is also a support for activities and part of a lifestyle. data collection related to sampling and measuring community behavior will be accessible [12] to a wide range of status and age levels. and considering the terms of society and behavior in an environment that impacts on dynamic data using smartphones, the technological solution for this participation application is to use a crowdsourcing approach [13], [14].

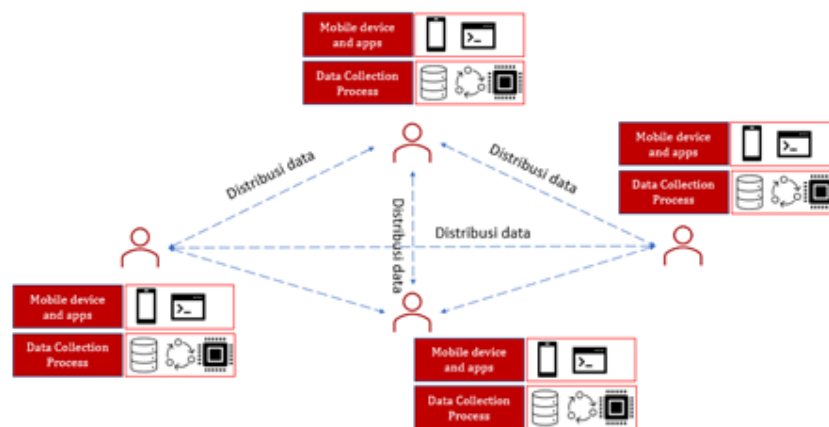


Figure 4. Concept Participation in Crowdsourcing

Figure 4 above explains in general the form of participation between all people as a community by using smartphones to get involved in environmental cleaning programs, using cameras to collect data, assessing activeness in disposing of garbage, waste sorting are features that will be included in the statistical parameters that have been displayed in table 2 previously.

c. System Design

The solution to the crowdsourcing approach is to use a mobile-based device, namely a smartphone. we design three main components that form an application system architecture to support the active participation of the community as follows.

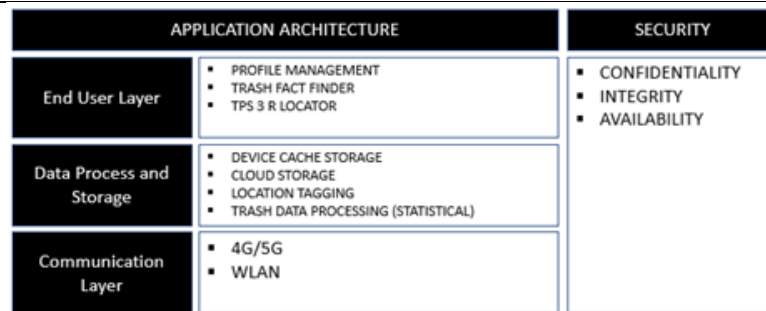


Figure 5. System Design

In Figure 5 above we arranged three layers which each of them is as follows.

a. End User Layer

The end user layer consists of three main features namely, (1) user profile management (2) Tash Fact Finder and (3) TPS 3R Locator.

b. Data Process and Storage Layer

This layer contains important activities in storing and processing data into information that was mentioned in the previous section, its features are (1) Data Cache management (2) cloud storage (3) tagging of locations and (4) statistical processing of garbage data.

We briefly describe the description of the application's functions in Figure 6 below.

Domain	Description
Feature	
End User Layer	
▪ Profile Management	contains functions to facilitate user registration, complete personal profiles, change passwords, points that have been earned and rewards that can be exchanged.
▪ Trash Fact finder	serves to facilitate the garbage detective program, by reporting trash that is seen anywhere with a smartphone camera, then bringing the garbage to a garbage collection site called TPS 3R.
▪ TPS 3R Locator	The TPS 3R locator functions to display information on the whereabouts of the waste collection site in real time, the point calculation mechanism is carried out by visiting the nearest TPS 3R and selecting the TPS 3R to which the waste will be given, until the waste enters the collection point, new points can be counted.
Data Storage and Process Layer	
▪ Device Cache Storage	Device cache is a mechanism for storing data that will be sent to the cloud in temporary storage on the user's smartphone, the goal is to manage large file uploads to be more stable.
▪ Cloud Storage	cloud storage is the main storage of this application, all user data, real time rewards and devices are stored in the cloud system.
▪ Location Tagging	functions to record participants' journeys in finding waste, reporting it and bringing it to TPS 3R, the travel history of application users is also an important record.
▪ Statistical Trash Data Processing	serves to calculate the number of findings of waste, statistics of areas with the most findings of waste, statistics of active user participation who care about cleanliness.
Communication Layer	
▪ 4G/5G	cellular-based communication services that can be used on all smartphone mobile devices
▪ WLAN	communication medium that allows access to the system via Wi-Fi

Figure 6. System Design

c. Communication Layer and security

Security is an important component that supports the successful mission of the proposed application, we adopt the mccumber cube approach to map security requirements along the three main layers in the application architecture using mccumber cube framework[15]. The proposed security arhitecture is shown in Figure 7.

APPLICATION	SECURITY								
	Confidentiality			Integrity			Availability		
	Human Factor	Technology	Policy	Human Factor	Technology	Policy	Human Factor	Technology	Policy
End User Layer									
▪ Profile Management	03	02	11	03	02	01	03	02	10
▪ Trash Fact Finder	02	08	11	02	08	01	02	08	10
▪ TPS 3R Locator	03	08	11	03	08	01	03	08	10
Data Storage and Process Layer									
▪ Device Cache Storage	07	08	13	09	08	13	09	08	13
▪ Cloud Storage	07	08	13	09	08	13	09	08	13
▪ Location Tagging	07	08	13	09	08	13	09	08	13
▪ Statistical Trash Data Processing	07	08	13	09	08	13	09	08	13
Communication Layer									
▪ 4G/5G	03	04	01	03	04	01	03	04	01
▪ WLAN	03	06	01	03	06	01	03	06	01

Figure 7 Security Architecture for Communication Layer

In Figure 8 involvement of the McCumber cube with the European Union Agency for Network and Information Security[16], which we identify with two parameters, namely the ID is the identity of the security component and the security feature is the description of the component itself.

Our list of security features is shown in Figure 8 as follows:

ID	Security Feature
01	Copyright Agreement and Confidential Agreement
02	On Time Password
03	User Id and Passwords / Personal Identification Number
04	Paging Protocol Protection
05	Secure Wi-Fi Detection
06	Wi-Fi Speed Monitoring
07	Storage Limitation
08	Data Transfer and processing third parties
09	Data Protection Impact Assessment
10	Software update mechanism
11	Privacy Aware coding guidelines
12	Security Evaluation
13	System log

Figure 8. Security Architecture

4. Conclusion

Technological innovation to support increasing community participation in reducing waste from self-awareness. a mobile-based system within a crowdsourcing framework is an advantage in reaching participants wherever they are, with smartphone devices, the data has a wealth of information in the form of images, trash locations, 3R TPS locations. and the need to make predictions in real time regarding community and waste typologies can be more convincing to do.

Future Work

Our work in the future is to build prototypes of the application designs that we have described above. trials regarding functions in each application layer become a reference for improving or increasing the success of these applications in supporting smart environmental programs in smart city rules

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