

## The Development of Online Disaster Information System Using Location Based Service (LBS) Technology

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### ABSTRACT

Indonesia is geographically located in the disaster vulnerable area and frequently hit by various disasters such as earthquake, flood, etc. So that Indonesian people aware that the disaster information system is very crucial. Thus, the development of information and communication technology application is needed for disaster management. For this purpose, this paper proposes on the development of online disaster information system based on location based service (LBS) technology by using short message service (SMS) gateway and global positioning system (GPS). Then, the web-based prototype of online disaster information system is designed and developed as the media to provide information of location and situation of the disaster area. Furthermore, a user interface is also designed and developed to transmit input data as the location information using manual SMS and automatically using smartphone based on SMS/GPS. The research method used in this research is a spiral method that begins with conceptual design, prototype development, application test, and evaluation. The results of this research are the web-based information system and the implemented user interface application for Android smartphone (we called it ASIKonLBS). The online mapping of input data from smartphone to the web-based system has been tested. It shows that the disaster location information can be mapped to Google Maps timely and accurately that can be accessed using the Internet connection. The evaluation of mapping delay time shows that it is lower than the refresh time of the web-based system. Therefore, the proposed online system can be categorized as a real-time system.

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## 1. INTRODUCTION

Nowadays, the planning and development of information and communication technology (ICT) in disaster management are mainly focused on the government disaster agencies and donor institutions sides without involving public and community. On the other hand, almost all members of society have used ICT devices in their daily activities such as smartphone, tablet, etc. This fact has motivated the development of ICT application for disaster that applying new method of communicating, coordinating, and sharing information among the disaster victim, society, and the formal disaster agencies. A prompt disaster management is one of the challenges in disaster management including quick response, evacuation plan, and logistic distribution in saving humanity from natural hazards [1]. In fact that the number of disaster agency staffs is very limited during the disaster so that it is not enough in giving assistant to the victims. To solve

this problem, the role of community is needed as well as the ICT support to facilitate the communication in community using smartphone. Smartphone has been equipped with many sophisticated features such as high resolution camera, GPS, video, sensor, and longlife battery to accommodate these features. Smartphone has also been connected to the internet to enable web accessing, data collecting, and information sharing among the involved component in disaster management. These features are provided in a timely and efficiently disaster management application.

The most important information when disaster hit an area is the location coordinate. Thus, the implementation of LBS technology is very crucial in building and developing the innovative ICT for disaster management as it provides feature and service based on location (geolocation) [2]. Supporting by wireless communication technology that provided a timely mobile communication with many features and services, LBS technology has two approaches [3]. First, the location data is processed on a server and the result is sent to mobile equipment. Second, location data is determined for an application based on the mobile equipment to be used directly. It will be very useful to overcome the disaster, where the information of the location is a key factor in disaster management.

During the emergency response and post-disaster, some problems arise such as slow aid, uneven logistic distribution, not enough volunteers, uninformed location for donors, critical displacement, and demanding coordination among the disaster management agencies because of lack information about location and situation of the disaster. This problem arises as the information about location is not available online during the disaster and post-disaster. Disaster information system for the pre-disaster stage is available, for example the information system of disaster risk management in [4, 5]. During the response stage, some of disaster emergency management applications have been introduced in [6-9]. However, all of the applications have to be supported by robust infrastructure of information and communication network that make it difficult to be implemented in Indonesia. Another information system that has been available during the rehabilitation and reconstruction is SAHANA [10]. Based on the fact mentioned above, the location and situation information of the disaster is needed to be delivered to disaster agencies and community using an easy, quick and accurate access. Therefore, this paper proposes the development of online disaster information system based on LBS technology.

In this research, LBS technology is applied based on the availability of Short Message Service (SMS) and Global Positioning System (GPS) on the smartphone [6, 11-13]. SMS and GPS services are very effective and economic to be reconstructed after the disaster. Moreover, there are so many users of cellular phone that will be increased in amount and will spread to remote villages. Thus, the SMS gateway and mobile GPS [14] will be simply to be implemented in the proposed smartphone application to help transmitting textual and spatial information to online web-based system. Sending information to the system can be done anywhere and anytime by the registered member (authorized user). The received information from the smartphone application (we called it web ASIKonLBS) will be saved in database and forwarded on online application by mapping it to Google Maps service on the web system. Hopefully, ASIKonLBS application and web-based system will give benefits in analyzing and responding the disaster to help community and government dealing with the circumstances after the disaster especially in making quick response to assist the disaster victims.

## 2. RESEARCH METHOD

The research method applied here is a spiral method as shown in Figure 1. In the system application development, there are four stages which are concept development, application design, building and testing, and evaluation.

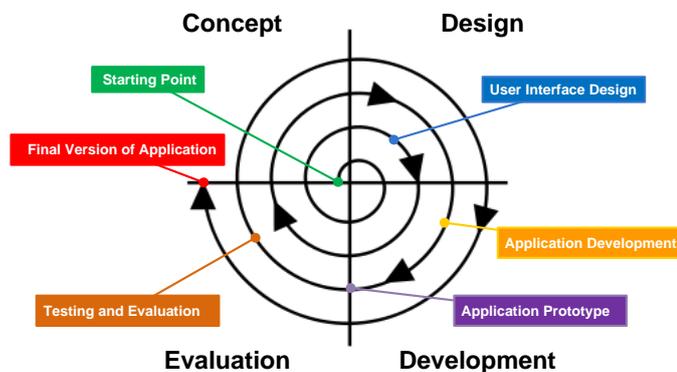


Figure 1. Research method

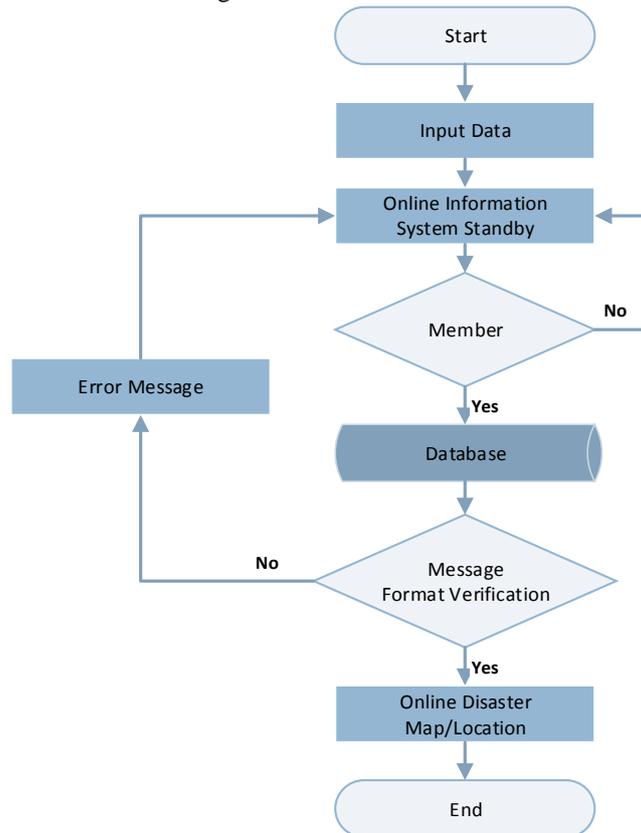


Figure 2. Flowchart of the application development

Based on the spiral method, the initial step is developing the online disaster information application concept where the disaster agency, society, and the victim at the location are able to send information by the proposed user interface to the developed web-based system. The design is started by designing the input data that will be sent manually using mobile phone by informing the coordinate of the disaster location or using smartphone by automating the GPS on a user interface. On the second step, to enable the information transmission, a user interface is designed based on LBS technology for several platforms of smartphone facilitated with GPS that is called ASIKonLBS. After designing the ASIKonLBS, the prototype of the web-based application is built following the steps shown in Figure 2. The message sent by ASIKonLBS will be validated based on the member status of the web-based system. If the message is sent by the member, then the information is saved in the database inbox of the system server. Then, the system will check the format of the input data about the disaster location sent by the application. If the format is compatible, then the information will be mapped to the online website system using Google Maps to enable the information to be accessed through the internet.

### 3. DESIGN OF APPLICATION

#### 3.1. The Concept of Application System

The concept of online disaster information system can be seen in Figure 3. The application is started with identification of the disaster location such as fire, flood, landslide, etc. It follows by the information sent by the community at the disaster location using cellular phone facilitated with GPS to track the coordinate of the location. The information that is compatible with the format of ASIKonLBS application will be sent to global system for mobile communications (GSM) network through base transceiver station (BTS) which is then forwarded to global system for mobile communications center (GSMC). Using SMS gateway, the information is transferred to the web system server. This information is stored in the database server of the system and will be disseminated to the user via web-based system and the map of Google Maps. The users (disaster agency staffs) who are outside the disaster location can access the web-based system to find out the situation especially the location of the disaster.

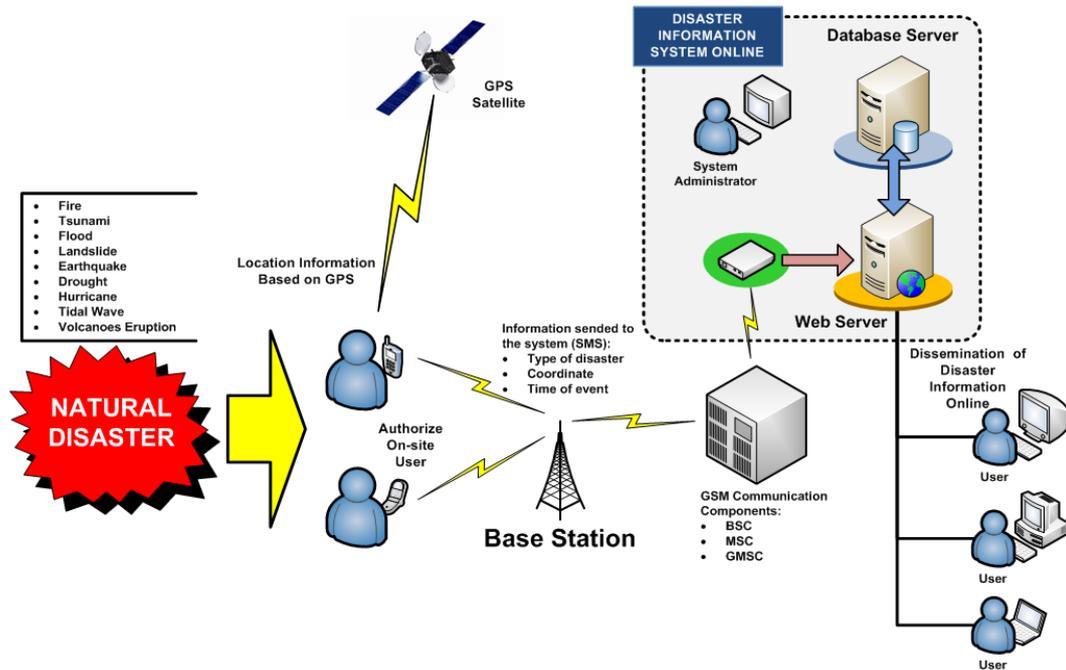


Figure 3. Conceptual model of online disaster information system

Transmitting information of the disaster location for ASIKonLBS is restricted to the member that has been registered to the application. The expected member that has to register to the web-based system is the staff from disaster bureaus such as Search and Rescue (SAR), Indonesian Red Cross (PMI), hospitals, and disaster management practitioners. The purpose is to avoid fake information coming to the ASIKonLBS system. The main focus is how to verify the received information as fast as possible before posting it to the system in order to approach real time information. The information of location and situation are very crucial for the community when the disaster strike the area. This information helps in building the preparedness and endurance of the community. The communication technology is very helpful in preparing the readiness in facing emergency situation. ASIKonLBS can be disseminated for early information in emergency countermeasure and mobilize aid after the disaster. The user of ASIKonLBS can access information using website that will be designed with the main feature of information of disaster location applying Google Map and open layers, disaster report, and the newest disaster mapped online.

**3.2. User and Technical Requirements**

Based on the concept of online disaster information system, as shown in Figure 3, the technical requirement in terms of hardware and software of the system can be identified as shown in Table 1. In accordance with some experiences of the user needs on ICT based disaster application, the following are the general facts for the proposed system:

- Data of disaster location are provided timely and accurately
- Data of disaster location are accessible by the public as soon as possible
- The disaster location can be monitored by the related agencies

Table 1. Hardware and software requirements

Hardware	Software
Server	Web server
Modem GSM	Now SMS Gateway
Mobile GPS	PHP
Smartphone	MySQL
SIM card	Apache
	Dreamweaver
	Google Maps API
	Open Layers

Table 2. Disaster code and icon [15]

Code	Disaster	Icon
101	Fire	
102	Tsunami	
103	Flood	
104	Landslide	
105	Earthquake	
106	Drought	
107	Storm	
108	Tidal Wave	
109	Volcanoe	

Keyword : INFO  
 Disaster code : 105  
 Longitude : 95.3212793  
 Latitude : 5.5689803



Format Input Data:  
 INFO 105 95.3212793 5.2689803

Figure 4. Example of input data format to ASIKonLBS [15]

Input data to ASIKonLBS can be sent only by registered member that is already registered in the system database to ensure that the received information is valid and from a trusted sender such as the member from the disaster agency staffs such as Local Disaster Agency, SAR, PMI, etc. To simplify the input data transmission, some of disaster types that have hit and have potentially hit Aceh Province are created in the specific codes and given in icon as nationally approved. The disaster codes and icons are listed in Table 2. The example of input data format for ASIKonLBS is described in Figure 4. This format is easy and simple to be applied in LBS technology as smartphone has been facilitated with GPS technology. In this way, the coordinate can be automatically retrieved by the smartphone.

The format of input data to ASIKonLBS application is determined based on the following parameters:

- INFO is the keyword to send the information using LBS technology through SMS gateway. This keyword is also used to enable the auto respons of the application by stated “*Thank you, your information will soon be processed*”. If the sent format is wrong, then the system will take the autorespons as follows “*Wrong Format, Please type INFO [space] Disaster code [space] Longitude [space] Latitude*”.
- Disaster code represents types of the disaster that have hit Aceh Province. These codes are listed in Table 2. The disaster code will be published on the system website and will be socialized to the member of the application.
- Longitude (X) is the point of coordinate that specifies the east and west position of earth as depicted in Figure 4.
- Latitude (Y) is the position point of coordinate of the imagenary line used to determine the location of the Earth’s equator, as depicted in Figure 4.

### 3.3 Information and Communication Infrastructure

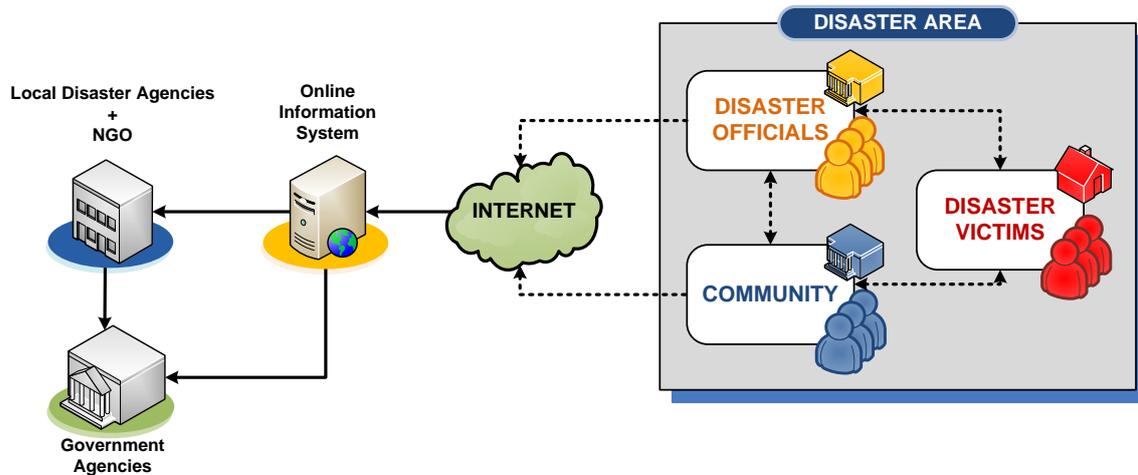


Figure 5. Information and communication infrastructure of online disaster information system

In implementing the online disaster information system, it is important to consider the infrastructure of the information and communication as shown in Figure 5. This infrastructure has to be supported by the cellular communication network as described in Figure 3. If the network connection is not available during the disaster, then victims, community and disaster officials at the area can send the information using the proposed user interface via satellite network. Furthermore, the internet connection is needed in transmitting the information to the online information system that implemented at the local disaster and government agencies. Internet connection is part of the social communication and media in giving the access of information to the community efficiently. Local disaster management agencies as the main responsible parties will give first response in providing aid to the victim. However, with the limited staffs at the agencies, community support is needed to assist the victim. Furthermore, aid from outside disaster area is very significant to minimize the total victim and damage caused by the disaster. Hence, all components at the disaster area can share information about the location and situation to the disaster management agencies and government. The community, victims, and staffs of disaster management agencies at the disaster location are able to send information in text message following the designed format using the proposed application of smartphone with LBS technology. During the emergency situation, textual information can be sent through satellite and wireless communication network even though the BTS at the area is down. Then the information is sent to the online disaster information system as the information dissemination mediator to the parties outside the disaster area using internet connection.

### 3.4. User interface for application

A user interface has been designed using phonegap with prototype design as shown in Figure 6. Currently, the prototype have been developed using Android Development Tool (ADT) and consist of 2 languages; Indonesian and English. In the prototype, user can send the information about disaster type, event time, longitude and latitude. The information that sent via SMS than received by the web-based system and shared to public via Internet. ASIKonLBS is developed to help the smartphone users sending information about the disaster that occurs around them. As it can be seen from the prototype that it guides the user to fulfill required information to enable it to be sent via SMS. Furthermore, ASIKonLBS can take geospatial information automatically by taking the coordinate information from smartphone GPS. The dropdown features gave the user to choose what kind of disaster type that occurs. Finally, the information then sent through SMS by using a phone number that is provided by application. Figure 7 shows a screenshot of information sent through SMS using a smartphone-based Android.

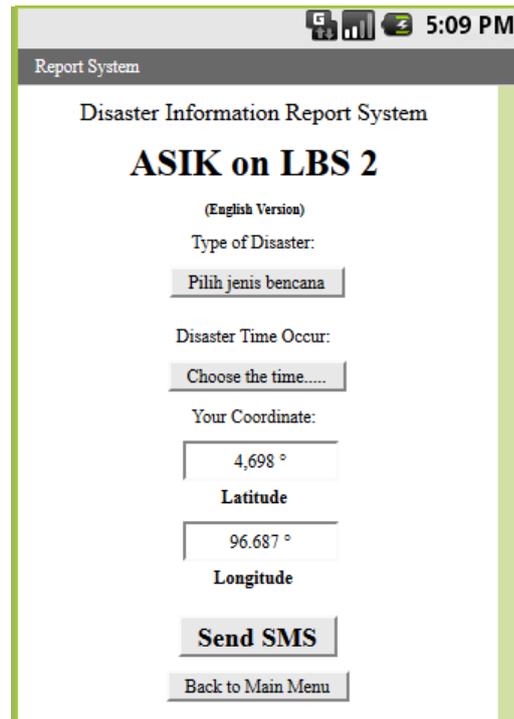


Figure 6. Design of prototype for user interface

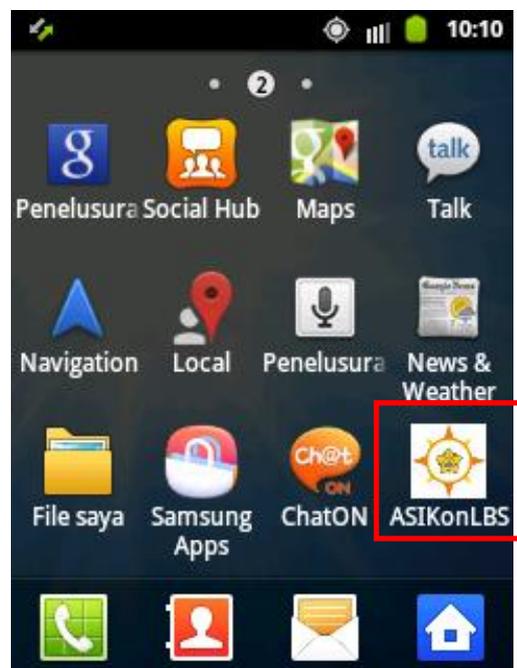


Figure 7. Main menu of the implemented ASIKonLBS based on Android



Figure 8. Features of ASIKonLBS based on Android

In the current state, the application that been build is using Android Development Tool (ADT) that only works for Android platform smartphone. For the future user interface, we will use phonegap framework because it can be applied to the multi platform of smartphone without using the different programming languages. In the phonegap, the programming is in HTML5, CSS3 and Javascript. By using phonegap build, the application is bundled by phonegap builder into the application with different smartphone platform. The bundle at the phonegap supports any smartphone type such as iOS Apple, Android, Windows Mobile, Symbian, BlackBerry, WebOS LG andBada (OS on Samsung). User interface with the data input format for ASIKonLBS to enable sending information to the web application as shown in Figures 6-8. Currently, this application has been implemented based on Android as displayed in Figure 7. It is designed as simple as possible so that the information can be sent as soon as possible when disaster occurs. To obtain, the location of user or disaster, the application uses the GPS sensor to find its location automatically. The implemented application has been evaluated as presented in Table 3, where the parameters work properly in the testing of the application features as shown in Figure 8. The two types of the prototype that been build are ASIKonLBS in Bahasa Indonesia and ASIKonLBS in English.

Table 3. ASIKonLBS evaluation

No	EvaluationParameters	Remarks	Result
1	Main menu display	Able to display disaster type, GPS coordinate and send SMS	Success
2	Disaster type	Able to display disaster type that should be selected for reporting to the web-based application	It has successfully be mapped to the google maps on the web application with appropriate icon of the disaster type
3	Coordinate	GPS sensor has ability to detect and find the location coordinate automatically	Valid
4	Send SMS	Send SMS menu is able to send the information to the web-based application successfully	Success

#### 4. PROTOTYPE OF WEB APPLICATION

Currently, the prototype of web-based online disaster information system using LBS technology is operated in localhost. The main page of the web-based system is shown in Figure 9. It shows ten times test the data input with various disaster events and different coordinates that are located in Aceh province using the implemented application on mobile phone. The data input is sent by manual short message and by using smartphone that automatically recognizes the coordinates of the location. The input mapping results showed that the system works well and the mapping process is the real-time because the delay of mapping is less than the refresh time of the system of 10 second. Therefore, this application can be a tool for first aid when the disaster occurs. The main users for the application and web-based system are disaster agencies, non-government organizations and government institutions. While the user interface (ASIKonLBS) of mobile device such as smartphone is needed by the community when they want to report the disaster in their area.



Figure 9. Main page of online disaster information system



Figure 10. Location and type of disaster information on web application

Table 4. Delay of online mapping into web application

Disaster Code	Longitude	Latitude	Transmit Time	Receive Time	Mapping Delay (second)
102	95.910645	4.488809	09.44.50	09.44.59	9
104	97.207031	3.634036	09.49.42	09.49.52	10
108	95.789795	2.855263	09.54.05	09.54.12	7
103	97.943115	4.565474	09.59.49	09.59.56	7
105	96.687000	4.698000	10.22.17	10.22.25	8
105	93.257953	5.913881	11.38.45	11.38.54	9
105	98.097954	5.443883	11.53.34	11.53.42	8
105	95.737954	5.643883	11.56.28	11.56.36	8
105	97.827954	2.143883	12.01.05	12.01.15	10
101	96.697951	4.543884	12.05.02	12.05.09	7
Average delay					8.3 s

Besides the online information mapping that sent by the member of system, textual information related to the disaster report can be displayed at the web of system by clicking the icon of the disaster on the web. Then, the tooltip will appear as shown in Figure 10, where this tool tip shows the information of disaster type, sender identity, and coordinate of disaster area in terms of its longitude and latitude. Thus, disaster agencies can check the validation of information and situation at the area. Furthermore, google street maps are also available on the web that can be used to retrieve the location easily. This feature will be useful for the decision maker; here is the government, to give a quick response on the disaster aid.

The effectiveness of online mapping from user interface ASIKonLBS to the web-based system can be evaluated by measuring the delay time of transmit time and receive time. Online mapping time has been

evaluated by ten deliveries via sms manual and through implemented application-based smartphone with various coordinates and types of disaster. The detail of disaster type, coordinate, transmit time and receive time can be seen in the Table 4. The mapping delay are counted and analyzed to find the performance of the web-based system. The delay here is the time required by the information from sender to be mapped on the web application as a recipient. The results showed that the average delay of information delivery through a user's applications and time of location mapping to the web system was 8.3 second. The average delay is still below refresh time of system by 10 second, so the proposed online disaster information system can be categorized as a real-time information system.

## 5. CONCLUSION

This paper has described the design and development of online disaster information system based on LBS technology where it consists of user interface application (ASIKonLBS) and web-based system for online mapping of the disaster location on Google map. ASIKonLBS is an application where the information of disaster location with the specific input data format can be detected automatically using GPS sensor on smartphone and then sent to the web-based system via SMS gateway and wireless network. While the web-based system is a system that provides the information of the disaster event on the web, especially the disaster location and map. The web-based system is needed by the people who are located outside of the disaster area and has responsibility to help the victim quickly such as local disaster agencies and government. In this research, ASIKonLBS has been designed with a simple input data format and has been implemented on the real application for Android based smartphone. Furthermore, the web-based system prototype has also been designed and implemented on the localhost that can be connected to internet for online mapping of the disaster information from ASIKonLBS. Both ASIKonLBS and web-based system have been evaluated in which the results showed that the user application and web system can be operated properly. The web-based system is timely proceeded and mapped the received information from ASIKonLBS on the Google Maps. Moreover, the online mapping delay has been analyzed by sending ten location coordinates with various disaster types on ASIKonLBS. The result showed that the average delay time is lower than the refresh time of the web-based system. Therefore, the proposed system can be categorized as a real-time information system. Considering the phenomenon and the frequency of the disaster hit Indonesia especially Aceh, this application and web-based system are very useful for emergency response and reconstruction stage.

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