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Designing Mobile-apps for context-aware notification: case study Merapi Volcano

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Abstract. The need for disaster preparedness becomes very important in Indonesia. Due to its geographical situation, within a ring of fire, Indonesia is prone to several disasters such as earth-quake and volcano eruption. This paper presents the design of a context-aware system to pre-emptively notify and provide some information to the population around Merapi volcano. The information contains some dangerous area and safe-place/shelter based on the user location. The proposed design can also notify the level of danger that might be encountered by the user and the mitigation path within a certain distance.

1. Introduction

A natural disaster is an extreme incident as a natural phenomenon of the Earth, such as tsunamis, floods, earthquakes, and other geologic processes. It normally causes injuries, loss of life, property damage, and trauma. Some economic damage may occur depending on the severity of the affected population and infrastructure. Other factors that contribute to the damage are 1) the lack of understanding of the characteristic of hazards, 2) bad behavior that leads to vulnerability, 3) no early warning system, and 4) lack of ability to mitigate when a disaster occurs.

To reduce the severity of the damage, populations in disaster areas need to be well prepared. Disaster preparedness is a state where someone is ready to handle the worst-case scenario during the disaster. It completely depends on the type of disaster that is frequently happened in a certain area. For example, to avoid severe damage from frequent earth-quake, people in Japan do not have any brick wall in their house, instead, they use woods to build a house. On a large scale, disaster preparedness not only reduces the effects of the disaster, but also to mitigate the impact on vulnerable populations and to respond effectively with the consequences. Therefore, disaster preparedness needs to be well-managed. Information Technology (IT) has been used in several works of disaster management such as [1][2][3] and [4]. However, they missed the use of the context-aware concept in that disaster-related information must be delivered according to user context. Misinformation, when disaster occurred, may lead someone to a more dangerous situation.

Indonesia is geographically located in the Pacific Ring of Fire where earthquakes and mount eruption frequently happen. As located also in the tropical zone, Indonesia is also prone to Flood, Drought, Land Slide, and Tornado. Such a condition makes disaster preparedness becomes very important in Indonesia. All those kind of disaster is managed officially by The National Disaster Management Agency (BNPB). Some works have been used by BNPB. They are: 1) DIBI [19], 2) InAWARE [20], and 3) InaSAFE [21]. However, those available IT-based systems to improve disaster preparedness are limited. They do not consider the context in giving the information. Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or



object that is considered relevant to the interaction between a user and an application, including the user and the application themselves [9]. Examples of context are location, identity, time, and social.

Disaster preparedness information must be delivered based on a certain user context, it is called a context-aware system. The context-aware system relies on the acquisition of data about the actual situation in which the system is operating and about the activities of the user who is interacting with the system. The system is normally in the form of mobile computing. Thus, the context-aware system is more relevant when the environment is highly dynamic and the user is mobile. For example, using geo-fencing concept [17], a user can be identified using their location to be given proper disaster information. People in Yogyakarta (Central Java of Indonesia) needs more information about Merapi Volcano, people in Padang (West Sumatra of Indonesia) prefers to have more information about earthquake and tsunami, etc. Such location detection can be done seamlessly without user intervention [17]. Thus, an information system must be smart enough to identify the context. Figure 1 shows a basic common context-aware system.

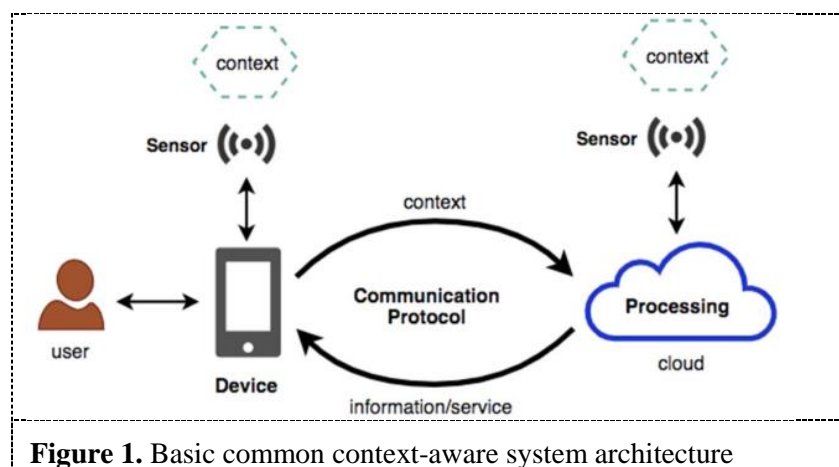


Figure 1. Basic common context-aware system architecture

In this paper, context aware system design that can be used during disaster is presented. The design is developed for mobile application to notify users when they are in disaster prone area. It considers comprehensively any input captured from mobile phones, including the location and user movement. In next section, some related works are presented to show the positioning of this paper. The requirements and design of the proposed context-aware system are described in section 3. The discussion of the proposed design is presented in section 4.

2. Related Work

Several studies on context-aware system for disaster management have been done previously. [5][6][7][9][13][14] were working on emergency relief phase. This phase focuses on how to help in disaster reactively or after disaster occurred. Identifying the needs of affected populations, managing responders on within the area, and taking care of logistic are the scope of most of the works on this phase. [8][10][15] were focusing on developing early warning system for natural disaster. Having a system that is capable to generate and disseminate a timely manner warning when disaster took place is the aim of such works. However, the works on disaster preparedness that implements context-aware feature is limited. In [16], a context-aware platform that enables the users to learn what to do and response during disaster is developed. The platform gives certain instructions to the users via augmented reality technology. The magnitude of damages during disaster becomes less after using this platform. Those works show that context helps the information being notified properly. Our proposed context-aware system design is implementing the concept of geo-fencing to notify any user that enter a predefined geographic area. This is relevant if a disaster area is fixed such as a volcano.

Table 1. Literature Survey on Disaster Management

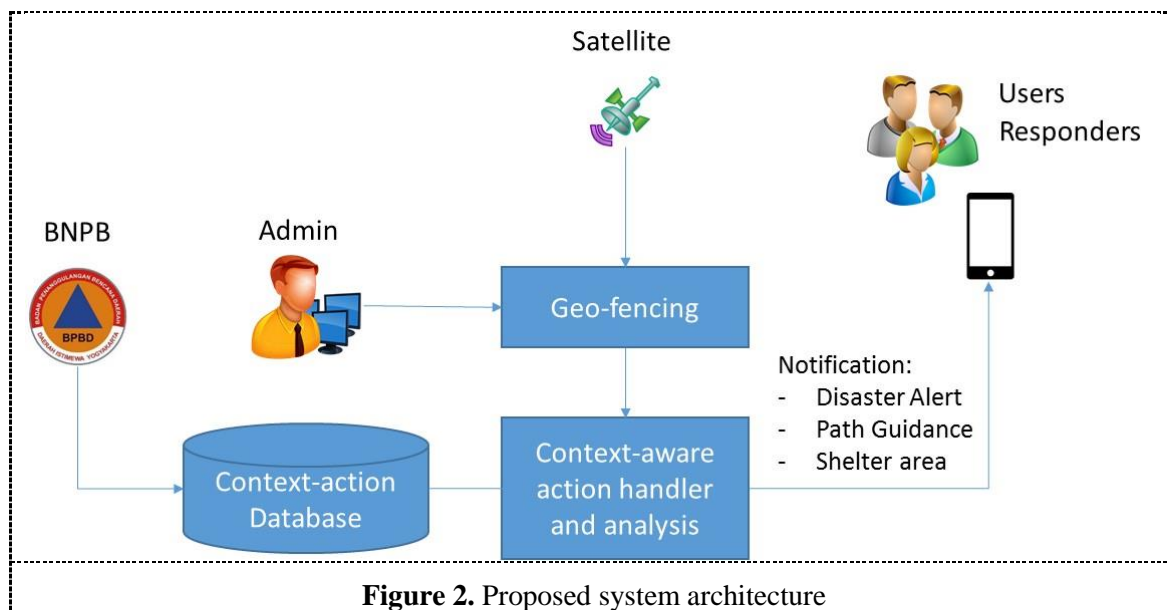
Phase in Disaster Management	Involved Parties		
	Institutions	Responders	People
Risk Analysis	[9]		
Preparedness	[16]	[16]	[11]
Early Warning	[8][10][11][15]		
Emergency Relief	[5][6][7][9][13] [14] [15][16]	[5][6][7][9][14][16]	[6][12]
Reconstruction	[13]		

3. Requirement and Design

In this paper, we focus on volcano related disaster that is frequently occurred in Yogyakarta. Yogyakarta is located in Central Java, 15 miles south of Merapi Volcano. Merapi is a basaltic to basaltic-andesite stratovolcano with a summit crater containing an unstable lava dome. Merapi is Indonesia's most active volcano and well known for partial collapse of lava domes and the generation of pyroclastic flows. During eruption, pyroclastic flows can travel as far as 8 miles (13 km) from the summit and reach speeds of 70 mph (110 km/hr). Pyroclastic flow deposits can be remobilized as lahars. It is very dangerous to any human being. In addition, about 70,000 of population in Yogyakarta lives mostly localized in around Merapi.

Based on related works and the case study, there are requirements need to be realized within the proposed context-aware notification for Merapi Volcano disaster:

- **Support Geo-fencing**
Geo-fencing is a location-based service that businesses use to engage their audience by sending relevant messages to smartphone users who enter a pre-defined location or geographic area. In this case, the system will generate location related information such as how dangerous the disaster to the user.
- **Support wireless communication**
As mentioned that this kind of system is more relevant to mobile user, the use of wireless communication tool becomes necessary as well. Mobile phone and tablet phone are the most suitable for the application.
- **Seamless**
Context-aware system should be continuously a seamless system. The system captures user context via phone-cell, sending it to the system to run the geo-fencing process, and provides the necessary notification without user knowing.
- **Connectivity with BNPB**
BNPB is an important actor within disaster management in Indonesia. They provides the most accurate and helpful information about a disaster and how to mitigate from it.



The design of the system is solely based on the situation within Merapi volcano. When users or responders (person who helps in disaster relief) come into a disaster area, the system will seamlessly detect the user location. The location will be analyzed by action-handler. The database contains a lot of action data given by BPNB. Action-handler will retrieve certain actions from the database to be delivered to the users based on geo-fencing process. Disaster alert, Path guidance and Shelter area are notified to the users.

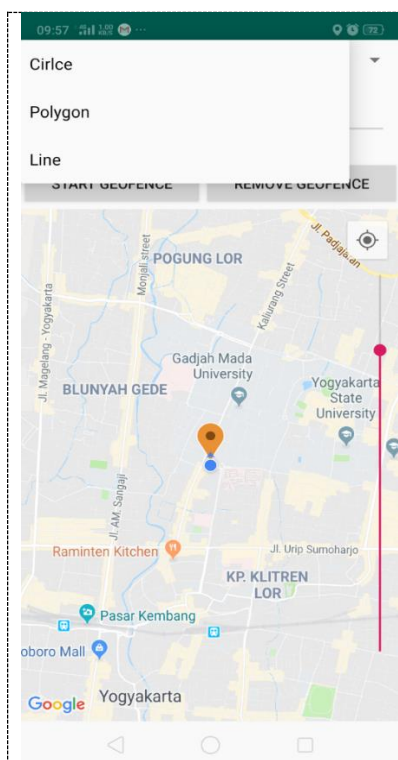


Figure 3. Area setting for system administrator

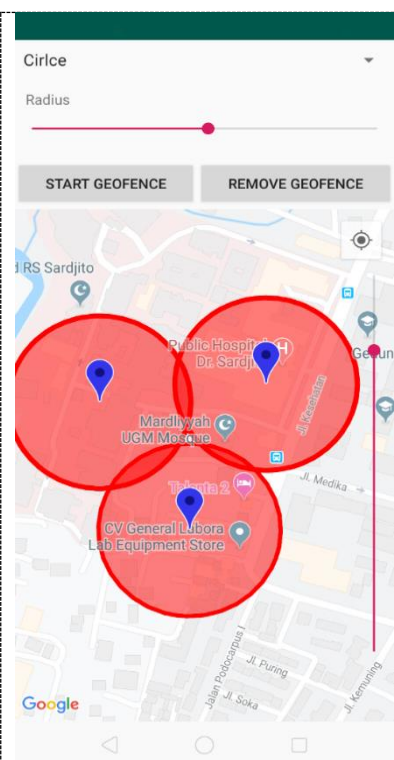


Figure 4. Sample of circle area created by the system administrator



Figure 5. Notification sample when user entered disaster area

4. Summary

This paper presented context-aware system design that is able to send notification in volcano disaster area using geo-fencing technique. An android-based prototype has been developed to show how the design being realized. The proposed solution is based on the experience of having a frequent Merapi eruption in Yogyakarta.

One of the major objectives of proposing this system is to test the feasibility of innovative technology in the area of disaster. Certain performance measurements have not been performed to study the effectiveness of the prototype. The prototype of context-aware alerting/notification proves that with the evolvement of mobile devices and pervasive technology, the presented solution is not far from becoming a modern alerting system. In addition, although the application is developed with specific focus on Merapi volcano, it can be applicable for another volcano.

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