GEOFENCING POST-DISASTER SCENARIO USING ANDROID APP

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ABSTRACT

Nepal is ranked one of the most vulnerable country to disasters in the world. The lack of properly coordinated disaster information management system including stages of mitigation, preparedness, relief, response and recovery is causing increase in loss of life and property. Nepal Government coordinating with different Non-Governmental Organization (NGOs) and International Non-Governmental Organization (INGOs) are collaboratively trying to build an effective disaster management system. But, the existing applications, tools and systems have not been enough to provide quick and effective relief, response and recovery services to people. Realizing mobile phone could be an effective tool in communicating, sharing information and sending and receiving alerts in a post-disaster scenario system, an android based application could be the handy means of communication. This paper discusses on the design and development of an android based app named D-Fencing and also outlines how this app can be used and implemented in a post-disaster scenario for effective communication and coordinated information management. The app uses the user's location retrieved from mobile phone's GPS or GPRS services and then checks this coordinates with the existing geofence in the system to find if the user is inside or outside the geofence. The app users can receive alerts/notifications on their mobile screen if their location is within or inside a defined geofence. The app also has additional features like users can subscribe to particular disaster information based on location of the disaster occurred or type of disaster occurred. This paper also discusses about what features could be added in the app in future to make it more effective in information management in a post-disaster scenario.

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1. INTRODUCTION

Natural disasters and extreme environmental events have a negative effect on humans. These events are the result of naturally occurring processes that have operated throughout Earth's history. They are situations where people need immediate response with local capacity, and national and international level assistance. Nepal is ranked one of the most vulnerable country to natural disasters and its difficult terrain has further added vulnerability (Network-Nepal). Number of factors like topographic features, adverse geo climatic conditions, environmental degradation, population growth, urbanization makes Nepal prone to such human induced risks like road accidents, drowning accidents and natural hazards like floods, landslides, earthquakes, wild fires, glacier lake outburst etc. (Network-Nepal). Classified as global hotspot (Dilley 2005), Nepal has been ranked as 11th most risk country to earthquake and 30th most risk country to floods and landslides (Pelling, Maskrey et al. 2004, Risk 2004). Recently, Kathmandu, the capital city of the country was hit by a major earthquake on 25th April, 2015 with the magnitude of 7.3 Richter scale causing over 8,800 casualties only in Nepal, and 450,000 displaced. A study suggests more than 97.4% of the population and 80.2% of total area is at high risk of casualties from two or more types of hazards (Dilley 2005). The disaster events recorded from 1900 B.S. to 2005 B.S. estimates about 7400000 human casualties over 13000 events registered in Nepal (Aryal 2012). The deaths and the loss of property could have been reduced if not eliminated if we had good and effective disaster management system. The main reason for loss of hundreds of lives regarding the post disaster situation is the lack of the information (medical help, food, water etc.) available to these people where they need. The people do not have the knowledge about precautions that needed to be applied on the specific disaster and the rescue providers don't know the actual location of the people that needs rescue. Nepal's Disaster Management Division under Ministry of Home Affairs along with international and national community interested as well as local communities and individuals are collectively working together to reduce risks and prevent disaster. Governmental institutions like Ministry of Home Affairs, Central Natural Disaster Relief Committee(CNDRC) together with National Society for Earthquake Technology-Nepal (NSET) initiated to establish a systematic data inventory of natural disaster events in Nepal and also build an effective disaster management system (UNISDR 2011). This organization is working for disaster management in Nepal (UNISDR 2011). But still it seems the efforts toward disaster management is not enough and it seems there is a total absence of organized and uniform information flow regarding natural disaster management in the country (UNISDR 2011).

Internationally, there have been some practice in implementation of some program for the effective information management post-disaster. The Sahana free and open source disaster management system conceived after the 2004 Sri Lanka Tsunami is a web based collaborative disaster management solution which was used in Philippines during Asian Quake in Pakistan (2005), Southern Leyte Mudslide Disaster in Philippines (2006) and the Jogjakarta Earthquake in Indonesia (2006) (Fajardo and Oppus 2010)with great effectiveness in rescue

and relief operation. Another project Collaborative, Complex, and Critical Decision-Support in Evolving Crises (TRIDEC), co-funded by the European Commission focused on the management of crisis situations and the development of an application for the Android smartphone platform which enables access to a continuously updated situation report for current natural disasters (Hammitzsch 2013).

Disaster management involves the stages of mitigation, preparedness, relief, response and recovery (Fajardo and Oppus 2010). This relief and response phase involve providing services and relief to the victims and others when disaster strikes (Fajardo and Oppus 2010). One option to provide relief and rescue services effectively in a post disaster scenario is by the use of the mobile application because in present context no other than mobile phones can penetrate to users quickly and efficiently (Mahapatra 2013). As of February,2014 there are 20961942 users of mobile phones compared to only 828828 users of fixed land lines i.e. 79.11 % of total population use mobile phones compared to only 3.12% landline users (NTA 2014, May) in Nepal. Nowadays mobile phones come with additional features of Wi-Fi connectivity, internet, GPS positioning, compass features, data storage etc. thus they are called Smart phones (Kushchu).Based on research released by Smartphone Summit, smart phones account for 10% of all cell phone sales and it is still growing and driving more interest among people (Krazit 2008, March 31). Also among various Smartphones, smartphones with Android OS are popular among people nowadays (Kushchu). Based on research released by Smartphone Summit, smart phones account for 10% of all cell phone sales and it is still growing and driving more interest among people (Krazit 2008, March 31). Thus, if android platform is used as the application development, maximum number of the users can associated with that application. As the number of users of smart phone is increasing day by day (Mahapatra 2013), the number of the application user will also be high due to which there is high probability that the response to the requester in disaster can be delivered in real time. It also can be used to alert high numbers of users about the disaster.

There are various ways to respond to disasters by using smart phone applications. Most of the applications that had been developed are used in alerting people or sending the notification to specific people only. Applications like Disaster Alert, FEMA have been developed and used in android platform for disaster alert and response system (KVN 2013). These already existing applications in the market show some promise for the disaster management. These applications might come handful for people if they want to know more about disaster information and also to get alerts. But none of the existing applications related to disaster management have employed the concept of geofencing in the field of disaster response system. A geo-fence is a virtual perimeter for a real-world geographic area—a virtually fenced off geographic location. However, the concept of geofencing has been widely used in the European and US business centers to promote their business and products by sending the alert notifications about their services to people entering their geofence (Nait-Sidi-Moh, Ait-Cheik-Bihi et al. 2013). Geofencing has also been used to restrict some mobiles (vehicles, persons) from accessing restricted areas, to trigger alerts when a driver exceeds an established speed threshold(Speed < 50 Km/h) or when a vehicle crosses a forbidden area (residential area, city center for big trucks) (Nait-Sidi-Moh, Bakhouya et al. 2013). Here, in this paper we discuss about the android application which the author have developed that sends notification or alerts to the people that are near to the disaster (inside a

virtual area) by using the geofencing technique. Using this concept for the disaster management, a virtual boundary surrounding the disaster area on post-disaster situation is created by the system administrator. The administrator defines the radius, center coordinates and also alert message for the specific disaster area. The users who uses the application when enters into this geofence area, they get the message that the admin has associated with the geofence, as notifications on their android smartphones. For developing a complete system incorporating geofencing and notification/alert system, we have developed an android application, central database system and a web application. This probably is a new concept as well as can be a very effective tool for the people in a post-disaster situation. The purpose of the application is to inform the users for taking precautions after any disaster occurs and if the user is about to enter or has entered the geofenced disaster area. The notification received by the user is whatever the administrator is targeting to inform to them about the disaster and the precautions to be taken into consideration for such disaster. They can receives alerts about the disaster and also suggestions to apply precautions when they enter into the geofence of disaster zones. This is expected to provide quick response to the people in the need of help.

2. METHODOLOGY

This part discusses about the methodology and techniques used in the design and development of the android app named D-Fencing for providing alerts/notifications to people in disaster affected areas in a post-disaster scenario.

The system consisted of the database, android application and the webpage. The figure below shows the overall system architecture, and defines how the overall system does its work, and provides the user the geofencing service.

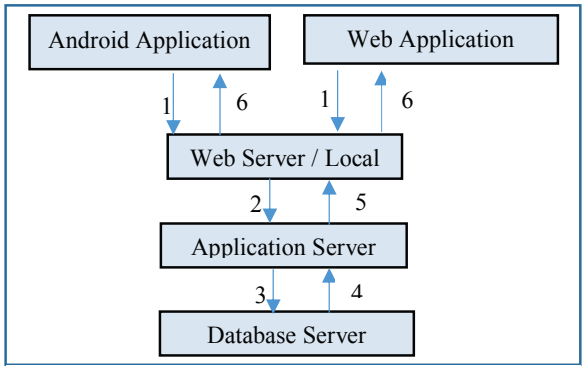

Figure 1: System Architecture

(1) *The android application and the web application both requests the data through internet to the web server*

(2) *The web server (PHP server) sends the request to the Application Server*

(3) *We have used the Apache Server as the Application Server. The Application Server then uses the PHP file to request the data from the Database Server*

(4) *The database server analyzes the request and then sends the data to application server*

(5) *which is then send to web server*

(6) *And finally to the requestor i.e. android application or web application*

The activity of the system was divided according to the three parties. They are server, administrator and the users. The servers respond to the request sent by both the users and the administrators. The administrator task is to create, update and change the status of the geofence. User gets the alert message when the user is logged in and is or within inside any active geofences.

2.1 Database Design

PostgreSQL was used for database management as it is interoperable, open and also supports various programming languages like C, C++, Java, Python, PHP (Matthew and Stones 2001). This database also supports spatial database extensions i.e. PostGIS

The database was designed with three tables: Users, Userlocation and Geofence. Users table was used to store the information on user, Userlocation table was used to store the current user location and Geofence table was used to store the information on the geofence.

2.2 Android application design

Android is the modified Linux version to use as the operating system for the mobiles. It was developed by the Android Inc., on 2005 which was purchased (along with its development team) by the Google for its development. Google then released the Android software as free under the Apache License (Lee 2012) that provides cell phones, tablets, and other handheld mobile devices with the power and portability of Linux operating system and reliability and portability of standard high level language. Android Application could be developed on any operating system i.e. Mac, a Windows PC, or a Linux machine (Lee 2012). We used Windows PC for application development and also have used additional tools and libraries required for android application development which were available freely on the market. The tools that were used on this project were:

a. Java SDK
b. Android SDK
c. Eclipse with ADK plugins
d. Notepad++
e. Osmdroid Libraries

Planning for the application was done before any coding. Planning was done to find what our main objective was and what components we need to integrate for development of our android application. Planning and designing the workflow for app development was done after the components were finalized. In our project, we divided the application into parts like icon design, splash screen design, users' forms for sign in and sign up, notification in android app, OSM map display in android, connection of android to the database, session manager for single time login, adding marker on map, drawing polygonal shapes on the OpenStreetMap (OSM) map in android. The whole was application was developed and designed for portrait format. For this application to run, the permissions that were needed were internet write external storage, access fine location, access Wi-Fi state, access mock location, access coarse location, access network state.

2.3 Webpage Design

Aside from the mobile application, we have also developed the webpage. The webpage is mainly for the administrative actions i.e. Create Geofence, Update Geofence and Change the status of the Geofence. Development of webpage can be done on various programming languages but we have used mainly PHP and HTML languages. Planning was done for designing and developing 4 pages which were: Log in Page, Create Geofence page, Update geofence Page and View Geofence Page. Based on the plan and design, these pages were developed accordingly using PHP and HTML languages. The tools and software used in webpage development for our project are:

a. Bracket
b. Google Chrome and Mozilla Firefox Browser
c. pgAdmin III
d. Bootstrap 3
e. JavaScript
    i. Openlayers
    ii. JQuery

3. RESULTS

In this section we are briefly discussing about the android and web application features and also briefly about the database used to hold the android app's and web app's data. This section also contains some snapshots of the android and web application.

3.1 Android Mobile Application Features:

The android application is user oriented app whose main objective is to provide notification/alert to users about the disaster events if they are entering into the geofenced area. The app provides various features to users for making easy for them to use. We briefly discuss here about the interfaces and the features that the user can exercise in this application.

Splash Screen Interface: The first screen that opens when any user launches the D-Fencing application

User Login Page: Page for the old users to login with their username and password. This help to identify them as the old user to the system

User Sign-up Page: Page for the new user to add their personal information to the system, after which they get their username and password for every time in the future to log in them

User Map page: After the users has logged in, the user are brought into this page where they can see their current position if either of GPS or GPRS is turned on in their device. Their location is then sent to the database system of the application every 1 minute (60 seconds). For retrieving the location of the device, the application uses the inbuilt GPS service of the device if available, otherwise uses the internet if available to approximately retrieve the location of the device.

Notification part: After the users have logged in and their location is sent to the system, their location is checked every 1 minute if is inside any registered and active geofences that are already stored in the system. If the check is true, then they receive notification in their device about that geofence and the message associated with that geofence.

User Logout Option: There is also the option of logout to facilitate the users to log out from the current session if they don't want to send their location any longer and don't want to get notifications any longer.

Note: The user should not log out of the service if they want to receive notifications based on their location is inside any geofences created by the system admin. Because if they log out they will not be able to send their location thus disabling them from receiving alerts and notification based on spatial information. Thus they should log out if they entirely don't need the service.

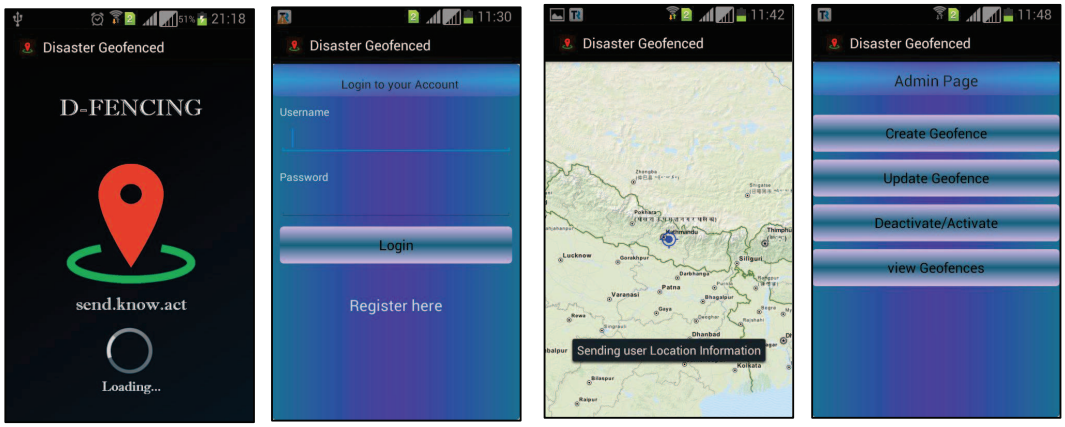

Figure 2: Sample interfaces of the android app

Admin Map Page: This page can be accessed only by the system administrator or the system analyst with the admin password and admin username. This page has the functionality for the admin to create geofence, update them and monitor the geofences and users within the geofences. This page contains four key options which will forward them to respective interfaces. The key buttons and their functionality are:

Create Geofence: Here the admin can create the geofence. There are options to give the name, specify the shape and size and message for the geofence.

Update Geofence: Here, the admin can see the available or the already existing geofence in the database and he is allowed to choose and update one of them.

Activate/Deactivate Geofences: Here he can see the list of all the geofences available in the database from the start of the system which he can manually activate or deactivate the geofences as per necessity. This also allows him to view the geofences status which are active and which are inactive.

Note: The difference between the active and inactive geofences is that, the users which enter the active geofences, they can receive details and alerts for that geofence, but if user enters or is inside the inactive geofences, the users don't receive any kind of notification and alerts.

View Geofences: This interface contains the OSM map which shows the world map with locations of all the users as well as the location of available active geofences. The inactive geofences are not shown on the map view.

3.2 Admin Web Map Interface

As the mobile interface may have limited options and limited screen size for the admin regarding creating, updating and viewing the geofences on the map, this project has also developed a web interface for the admin which have all options for him which he had in the mobile device. He can create, update the geofence and also view the geofences and the users in the geofences and he also has the ability to activate and deactivate the geofences. The web interface is shown in the figure given below.

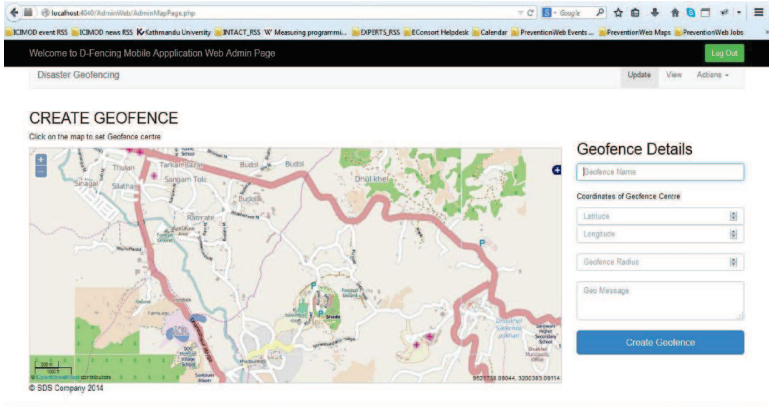

Figure 3: Web Interface for the Administrative tasks

3.3 Database

PostgreSQL database is used to manage the database system. The database contains three main tables to store the data from the web page and android application. Data are received to PostgreSQL and send from here using Post Hyper script (PHP) and Standard Query Language (SQL). The data received were stored in three main tables as follows:

Users Table:

User Location Table:

Geofence Table:

	id [PK] serial	name character varying(100	latitude double precision	longitude double precision	radius double precision	message character varying(1000)	username character varying(50)	status integer
1	70	Today created	27.619266175631	85.538562041664	100	Apple at Ku falss from heaven	admin	0
2	71	aaaaaaaaa	0	0	10000	aaaaaaaaaaaaaaaaaa	admin	0
3	72	Apple	27.619266809372	85.538658601189	1234	KU IT Park	admin	1
4	76	dfcgvhbjn	27.619592715266	85.539776545874	22222	cgvghb njk	admin	1
*								

Edit Data - postgres (localhost:5432) - Project - users

File Edit View Tools Help

No limit

	userid [PK] serial	fullname character varying(50)	username character varying(50)	email character varying(50)	phone character varying(50)	password character varying(50)
1	79	Dipesh Suwal	d	dipehsuwal@gmail.com	9801016549	8277e0910d750195b448797616e091ad
2	80	Suresh Manadhar	s	sureshmdhr@gmail.com	9801077811	03c7c0ace395d80182db07ae2c30f034
3	81	Shuman Baral	sh	sumanbaral@gmail.com	9818619645	77cbc257e66302866cf6191754c0c8e3
*						

	id [PK] serial	username character varying(50)	userlatitude double precision	userlongitude double precision	datetime timestamp with time zone
1	62	d	27.61982	85.5393552	2014-07-10 15:41:56+05:45
2	63	d	27.61982	85.5393552	2014-07-10 15:41:56+05:45
3	64	s	3	0	2014-07-04 12:19:41+05:45
*					

Figure 4: Figure showing Psotgres databse table holding data

4. DISCUSSION

The main goal of the project was to develop an alert system for the post-disaster scenario which was planned to accomplish by developing an android application that sends alert/notifications to the users whenever they enter the area designated as disaster effected or disaster-prone areas by the system admin. Regarding effective disaster information management, it was found that there were some existing android applications like FEMA, Disaster Alert, UbAlert, Natural Disaster Monitor (KVN 2013). Most of these applications, sends alert to all the people regardless of their location. So the person living in one country also receives alert for the disaster occurred on another place. To accomplish location based alerts our application has employed the concept of geofencing, which is new in the disaster management field. Geofencing concept is about creating a virtual boundary in the physical environment and then adding certain type of trigger when actions like entering/leaving or living in that boundary occurs. In Nepal, there is lack of properly coordinated disaster management system (Network-Nepal). Due to which the deaths due to disaster is considerably high. As android is becoming popular among people nowadays (Mahapatra 2013) and its penetration to people is increasing rapidly, our android based application could be very handy and helpful to alert many people during disaster.

D-Fencing app could be a very handy app to be used by people because this app enables users to receive alerts and notifications based on their location. Users' location can be tracked every minute by the use of this application. Thus, this enables them that they receive any disaster related information and the safety measures they need to apply when they enter these prone areas. Secondarily, since their location is being tracked every minute, they can never be lost anywhere because they are being tracked down every minute if they have continuously logged their location in the app's system through internet. This application is also useful to top level admins, disaster responders, social workers and others because if they want to provide information about some events spatially, only concerned to people of region to certain radius, then they can use this app to create the kind of alert they want to convey and also define its spatial extent. But there are some limitations of this android application. Some of them are:

- The geofence are created by the admin. So the admin must be person that has the technical knowledge on the geofence and also he/she must have the data available to him immediately after the disaster is occurred. Also the geofence and the alert message are dependent on the system admin for this android app.
- This application provides the location of user by the use of GPS or mobile data. So the application is dependent on the accuracy of the location provided by device's GPS or mobile data.
- User need to open the application all the time to get the alert about the disaster. So there is drainage of more battery on mobile phone.

Recently, the application has include some addition user interfaces for providing information about precautions and safety measures they can adopt to be protected from different disasters. The app also had some added user interactivity like they can create geofence of their defined

territory so that they will receive information about any disaster events registered within the geofence created by them. Furthermore, this system expects the disaster management organization or responders as admin for now. But the level of admin and categories of admin can be categorized in different levels as disaster admin, commercial admin, education admin so that they can create their own type of geofence and alerts themselves for their specific type of intended users.

4. CONCLUSION AND RECOMMENDATION

Realizing the need of effective application for disaster information management in case of Nepal or globally, an android application known as D-Fencing has been developed for Android based smartphones. This application can be useful medium of communication in a post-disaster situation in the response phase. Users can get alerts and notifications on their smartphones based on their locations. Users android inbuilt GPS or GPRS is used to retrieve the location of device and these coordinates in WGS coordinate system are sent to the central database hosted in PostgreSQL database every minute through the medium of internet. Thus, this also enables the system developer to keep track of the users every minute. The application might also come handy if users may feel secured with them being tracked every minute thus it helps others to track them down whenever they faces to some problems or they got lost. The main purpose of the app is to provide all registered and logged in users (users in active session) the alerts and notifications if their position is within or inside any active geofences that is registered in the main system. The users obtain alerts only if their position is within the active geofences. These geofences are created by the system admin or the system developer or the disaster management organizations who want to create disaster alerts and notify people. D-Fencing app now includes any shape polygonal geofence advance to the current app which includes only circular geofence. Also, for now, the users have limited interactivity with application. They can only register themselves and get alerts or create their own defined geofences and get alerts of event registered in this area. In future, we except to increase user's interaction and we are working on adding information interface for users where they can get information about what safety measures they can apply to be safe from different disasters like earthquake, flood, landslide, epidemic and others. Added user interfaces include user interface where they can create their own personal geofence around their house or offices or colleges so that they can receive alerts about any kind of events ifs registered in this designated areas.

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BIOGRAPHICAL NOTES

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