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Marikina City Situation Mapping and Traffic Management System for Disaster

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Abstract: The Philippines is the third country most vulnerable to disaster worldwide due to the frequency of calamities. Floods, which are usually caused by strong typhoons, heavy rainfall or tsunamis caused by earthquakes, are responsible for 40% of all natural disaster occurrences. The Philippines' drainage systems are inferior, it only takes a short stretch of flooded road to make a whole road impassable, especially by vehicles. In September 26-27, 2009, Marikina City was hit by Tropical Storm Ondoy – the continuous rain without let-up, along with inferior drainage systems, resulted in severe flooding and vehicles being submerged. The research group concluded that the issue of Marikina City's traffic congestion is caused by the city's inadequacy in gathering and distributing data in real-time, particularly its Traffic Management during disasters. The main objective of this study is to be able to deliver a reliable near real-time situation mapping and traffic management information system, with the use of crowdsourcing, to cater the needs to Marikina city's traffic information dissemination. The methodology used was Rapid Application Development (RAD); technologies and tools used for developing the web and Android applications were Eclipse, JQuery, Apache Tomcat, Twilio SMS, Google App Engine, Google Maps (API and for Mobile), SVN, Android Development Tool, Android SDK and Google Cloud SQL. Both mobile and web applications were tested hands-on by 3-5 of each of the system user categories (MMDA, MCDRRMO, MTD, Motorists, web-users, SMS-users) to see if the requirements of the system were met, with focus on the systems' aesthetics, functionalities, GPS and crowdsourcing capabilities. Fulfilling the wish of the group to create a Disaster Management System and to help Marikina City's Disaster Management Office, the group was able to develop a working, functioning web system and Android Application.

Key Words: Crowdsourcing; Traffic Situation Mapping; Information System; Android; Disaster Management

1. INTRODUCTION

1.1 Background of the Study

According to a study by the Citizens' Disaster Response Center, more than two dozen natural calamities plagued the Philippines in 2010 (CRED, 2011). In 2009, a total of 191 natural and human-induced disasters were reported in the Philippines. These killed 903 persons, and affected more than 2.8 million families or 13.6 million people (CDRC, 2009). The Philippines also placed third in the list of countries hit with the most number of natural disasters, according to Citizens Disaster Response Center (CRED, 2011).

The Philippines' drainage systems are inferior. The drainage pipes' diameters are so small incomparable to the volume of rainwater which easily inundate the streets before water can be channelled to the sea. In other countries, the drainage pipes are so large that vehicles can enter in (Ang, 2010). It takes only a short stretch of flooded

road to make a whole road impassable. (Ang, 2010) In 2009, the worst flooding to hit Marikina City in Metro Manila in over a hundred years happened on September 26-27, 2009 caused by Tropical Storm Ondoy. The continuous rain without let-up along with inferious drainage systems resulted in vehicles being submerged (MCDRRMO, 2012). Critical areas that have an increased risk of flooding around the metro should be targeted. Also, an improvement in the drainage system in major metropolitan areas should be prioritized. (Ang, 2010)

1.2 Relevant Development/s

In the U.S., NAVTEQ Traffic.com is the country's leading online and mobile traffic information system which offers different services designed to help the user/s in their daily lives. NAVTEQ Traffic obtains information from diverse data sources including probe, proprietary sensors, government sensors, and incident and event data gathered through round-the-clock, local operations centers based across the United States. They deliver traffic information to the user/s through satellite radio, broadcast and cable TV, through wireless applications and services, and the Internet. (NAVTEQ, ND) While in United Kingdom, the country uses TDC Systems Limited. This system has the following features: Real-time traffic monitoring, Congestion monitoring & Incident Detection, and Journey Time System. (Journey Time System, ND)

Marikina City's Current Traffic Management System: MCDRRMO will get the weather condition status from PAGASA. If there is a possibility of a storm passing thru the country, MCDRRMO will identify if the storm will strike Marikina City or not. Once the city is experiencing rainfall, MCDRRMO will send scouts to patrol the streets of the city to see if there is flood at a certain street/road. MCDRRMO mentioned that a scout carries a meter stick along with him to measure the depth of flood to see if which type of vehicle can pass through a street in the event of a flooding. On the other hand, the traffic department said that the scouts only estimate the depth of the flood. Information on flooded areas will be sent to MCDRRMO via SMS or radio. MCDRRMO will set the chart up to reflect the actual flood situation of the streets. The following format is: Street Name, "Flooded" or not, Passable by what type of vehicle. Using an improvised chart made of pieces of cardboard for plotting the situation map, MCDRRMO will put a check mark if a specific road is passable and Xmark if otherwise (MCDRRMO, 2012)

After collecting data from the scouts patrolling the streets, information is passed to the Local Traffic Department of the city. Traffic management conducted by the traffic enforcers in Marikina City is done by word of mouth, or via text messages or radio. MCDRRMO will also send a report to MMDA so that the latter will be able to do corrective actions to help aid traffic in Marikina City. Marikina City Traffic Department is in charge of closing roads, which were affected by a storm. Once the scout decided that the road is not passable by vehicles, the scout will inform the traffic department and MCDRRMO, thru radio, regarding the flooded streets. After which, a signage will be sent to the street saying that this street has been closed due to flood and is not passable anymore. Detour signs are given to the motorists for alternative routes.

Problem Statement: Marikina City has poor near real-time data collection and dissemination for traffic and disaster management when disaster (more specifically, flooding) occurs. First, the data regarding street situations is passed thru the use of radio. The information is passed first to MCDRRMO and also forwarded to the Traffic Department of Marikina. Information is renewed every fifteen to sixty minutes. The city government focuses on flooded barangays, which citizens who lives in that vicinity need to evacuate, not giving much attention to stranded motorists. Without formal detailed reports that are stored, the city only knows which streets are commonly flooded without giving a statistical data about it, only thru word of mouth. Most motorists are only informed about the closed street just when he/she is turning to that flooded road. Passing of information to the motorists is insufficient – insufficient in a way that motorists are only told about the closed street when cars are already traversing the flooded route. As a result, most motorists would pile up in that road causing heavy traffic and exposing them to more danger of getting flooded and stranded.

The group proposed a Situation Mapping system wherein not only MCDRRMO will report, but also through the use of Crowdsourcing, citizens can contribute by reporting in the proposed traffic information system by leveraging on the use of Android smart phones and its embedded sensors. Crowdsourcing utilizes multitude of data collected from various sources provided by different individuals in order to make sense of the situation and come up with a solution to the problem based on the consolidated data (Crowe, 2012).

1.3 Objectives and Scope of the Study

The main objective is to study the viability of using Android phones (and the web) on situation mapping to cater the needs of motorists from traffic

congestion in times of disaster (flooding) in Marikina City. Specifically, it aims to: to research various situation mapping concepts and models applicable to the Philippine setting; to gather local cases in Marikina City in relation to flood, traffic management and situation mapping; to identify the loopholes in the current flood and traffic information system as applied to situation mapping and ICT applications; and to know the viability of using crowdsourcing in disaster situation mapping.

The study only focused on Marikina City's disaster management processes, most especially when it comes to tropical cyclones and flood. The study was focused on the traffic management of the city, specifically on the 5 major streets of Marikina City.

2. METHODOLOGY

The group used Rapid Application Development (RAD) in developing the proposed system. The Rapid Application Development (RAD) is a team-based technique that speeds up the Information System development and produces a functioning Information System. RAD relies heavily on prototyping and user involvement, the RAD process allows users to examine a working model as early as possible and the prototype can be modified and in the interactive process continues until the system is completely developed. The RAD model consists of four stages: requirements planning, user design, construction and cutover. (*Systems Analysis & Design Methods*, 2007).

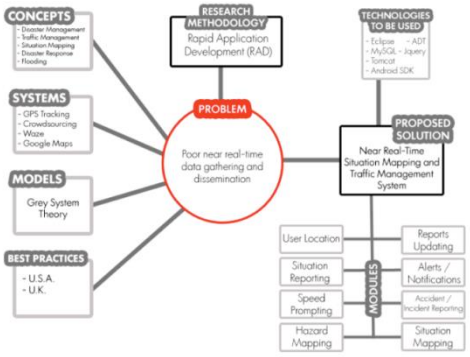


Fig. 1 Conceptual Framework

The conceptual framework was used by the group to show the proposed solution's modules along with its inputs and expected outputs. The framework also shows the tools used in developing the system and identified the users that would be involved.

3. RESULTS AND DISCUSSION

By benchmarking technologies and techniques done by other countries / groups, the group basically used crowdsourcing as the grounds for collecting data and processing these data to information that will be used for reports about road situations of the 5 major streets in Marikina when disaster hits the city. Reports from: (1) Android Application users, (2) Web-users, (3) MMDA/MTD/MCDRRMO, and (4) Scouts will be gathered and processed, then will be mapped in the hazard/situation map. Reports from Android, MMDA/MTD/MCDRRMO users will be sent directly to the system. Web-based system users' reports are subject to verification, these reports would be forwarded to the MCDRRMO/MMDA users where they would identify if the report is correct or not. If a report from a web-based user is approved, it would be sent to the system's Hazard Map; if rejected, the system would discard the report.

Modules of the system are the following:

3.1 Situation Reporting

In this system, reports per street are expected to get renewed every minute since it is assumed that there are a lot of motorist who will use this system. This module is available for both web and Android system. Street situation report will be gathered by the users in order to map the situations in the system's hazard map. The following are needed in order to fulfill this module: (1) Road Name, (2) Situation Type, (3) Traffic Level, and (4) Description. The group implemented Street Segmentation on each of the 5 streets used in the system. These street segments will vary in length but they provide an easily identifiable unit that can be quickly located and sampled in an emergency (USDA Forest Service, 2001).Users can highlight parts of a street to report at. Highlight colors will be based on the traffic level.

Reports Verification for Web-based Non-admin (Citizen) User Reports: The group implemented a verification system in the web application. Information from scouts, mobile citizen users, credible users, and other citizen web users are gathered to further analyze the credibility of a citizen web report. A report credibility formula was implemented to determine how truthful a traffic report sent by a citizen user is. Different weights are used for the formula (all of which are within the 15-minute time interval of reports on a street with the same situation type):

1. Mobile scout reports

2. Mobile citizen reports
3. Aggregated reports from other citizen web user
4. Credible Citizen Web User - if there is 1 or more credible citizen users included in the aggregated reports
5. Trustworthiness of the user (who sent the report)

$$CW = ([(a / TSR) * 35\%] + [(b / TMR) * 25\%] + [(c / TCR) * 25\%] + [(d / TQ) * 10\%] + [Trust * 5\%]) * 100 \quad \text{(Eq. 1)}$$

where:

CW = Credibility Weight
TSR = Total Scout Reports
TMR = Total Mobile Reports
TCR = Total Credible Reports
TQ = Total Quantity of Web Reports
a = situation reported by scout which is the same as situation reported by the web citizen user
b = situation reported by mobile citizen users which is/are the same as the situation reported by the web citizen user
c = situation reported by credible web citizen users which are the same as the situation reported by the citizen web user
d = quantity of the same situation reports which are the same as the situation reported by the citizen web user

Further explaining the credibility weight formula, each value are gathered by getting first the same location/street reported by all users of the system, specifically: Scouts, mobile users, credible web citizens, and non-credible web citizens. In the formula, these reports will be grouped according to:

TSR (TotalScoutReport)
Total number of reports by scouts
TMR (TotalMobileReports)
Total number of reports by mobile citizen users
TCR (TotalCredibleReports)
Total number of reports sent by credible web citizens
TQ (TotalQuantity)
Total quantity of all citizen web reports (credible/non-credible)

After gathering these reports, the system filters the reports by the same situation type (Flood, Blocked Road, Closed Road, Accident, or Bad Weather) and matches it to the situation type of the report sent by the citizen web user.

Looking back at the formula, these filtered reports will now be known as the following:

a: filtered scout report
b: filtered mobile reports
c: filtered web reports sent by credible web citizens
d: filtered citizen web reports

The system will then get the quotient and weight percentage of each. The filtered reports of each user type will be divided by the total reports of the same user type. After which, the system will get the weight percentage of each of the 4 quotients. The following are weight percentage:

Scout report:	35%
Mobile reports:	25%
Credible reports:	25%
Quantity of same reports:	10%
Total:	**95%**

To complete the credibility weight of a web report, the 5% will come from the trustworthiness of the citizen who reported the situation. Trustworthiness of a citizen user will be based on the user's Reputation Score. Explaining again the Reputation Score gauge, a citizen can be identified as credible, non-credible, or delinquent. The value of "trust" in the formula will be only either 0 (zero) or 1; 1 meaning that the user is a credible user; otherwise, 0 if the citizen web user is not credible or delinquent. As the system gets the credibility weight of a report (in percent), the system will identify if a report can be subjected for rejection, approval, or verification (by scouts). If the credibility weight of a report is 80% or above, it is highly subjected for approval. If the credibility weight of the report is from 50% to 79%, the admin web user can send a verification to the scout or approve the report. If the credibility weight is 25% below, the system will prompt the web admin that this report is subjected for rejection.

3.2 Situation & Hazard Mapping

The system automatically plots the report. This map shows which streets are traffic, flooded, and closed. The hazard map is synched with the Android mobile application. This map is updated every 5 minutes to give the users an updated information regarding street situations.

After highlighting the affected area of the street, the highlight color is changed depending on the situation – Red if the traffic level is high, orange if moderate and green if there is no congestion in the said street. The streets affected will display an icon, when clicked displays the specific details of the situation in the map. Android application reporting has a different way of plotting from the web application.

3.3 Reports Updating

The purpose of this module is to update the users of the latest situations of reports within the last 15 minutes. The system will get reports in the last 15 minutes and highlight these reports in the map accordingly. If the report exceeded its 15-minute limit, the system will remove the report and replace it with a newer report.

3.4 Speed Prompting (Activation of Android Application)

Activation of the Android Application is a module which features real-time tracking of speed using the GPS of an Android phone. The application will get the speed of the Android phone (assuming that the user is inside a car, driving). The application will track the speed of the user once the speed is more than 0kph for more than 30 meters. If the speed of the vehicle is more than 40kph and reduced speed of 50% in less than 5 seconds, the application will ask the user if the user is experiencing traffic or not. A pop up window will appear in the application asking the user if he/she wants to report. If the user does not answer within 5 seconds, the pop up window will disappear and speed prompting will continue. If the user says yes to sending a report, the application will ask for the following details: (1) Situation Type (Accident, Road Work, Blocked Road, Flood), (2) Traffic (Light, Moderate, Heavy) and (3) Additional Description.

The application would verify the user/s current location via GPS and would also include this in the report to be sent (for basis in the situation map in the web system). If the user reports that the street he/she is located in is flooded, the application would use the "vehicle type" indicated in "options" and include in the report that it is passable by the vehicle type of the user.

3.5

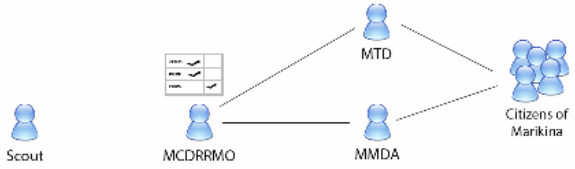
3.6 Notifications and Alerts

Specifically, this module is added for the benefit of: (1) Citizens who are signed in to the system since notifications will be provided to let the users know of the latest traffic reports sent by the admin, or approved by the admin, (2) Scouts who are in duty to patrol the streets since a notification will be sent to their android phones in order to verify the situation of the streets that MMDA/ MCDRRMO/MTD has indicated. If the street matches the situation that has been sent to them, scouts can approve the report directly from their mobile application. The system will receive this approval and will then reflect on the Hazard Map. (3) Administrators of the system (MMDA / MCDRRMO / MTD) since notification/alerts would be sent to the Administrator account which consists of verification reports from scouts patrolling the streets of Marikina. The verified reports are then posted to the hazard map which could be viewed by web-based and android user/s. Lastly, (4) Users who do not own an Android mobile phone but wishes to receive traffic reports thru SMS notifications.

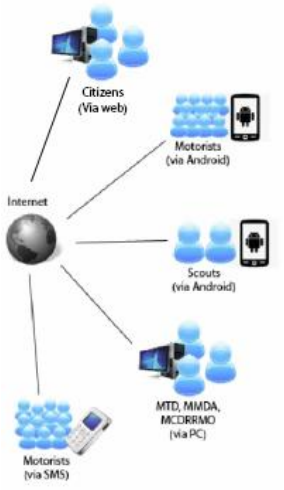
4. CONCLUSIONS

The group was able to come up with a solution to MCDRRMO's current traffic information dissemination problem by using the system the group has developed.

Collection of Data. In the existing process of MCDRRMO, traffic situations only come from scouts via radio and reports per street is being updated every 15-30 minutes. Information from the scout gets passed to MCDRRMO, then MTD and MMDA.



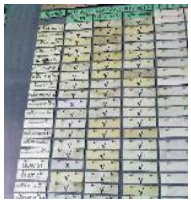
Passing of information from one department to another causes delay in information dissemination, affecting the rapid response.



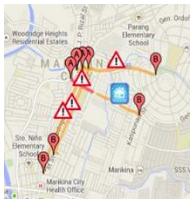
The group solved this problem by building an application that is based on crowdsourcing, a system that gathers traffic information not only from the scouts or the local government of Marikina, but from the crowd, or the citizens of Marikina. The system consists of 2 applications, web-based and Android-based applications. The group provided an Android application suited for scouts to create traffic reports, and also to receive notifications to verify citizen web reports. Web reports come from citizen web users who send traffic information.

Situation Mapping. Plotting of traffic information is currently made by the use of a situation chart, an improvised chart made of cardboard for plotting the situations of each street, marking X or check marks if a street is passable or not. The group improved the situation chart of

MCDRRMO by providing a Google Map-based situation map.



Before



After

The situation map shows the streets and the traffic level per each street segment. It is also shown the situations per street segment. Not only MCDRRMO can view this situation map, even MMDA, MTD, scouts, mobile users, and citizen web users can view this map.

Reporting. The group included in the web application that the admin users of the web system can generate different types of reports: monthly, daily, weekly, annual reports. Also they can see the most accident prone streets per time/date interval or which streets are flooded most.

Recommendations

The system date was hard-coded on a fixed date (March 13, 2014) for demo purposes. Although there were some difficulties in getting the exact GPS coordinates of an Android user, the group wishes to improve the Android application's GPS locating feature. Also, speed prompting sometimes takes a while to prompt. Reporting capabilities can only be done in both web and Android applications. A mobile reporting for non-Android users can also be included as another system capability.

Furthermore, if only MCDRRMO or MMDA have legitimate historical data of their traffic information in Marikina, the Reports Analysis module in this system would have been more realistic in terms of information given. MCDRRMO, MTD, and MMDA does not keep a record of their past disaster reports on the city's streets.

Reports would be more helpful if bars on the graphs were color-coded. A feature where when an admin web user generates a report, it can be sent to the e-mail of the mayor or any of the officials in the Marikina City local government could also be added.

Stressing on the internet connection in the country, if given more time, the group would like to fix the design of the system to further improve the speediness of the application when loading its Hazard Map or its pages on the website, also to the mobile application.

5. ACKNOWLEDGMENTS

The group extends their deepest gratitude for the other contributors for this study for without them, our project would not be accomplished; we would like to thank our mentors, Mrs. Lissa Magpantay and Mr. Christian Echavez, Also we would like to acknowledge Marikina City Disaster Management Office and Marikina Traffic Department for the time and information given to our group.

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