Automated Call Receiving and Forwarding Mechanism for Supporting Integrated Disaster Management System

Norazlina Khamis, Lee Chin Yang, and Azlin Nordin

***Abstract*—Disasters have caused great loss of lives and economic loss besides disruption of services and infrastructure. In any case of a disaster, prolonged arrival of relevant agencies such as the rescue teams means delayed commencement of all restoration work that should be done after the incident. This prolonged arrival is one of the factors that delay in alerting the relevant agencies for them to commence in action. Currently in Malaysia, the call receiving and forwarding procedure is handled by *MERS99* with human intervention, i.e telephone operators. This research proposed an algorithm which able to receive a call and identify the relevant agencies to be directed to the event based once the GPS location of the mobile user who made the report. Thus, human intervention in the current procedures is being minimized. The efficiency of the algorithm is evaluated by comparing the response time of the current procedures with the implementation of the algorithm in the proposed prototype. Based on the evaluation, it is shown that the proposed algorithm are able to shorten the length of time between and incident happens and relevant agencies being dispatched to the event.**

***Index Terms*—Disaster management, landslide, call routing algorithm, software, web based application.**

I. Introduction

Disasters, such as landslides have becoming common and have caused great loss of lives and economic loss of billions of ringgit in Malaysia besides disruption of services and infrastructure. Landslides in Malaysia are mainly attributed to prolonged rainfalls, in many cases associated with monsoon rainfalls. Among the most famous landslides incidents are Bukit Antarabangsa and Hulu Kelang landslides. On December 1993, a slope failure happened in Hulu Kelang which consequently caused a block of the Highland Tower collapsed and claimed 49 lives. The speed at which the rescue teams were being dispatched to these troubled sites is important.

Delivery of emergency services underpins government's ability to develop the country. To put the situation under control after a disaster happens, a disaster management system is required in a nation. The current approach of delivering public emergency services dealing with disaster is through the use of Malaysian Emergency Response Service 999 (MERS 999).

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MERS 999 [1] was introduced in 2007 for the employment of single universal emergency access number. Essentially, it is an integrated system to automate emergency call taking and dispatching via a single number: 999. It is important to note that MERS 999 consolidates services from five of Malaysia's core Public Safety Emergency Agencies in one platform: 1) *Police*, 2) *Fire* and *Rescue*, 3) *Hospitals*, 4) *Civil Defense* and 5) *Malaysia Maritime Enforcement Agency*. This means that MERS 999 is not only dealing with disasters, but also with crimes, accidents, fire, border invasion and so on. Hence, in a case of landslide, for example, the fire and rescue agencies will be alerted by MERS 999 to perform rescue operation, the police to manage and restore the order at the scene, and hospitals nearby to send ambulance units to rush the dead and injured to the hospitals.

This paper will discuss the motivation and the formulation of an algorithm to support the current process of reporting incidents and forwarding it to the relevant agencies. The proposed algorithm will mimic the current process, which is currently done by human intervention.

II. Background Study

Landslide is one of the top ten disasters in Malaysia [2]. In [3] stated that there is an increase of hillside development and this has become a major concern in Malaysia. Such a scenario has received attentions especially after the Highland Towers incident, which had killed 48 peoples. The collapse was attributed partly to a series of retrogressive slides of a cut-slope located behind the condominium [4]. Others chronology of landslides disasters which had occurred in Malaysia are the natural landslides tragedies at Pos Dipang, Kampar, Perak on 29 August 1996, and killed 39 people. The Malaysian National Slope Master Plan 2009-2023 [5] shows that reported landslides and fatalities from 1973 to 2007 indicated an increase in the number of fatalities with an increase in the number of landslides. Some major landslides along highways also resulted in serious disruptions to the transportation network and adversely affected the public. Landslide can cause a significant economic loss both direct and indirect losses.

Disaster management can be defined as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters [6]. Disaster management aims (a) to reduce, or avoid the potential losses from hazards, (b) assure prompt and appropriate assistance to victims of disaster, and (c) achieve rapid and effective recovery. Disaster management does not necessarily avert or eliminate the threats themselves, although the study and prediction of the threats is an important part of the field. The basic levels of emergency management are the various kinds of search and rescue activities.

Disaster management generally has four phases or stages, (a) mitigation, (b) preparedness, (c) response and (d) recovery as illustrated in the Disaster Management Cycle [6]. Mitigation efforts are attempts to prevent hazards from developing into disasters altogether or to reduce the effects of disasters. The mitigation phase differs from the other phases in that it focuses on long-term measures for reducing or eliminating risk, for examples, building codes and zoning, and public education. In preparedness stage, plans of action are developed to manage and respond to disasters and actions are taken to build the necessary capabilities needed to implement such plans, for example, emergency exercises. The response stage includes mobilization of the necessary emergency services and first responders in the disaster area. In other words, it means responding to disaster when occurs, such as dispatching search and rescue team. The aim of the recovery phase is to restore the affected area to its previous state. It differs from the response phase in its focus; recovery efforts are concerned with issues and decisions that must be made after immediate needs are addressed. Recovery actions include rebuilding destroyed property, re-employment, and the repair of other essential infrastructure. In this research, the proposed algorithm will be one of the tools in supporting the response phase.

III. Motivation

In any case of a disaster, prolonged arrival of relevant agencies such as the rescue teams means delayed commencement of all restoration work that should be done after the incident. This prolonged arrival is mostly due to the delay in alerting the relevant agencies for them to commence in action. The rescue teams must arrive to the disaster site as soon as possible to avoid more loss of lives and then restoration of infrastructure follows after. Inaccurate information retrieved about the incident before arrival of a rescue agency, for example, the exact location of the incident greatly reduce its response time and can cause unnecessary more loss of lives. In the event of delayed or inaccurate reporting, local authority will also face the consequences of being criticized for lack of efficiency in handling such cases. Government's ability to develop the country will be impeded.

The length of time between an incident happens and relevant agencies being dispatched to the troubled site is something that must be taken into account. This length is called a delay [7]. An effective emergency management system must strive to reduce this delay as much as possible. Given all the importance of receiving accurate information and a better response time of a disaster management system, there is a need to devise a system that takes into account of these two main attributes.

The current disaster management procedure is shown in Fig. 1. Based on the figure, the current procedure is prone to human error. This is due to the nature of communication and higher response time. The call receiving and forwarding process is tedious where it is involve a verbal communication between the operator and the mobile user as well as between the operator and the agency.

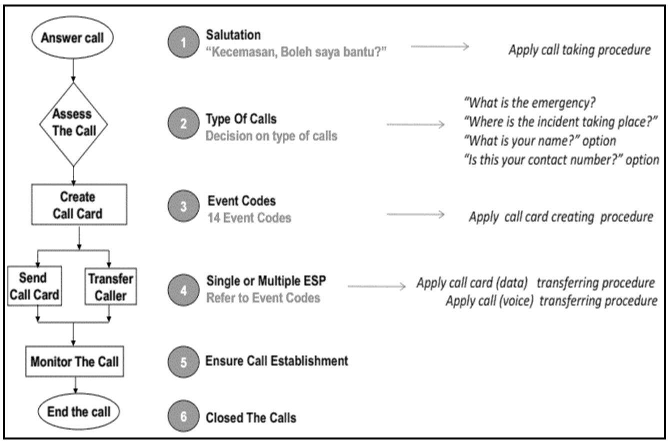

Fig. 1. Current procedure in MERS99 [1].

Thus, it is believed a new mechanism need to be integrated in the current procedures to minimize the human intervention which can be seen from Fig. 1 (item number 1 to item no 6). Nowadays, Information Technology is utilized to provide systems to manage disasters and required rescue operation [8]-[10]. Thus an automated receiving and forwarding mechanism is proposed in supporting the current process through Integrated Disaster Management System (IDMS) as depicted in Fig. 2 below.

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Fig. 2. Overview of IDMS.

The user who made a report will press a button in his/her smartphone. Then the location of the caller will be detected automatically by utilizing GPS functionality. Next, the appropriate action will be taken based on the data received from the caller. The following section will discussed the method employed for development of IDMS.

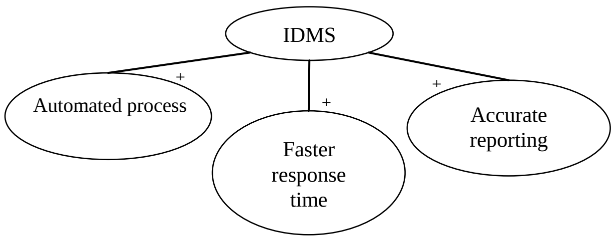


Fig. 3. Goal model.

IV. Methods

The goals of IDMS are automated process, accurate reporting and faster response time by removing the human factor. The goals are captured in the goal model shown in Fig. 3.

A. IDMS Functional and Non-Functional Requirements

The core functional requirements for the IDMS web-based system can be derived using a goal-oriented approach and this will be the starting point of system analysis. Table I shows some of the core requirements that can be derived directly from the goals.

TABLE I: Core Requirements of IDMS

Issues in MERS 999	Goal and relevant requirement
The process of communication between the operator and mobile user and between the operator and agency is tedious, especially when the mobile user is unable to properly convey relevant information.	Goal Automated process (removing human factor) Requirement The web-based system must be able to automatically receive report from mobile user and automatically alert the nearest agency.
The lengthy process and the average time needed for the operator to pick up calls constitute a longer response time.	Goal Faster response time from receiving and forwarding a call Requirement The system must have a response time of not more than 5 seconds.
Communication is not always successful. Mobile user might report the location inaccurately due to stress or being not familiar with the place.	Goal Accurate reporting of location. Requirement The web-based system must be able to detect the location of the mobile user automatically.

The IDMS must have a log in function to prevent access from unauthorized users. The system is expected to be more efficient in terms of alerting the relevant agencies. Since the system is considered as critical, it should be accessible and available most of the time. With a sufficient memory and computing resources, the system should be fast enough to obtain data from the database. This is important in generating an overview or detailed report. Based on this description, the web-based system should have the essential non-functional requirements below:

- Security: The web-based system must have a log in function to prevent access from unauthorized users.
- Performance: The web-based system must have a response time of less than 5 seconds; The web-based system must be able to send or receive up to 2000 messages at a time.
- Availability: The uptime for the web-based system must be 99% of any day.

This project involves two main module, Admin module and Mobile application modules. The use case diagram for IDMS is presented in Fig. 4.

Based on use case in Fig. 4, when a mobile user triggers something on the mobile phone app with the intention to report on a landslide incident, the mobile app communicates with the web-based system by sending an alert (report) with information such as geographical coordinates of the mobile user and pictures of the incident. Send report use case includes determine location and alert agency use cases in that the web-based system will then determine the location of the mobile user and alert the nearest agency. The alert agency includes determine nearest agency use case as it is needed to determine the nearest agency to the location before alerting the agency. The agency receives the report and dispatch teams to the site, which is beyond the scope of this project. The report is also stored in this web-based system and this function is captured as an inclusion use case, 'store report' in the diagram above, which can be retrieved to be viewed by the admin. The web-based system includes a real-time monitoring board feature which allows the admin to the incoming alerts (reports). The admin can generate system report for analysis, weekly, monthly or quarterly, usually in a table format.

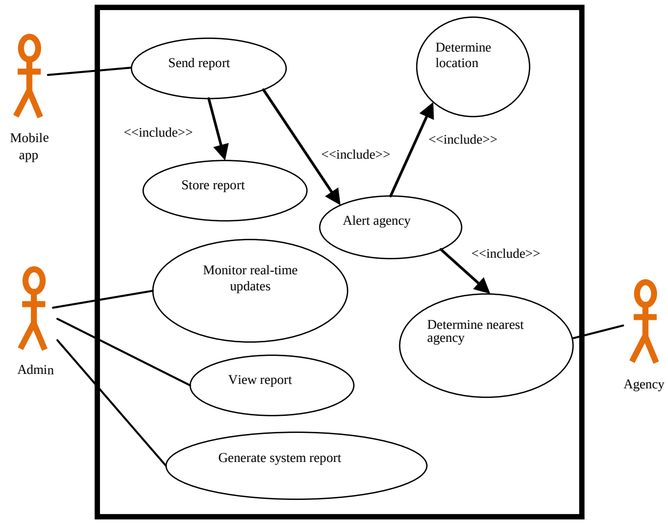


Fig. 4. Use case diagram for administrative module.

B. IDMS System Architecture

The system architecture of IDMS web-based administrative system is a simple three-tier application as shown in Fig. 5. Admin will log in the web-based system through the computer browser (front tier). The browser acts as a graphical user interface of the system. Example of usage of the browser is the admin can view the stored landslide incident reports. The web server (middle tier) contains logics to perform functions such as processing data. The mobile app communicates with the admin module's web server by means of exchanging data such as sending report and getting acknowledgement that the report has been received. The related agency module also receives information (report) from the web server regarding a landslide incident.

Apache is found to work best with MySQL database. WebSockets is a recent technology that makes real-time update or exchange of information easier. When a report is sent by the mobile to the server, data is processed server-side, then instead of having clients to request for any information, information can be "pushed" real time to clients. Fig. 6 shows the communication of data using Pusher API. Clients make HTTP request to server for webpages while WebSockets protocol here is used by the server to push real-time information to the subscribing clients.

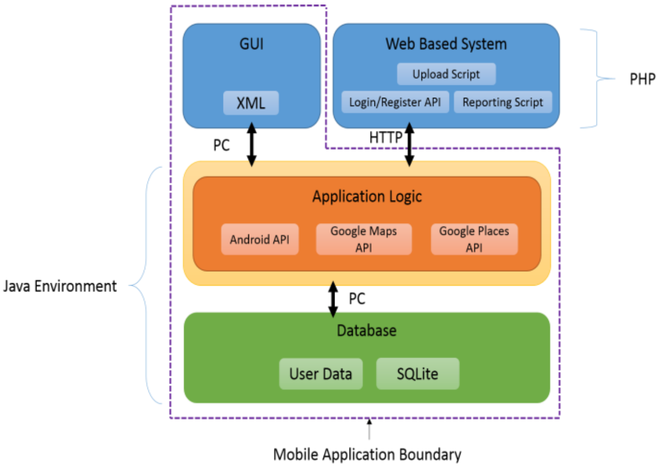


Fig. 5. IDMS system architecture.

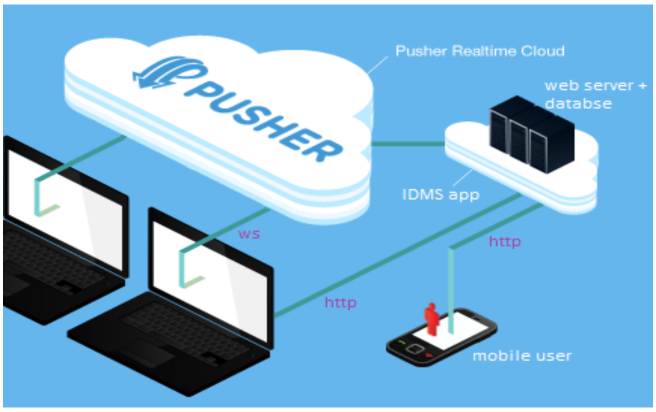


Fig. 6. Pusher API and websockets protocol.

C. Call Forwarding and Receiving Mechanism

To support the automation of call receiving and forwarding in the current procedures, we proposed an algorithm that returns the data of all the nearest agencies once the GPS location of the mobile user is identified as described in the following:

- Step 1: The mobile user sends an alert. The system receives its GPS coordinates.
- Step 2: Using the GPS coordinates, the system queries its database to return all agencies (and their data) within a radius of 20km from the GPS, group the agencies by type, and limit 2 entries per type. The number is changeable.
- Step 3: This portion or loop is essentially to check whether at least 1 agency per type is returned by the database. If not, it will query the database again but with a 20km increase in radius. At the end of this loop, at least 1 agency per type is returned.
- Step 4: Now that we have the GPS coordinates of the mobile user and the agencies, we can get the driving distances between each agencies and the user using Google Map web services.
- Step 5: The results returned are sorted by agency type. Then for each agency type, the nearest driving distances to the mobile user is determined. All nearest agencies are then alerted.
- Step 6: The system push update to its client and a report entry appears on the client's real time monitoring board.

These steps are then formulated into an algorithm and implemented in the development of the IDMS prototype.

V. Results and Discussion

The purpose of evaluation is to assess whether the system has met the objectives of the project. There are two main parameters being evaluated for the efficiency of IDMS as discussed in the following section.

A. Alerting Nearest Agencies

The web-based system has been tested to successfully receive report from the mobile app and show it on the user interface. In Fig. 7 each report appears as a link on the left panel. When a user clicks on the link, it loads Google Maps showing the nearest agencies along with information such as driving distance to the incident location. Fig. 7 also shows the message and image received by the web-based system from the mobile app.

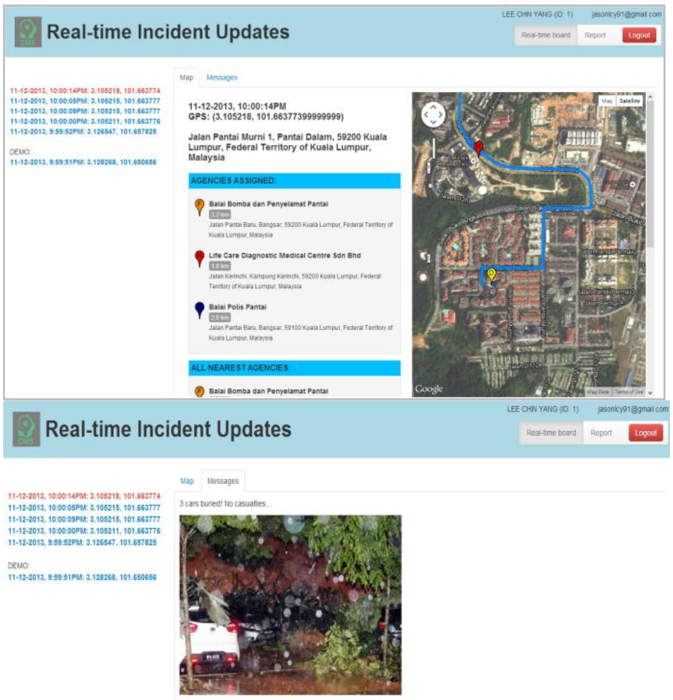


Fig. 7. Real-times incident updates.

Related agencies, if logged in, will receive real-time notification (Fig. 8). Clockwise from the top left, fire station, admin, hospital agency and police agency. The admin will receive notification for any report sent to any agency.

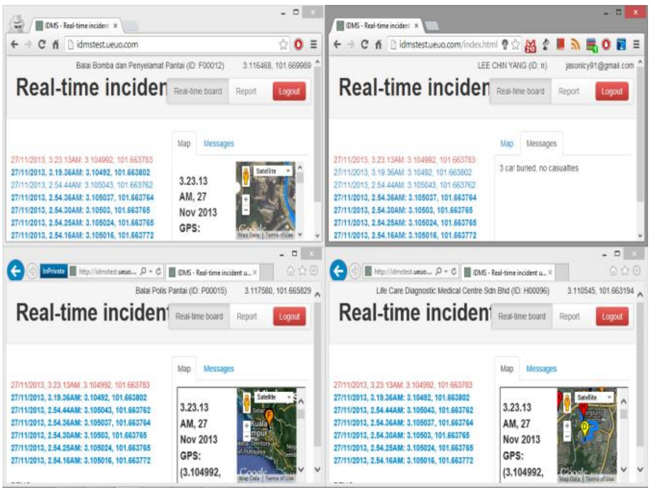


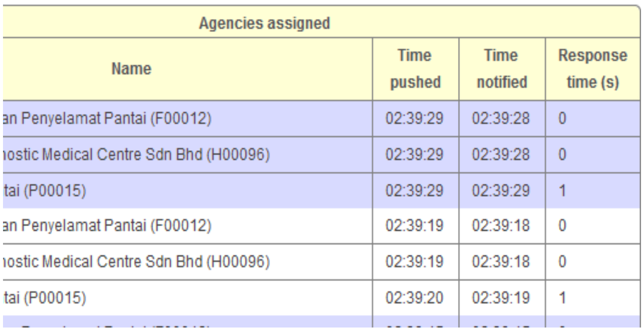
Fig. 8. Related agencies, if logged in, will receive real-time notification.

B. Evaluating Response Time

To evaluate the response time of this specific module, the response time should be defined as:

time notified – time received

where *time notified* is the moment an online agency receives a real-time notification on the screen, and *time received* is the moment the data sent from the user mobile reaches and received by this web-based system server. In average, the response time is 1-2 seconds. Fig. 9 shows few results captured.



Agencies assigned			
Name	Time pushed	Time notified	Response time (s)
an Penyelamat Pantai (F00012)	02:39:29	02:39:28	0
ıostic Medical Centre Sdn Bhd (H00096)	02:39:29	02:39:28	0
tai (P00015)	02:39:29	02:39:29	1
an Penyelamat Pantai (F00012)	02:39:19	02:39:18	0
ıostic Medical Centre Sdn Bhd (H00096)	02:39:19	02:39:18	0
tai (P00015)	02:39:20	02:39:19	1

Fig. 9. Evaluation of response times.

It is important to note that the latency between the data leaving the user mobile and the data being received by the system depends very much on the internet connection (this can be solved if data can be transferred using cellular network without charge). Hence, the response time of this web-based system should indicate the time it needs to process the data and send to the agencies. Although the system resides in a server and data can be processed internally, this project uses an online hosted API that enables push (real-time) notifications, thus internet connection is needed. To solve that problem, a self-hosted API can be used and should be used should the system be implemented for use. When a self-hosted API is used the response time will be even lower as data will be fully internally processed. However, due to the time restriction, the online API is continued to be used and internet connection has to be good when testing for average response to avoid the bias.

TABLE II: RESULT FOR TEST 1

Date (initiated)	Time initiated	Time received	GPS
2013-12-11	19:27:45	19:27:46	3.105080, 101.663808
2013-12-11	19:27:36	19:27:38	3.105080, 101.663808
2013-12-11	19:27:20	19:27:23	3.105080, 101.663808

According to data released by MERS 999 [1], it was seen that 80% of calls take a minimum of 20 seconds to be answered. This does not include the time it also takes to communicate the incident. This project looks to reduce this time. In order to evaluate whether this has been achieved by the IDMS two tests were carried out.

- Test 1: 10 reports are sent from the mobile application containing no text. This type of report is most similar to that of reports given by phone. This is because a person cannot communicate images by phone.
- Test 2: 10 reports are sent from the mobile application containing both a message and an image. This is a more comprehensive report than that which is currently sent by the current phone system.

The snapshot results of the tests are shown in the following two tables (Table II and Table III).

TABLE III: RESULT FOR TEST 2

Date (initiated)	Time initiated	Time received	GPS
2013-12-11	19:35:55	19:35:58	3.105080, 101.663808
2013-12-11	19:35:30	19:35:32	3.105080, 101.663808
2013-12-11	19:34:46	19:35:13	3.105080, 101.663808

To calculate the time taken to send a report, the following formula is used:

Reporting time= Time initiated – Time received

After calculating the individual reporting times, an average value was calculated:

Average Time Taken to Send Report (No picture)	Average Time Taken to Send Report (With image)
2.1 seconds	12 seconds

It is found that sending a report with an image will require a longer time compared to sending without an image.

C. Load Testing

A load test was done and result is shown in Fig. 10.

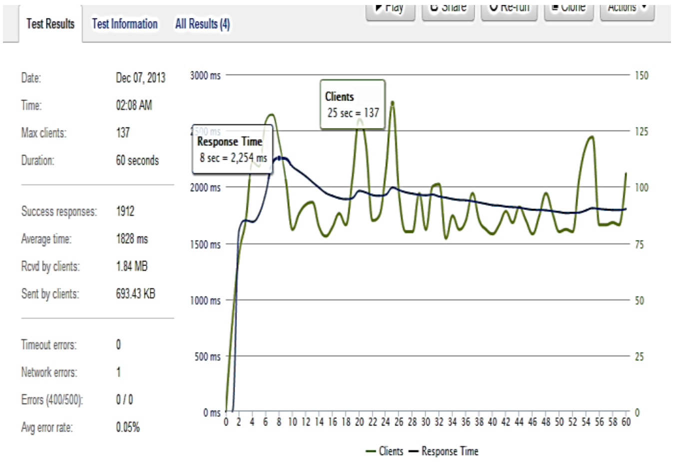


Fig. 10. Load test results.

Concurrent users are simulated as mobile users sending data to the server for 60 seconds with a peak number of clients of 137. The highest response time was 2.254s while the average response time was 1.828s.

VI. CONCLUSION

We have discussed and showed how an automated web-based admin system can provide convenience, efficiency and effectiveness when dealing with disaster and communication. The most important element in dealing with disaster is undeniably the speed, so response time in every aspect of emergency handling is critical and ways should always be explored to improve it. The response time of this web-based system is very low. In future expansion, the project should expand to include different disaster type and to only alert relevant parties based on the disaster type. Based on the evaluation, this project is considered successful in proving of the concept. A web-based admin system for Integrated Disaster Management System should be seriously considered as a solution.

REFERENCES

[1] FutureGov. MERS 999: A NATIONAL EMERGENCY RESPONSE PLATFORM Articles FutureGov - Transforming Government Education Healthcare. [Online]. Available: http://www.futuregov.asia/articles/2013/jan/17/mers-999-national-emergency-response-platform/

[2] M. A. Salem, D. M. A. Islam, A. K. Azad, and A. R. A. Dahlan, "Collaborative disaster management system: an exploratory for landslide in Malaysi," *Collaboration, communities, well-beings and information systems*, Kuala Lumpur: IIUM Press, pp. 179-188, 2011.

[3] Z. Othman, *The Use of High Density Scanner (HDS) For Landslide Monitoring The Preliminary Stage*, 2008.

[4] B. K. Tan, "Geologic factors contributory to landslides – Some case studies in Malaysia," in *Proc. the Seventh International Symposium on Landslides*, vol. 2, pp. 1121–1124, 1996.

[5] Malaysia: National Slope Master Plan 2009-2023, Public Works Department, 2009.

[6] S. K, Baharin, A. Shibghatullah, and Z. Othman, "Disaster Management in Malaysia: An Application Framework of Integrated Routing Application for Emergency Response Management System," presented at the International Conference of Soft Computing and Pattern Recognition, 2009.

[7] C. M. Chemtob. Delayed Debriefing: After a Disaster. [Online] Available: http://www.cism.cap.gov/files/articles/Delayed%20Debriefing-After%20a%20Disaster%20=%20Claude%20M%20Chemtob.pdf.

[8] N. A. Hassan, N.-A. Hayiyusuh, and R. Nouri, "The Implementation of Knowledge Management System (KMS) for the Support of Humanitarian Assistance/Disaster Relief (HA/DR) in Malaysia," *International Journal of Humanities and Social Science*, vol. 1, no. 4, pp. 103-112, 2011.

[9] A. Mansourian *et al.*, "Using SDI and web-basedsystem to facilitatedisastermanagement," *Computers & Geosciences*, vol. 32, no. 3, pp. 303-315, 2005.

[10] M. Careem *et al.*, "Sahana: Overview of Disaster Management System," *International Conference on Information and Automation*, pp. 361-366, 2006.

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