DESIGN OF A FOSS SYSTEM FOR FLOOD DISASTER MANAGEMENT

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ABSTRACT

In this paper we study how information technology solutions can be used when disasters strike. This research in progress focuses on flood disasters and it proposes the design for flood disaster management. To increase the utility of the disaster management information system, we follow the free and open source system (FOSS) concept. Informed by the management tasks of flood response, we elaborate the system requirements and key functionalities. The system has received preliminary evaluation by the domain experts and is currently under further development.

Keywords

Disaster management, flood incident, FOSS, design requirement

INTRODUCTION

Computer applications play an important role in disaster management (Altschuller and Benbunan-Fich 2008). In this paper we focus on flood disasters and suggest information systems to improve disaster management. Flooding causes damage to life, livelihoods and the environment. Over the past decades, the pattern of floods across all continents has been changing, becoming more frequent, intense and unpredictable for local communities, particularly as issues of development and poverty have led more people to live in areas vulnerable to flooding.

We propose an improved disaster management system that supports flood response. The system is designed following FOSS concept to leverage benefits such as low cost, flexibility, and improved compatibility. We describe in details the requirements, features, and architectures. It also complies and extends similar systems that are currently in place. We have collected opinions from domain experts on the system design. The paper contributes to the research community in that it proposes system designs that address an important aspect of social concerns – namely disaster management in the context of flooding. The research augments the SAHANA system by offering GPS-based flood warning, managing rescue transportation, RSS notification, and team formation and coordination modules. The paper also benefits the practitioners in presenting a platform that emergency responders may rely on to respond to and mitigate flood incidents.

The paper is organized as follows. In the subsequent section, we discuss the background of disaster information system as well as free and open source software (FOSS) concept. Next, we present a brief review on management of flood disasters and implications for system design. We then present the overview of the system and design requirements. We conclude the paper with discussion of limitations and future research.

Background

Research on emergency management information system has proposed development of core design premises and principles that enable system management of "*all-hazard*." Currently most of the disaster management systems in

Reviewing Statement: This paper represents work in progress, an issue for discussion, a case study, best practice or other matters of interest and has been reviewed for clarity, relevance and significance.

place are proprietary systems. Examples are such as DisasterLAN (www.disasterlan.com), E-Team (www.eteam.com), and Web-EOC (www.esi911.com). These proprietary systems are however challenged by limitations such as high cost, low flexibility, and constrained compatibility (Ashcroft, Daniels and Hart 2002; Burghardt 2006). To this end, this paper adopts free and open source system (FOSS) concept and develops a functional system to evade many of the existing challenges.

We endorse the free and open source software (FOSS) concept in developing the system due to reasons such as lack of funds to generate proprietary software, greater flexibility, wealth of knowledge, and improved compatibility. Our system may extend a pioneer FOSS flood disaster management system - SAHANA. IT professionals from Sri Lanka developed SAHANA with the goal of coordinating relief activities to bring out highest degree of effectiveness among the users. The development activities were lead by Lanka Software Foundation. SAHANA was developed keeping in mind that the system could provide large scale benefits only if they are deployed extensively. The result is the use of FOSS concept to make wide spread deployment and customization a reality. SAHANA is developed on a platform (PHP, MYSQL and Apache) that can be downloaded to a user's terminal and can be customized or configured according to the needs of the situation to be handled. Such fast paced relief measures can map resources to the needs, save lives, reduce chaos and provide coordination and focus to the responders.

SAHANA offers useful modules such as (1) missing person registry, (2) organization registry, (3) shelter registry, (4) request/aid management, (5) volunteer coordination, and (6) situation awareness. While SAHANA has been used to manage floods caused by Tsunami, it does not support many of the important functionalities that are imperative to flood response. In this paper, we develop a functional system that offers those missing features and hence provide a full-fledged flood management solution.

Flood Management and system design

Information systems for disaster management may vary based on the disaster scenario of interest (Chen, Sharman, Rao and Upadhyaya 2007). In this paper we focus on flood disaster and develop a fully functional FOSS system. Flooding is the leading cause of weather related deaths in USA (CDC 2007). It is therefore important that we enrich the existing emergency management systems to properly handle flood incidents with an attempt to reduce the loss of personal lives and properties. Disaster management systems should be able to coordinate the response efforts during the floods and quick disseminate information among the stakeholders. In case of floods, there will be a wide variety of disaster management organizations (DMOs) involved: EMS (Emergency Medical Services), water boards, dike/levy/barrier controllers, Army Corps of engineers, helicopter rescue group, relief and rehabilitation unit, and government decision makers.

Flooding management is a complex task. To make informed decisions, emergency mangers need to learn, both the current and future, course of the disaster development. They need also to quickly transport and deploy task critical response resources such as sandbags along the frontline of disasters. Emergency responses are very often limited and thus the execution of transportation is vital to curtail the disasters and leverage the response capabilities. Further, the wide impacts of floods are likely to call for regional responses. Following mutual aids protocols and pre-plans, responders from the local areas form into temporal workgroups in trusted manner (Ba, Whinston and Zhang 2003) and attack the emerging management problems in a collaborative and coordinated manner. Any disaster management information systems should carefully address these major issues.

Flood management teams may also interact with the general public. Warnings and relief messages are important for the citizens to evacuate from affected regions, find food and water supplies, and locate temporary shelters (Chen, Sharman, Rao and Upadhyaya 2007). This will be updated by responders as and when needed for citizens to act fast during and immediate after the disaster. Failures to disseminate information may cause hyped panics and even hamper the response operations. Several flooding warning systems (e.g., Automated Flood Warning System by The National Weather Service) have been in existence yet not integrated into incident management systems. And thus, information systems for flood management should add capabilities to timely publish information to the general public.

The proposed system will offer components that assist incident management and citizens in the following ways. Few major features are listed below. These features have not been incorporated in SAHANA systems.

- Flood warning system which could be integrated on vehicle GPS
- Management of means of transportation used for rescue operations
- Really Simple Syndication (RSS) feeds on mobile phones

- Team formation and coordination module

System Overview

We chose Model-View-Controller (MVC) as the architecture to design our flood management system as it provides the following benefits. Using MVC, the model and view components may vary independent of each other, making the system highly maintainable and extensible. As new features are allowed to be added into the application in the future, it makes the development process less time consuming and less demanding. Furthermore, MVC makes the application vastly modular which helps in achieving the separation of concern and control. Overall it improves performance as complex business logics are avoided in the presentation logic. For disaster management, these benefits are appreciated.

Disaster response requires timely information. AJAX technology has been increasingly utilized in information systems designs to improve information loading speed. Since AJAX is based on asynchronous mode of communication between the server and the client, user need not wait for the response for a request from the server before sending the next request. Also, AJAX eliminates the need for loading the whole page since it refreshes only the part of the page that is supposed to display new data. That makes it possible for AJAX applications to work fine even in places where high bandwidth is not available. This suits the emergency situation once again. As a result, AJAX makes rendering of content on user interface possible in a few split seconds. This also increases the volume of activities that a user can perform in a given period of time significantly. We therefore use AJAX technology in the design of the improved flood disaster management system.

Requirement Specification

To preserve the page size, we briefly discuss the system design. Below we provide the system requirements for helicopter rescue service which is one of the features of our application. Definitions:

- Dispatcher: A person who dispatches calls on the Disaster Management Application. He also decides which helicopter should go to which area.
- Disaster recovery application call database: A repository that holds the details of each call for a helicopter. This information is displayed to the Dispatcher dynamically through the Disaster Management Application.
- Pending calls: Calls for which no action has been taken by the dispatcher yet.
- Actors: Refers to the citizens or DMO staffs who place calls.

Following are the system requirements for this scenario:

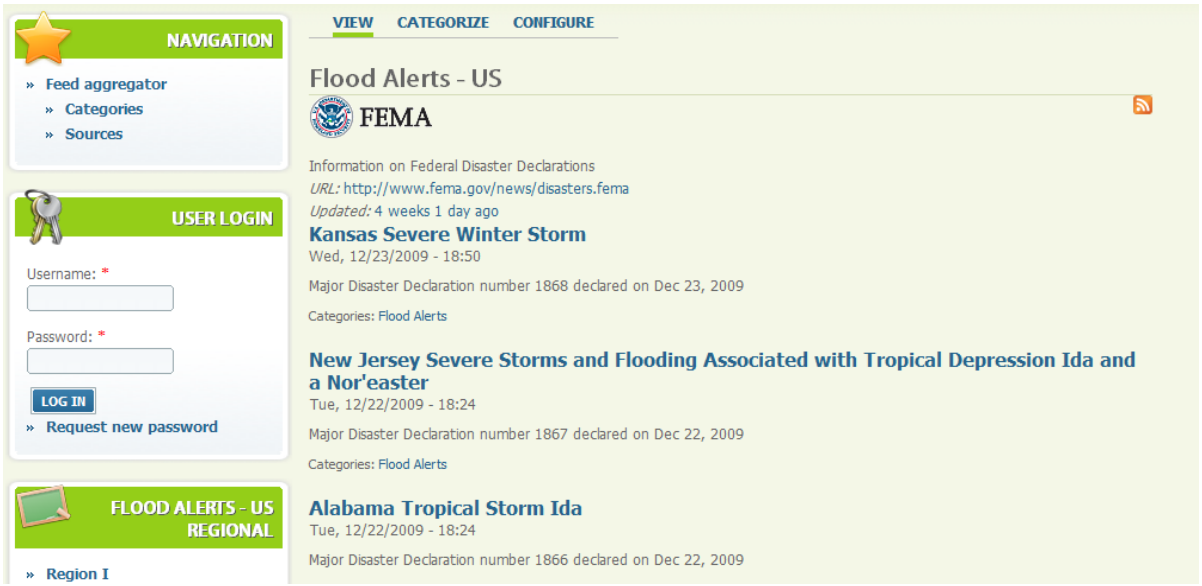
1) The calls should be handled according to a given time frame
   1.1) Every call has to be dispatched within a given time. For instance: within 3 minutes.
   1.2) Every call detail needs to be logged by the dispatcher. Information should include dispatch time, time to reach destination and so on
2) System should provide interface for the actors
   2.1) Actors should be provided with a form that the feature to take in details about the calls they place.
   2.2) Form should also capture the information about the dispatcher such as name, contact details etc.
3) System should provide interface for the dispatcher
   3.1) Dispatchers should also be provided with an interface that displays details of all the calls paced by the users and also which shows the status of each call as he/she works on each call.
   3.2) System should allow the dispatched to view the status of each helicopter.
   3.3) Based on the status of a helicopter, it has to be assigned to a call. Once this is done, dispatcher must be able to change the status of the call from pending to assigned.
   3.4) User should be able to capture information such as the time at which a helicopter was assigned to a particular call and dispatched from the DMO site.
   3.5) System should automatically change the status of a helicopter as soon as it is assigned or released from a call.
3) The system should be able to log each call history for auditing purposes later.

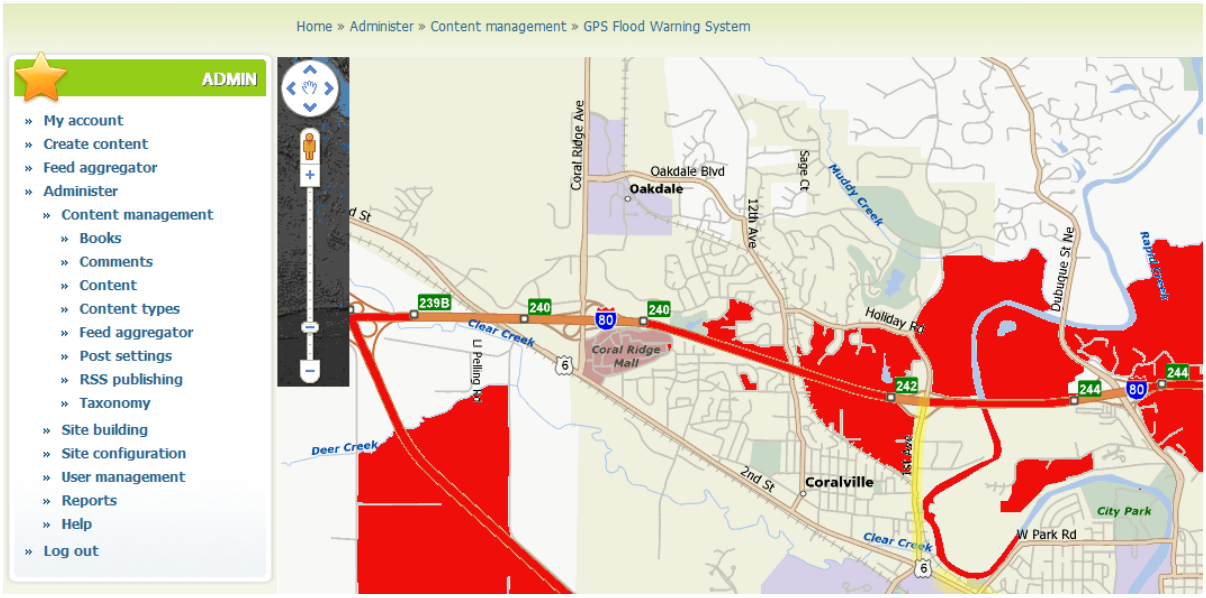
As another example, the design requirement for flood warning system is:

1) Maps should be loaded dynamically
   1.1) Flood flow should be refreshed at a frequency of once every 8 seconds or less.
   1.2) Rate of flood flow, severity level, danger alerts should be provided as per the above frequency range
2) System should provide interface that is highly interactive.
   2.1) Based upon the flood scenario, system should provide decision support based on pre-defined plans
   2.2) Decisions should include alternate route to be taken and safety measures based on the specific situation the user is involved in.
3) Centralized monitoring systems
   3.1) User should be able to alert DMOs about the scenario they are in. This will aid in rescue operations.
   3.2) GPS should have one touch system that could alert centralized systems and DMOs staffs.

Example Screenshots

Example screenshots of the functional systems developed are provided as below. They demonstrate the RSS Feeds Flood Alerts, flood event creation, and dynamic flood alert maps on mobiles and standard GPS devices.





Relationship with SAHANA

This flood management system design may complement SAHANA system in a number of ways. The proposed team formation and coordination model may leverage the organization and volunteer modules in SAHANA as the new module helps manage the entire pool of human resource. The management of rescue transportation may expand SAHANA to not only supervise shelters but also resources such as helicopter. The GPS flood warning system and RSS feeds may enhance the situation awareness feature in SAHAHA and allow for improved information sharing and decision making.

Preliminary Evaluation

Multiple experts from research and government agencies have offered their opinions on the system. They have years of experience in flood incident research and management. Through open-ended survey questions, we solicit their opinion on the requirements of the system, the scope of support, and value of the functionalities. The experts recognize the unique benefits of the system in supplementing SOHANA, the usefulness of Ajax in system implementation, and the relevance of the variety of system features. The experts have also suggested for studying a larger group of stakeholders, adding risk assessment data identified prior to flood, adding predetermined response plans, and cautioned the potential pitfalls of database scalability in the use of Ajax. More extensive evaluation and revision of this system is expected to be completed in the future.

CONCLUSION

We believe that the presence of an improved information system will support and enable flood disaster management at higher effectiveness and efficiency. In this research in progress, our development follows FOSS concepts and it may augment the existing SAHANA system to offer better support for flood response management. We have identified some features of flood management system and propose the system design. This may give a prime advantage to the practitioners to collaborate among themselves to share critical information and plan their disaster activities accordingly. The current system is however subject to further validations with respect to its performance and usability as perceived by the flood management responders. Future features that would be included in our application system would be the library of flood disaster of information and artificial intelligent techniques to predict and determine the pattern of floods which could be used by the strategists to devise plans and to provide a single platform that would help in aggregation of information regarding flood mitigation techniques from various NGOs throughout the world. Future study will also consider more of the unique challenges in flood incident such multi-jurisdictional collaboration and prolonged response and recovery period.

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