

WEB-BASED DISASTER AND CRISIS MANAGEMENT SYSTEM

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ABSTRACT

Disasters and crisis are problems that have the power to seriously impact populations, government institutions and infrastructure, and which can result in both human and material loss. In the last couple of years, due to several factors such as climate change and increase in population, countries have seen an increase in the number of disasters and crisis. In this paper, we present the importance of having an infrastructure for the management and handling of these types of events. We will also present a newly-created system (comprised of a web-based application, web services and mobile applications) that can help institutions to better handle disasters and crisis by simplifying and improving the way events are managed and shared with the public.

I. INTRODUCTION

In the last couple of years, almost every country has seen a dramatic increase in the number of disasters and crisis. Increased population, climate change and technical progress has resulted in breakdowns of energy grids, floods, wildfires and technical accidents such as destruction of dams and oil leakages.

Unfortunately, very few countries commit sufficient resources to disaster management, regardless of past experience. This is true both for poorer developing countries and also for rich developed countries [1]. Because of the lack of real infrastructure for responding to disasters and crisis, it is usually very difficult for people responsible for managing events to respond quickly and effectively, and it is also very difficult for the people affected by such an event to respond to it accordingly. Thus, recently, the disaster risk reduction community has focused towards ICT solutions [2]-[6].

In this paper, we will present a web-based system for managing disasters and crisis. The system is currently used by the Crisis Management Center in the Republic of Macedonia for collecting, processing and sharing events. It is also used for generating reports that are presented to other government institutions. We will also show how, by using modern phones, these events can effectively be shared with the general public.

The paper is organized as follows. In section 2, we review the current organizations that are responsible for handling disasters and crisis in the Republic of Macedonia. In section 3, we review the features and abilities of the proposed system for managing events. In section 4, we show how all these features are implemented in one very simple and easy to use web-based system. We also present the implementation of several mobile applications for viewing and sharing/submitting events. In section 5, we present our plans for future work. Finally, in section 6, we give some concluding remarks.

II. ORGANIZATION

Every country has the need for a mechanism to manage disasters and crisis; and also instruments for enforcing different strategies for handling different kinds of events. In the Republic of Macedonia, this need was resolved by the establishment of a national Crisis Management Center.

The Crisis Management Center is an independent state administrative subject responsible for the prevention, early warning, mitigation and handling of all crisis events. It is also responsible for coordinating international actions in the case of a global (or regional) crisis situation. Its main functions also include the preparation for all risks to the security of the country and its citizens.

According to the Law on Crisis Management in the Republic of Macedonia, there are several types of risks and/or threats that could affect the country's population [7]:

- Natural catastrophes (floods, fires, earthquakes, extremely low/high temperatures, etc)
- Epidemics, Epiphytes
- Technical accidents and ecological disasters (explosives, contamination, massive poisoning, etc)
- Security threats (terrorism, crime, weapons of mass destruction, etc)
- Other threats and risks (threats that affect various types of citizens, etc)

The National Crisis Management Center is divided into several sectors and departments. It also contains a number of regional CMC centers that are responsible for the gathering and management of information for different regions inside the country. The general organization of the system for responding to crisis in the Republic of Macedonia is presented in Figure 1.



Figure 1: Organization of the Crisis Management Center

In case of an emergency, the Crisis Management Center is responsible for providing an overall support (both expert and organizational) to the Steering Committee and Assessment Group. This is done by proposing measures and activities for resolving a potentially dangerous situation or crisis event.

III. FEATURES

In order to simplify and improve the operations of the Crisis Management Center, the Faculty of Computer Science and Engineering from Skopje, with the support of UNDP, has developed an entire system for managing disasters and crisis. The main purpose of the system is to open government data and present ways in which these data can be used to improve citizen lives.

The system is composed of three basic parts:

- **main (server) application**, which is used by professionals working for the Crisis Management Center
- **web services**, which offer data to the public
- **mobile applications**, which can be freely downloaded and used by citizens in order for them to stay informed of important events

Employees at the Crisis Management Center login (with their credentials) on the server application and add or modify events. In general, there are two types of events: private events (visible by government employees) and public events (which are visible by everyone). Events are described in several languages, so people of various cultures and nationalities can find them useful. On the server application, users can filter events by time, location, event type, visibility and status. Events are presented either in map view (tagged images on a map) or event view (simple list of events).

Besides adding, viewing and modifying events, users can also generate reports for various events and time periods. Reports can also be generated in various languages.

The system offers several types of web services to anyone interested in the information. These services are also used by the mobile applications in order for them to retrieve active events and/or events that will be active in the near future - these are the events that can be potentially useful to citizens. The web services offer various types of filters in order for the users to select and download only the data that they are actually interested in.

Citizens that want to retrieve the events handled by the Crisis Management Center can download one of the three mobile applications (one for each of the most popular mobile operating systems - Android, Windows Phone and iOS) and use those applications to stay informed of potentially dangerous events and conditions. They can also read recommendations that explain what to do in case of a specific disaster (fire, flood, earthquake, etc).

Through a popular practice known as crowdsourcing, instead of simple being passive recipients of data, the system offers citizens the opportunity to inform others (other citizens or government institutions) of events that are happening around them: by describing the events and possibly sending images. By combining the efforts of many volunteers that submit information, the system ends up collecting a relatively large number of events that users could be interested in.

We also believe that the system can potentially be used in other areas, such as resource management or planning.

IV. IMPLEMENTATION

A. Server application

The server application is a web-based application that enables employees of the Crisis Management Center to manipulate events of various types. In practice, there are a total of 22 distinct types of events, organized in 7 categories. There are also three types of users that the system supports: viewer, editor and administrator. This enables the Crisis Management Center to delegate different responsibilities to each employee. By default, administrators have full control of the system and can add or modify events, add or change information for other users and also view events and generate reports. Editors have the same responsibilities as administrators, with the exception that they are not allowed to modify information for other users. Viewers can only view events and have no way to impact the data that is stored in the system database.

When a new event needs to be registered, an employee of the CMC center can use the system to add an event to the event database. The procedure for adding new events is very easy and intuitive, and it comprises of two parts: selecting a location (by clicking on a map) and describing the event (by entering time information, description, status, duration, details whether the event is private or public, etc). Currently, the system uses Google Maps for tagging locations, retrieving addresses, searching for places, calculating altitudes and other similar actions.

When a new event is added, the person that registers it needs to either enter a description for the event in all required languages (currently English, Macedonian and Albanian) or accept the default text generated by the system (the default text contains the event type, address, start time and duration).

An overview of all current, past or future events is also available (as shown on Figure 2). Events can be searched by address, description, type, status or visibility. They can be presented on a map (using Google Maps) or in a list. Events can be activated, deactivated or deleted directly from the list.

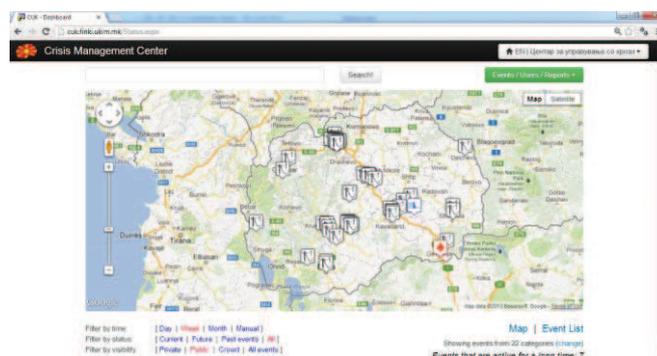


Figure 2: Server application

The application is built in .NET 3.5 and it can run on every modern IIS server. In the background, it can use any popular SQL database to store data. Currently, the system used by the Crisis Management System uses a Microsoft SQL Server database.

Besides searching, adding and modifying events, the system allows employees to generate reports for various event types and time periods. These reports are later used by other government organizations.

To generate reports, we use the open-source DocX library (a .NET library that allows developers to manipulate Word 2007/2010 files). DocX is fast, lightweight and, most importantly, does not require Microsoft Word or Office to be installed on the system running the server application [8]. It is released under the Microsoft Public License (Ms-PL). Because the system generates files in Microsoft Word format, the reports can be opened in almost every popular software for editing rich documents. They can also be viewed online by using free services such as Google Docs.

Lastly, the server application is also responsible for saving and presenting events created by outside users. These events are visible by other citizens and also by personnel from the Crisis Management Center. Administrators and Editors (employees of CMC) have the ability to delete events, modify parameters, deny images and ban certain users from posting events. In order to make sure that all information is entered in the correct form, all events are pre-validated by the system before they are inserted in the event database.

B. Web services

The Crisis Management Center enables various organizations and citizens to use the data that is stored in the event database. Only a small portion of the events, currently marked as private, are kept for internal use by the institution, or for use by other government entities.

The web services allow users to access the data in real time, by submitting a GET request to an URL address determined by the required content type, time parameters, status filters, visibility filters, etc.

In practice, the system offers all information in two distinct formats: XML data or JSON data. These are the two most commonly used formats for transferring data on the internet. To generate XML documents, we use the standard .NET System.XML.Serialization package. On the other hand, in order to produce JSON output, we use the free, open-source Json.NET library. Json.NET is a Flexible JSON serializer that enables users to convert .NET objects to JSON and back again.

The web services enable users to select events by specifying time parameters (whether they want events that were added a day, a month, or a year ago), specifying status (whether they want active, past or future events), and specifying visibility (whether they want to retrieve events that were generated, or approved, by government employees, or they are interested in events submitted by citizens - using one of the mobile applications presented in the following section).

C. Mobile applications

One of the main reasons for creating the system for managing disasters and crisis was informing citizens of potentially dangerous events that occur near them; and to teach people

what is the best way to handle an event of a certain type (what to do in case of an emergency - fire, earthquake, disease, etc). To do this, the information available in the system is directly accessible by citizens, through the usage of one of several mobile applications: one for Android devices, one for iOS devices, and one for devices based on the Windows Phone Operating system. Although they were developed separately for each platform, all applications (generally) follow the same pattern and offer the following services:

- map view of events
- list view of events
- links for publishing events on social media
- preferences (configuration)
- information on what to do in case of an emergency

Users are allowed to select what events they are interested in by choosing event types, time frames and radius (from their current position, which is automatically determined using GPS). The applications are available in 3 different languages (English, Macedonian and Albanian), so they can be used both by domestic citizens of Republic of Macedonia, but also by foreign citizens (tourists) that come to visit the country. Both the application interface and the event data is presented in the language of choice.

The information on what to do in case of an emergency is carefully created to be as useful as possible, and it is also presented in different languages. The application also provides important telephone numbers (for different institutions) and the means to dial any of those numbers by a single tap on the mobile phone.

Figure 3 shows two screenshots of the iOS version of the application.

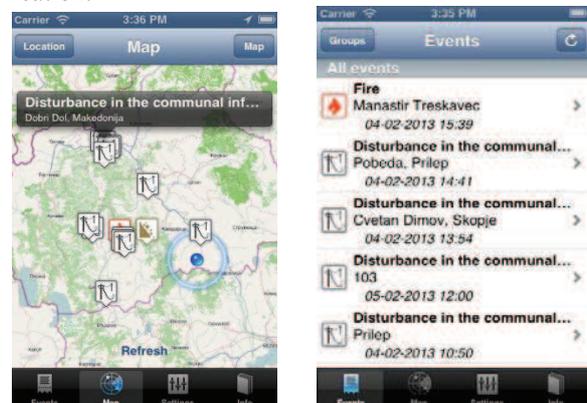


Figure 3: Mobile application (iOS version)

The mobile applications also enable users to contribute data both to their government and also to other users. Users are encouraged to report an event that they believe can be potentially interesting to other users by filling in a very simple form. Most of the data (such as coordinates, altitude, address, etc) is automatically determined by the application, by using services such as Google Maps. Users can also take images and include them in the event description that they are sharing with others. Images are automatically resized, compressed and converted to PNG format in order for the applications to use as little traffic as possible.

In practice, the iOS application uses maps from OpenStreetMap to present locations. OpenStreetMap is a project that creates and distributes free geographic data for the world. The data is free to download and use in various applications under its open license [9]. The iOS application can be freely downloaded from the App Store.

The Android application, on the other hand, uses Google Maps to present events in a map view. The application is freely available for download on Google Play. Figure 4 shows two screenshots of the Android version of the application.

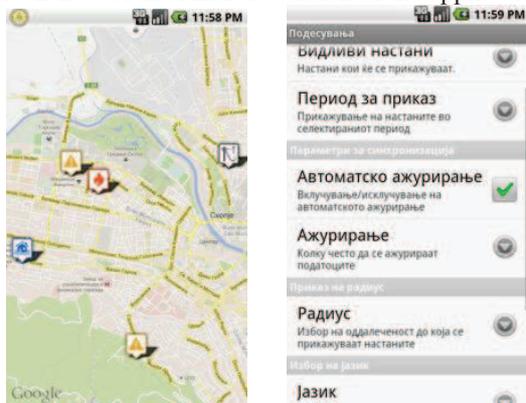


Figure 3: Mobile application (Android version)

All three mobile applications enable users to select whether or not they want to be notified of important events that occur around the country. This is achieved by "pushing" data to the citizen's phones by the server application. By default, people that have one of the applications installed on their mobile phone are notified of each event that occurs in the country and is marked as important by an employee of the Crisis Management Center.

V. FUTURE WORK

One of the main areas in which the system can clearly be improved is the ability to group similar events. Often, different citizens notice an incident and submit, in relatively the same time, separate descriptions and images for one event. This is presented separately by both the web-based system and the mobile applications. We plan to improve this by notifying users that a similar event is already created, and that they can potentially enrich it with more images or more detail description instead of creating a separate event. Also, we plan to upgrade the web-based server application to report such similar events and allow administrators to group them by following a simple and easy-to-pursue procedure.

The second area in which the system can be improved is the way in which notifications are sent to users (or, in other words, the way events are "pushed" to citizens phones). Currently, the mobile applications allow users to select whether or not they want to receive push notifications, but our plan is to enable them to select how many notifications they want to receive daily, what types of events are interesting to them, what positions (and radius around that) do they find important, etc.

Finally, we believe that social media will continue to play an important role in spreading information between citizens. To

better enable people to share data, we plan to improve our web-based system such that it can present data in their own globally unique page, so that events can be shared in a form that not only contains text, but also images, maps and comments.

VI. CONCLUSION

In the last decade, countries have seen a significant increase in the number of disasters and crisis. Reasons for this increase include technical progress, increased population and climate change - among others. Because of the lack of real infrastructure for responding to disasters and crisis, it is usually very difficult for all people effected to respond to such an event.

In this paper, we have presented a system, currently used by the Crisis Management Center (an institution responsibly for handling disasters and crisis in the Republic of Macedonia), that is both powerful and intuitive, and which simplifies the process of collecting, processing and sharing events. It is composed of a server application, web services, and mobile applications for the 3 most widely used mobile operating systems (Android, iOS and Windows Phone).

Among other features, apart from simply showing events, the mobile applications enable users to also contribute data (crowdsourcing). Users are encouraged to submit events that they believe can be useful to other citizens and/or institutions. Citizens can also take images and include them in the event description that they are submitting.

Finally, we have shown that we plan to improve the system by changing the way events are "pushed" to citizen's phones, by simplifying and improving the way events are shared on social media and by automatically grouping data that corresponds to the same event.

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