Development of an early warning and coordination system for addressing and managing natural disasters

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ABSTRACT
The development of an early-warning and coordination system to support the operations of Civil Protection Agencies is based on geo-spatial early warning decision support systems combined with integrated geographic information system (GIS) solutions and multi-criteria decision analysis (MCDA) fuses text and geographic information into one view. The goal of is to use geo-spatial decision support systems (GE-DSS) for rapid deployment, interoperability, transferability and sustainability to assess, prepare for and respond to multiple and/or simultaneous natural and man-made hazards, disasters, and environmental incidents by using existing models/systems in a synergistic way on one multi-platform, distributed and integrated framework. The application allows the optimization and coordination of the civil protection bodies while handling emergency cases. The design of this system has the prospect of monitoring and assessing the current situation, with the possibility of parallel distribution of information to those responsible for the current events using geographical data. Major innovations are (a) the ability to facilitate early warning in the sense that it will provide timely geo-spatial (RS/GIS) information that will allow effective action to be taken to avoid or reduce risks and improve preparedness and (b) in times of crisis, the GE-DSS system will enable decision makers to instantly assimilate and analyze dynamic streams of information from the field to make actionable decisions for multi-hazard or disaster preparedness.

Keywords: Crisis Management, Civil Protection, Geo-spatial decision support systems

INTRODUCTION

CIVIL PROTECTION & CRISIS MANAGEMENT PLATFORM

To support Civil Protection functions with an efficient and innovative way, it is suggested to create an early-warning and coordination system to support the operations of Civil Protection Agencies, based on geo-spatial early warning decision support systems combined with integrated geographic information system (GIS) solutions. With this system the coordinating body will have an access to all necessary information, for an event that requires direct action and apply the appropriate protocols for crisis management. The end purpose is to be able to effectively coordinate stakeholders through classical and modern type communication systems. For reasons regarding efficiency, performance and consistency, a unified programming platform, will be setup that will be used in common for everyone (experienced users, actively participating citizens, Civil Protection Agency officials, etc.)

The proposed system focuses is on the collection of real-time and archived data, in order to realize time-critical decision support systems and emergency management. Early application areas include pollution monitoring [1], traffic and road condition control [2], [3] and earthquake monitoring [4].

PAST EXPERIENCE

The EU-POSEIDON project [5], [6], [7], was a vast civil protection exercise, describing a sizeable earthquake of the Hellenic Arc, which would cause not only considerable damage, but also would create a devastating tsunami at local level and a moderate tsunami elsewhere in Greece and the Mediterranean. This is a scenario similar to that which produced the 365 BC in SW Crete. Based on a thorough risk assessment, large parts of the two major cities of Crete (Heraklion and Chania) would be affected, while the tsunami could destroy areas in the southwest of Crete. Many other islands and regions in Greece would be affected by the earthquake. The project included a full field and one post-command (Board) exercise in Crete which were evaluated according to a standard evaluation methodology by repetitions of the CP European Union mechanism. While the exercise was underway, scientists of the group, further complicated matters for the emergency planning by introducing additional events, aiming to test local capabilities to a critical degree, in order to seek immediate assistance from European partners. Teams from France and Cyprus responded in order to assist. During the exercise sophisticated ICT systems we used for patient case screening (Triage) which was based on crowd-sourcing applications.

FORTH participated in 2006-2007, in the European SAFE project co-funded by the European Space Agency (ESA), which developed and presented the added value of transnational early warning systems and crisis management (Greece-France). The aim was to create a standard emergency response map using modern telecommunications services. Also FORTH in 2009-2011, together with the Cypriot Defense Agency, the National Secretariat for Civil Protection and the Hellenic Red Cross, participated in a cross-European project "B442" Civil Protection Exercise funded by the European Commission and coordinated by the regional administration of Crete [8].

PLATFORM DESCRIPTION

An integrated platform, allowing setup on multiple operating systems (e.g. intended for Java bycode and executed over a Java Runtime Environment -JRE installed for standalone Java applications, or in a Web browser for Java applets), with a simple, user-friendly interface for porting crisis information over the web. For efficiency & consistency purposes, a unified platform programming core should be employed for all, expert users, actively-participating civilians, Civil Protection Agency officers, etc. The solution of any planning and/or management problem encompasses a more or less formalized decision-making procedure that goes through the following sequential steps [9], [10]: i) the problem is defined, the decision-makers and the stakeholders are identified, and the overall purpose of the planning exercise is clearly stated; ii) data are collected and used to set-up descriptive and decision models and iii) models are employed to inform decision-maker(s) on alternative trade-offs and to guide the process towards a final negotiated compromise solution.

The user-interface complexity and administrative rights should vary depending on the status and rating of the end user. The interface for specialized Civil Protection Officers and expert users will include incidence monitoring, input and output filtering, input and metadata visualization with disaster response mapping, archiving, exporting results both to public and authorities and administrative rights to the platform, whereas the civilian distribution of the application should only include an interactive input and feedback interface without any other privileges (see Fig. 1).

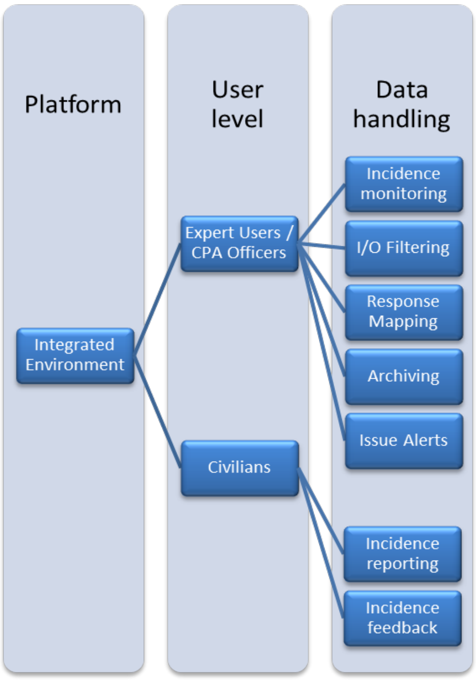

Figure 1: Hierarchy of Crisis Management Platform

The system should be able to operate over PCs, cloud operating systems, mobile devices and collect data both manually and automatically (from online resources, post-processing existing data and publishing metadata outputs). Modern mobile devices allow easy geo-tagging to all produced data (imagery, text, videos, posts, etc) thus allowing a near-instant integration of the event's location to the platform's database. Data input & output, system alerts and administrative commands should be able to be processed independently of the network status (online / offline) and made available when a network connection (Ethernet, Radio Data Transmission, Wi-Fi, 2G, 3G, 4G) can be established,[11], [12], [13].

BASIC USER REQUIREMENTS AND INPUT METHODS

In the following section the basic user requirements are established for a disaster management platform incorporating information from crowdsourcing, [14], [15], [16], [17], [18]. The general key-features that need to be taken into account are:

- Reported information must be easily discovered.
- Information that is reported needs to be delivered with as little delay as possible (the closer to real-time, the better).
- It must be possible to validate reports for authenticity and accuracy.
- Locations need to be as accurate as possible to allow for accurate response.
- Information from multiple sources must be combined.
- Information needs to be integrated with professional geo-information applications.

A detailed list of user requirements can be found in [18].

AUTOMATED DATA INPUT AND MANIPULATION

For the optimal and constant monitoring of the current situation, the system collects meteorological, coastal and seismological data from different Web sources. This is very important both for the prediction (mainly natural disasters associated with climate) and the proposed possible method in order to handle every particular event. Indicatively, the following data providers are mentioned:

- Continuous monitoring of Long-term and Short-Term Meteorological Data from:
  - Hellenic National Meteorological Service (HNMS) http://www.hnms.gr/hnms/greek/index_html
  - SKIRON Integrated limited area modeling system, by the Atmospheric Modeling and Weather Forecasting Group, National and Kapodistrian University of Athens http://forecast.uoa.gr/forecastnew.php
  - US Reanalysis Data Set, National Center for Atmospheric Research (NCAR) http://www.esrl.noaa.gov/psd/data/reanalysis/reanalysis.shtml
- Real-time seismic activity Monitoring from:
  - Institute of Geodynamics, National Observatory of Athens http://www.gein.noa.gr/el/
  - European Mediterranean Seismological Centre http://www.emsc-csem.org/

INFORMATION HANDLING

In a crisis situation, data handling play a crucial role to the decision-making authorities. In a large area event (e.g. a flooding), multiple secondary events can take place, such as a landslide following the initial disaster. Depending on the type, the extend and the probable outcome of a disaster situation, the platform will be required to assess and handle the incoming and previously stored relevant data. Much of the incoming information originating from non-expert users and civilians may be inaccurate. The system, depending on the existing data and the amount of the incoming information will require to filter-out those irrelevant to the emergency and at the same time, to discretize the information regarding the main event and the subsequent occurrences (directed by a trained Civil Protection Officer). This will allow a more effective dissemination of the available Municipal / State resources and a more focused and immediate response.

DATA DISSEMINATION

The platform should be able to notify the users directly via automated Alerts on the interface’s mapping system and produce geo-tagged locations. Depending on the administrative level and expertise (officer, medical responder, expert user, concerned civilian), different users, will receive different information packages. In those cases where, access to the platform’s interface is unavailable the system will also send relevant information via email, sms, mms, IVRs. System communications are categorized according to the following:

1st Level: Issue Notices: Depending on the event type, the system lists the appropriate services and automatically sends notifications.

2nd Level: Field communications: Data transfer to and from the field by the central Service Administrations and the Civil Protection Office.

3rd Level: Citizens’ communication with the system: Development of a two-way communication system between the citizens and the system for delivering notices via mobile phones and issuing ALERT messages.

Online crisis management protocols involve updating and validation of information, using special encoding for the ongoing urgent incident, from the Crisis-Management-Center with the event's location (see fig. 5). The aim is to support users in the Administration Center for the immediate notification of competent bodies (Civil Protection Agency, Regional Administration, Police, Fire Services, Ambulance Services, Hospitals, Crisis Support Services, External Systems, etc.)

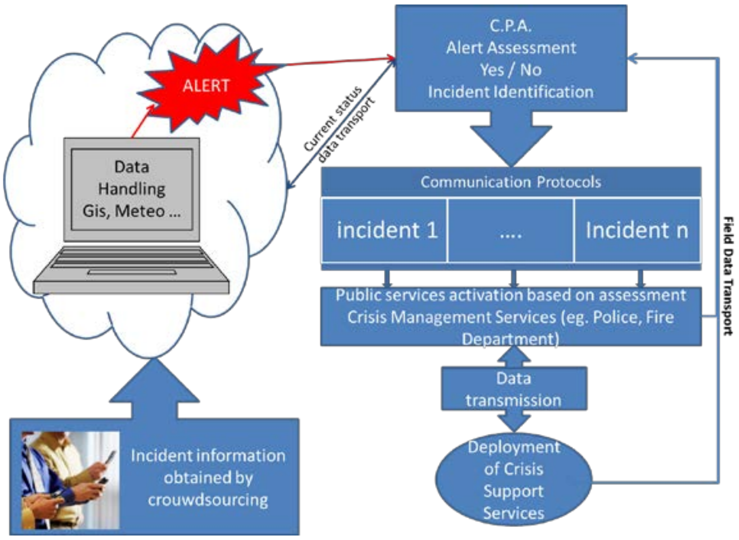

Figure 2: Interface diagram of the services, information systems and databases of the Crisis Management application.

DISASTER MONITORING SCENARIOS

The response system will be capable of tracking the following disasters and to assess the current situation by informing the proper Authorities of any subsequent occurrences. The system will also provide information of any relevant historical events taken place and use geographic data to display the information.

Table 1: Types of Disasters with relevant information database provided by the response system and ALERTS issuing.

Disaster	Relevant Information Database	ALERTS issued by the system
Forest fires	Access to historical data, locate detailed terrestrial mappings of inflicted area	Notices from citizens – services. Increased intensity winds and temperature. Link to HNMS website for data collection.
Landslides	Access to historical data, locate detailed terrestrial mappings of inflicted area	Notices from citizens – services.
Earthquakes	City Survey Maps with marked concentration sites, access paths, site ranking based on the seismic acceleration.	Notices from citizens – services. Link to EAA for earthquake, tsunami alert information.
Storms, typhoons	Access of current and predicted meteorological data (expected amount of rain, wind speed, peak event period, etc).	Notice when the expected volume (precipitation/wind) exceeds a given value. Notices from citizens – services. Increased intensity winds and temperature. Link to HNMS website for data collection.
Hot / Cold weather fronts	Access of current and predicted meteorological data (maximum / minimum temperatures, duration).	Link to HNMS website for data collection.
Industrial and technological risks	Wind Speed and Direction, establishment of safety radius and immediate concentration sites.	Notices from citizens – services. Link to HNMS website for data collection.
Sea pollution and oil-spills	Access of current and predicted meteorological data, access to historical data regarding wave and current direction.	Notices from citizens – services. Link to SKIRON website for data collection.
Traffic accidents	Road network mapping, evaluation of alternative routes	Notices from citizens – services.

CONCLUSIONS

The development of an early-warning and coordination system to support the operations of Civil Protection Agencies is based on geo-spatial early warning decision support systems combined with integrated geographic information system (GIS) solutions and multi-criteria decision analysis. It can be an integral tool in Civil Protection applications, accelerating its mechanisms and further assisting the search and rescue operations. The integration of GIS and multi-criteria analysis methods maximizes the system's utilization by decision-makers and Civil Protection Parties.

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