A cloud based framework for Emergency Management: experiences in Calabria Region

Extended Abstract

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Abstract. We present an ongoing project aimed to support the management of the procedures, mainly the handling of emergency calls, for the centralized regional emergency management agency (Protezione Civile Regionale in Italian). The main goal consists in enabling the sharing of information among different active locations that are in charge of acting in any emergency which occurs on the territory. We present a prototype version of the system that has been implemented by following the Calabrian Emergency Management agency specifications. The system is in charge of collecting information regarding various types of emergency such as earthquakes, floods, stormy seas and other extreme weather conditions. In addition, the system offers some functionalities for the management of emergency teams as well as volunteers and available resources (e.g., vehicles) by means of the application of geographical optimization paths. The requirements include also the design and development of a mobile application allowing citizens notify in real-time emergency conditions (e.g., forest fires during summer time).

1 Introduction

The Calabrian Emergency Management Agency (Protezione Civile Calabria, or PCR in short) is in charge of managing all the activities related to the prediction, prevention and emergency management. All the activities for efficient rescue operations, are defined and specified in a national guideline. One of the tasks regards the collection and management of data related to emergency information acquisition (e.g., from citizens' reports arriving via phone calls) and to define activities and apply protocols. The definition of prevention procedures and of emergency plans is one of the main task of PCR to protect and often save human life.

We here present an ongoing project and a system prototype that has been defining with PCR. Recently, PCR decided to make a reorganization of its telecommunications infrastructure, application procedures and communication flows through regional sites and, as a consequence, it has to integrate all the communication facilities through the definition of a centralized structure. The aim is to define a datacenter where information regarding: (i) emergency calls and catastrophe monitoring; (ii) source data management (iii) protocols applications to save life and people as in case of earthquakes or floods or landslides due to heavy rains. The PCR is in charge of apply intervention even in case of car accidents or problems in reaching populations. ICT protocols and infrastructures are in charge of being updated in Calabria Region. We here report about the definition of a new workflow implementing what is currently managed without automatic procedures.

The idea is to define a system able to manage the emergency calls by means of pages and multimedia information that has to be organized by the central operative unit. For instance in the following we report a possible scenario:

1. a citizen is in trouble because of extreme weather conditions;
2. he calls the PCR with an help request;
3. the incident room gets the help request which is assigned an emergency level;
4. a new intervention request is generated and sent to other operative rooms;
5. the nearest operative room identifies a team and the needed resources;
6. the team intervenes and sends feedback back to the incident room;
7. the incident room shares the information with other rooms;
8. eventually the incident is closed and archived.

An efficient emergency response is strongly related to a careful and attentive prevention activity and emergency planning, which are preliminarily carried out before any emergency occurs. In order to predict possible flaws which could occur on the territory, the PCR has many systems and operational sources already working. Some of the preliminary goals of our work with the PCR have been: (i) identification and analysis of the existing components of the PCR information system already in use; (ii) definition and planning of the extraction, transformation and loading procedures from the operational sources towards an integrated database; (iii) definition and implementation of a new information system for the emergency management.

PCR is a Regional Public Administration Unit which is part of a network of other Regional units who refer to the Presidency of the Council of Ministers. It is composed by 180 employees, 91 of which work in the incident rooms (21 for each turn). Each of the incident room dislocated on the territory, is in need to share information about resources, events and updates in real time. Furthermore, due to the inherent complexity and unpredictability of emergency events, the interaction for a human operator with the system has to be minimal and extremely efficient. We decided to design and implement an information system with a lightweight web-based interface implementing an integrated and interactive dashboard for the incident rooms, which allows to perform:

– *scenario analysis and planning* - allowing a PCR operator to acquire and visualize all the data about the event and to plan and enumerate the resources around it;
– *environmental monitoring network* - able to retrieve and visualize real time information from the regional sensor network;
– *models from intervention scenarios* - a system module able to analyze use cases from the past, ranking them by similarity with the current emergency event;
– *inspection reports* - with which PCR operators can obtain detailed reports about present and past emergency events;
– *vehicles and resources management* - a dedicated module for the efficient planning and management of emergency vehicles.

A first conceptualization of the integrated dashboard for emergency data management is depicted in Figure 1, which reports a simulation of an emergency event with its related data aggregated and updated in real time.

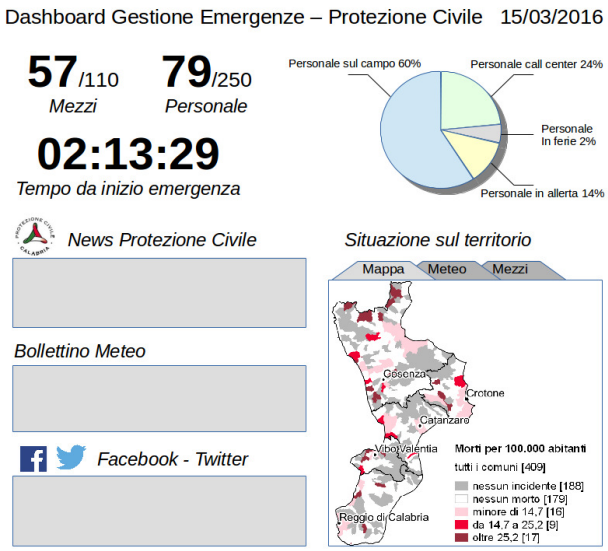

Fig. 1. Dashboard mock-up for the integrated visualization and management of emergency related data and events.

From the initial analysis phase we identified a set of existing systems and information sources in the PCR: (i) SITGE (Sistema Informativo Territoriale per la Gestione delle Emergenze) system, an old and unmaintained web-based geographical information system developed with ESRI technology, containing partial data for the emergency management with particular reference to fire

events visualization, (ii) GIOVE (Portale per la Gestione Integrata delle Organizzazioni di Volontariato nelle Emergenze di Protezione Civile) a database containing voluntary associations informations about vehicles and resources, (iii) an hardware/software system for the management of fire emergencies composed of 12 stations with high definition cameras, thermal cameras, humidity, temperature and wind direction sensors implementing a prediction model and a decision support system in the event of a fire; (iv) a regional isofrequency microwave radio network, used for emergency radio communication, covering 80% of the territory with nodes at 10-15 km from each other.

2 Related Work

In [3] a two levels architecture for an Emergency Management System has been presented. It consists of one back-end level for control rooms and one front-end level for teams sent to the affected area. Each of two level is a peer-to-peer (P2P) system. The lack of a fixed infrastructure for P2P systems makes this kind of network suitable in emergency management scenarios where it is needed to quickly deploy a network, but the presence of access points is not guaranteed. This architecture has been developped studying the organizational requirements of Civil Protection Department of Calabria and the *Augustus method* (`https://it.wikipedia.org/wiki/Metodo_Augustus`) that it adopts. As well, since the available bandwidth (roughly 11 Mbps) is enough, MANETs can guarantee a good QoS level. As far as communication of front-end teams with back-end, TETRA seems to be a good choice.

TErrestrial Trunked RAdio (TETRA) is an ETSI standard to build specialist Professional Mobile Networks (`http://www.etsi.org/technologies-clusters/technologies/tetra`). The low frequency used by TETRA guarantees an excellent geographic coverage. TETRA is specifically intended for Police Fire Brigades, Army, etc., and its relays are generally arranged so that, even if some of them go down, the others can cover most of the area.

In [4] an upgrade of the old SITGE system has been presented. The updated system had new features for the computation of indices allowing to identify areas in fire risk.

Each italian region has its own Emergency Management Information System. Usually, a platform of this type has a set of modules allowing to manage the objects of the domain (events, volunteers, vehicles, maps, etc.) and their interactions (e.g. `http://www2.regione.piemonte.it/protezionecivile/index.php/sistema-informativo`).

Similarly, in [5] a model for management of bioemergency is presented. Tools for path optimization and emergency camp positioning is presented. In [6] algorithms for emergency intervention and rescue planning are reported.

The system, here proposed, starts from requirements of the new PCR and it is in plan with respect to new italian reorganization due to recent natural disasters. We plan to include logistic and algorithms to plan rescues, resources according to land orography and streets. The idea is to create an emergency

support system for the PCR able to feed a continuously growing database of events and interventions which will be valuable for research because data contains both spatial and temporal dimensions, which can be exploited through spatial and temporal techniques and models (see [7]).

3 System Architecture

We designed a first system prototype by using deployment of components. Figure 2 shows the components layers: (i) the visual part of the emergency management prototype (presentation layer) consists of the JSP pages that contain the views of the data; (ii)the middleware level hosts the web application and data access module and (iii) the database level which is an instance of MySQL database. Figure 2 reports components and their interactions.

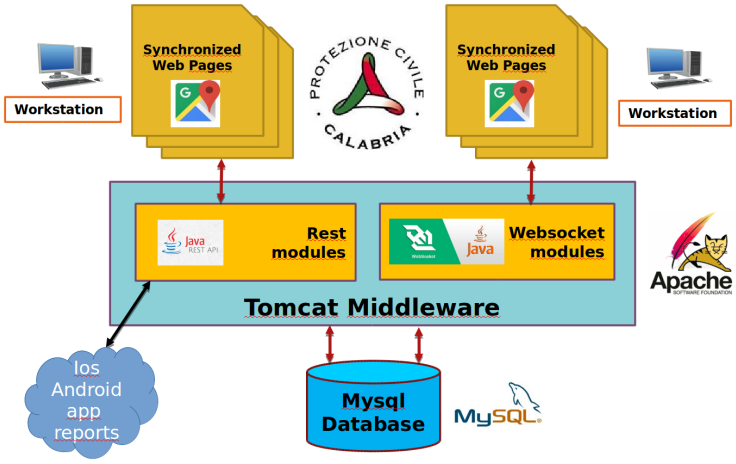

Fig. 2. Functional Architecture of the Emergency Management System

The functionalities regard also the possibility of signalling emergency cases by using a mobile app. A citizen can take a picture and define one of the possible application emergency cases. Citizen position as well as personal data (in case of availability in supporting rescuers) can be sent with simple steps. The system prototype has been implemented in a cloud based environment, to maximize system scalability, availability and redundancy. In order to preserve the integrity and privacy of PCR's own data, we set up an instance of the OwnCloud environment exclusively used by the PCR, to support the functionalities of the presented system, some of which are: (*i*) artifact exchange among incident rooms, (*ii*) end users' data acquisition and storage from the mobile app, (*iii*) storage of daily and periodic reports about PCR emergency management. Nevertheless the adoption of a proprietary cloud environment has some drawbacks. For instance, the limited number of nodes implies some potential problems regarding

the application scalability, while the management of the cloud architecture itself can be a costly and complex task to be sustained by the PCR.

Emergency can be managed in one of the operative units by accessing to a web screen where the emergency is verified and validated, and intervention protocols are selected and applied. Resources are also managed as well as the evolution of rescues activities. Consider that in case of emergency the communication activities and signals reach an high frequency in terms of number of call or app instances, thus the system should be able to track the activities. PCR has to both (i) avoid loosing emergency alerts as well as (ii) filter out the less relevant ones. Algorithms to prevent and automatically manage the relevance of alerts can be applied.

Figure 3 reports an example of using the developed application. There are different user profiles. A citizen can apply sending information about emergency situation with pictures and giving the status (e.g., available, not available) in staying on site to give information in case of emergency updates (e.g., fire conditions) in case of safe observation position.

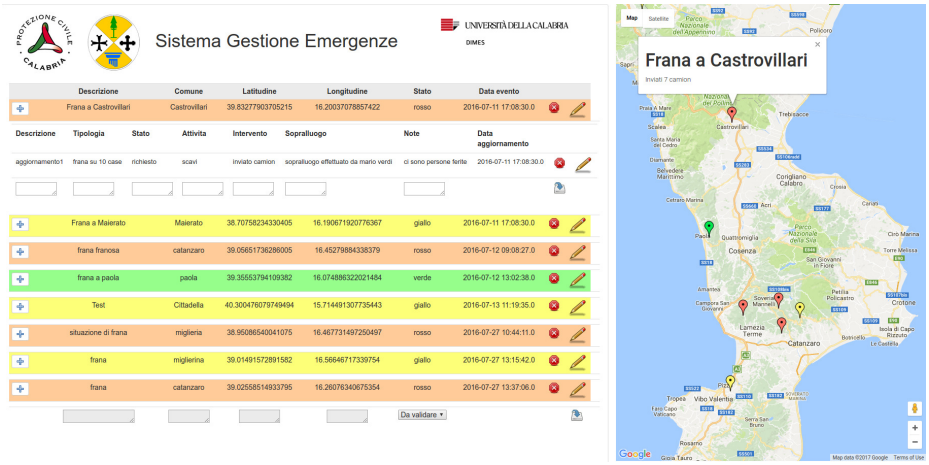

Fig. 3. Web user interface of the implemented Emergency Management Tool prototype

The workflow process has been designed by using a model called rasor model (standing for Rapporto Attivitá Sala Operativa Regionale) which contains information regarding emergency protocols. It contains alerting messages classification, municipality, location and closest emergency team for the event; type and status of the event; rescue team reports and emergency updates; resource details and emergency status time tracking; final reports. The database has been designed using such a schema (a snapshot in italian is reported in Figure 4). It maps the rasor model where emergency signaling regarding reports on new emergency are annotated by PCR operators.

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REPORT SU NUOVE EMERGENZE SEGNALATE DURANTE IL TURNO DI SERVIZIO E AGGIORNAMENTI CIRCA EMERGENZE IN ATTO

DATA Inizio evento	ORA Inizio evento	DATA Ultimo aggiornamento	ORA Ultimo aggiornamento	STATO EVENTO (colorazione che indica la gravità dell'evento all'ultimo aggiornamento)	FONTE Ultimo aggiornamento	COMUNE	PROVINCIA	LOCALITA' LATITUDINE LONGITUDINE	TIPOLOGIA EVENTO, E CRITICITA' PRINCIPALI	Tipologia attività richieste alla SOR	DETTAGLI

Fig. 4. Extract from the Rasor Intervention Model used to map the emergency interventions information

Finally in Figure 5 we report the database schema used to map the information related to the resource and rescue management.

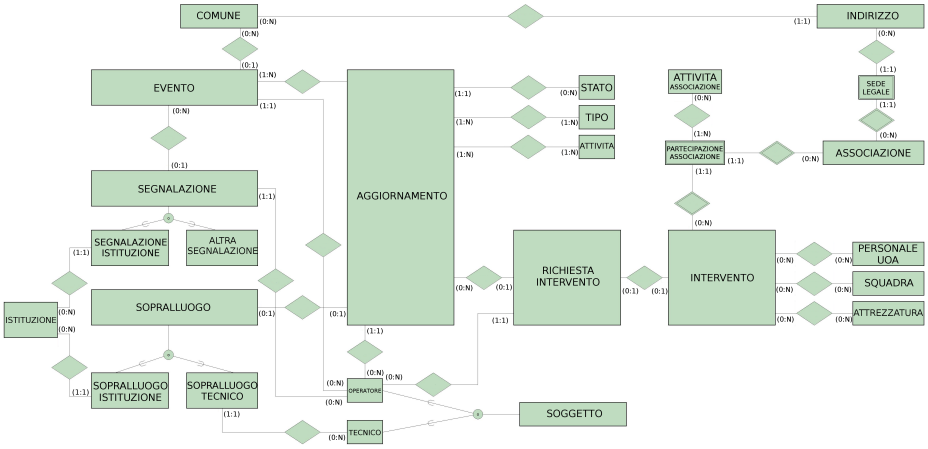

Fig. 5. Extract of the Database Schema to map the emergencies

4 Use Case and applications

Firstly, we report a typical use case implemented by the PCR incident rooms in an emergency, at present time: (*i*) an emergency call arrives at one of the incident rooms by phone; (*ii*) the operator asks for details and compiles the paper registry (which is a non-shared distributed resource); (*iii*) the operator is in charge of distributing the news by phone to the other incident rooms; (*iv*) the decisor (e.g., PCR's Director) plans the intervention(s) and orders the teams to intervene on site; (*v*) the various teams give feedbacks on the intervention status back to the incident room via phone.

We here report some use cases implemented with the system to automatize the use case shown above and others encountered during the requirement analysis for the PCR.

Gathering emergency calls. Currently PCR has already implemented a number of initiatives for the dissemination of competence information through the use of social networks in addition to more traditional communication channels. In order to ensure similar fruition and the maximum possible dissemination of information, the system acquires calls and information coming from web based communication channel (mobile one). Furthermore, the mobile interface will be integrated with the most used social networks (i.e., facebook, twitter) but also the backend will gather comments and enquiries coming from the PCR social network pages and analyze them, rendering ad-hoc statistics on the system dashboard for the PCR management.

Managing resources. As part of the reorganization of the management of mobile vehicles, the system offers a fleet management module to provide an additional flow of information of great importance in the management of emergency situations. Modeling of minimum risk routes is still an open research topic, as well as the development of algorithms to simulate scenarios on networks.

Fire management System. Information regarding fire events, are acquired from an already existing module and the information is mapped on the dashboard with the location as well as the sequence of intervention updates.

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