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# CroSafe: an Online Social Network for helping the Emergency Mitigation phase through Crowdsourcing

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*To the people who can stand me*
*and still have the will to support me*

# Abstract

According to many, social media and mobile technologies are changing our approach to many everyday situations, opening to the possibility of crowd-sourcing data upon a wide range of issues.

While this usually means getting to know what the *crowd* thinks of a brand (i.e. Sentiment Analysis), or allows us to create common knowledge out of an indefinite number of people (i.e. Knowledge Sharing), there are researches which focus on the interaction between social medias and the cycle of Emergency Management.

Some processes, such as the recent economical crisis, together with the amount and heterogeneity of hazards to be faced, sped up the need for Authorities to find new methods for dealing with an emergency, in all of its phases.

This work focuses on one phase, specifically the Emergency Mitigation phase, which acts pre-emptively in order to try and avoid hazards from bursting out into emergencies or at least restrain the damage caused.
Even though this is the most cost effective phase, its indefinite duration and high level of uncertainty (a risk may never leave its dormant state), make it more and more present as an entry in budget cuts of administrations, both at a national and local level.

We therefore evaluate the possibility of creating an Online Social Network in order to crowdsource, using models implemented by established communities, data that may be useful to map and assess hazards to mitigate.

In order to make the community available to the highest possible number of people, we decided to narrow down the scope of hazards managed by the application to the ones we refer to, as “local” or “small-case”. Those are inherently local (i.e.: strike small portions of territory) and are easily identified by any typology of user, thus not requiring specific knowledge to the members of the community.

After an initial validation of the idea, obtained through literature review

and analysis of similar products, we outlined the main features that the online social network should have in order to maximize data quality and users' participation.
Subsequently, we asked 121 people to complete a survey in order to evaluate the characteristics identified, then we finally proceeded with the implementation of a prototype made up by a Web Application, available online through a web site, and an Android client that allows users to report hazards from their mobile device.

At the moment of writing, the community has been online just for a little less than three weeks, but the results already show encouraging hints that confirm the data gathered during the initial analyses.
We must say, though, that the prototype doesn't implement yet all the features identified throughout the work and, in order to have more reliable results, we should wait for the final release of the application with its mobile client(s).

We therefore think that this thesis contributes to the research concerning the interaction between Social Media and Emergency Management, under multiple aspects: it validates both theoretically and empirically the possibility of using crowdsourcing for Emergency Mitigation, therefore outlines the main characteristics of a tool to achieve such aim and shows the implementation of an application coherent, although partially, with the characteristics traced by our analysis.

# Sommario

Secondo molti, i social media e le tecnologie mobili stanno cambiando il nostro approccio anche alle più comuni azioni giornaliere, rendendo possibile l'applicazione del crowdsourcing su un'ampia tipologia di compiti.

Ormai esso viene utilizzato per ottenere le opinioni delle persone a riguardo di un marchio (la Sentiment Analysis) o ancora per raccogliere e rendere pubbliche le conoscenze di un numero indefinito di utenti (Knowledge Sharing). Ci sono anche ricerche indirizzate all'analisi delle interazioni tra i social media e il ciclo di Gestione delle Emergenze.

Alcuni processi, tra cui la recente crisi economica, assieme alla dimensione ed alla eterogeneità dei pericoli che ci si trova ad affrontare, ha reso sempre più forte il bisogno, da parte delle Autorità, di trovare nuovi approcci per affrontare le emergenze in ogni loro fase.

Il seguente lavoro si concentra in particolare sulla fase di Mitigazione, che prova ad agire preventivamente sui rischi in modo da eliminarli alla radice o quanto meno diminuire i potenziali danni causati nell'eventualità si trasformino in emergenze.
Anche se questo approccio è certamente il più efficace dal punto di vista dei costi, la sua durata indefinita e la sua alta incertezza (un rischio potrebbe anche non trasformarsi mai in emergenza) rendono i piani di mitigazione una voce sempre più presente nelle liste dei tagli dettati dalle amministrazioni, sia a livello nazionale che locale.

Valuteremo, quindi, la possibilità di creare un Online Social Network che renda possibile fare crowdsourcing, utilizzando modelli implementati da comunità di successo, di dati utili per mappare e valutare rischi da mitigare.

Per rendere la comunità il più possibile aperta a tutti, abbiamo deciso di restringere la tipologia di rischi gestiti dall'applicazione a quelli che definiamo "locali" o di "piccola scala". Questi interessano una porzione locale di territorio e possono essere identificati da qualunque tipologia di utente non imponendo, in questo modo, alcun ostacolo all'ingresso della comunità.

Dopo aver convalidato la nostra idea, attraverso un'attenta analisi della

letteratura di settore e l'analisi di prodotti simili, abbiamo definito le principali caratteristiche che dovrà avere il social network per massimizzare la partecipazione e la qualità dei dati.
In seguito, abbiamo chiesto a 121 intervistati di completare un questionario per valutare le caratteristiche dell'applicazione ed infine abbiamo proceduto con l'implementazione di un prototipo, formato da una applicazione web, raggiungibile attraverso un sito internet, ed un client Android che permette agli utenti di fornire segnalazioni in mobilità.

Al momento della stesura, la comunità è online solamente da poco meno di tre settimane, ma i risultati ottenuti mostrano già segni incoraggianti che vanno nella direzione dei risultati ottenuti durante la fase di studio preliminare.
Dobbiamo dire, inoltre, che il prototipo non implementa ancora tutte le caratteristiche individuate nel corso del lavoro e, per avere dati più affidabili, dovremmo sicuramente aspettare il rilascio dell'applicazione completa e dei client mobili.

Crediamo, comunque, che il contributo di questo lavoro alle ricerche sull'interazione tra i Social Media e la Gestione delle Emergenze sia valido sotto molteplici aspetti: da un lato convalida teoricamente ed empiricamente la possibilità di utilizzare il crowdsourcing per la Mitigazione delle Emergenze, dall'altro definisce le caratteristiche di uno strumento per ottenere questi risultati e, infine, mostra l'implementazione di un'applicazione che, sebbene parzialmente, abbia le caratteristiche individuate dalla nostra analisi.

# Ringraziamenti

Desidero innanzitutto ringraziare chi mi ha seguito e guidato in questo lavoro: la prof.ssa Chiara Francalanci e l'Ing. Pierluigi Plebani. Senza di loro e i loro consigli, non sarei mai arrivato al punto di poter scrivere questi ringraziamenti.

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Non posso dimenticare gli amici di sempre, quelli che conosco da anni o quasi da una vita, quelli con cui esco, gioco, parlo, rido e mi diverto. Senza di loro, sarei solo.

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E infine ringrazio i miei genitori, che mi hanno sopportato e supportato durante tutti questi anni. Senza di loro non sarei qui.

Ah, ultimo ma non meno importante. Ringrazio me stesso e la mia testa dura. Hai visto? Alla fine ce l'hai fatta.

# Contents

# Chapter 1

# Introduction

> *"Emergency communications used to be very top-down, hierarchical and linear where public officials and experts were the one who pushed the information out [...] Now we have these new kinds of citizen communications tools that are decentralized, flat and lateral, creating the potential for a brand new way of communicating altogether."*
>
> Sutton, J. [86]

The World as a whole is going through an hard time: people feel endangered by their surrounding environment and the recent economical crisis, together with the amount and heterogeneity of the problems, doesn't allow the Authorities to manage the situation on their own, especially when it comes to implementing a long term plan for mapping and assessing risks on the territory.
Luckily a new actor is stepping on stage in the process of finding innovative solutions to this matter: the Citizens themselves.

Those people are nowadays empowered by technologies, such as mobile phones and internet connection, that are becoming more and more popular. Moreover, in the past few years, we witnessed a change which brought mobile phones to evolve into the so called smartphone, a device which embodies multiple functions into a single mobile platform.
Those functions include classical ones, such as calling and texting, with the addition of some advanced features, such as GPS, camera and video camera together with the ability of accessing a mobile broadband connection, thus allowing the user to share information and news as they happen.

This evolution changed both the sharing modality and the contents of data found online: any smartphone user can share, tag and verify news in real

time, while anyone with an internet connection can access this heap of information.
Moreover, the speed of information and media sharing has been greatly increased by *Online Social Networks*.

Almost everyone knows Twitter, Facebook, YouTube, Flickr and Foursquare, but researchers are still investigating how *valid* and *reliable* information extracted from these services may be, thus investigating crowdsourcing[1] as a way to obtain real time information over matters of interest.
Recently, some business possibilities have been investigated in this direction: among those, *Sentiment Analysis* [2] tools, Human Intelligence Tasks (v. Amazon MTurk) or even projects with public beta versions.
An exhaustive list of projects involving a crowdsourced side, is reported on Wikipedia (v. `http://en.wikipedia.org/wiki/List_of_crowdsourcing_projects`), a major crowdsourced project itself.

The aim of this thesis will be to build a tool for adding crowdsourcing to the ways used to gather data during the phase of Emergency Mitigation and more specifically to its sub-phase of Risk Mapping, therefore using computing systems and the *wisdom of the crowds* to add a *social* dimension to the prevention of emergency situations.

This goal will be achieved by means of an initial literature review, carried out extensively through publications focused on Online Social Networks, Crowdsourcing and Emergency Management, that will give ground to the implementation of the innovative application proposed by this work.

Subsequently we will outline the main characteristics of the application itself and finally proceed with its implementation, in the form of an Online Social Network for crowdsourcing geo-located Hazards directly from local people, thus creating an updated map that shows spots of possible Risks as reported and validated by the local community.

At the moment of writing, the community has been online just for a little less than three weeks, but the results already show encouraging hints that confirm the data gathered during the initial analyses.
We must say, though, that the prototype doesn't implement yet all the features identified throughout the work and, in order to have more reliable

[1] **Crowdsourcing**: the act of sourcing tasks traditionally performed by specific individuals to an undefined large group of people or community (crowd) through an open call. [93]

[2] **Sentiment Analysis**: refers to the application of natural language processing, computational linguistics, and text analytics to determine the attitude of a speaker or a writer with respect to some topic or the overall contextual polarity of a document. [95]

results, we should wait for the final release of the application with its mobile clients.

Anyway, results reported by the literature, such as the success of the Ushahidi platform and Boston's Citizens Connect, together with a useful mail exchange both with the Director of Community Engagement of Ushahidi and the co-chair of Boston's office of new Urban Mechanics, confirmed that Crowdsourcing in Emergency Management works and that some of the most innovative and active communities for Social Emergency Management are actually considering similar tools for Emergency Mitigation and Hazard Mapping.

The most innovative elements that this work will bring to the research area, are the focus on the Mitigation phase (where most of the active projects focus on the Response and Recovery phases) and the idea of using the typical engagement elements present in the Online Social Networks, to the scope of Emergency Management in its less time–dependent phase.
This approach tries to push users into a long–term interaction with the application, thus allowing the creation of a constantly updated geo–tagged collection of reports of possible Hazard spotted on the territory, leveraging on the high accuracy of data usually produced by users who have the feeling of doing something useful for the others (i.e. helping the community to mitigate Emergencies).

This thesis is structured as follows.
In Chapter 2, we introduce the current state of the art about Emergency Management, Crowdsourcing for Emergency Information and Online Social Networks, pointing out the main entries in the literature, which justify the development of this work.
In Chapter 3, we formally define the problems present in current solutions, thus setting up the solution represented by the work at hand.
In Chapter 4, we describe the technologies used, the requirements of the application (elicited through Use Cases) and finally the functionalities present in the resulting prototype implementation.
In Chapter 5, we introduce the high level Architecture of the system, together with a more in-depth Design analysis of its main modules .
Finally, in Chapter 6, we sum up the work, discuss about current result achieved by the prototype and suggest further directions of work.

# Chapter 2

# State of the Art

> *"It is recognized that while a top-down policy is needed, it is really the local-level bottom-up policy that provides the impetus for the implementation of mitigation strategies and a successful disaster management process."*
>
> Pearce, L. [64]

This work will tackle the problem of Crowdsourcing Information for the Emergency Mitigation phase from multiple sides: it will try and understand whether and how using an Online Social Network can help such an important stage of Emergency Management while outlining some interaction models that can help building an effective tool for collecting updated and valuable data.

Chapter 2 will therefore reflect the aforementioned division and introduce the topics and their current state of the art, as found in literature, in sections 2.1 to 2.4.

Section 2.5 will conclude Chapter 2 by summing up the conclusions emerged from the literature review thus introducing the *literature gap* where the current work will be carried out.

## 2.1 Emergency Management

The following section will introduce the cycle of Emergency Management as a whole, by describing its classical implementation as found during the literature review.

### 2.1.1 The Emergency Management Cycle

Emergency Management has its roots in ancient history: as [64] says, *"As long as there have been disasters, individuals and communities have tried to find ways to fix them, but organized attempts at disaster recovery did not occur until much later in modern history."*

Unlike other more structured disciplines, it has expanded and contracted in response to events, technologies and leaderships.
For example, both the terrorist attacks of September 11, 2001 and the Hurricane Katrina in 2005 brought dramatic changes to emergency management as proposed by the United States' FEMA[1].

A simple definition for emergency management is the one reported in [64]: *"[Emergency Management is] a discipline that deals with risk and risk avoidance."*
Risk represents a broad range of issues and includes an equally diverse set of players, thus the range of situations that may represent an emergency is extremely broad and touches a lot of everyday situations in everybody's life.

Back in the 1960s, a seminal study defined Emergency Management as a cycle of Preparedness, Response, Recovery and Mitigation.
We will introduce in the following subsections each and every phase as presented in the introductory book *"Introduction to Emergency Management"* [41] (cf. Figure 2.1).

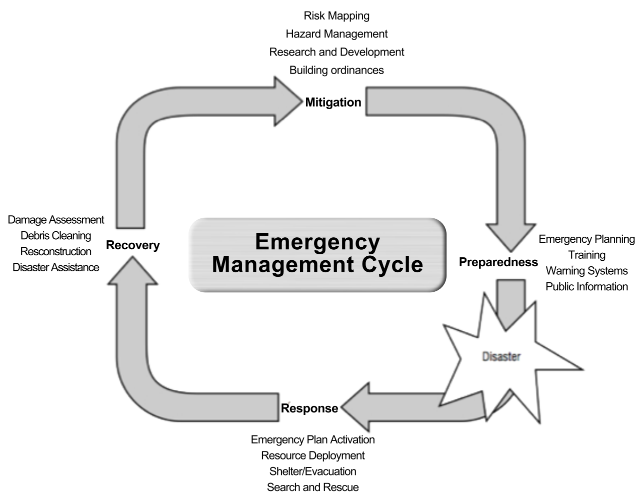


*Figure 2.1: The Emergency Cycle Management*

[1]FEMA is an acronym for Federal Emergency Management Agency, the agency that takes care of Emergency Management on the US soil

### Preparedness

Preparedness in the field of Emergency Management is defined as the state of readiness to respond to any kind of emergency situation.

Preparedness has advanced significantly throughout time and no emergency management organization can work without a strong preparedness capability: the capacity to respond and recover from emergencies and disasters is developed only through planning, training and exercising. Those are the heart of the preparedness phase.

Preparedness itself, too, is made up by different cyclic steps, as outlined in the Figure 2.2.

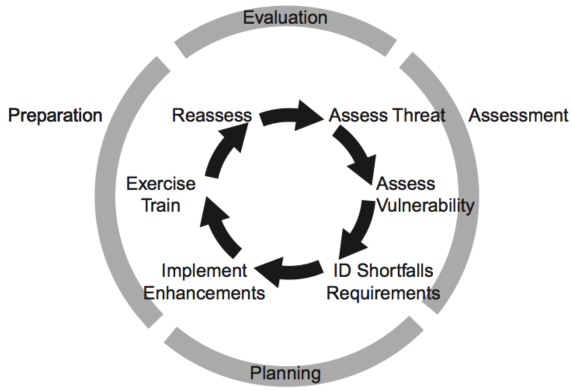


*Figure 2.2: The Preparedness Cycle*

The preparedness cycle begins with the creation of various plans through which disaster response and recovery becomes possible. Plans are strictly connected to the emergencies that are likely to happen, so this step is strictly connected to the Mitigation phase (see Mitigation). A lot of time is spent on planning and this may be the most crucial step in the preparedness phase, whose output is an *emergency plan*.
The second step consequently organizes the equipment and infrastructures that are required for the plan to actually succeed. Priorities must be given in this step (as the demands always exceed the funds) or new approaches must be tested (e.g.: sharing equipment that's rarely used, developing cheaper technologies, etc.).
Afterwards people must be trained to adhere to the plan at every level. Fire fighters and policemen must know how to act in case of an emergency, but also citizens must know how to behave correctly. Spreading this knowledge to everyone is one of the aims of Emergency Management: citizens who

know what to do, will react better upon disasters.
Strictly connected to training, is exercising upon plan in emergency simulations. "Practice makes perfect" is the motto of this step.
Final step is the evaluation of the performance of the plan as applied to simulations and real emergencies. This step then applies the knowledge gathered by this evaluation to modifying the previous steps in the preparedness phase, in order to improve the response to the emergency.

### Response

The response phase starts when a disaster event (or even a simple emergency) occurs: the first responders, apart from local citizens, are usually local police, fire and emergency medical personnel.
This work will use the division pointed out by [41] that defines the Response phase as "the immediate actions to save lives, protect property, and meet basic human needs".
When local authorities cannot handle successfully the situation, the emergency will turn into a disaster and the support of national or even international agencies is needed for rescue, securing and restoring order in the affected areas.
This is usually the phase where emergency plans, prepared and tested in the preparedness phase, are actually used and adjusted to meet the specific running emergency.
Communication in this phase is fundamental, both among rescue teams (the bigger the emergency, the more agencies will take part to the emergency response and the higher the need of communication for coordination will be) but also between authorities and struck populations.
The latter kind of communication is especially made possible nowadays, thanks to cheap and widespread technologies (i.e.: cell phones and medias) that make possible for populations to help themselves mainly during disasters that cannot be easily handled by authorities because of their extraordinary strength and wide range of population affected.
Although, as reported in [41], [91], [58] and FEMA press releases, authorities are evaluating the use of social media and new technologies for emergency response, mistrust and the lack of a precise roadmap is holding back this technological revolution even if, we must say, new technologies are being independently developed, thus not officially used in emergency plans, by companies such as Ushahidi.
One of the disasters more analyzed in literature is the earthquake that stroke Haiti in January 2010. That was, in fact, the first disaster that witnessed

the use of many independent projects that tried to use crowdsourcing for disaster relief.
An introductory overview upon these projects will be presented throughout Subsection 2.2.4.

#### Recovery

The division between the Response and the Recovery phase has never been clear: theoretical debates have been raging about when the response function ends and the recovery function begins.
The current work will use the response definition stated in the Response paragraph, while the Recovery phase cannot be so easily classified: it usually starts early, even overlapping with the Response phase and then continues for weeks, months and even years, depending on the severity of the event.
Moreover, while the Response phase is dominated by a single aim (i.e.: saving endangered populations), the recovery function is characterized by a complex set of issues and decisions that must be made at different levels by individuals and communities.
Those decisions involve resolutions relative to rebuilding homes, replacing property, resuming employment, restoring businesses, and permanently repairing and rebuilding damaged infrastructure. Every decision must be taken, carrying out a trade-off between immediate issue resolution and long-term goals to reduce future vulnerability.
Ultimately, since the Recovery phase has such long-lasting effects and usually high costs, the participants in the process are numerous. They include all levels of government, the business community, political leadership, community activists, and individuals. Each of these groups plays a role in determining how the recovery will progress but a lack of planning may result into complete failure of the whole Emergency Management cycle as partially happened in the rebuilding of the Italian city of L'Aquila [75].

#### Mitigation

To begin with, we'll outline the basic difference between Mitigation and Preparedness since the two phases, even though intrinsically different, are often confused, mainly because they often partly overlap in the Emergency Cycle.

In most simple terms, Mitigation efforts are attempts to prevent *hazards*

from developing into *emergencies* or *disasters*[2] altogether or to reduce the effects of disasters. Those efforts are of undefined duration, and may theoretically last forever if the hazard never leaves his dormant state, or if its root is completely removed.
Therefore in this phase, unlike for the Response phase, we don't need immediate response to requests.

Preparedness, on the other hand, seeks to improve the abilities of agencies and individuals to respond to the consequences of a disaster event once the disaster event has occurred. Preparedness assumes the occurrence of an event, whereas mitigation attempts to prevent the event altogether.

All the phases of Emergency Management, and especially the Mitigation phase, are the premise for Emergency Management to be integral to the concept of *safety* of every citizen.

The concept of *safety* can have many different meanings. The Concise Oxford Dictionary defines it as *"freedom from danger and risks"*, while the Merriam–Webster Dictionary describes safety as *"the condition of being safe from undergoing or causing hurt, injury, or loss"*.

According to etymologist Douglas Harper, the word safe first came into use in the English language around 1280, derived from the Old French sauf, which in turn stemmed from the Latin salvus, meaning "uninjured, healthy, safe". The Latin word is related to the concepts of salus ("good health"),saluber ("healthful"), and solidus ("solid"), all derived from the Proto–Indo–European base word *solwos*, meaning "whole". Thus, at its root, the concept of safety revolves around wholeness and health. [59, 25]

Being such an interdisciplinary concept, safety is commonly viewed through the lens of specific domains.
For example, injury prevention researchers have defined safety as *"a state or situation characterized by adequate control of physical, material, or moral threat"* which *"contributes to a perception of being sheltered from danger."*

It's right due to the multitude of views on the definition of safety, that a collaborative effort was launched in 1996 by two World Health Organization (WHO) Collaborating Centers on Safety Promotion and Injury Prevention, sponsored by the Ministry of Health, Quebec, Canada, and Karolinska Institute, Stockholm, Sweden.

[2] An emergency is a deviation from planned or expected behavior or a course of events that endangers or adversely affects people, property, or the environment.
Disasters are characterized by the scope of an emergency: an emergency becomes a disaster when it exceeds the capability of the local resources to manage it. [48]

Their intent was to develop international consensus on the conceptual and operational aspects of safety and safety promotion. The result was published in a document in 1998, entitled *"Safety and Safety Promotion: Conceptual and Operational Aspects"*.

The resulting definition of safety is the following:

*"Safety is a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community. It is an essential resource for everyday life, needed by individuals and communities to realize their aspirations."* [55]

It's still clearly a really generic definition, but it clearly points out two aspects:

- The connection between safety and Hazards
- The importance of safety for everyday life both of individuals and communities

We will continue by pointing out two more definitions, upon which the thesis work will be built.

**Hazard**

An Hazard is defined by the United Nation International Decade for Natural Disaster Reduction (UNISDR) as it follows:

*"A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage".* [99]

What an Hazard may lead to, when uncontrolled and through an Incident, is a so called Emergency or Disaster. The difference among the two, is highlighted in the footnote of page 10.

When such a situation breaks out, the Authorities are forced into moving on with the Response phase of the Emergency Management cycle outlined in the previous sections.

To avoid this outburst of an hazard from its dormant/potential state (with only a theoretical risk of harm) into an active state (where it can create an emergency situation), we must focus on the Mitigation phase, as suggested in literature [65, 71].

**Risk**

The concept of Risk is strictly connected to the one of Hazard. A simple and clear equation connects the two concepts through the Exposure term that identifies the the population's vulnerability to the Hazard.

$$\textbf{Risk} = \textbf{Hazard} \times \textbf{Exposure}$$

Thus, the higher the risk, the more urgent the vulnerabilities to the hazard must be targeted by the mitigation and preparedness phases.
If, however, there is no Exposure then there will be no risk, e.g. an earthquake occurring in a desert where nobody lives.

In 1997, after some deep changes inside the FEMA, an important step in disaster mitigation was launched through a project, called Project Impact: Building Disaster-Resistant Communities.

This project was designed to mainstream emergency management and mitigation practices into every community in America. It went back to the roots of emergency management. It asked a community to identify risks and establish a plan to reduce those risks. [41]

The project was suddenly shut down by the Bush administration in 2001, but its results became visible shortly afterwards, when a 6.8 magnitude earthquake shook Seattle (WA), one of the most active Project Impact communities, and its mayor appeared on national television giving Project Impact the credit for the minimal damage from the quake.
When vice president Dick Cheney was asked why the program was being eliminated, he responded that there had been doubts about its effectiveness. Shortly after, Congress put funding back into Project Impact.

Back to the present, in October 2011, the Administrator of FEMA, Craig Fugate, was the first to mention the use of social media in the future roadmap of the Agency: its failure during the outbreak of hurricane Katrina and fund cutting due to the focus moved to Terrorism (through the Department of Homeland Security), clearly sought for deep renewal inside the agency and, as Fugate said, *"We now leverage cutting-edge technology as well as important social media tools to communicate in a more effective and dynamic way."* [22]

To complete our introduction, we will use the FEMA's new Risk Mapping, Assessment and Planning[3] project (Risk MAP [30], cf. Figure 2.3) in order to show how the mitigation phase, too, can be seen as a cycle of actions taken in order to mitigate hazards.

The main phases identified by Risk MAP are:

1. **Identify Risk**: a risk on the territory is identified and possibly mapped through any available mean

2. **Assess Risk**: risks mapped in phase 1. are therefore assessed by specialists who evaluate their actual level of risks to the society

3. **Communicate Risk**: communication and sharing of risk data and related products (mitigation and emergency plans), is carried out to all levels of government and the public, through available technologies

4. **Mitigate Risk**: the risk mitigation itself is aimed to eliminate or reduce the long-term risk to life and property from natural and technological hazards


*Figure 2.3: The Mitigation Cycle*

[3]Risk MAP is a project launched in 2010 to map, assess, mitigate and increase social awareness on the flooding risks all over the United States of America. We generalize its vision (which, anyway, doesn't carry any flood-specific element) to be used with any risk mitigation-related action.

## 2.2 Crowdsourcing

The section will define Crowdsourcing, present some scopes of application found during literature review and introduce a new systematic approach to categorize Crowdsourcing application.
Moreover, subsection 2.2.4 will present the works that deal with Crowdsourcing for Emergency Management, pointing out where the current work may fit as a new approach to this extremely actual problem.

### 2.2.1 Definition and History

The term *Crowdsourcing* is a relatively new term: it first appeared in a 2006 Wired issue. The article was mainly about the rise of crowdsourcing, told by four different points of view [42].

As the article author himself noticed, in a blog post shortly after the article was published in June 2006, the term *Crowdsourcing* *"it's starting to appear without reference to me or the original article in Wired"* [26].

Moreover, the same blog entries tries to give a definition to this neologism. Crowdsourcing is then first defined in the following way:

*"Simply defined, crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals. The crucial prerequisite is the use of the open call format and the large network of potential laborers."*

Moreover, in the same Wired article, the author wishes to underline how Crowdsourcing is different to the "old" Outsourcing, through the words of an InnoCentive's[4] loyal customer:

*"Outsourcing is when I hire someone to perform a service and they do it and that's the end of the relationship. That's not much different from the way employment has worked throughout the ages. We're talking about bringing people in from outside and involving them in this broadly creative, collaborative process. That's a whole new paradigm."*

[4] As defined on Innocentive.com website, *"InnoCentive is the open innovation and crowdsourcing pioneer that enables organizations to solve their key problems by connecting them to diverse sources of innovation including employees, customers, partners, and the world's largest problem solving marketplace."*

Since 2006, crowdsourcing abandoned its initial business–related application, to become an multidisciplinary phenomenon that embraces fields of computer science, business and behaviorism. This scope change, brought to the need of a broader definition, once more suggested in [26]:

*"Crowdsourcing is the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call."*

### 2.2.2 Applications

Since there is no exhaustive study over the kind of tasks that can be crowdsourced (a good introductory publication with use cases can be found in [10] and a first attempt of categorization is in [77]), to better understand the phenomena of Crowdsourcing, we will proceed as most of the literature and introduce some of the best known use cases and applications.

| Name | Description |
|---|---|
| **Amazon Mechanical Turk** | Amazon Mechanical Turk (AMT) is a popular crowdsourcing marketplace, introduced by Amazon Inc. in 2005. It is basically an online marketplace for small tasks that cannot be easily automated (i.e. cannot be easily accomplished by a computing machine) and thus require human intelligence. In the marketplace, employers are known as requesters and they post tasks, called human intelligence tasks, or HITs. The HITs are then picked up by online users, referred to as workers, who complete them in exchange for a small payment, typically a few cents per HIT. AMT is basically an online crowdsourcing virtual labor platform that acts as intermediary between the demand of work time and its supply from the users in the crowd. [50] |
| **Wikipedia** | Wikipedia is a free, web-based, collaborative encyclopedia project. Its over 20 million articles have been written collaboratively by volunteers around the world. Wikipedia is an example of crowdsourcing project in which the task to be accomplished by the crowd is the collective writing and editing of articles. Moreover, Wikipedia is an example of crowdsourcing system unlinked to the business world: users in the |

| | |
|---|---|
| | crowd are volunteers and the reward mechanism is completely not monetary. [51] |
| **InnoCentive** | InnoCentive is an "open innovation" company that takes research problems in a broad range of domains such as engineering, computer science, math and business and frames them as "challenge problems" for anyone to solve. It gives cash awards for the best solutions to solvers who meet the challenge criteria. It is somehow similar to Amazon Mechanical Turk but the tasks that it proposes are of a different kind being complex scientific problems. Thus, the reward mechanism is different and much higher (in the range of tens of thousands of dollars). [2] |
| **Waze** | Waze is a social mobile application providing free turn-by-turn GPS navigation based on the live conditions of the road. Moreover, the maps used by the service are updated by the users themselves, who can report new streets, errors and directions of traffic together with reporting accidents, speed traps and other traffic related issues. To use the GPS navigation, the users have to install the Waze's software in their mobile phone, thus automatically building the traffic map for the community. A collection of algorithms is then used to aggregate this data and build a knowledge base. |
| **Boston's Citizens Connect** | Boston Citizen Connect is an application that allows citizens of the city of Boston, MA to report problems upon Boston's territory. Those report are categorized by the users, choosing the right kind of report from a list maintained by the City Hall of Boston, adding a brief description, an optional picture and the geographical location as automatically retrieved by the smartphone GPS module or selected from a map. The project was first launched in October 2009, on a low budget (25,000$) and many doubts: will the citizens use the service? Will the workers accept the reports? It turned out that, after two years, more than 12000 people downloaded the mobile application (Android and iOs version available) and as of October 2011, 14% of the request that come in to the City Hall, come |

**Boston's Citizens Connect**

through the mobile application (against the 66% that come through telephone and 20% through the website). Moreover, the application also has a Web based access, and reports can be submitted also through twitter, sms and web. [19, 18] As [20] pointed out *"Boston Citizens Connect app would only benefit the government if the information being submitted is a true issue"*. There is no unbiased study upon the data quality gathered by Citizens Connect, but Chris Osgood, one of the people in charge of the project, confirmed that, to his memory, no reports have ever been completely wrong (see Annexes B.1, B.2). Moreover [19] reports plans for the future of the application to expand to other departments in Boston, so that it sounds like the City Hall will continue the development of the application as it had a good success. Additionally the service provides a site for constituents to map and download stats on neighborhood issues, aggregating reports coming through all the communication means (mobile application, website and telephone).

### 2.2.3 A Systematic Approach

As we've noticed during the literature review on Crowdsourcing, most of the publications are mainly studies and reports over specific the use of crowdsourcing as applied to specific scopes: to give the work a deeper theoretical background, we will use the framework proposed by [69].

The work tries and clearly categorize 61 Crowdsourcing applications under various dimensions. This systematic and broad study will help us, first categorizing the crowdsourcing application for this paper and then finding the best patterns (especially for the incentives and community design) to maximize the user's satisfaction together with data quality.

Moreover, building the crowdsourcing application in a specific expertise (the one of voluntary work for the common good), we will also refer to [73], a study that empirically shows how crowdsourced workers tend to provide more accurate data when they feel like they're working for a good cause, while people who work under an (even small) payment, usually work faster but less accurately.

Subsection 2.2.4 will deal more in detail with the literature review about crowdsourcing in Emergency Management.

Thanks to those studies, we will give broad theoretical foundation to the design of our application which will then be built exploiting the successes and failures suggested by the literature review.

### 2.2.4 Crowdsourcing for Emergency Management

Lately, many literature entries have been pointing out how important Crowdsourcing may be for Emergency Management.

For instance [90] considers the possibilities for collective participation in the every phase of an emergency:

- **Prevention–Mitigation**: in this phase the knowledge about the area and the environment surrounding a potential emergency is necessary for identifying the problem itself, especially when it's set in an highly dynamic environment.
  So we may crowdsource information about dormant hazards right from the local community.

- **Preparedness**: in this phase experts already have a great amount of information on the potential emergency, so collective intelligence is not necessary.
  What may be useful here, is crowdfeeding[5] preparedness information to citizens.
  This can be achieved, for example, through a check–in based application or some games that may prepare people and also increase their participation in this phase [84].

- **Response**: during this phase, the emergency team is dealing with the situation as it evolves. The context is then constantly changing, thus it is important to keep up with these changes.
  It is hard, in such an environment, for a team alone, to keep up with multiple events that may occur (and that will increase with the size of the disaster). Therefore such information may be collected from the crowd: this approach is the most studied in literature, mainly through publications that analyze how different procedures behaved during real–world disasters.

[5] Crowdfeeding is the act of sharing information out to a large group of people or community, through an open sharing system.

One of the most studied disasters is the Haitian earthquake of January 2010: in that circumstance, many voluntary projects tried to help the authorities in Emergency Management. One of those projects was the 4636 project: since 85% of Haitians were reported to have access to mobile phones, and the mobile-network system, though heavily damaged, bounced quickly back on, the free number was created to gather text messages that reported help request and others, at a rate of 1-2,000 messages a day: those messages were written in the local language, carrying often information that had to be interpreted by people who knew by person the streets of Haiti and the local slang of different areas.
That is where Ushahidi volunteers helped: they translated and mapped help messages from local language (Creole French) to English, the language used by most of the rescuers. The median turn-around from receiving a message to having it translated, categorized, geolocated on an apposite deployment of Ushahidi[6] and streamed back to responders in Haiti was less than 10 minutes [58].
Another need in the aftermath of the disaster, that was addressed through crowdsourcing, was the need of a complete and updated public map of the Haitian area. This issue was solved by OpenStreetMap volunteers that used downloaded and public satellite images in order to trace and record the outlines of streets, buildings and other places of interest. Moreover, on-the-ground volunteers, using portable GPS devices, were able to upload additional information. Unluckily, different online mapping services were not cross-compatible thus making voluntary and uncoordinated efforts useful but not up to the degree they could have reached if all the work would have been focused on just one service [98].
Another connection made possible by using crowdsourcing and crowdfeeding in this phase, is the one among the citizens themselves: as [88] notices, in the aftermath of the earthquake that stroke the city of Christchurch (New Zealand) on the 22nd of February 2011, many citizens opened up their private wells, for people to use the water for washing and drinking after boiling. Word of mouth did the job for people living in the surrounding areas, but through a system of Proactive Crowdsourcing, they could have created a resilient service that

[6] Ushahidi (`http://www.ushahidi.com`) is a no-profit company that developed an open-source software, used for the first time in the aftermath of the kenyan elections of 2008, to create reports to testify emergencies on a territory, by categorizing and mapping them on a public interactive map.

would have helped citizens even before the authorities intervention.
A similar approach was the one analyzed by [83] during the Haiti earthquake: a group of volunteers began analyzing the tweets related to the disaster, and re-tweeted after cleaning and applying some hashtags[7] to make them easily spottable both by an automated system and by other citizens. Unlike Ushahidi they operated using just the tools of an existing and well-established social network (i.e. Twitter).

- **Recovery**: in this phase, we may crowdsource information about the surroundings of the stroke area, in order to see what isn't functioning as it should, and dispatching proper help to these locations. Those reports could be mapped and would help better planning and prioritizing the recovery operations.

## 2.3 Online Social Networks

Publications dealing with the analysis of Social Networks (*Social Network Analysis* – SNA) in its "classical" form (i.e. regarding networks of social relationships, regardless of their on/off–line status), appear in a wide and multidisciplinary range of papers and journals.
A chronological analysis points out a steep increase in official publications since 1981. In the following years we witness a growing differentiation in the research areas linked to the publications, therefore pointing out different research branches for different scientific areas. [61]

Since the increase of publications, many works dealing with the Mathematic and Computer Science aspects of *SNA* are present outside its sociological dimension.
Mathematics tries to formalize this area through the application of the *Graph Theory* to social networks [8], while Computer Science tackles the problem from a different side, which can be synthesized by the following sentence: *"When a computer network connects people, it is a social network. Just as a computer network is a set of machines connected by a set of cables, a social network is a set of people (or organizations or other social entities) connected by a set of socially-meaningful relationships." [92]*

Between the 1990s and the beginning of 2000s, we witnessed the birth of the first *Online Social Networks – OSN* carrying advanced functions for the

[7] As defined by the Twitter Help page *"The # symbol, called a hashtag, is used to mark keywords or topics in a Tweet. It was created organically by Twitter users as a way to categorize messages."*

management of online relationships and the ability to easily find and connect to friends and acquaintances (some of these epoch-making programs' names are SixDegrees.com, Friendster and MySpace [9]).
These new functionalities allowed the spreading of these *OSN*, a trend that still continues nowadays [16, 9]. This impressive rise in user numbers caused an increase of interest also by the researchers, who approached the *OSN* with curiosity and with the impression that their impact on modern society could be fundamental [16].

We therefore find in literature researches about *OSN* ranging from the analysis of the dangers connected with the, often unaware, spreading of personal data through their pages [52], to the opportunity (and maybe, nowadays, need) of using such public data for obtaining better results in online queries and generating quasi real-time *Sentiment* regarding brands [63].

The topics upon which literature entries can be found in the scope of *OSN* is way vaster than the short list just outlined. A more exhaustive listing, though, lies outside the aim of this work.

The following subsections (2.3.1 – 2.3.5) will introduce the main *OSN* present nowadays, outlining their main characteristics.

### 2.3.1 My Space

MySpace (currently known also as My_____) is one of the first successful *OSN*: it appeared first during the year 2003, and lived its period of "glory" between 2005 and 2008 [35].

Since 2008, the company is undergoing a major crisis, with high users' loss and multiple changes in its management. Some researchers (among which [87]) analyzed carefully this phenomena, as the first and most notable example of shrinking *OSN*.

The motivation for interests' loss among the users of MySpace is not yet completely clear, but it's certainly affected by multiple factors (lack of appeal in the website itself, little innovation brought during the years, generic deficit of usability, etc.).

Something appears clear enough throughout the analysis, though, and this is a sudden decrease of daily accesses in conjunction with the rise in popularity of Facebook [87].

Operating in a Networked Market[8], MySpace followed the development of a product which, being unable to stand out and introduce something new with respect to the *best in class* (i.e.: Facebook), fell victim to typical behavior of *Winner Takes All* [27].

On June 29, 2011, Myspace was sold to Specific Media and Justin Timberlake for approximately $35 million [37], *"far less than the $580 million News Corp. paid for Myspace in 2005"* [78].

### 2.3.2 Facebook

The history of Facebook is the one of a Social Network released for the first time as "The Facebook" in the Harvard University local network on February 2004.
Since its release, it chalked up a series of impressive statistics: within 24 hours, already 1200 Harvard student signed up and, after one month, over half of the undergraduate population had a profile.

The network was then extended to other Boston universities, then to the Ivy League universities and eventually to all the universities in the US.
August 2005 was a milestone in the history of the Social Network, as it turned its name to Facebook and then moved to its newly bought domain "facebook.com".
September 2006 brought another important event to Facebook, when the registration was extended to anyone with an email address.

During the upcoming years, its founder and president, Mark Zuckerberg, refused to sell his *OSN*, opening his way into becoming the world's youngest billionaire in 2008 [68, 38].

In the same year, Facebook was the fastest growing *OSN* and, year after year, it climbed into reaching 800 Million users in September 2011, as reported in the Wikipedia page, which analyzed the official Facebook blog entries since August 2008 [94].

The reasons for the success of Facebook are not entirely known, nor will probably ever be, since they're a mix of multiple factors most of which cannot be further analyzed for their intangible contributes, but some studies pointed out how one of the reasons for people to keep on using Facebook is

[8]According to Shapiro, all Networked Markets "*have a fundamental economic characteristic: the value of connecting to a network depends on the number of other people already connected to it*". [80]

the high degree of satisfaction reached upon the users' needs on the Social Network: need for maintaining offline contacts, information seeking and entertainment [81].
One of the most outstanding abilities Facebook has, is the appeal it has to over 30 years old users, which in fact represents the fastest growing age group inside the *OSN* [15]. This suggests the presence of information and interaction modes on Facebook, that are of interest for this age group.

Still, in May–June 2011, Facebook witnessed a decrease in user's numbers in areas (i.e.: the US) that host the most resilient users' community for the Social Network [40, 60].
Even though Facebook wasn't officially worried by the results of the study, it introduced, throughout 2011, some major updates to its platform [28], latest of which a complete visual upgrade from the classic "Wall" view, to the new "Timeline" view [29].

This aspect, points out one of the main successful abilities of Facebook, common to others successful Web Applications: the ability of understanding the users' need and carrying out innovations in order to satisfy those needs. This point is, as a matter of fact, critical to the success of Facebook (as well as other *OSN*) [81].

Moreover, as in the case of MySpace and all the *OSN*, Facebook operates in a Networked Market, and the so called "bandwagon" effect cannot be left out while examining the reasons for its success: people use Facebook because everyone else is and they don't want to be left out [13].

### 2.3.3 Twitter

The history of Twitter differs from the one Facebook in, pretty much, everything. While the latter comes from an intuition of a student in one of the best Universities in the world, the first comes from a daylong brainstorming session that had to "reboot" or reinvent a former podcasting company, called Odeo.

During this session, Jack Dorsey had a new business idea: the creation of a *"service that uses SMS to tell small groups what you are doing"*.
The first use case that was thought, was city-related: *"telling people that the club he's at, is happening"*.
It was March 2006, and *twttr* (the former name of Twitter) was born. [54, 96]

Since then Twitter developed a main characteristic, that makes it really useful for real–time analysis of event in an online Network: *"Twitter usage* *noticeably spikes during disasters and other large events"* [57].

This characteristic, and the fact that Twitter is the second most used Online Social Network as in Q3 2001 with around 300 million users [32], arouse the researchers' interest.
Many studies have been published dealing with Twitter, and their main focus sweeps from simply categorizing the users and understand why they tweet [47], to evaluating the use of tweets in fields like sentiment analysis [62], real time news recommendation [67] and emergency management [57], just to mention some.

As we've seen, both the initial idea of the project and the analysis over everyday use, show how Twitter differs from Facebook: the first, in fact, is a so called "micro-blogging" Social Network, where users can exchange information, news and update each other over current happenings by 140 characters-long messages while the second, as introduced in subection 2.3.2, is mainly used for keeping offline acquaintances updated and generic entertainment.
This allows Twitter to survive inside the Networked Market of *OSN* dominated by Facebook, thanks to its difference and complementary aspects with respect to Facebook.

### 2.3.4 LinkedIn

LinkedIn (also known as LI) is a completely different kind of Online Social Network, more business-related and with a focus on professional information: it encourages users to construct an abbreviated CV and to establish "connections".
Profiles are strictly professional, with little or no information about hobbies, political or religious affiliations, favorite music, books or movies included.

A core notion is that members can explore the direct connections of their connections. More distant LI members can be approached via an introduction forwarded through the shortest chain of intermediaries. Paying members can search for LI members meeting certain occupational or other characteristics, which is particularly useful for recruiters or consultants.
Like a CV, a person's LinkedIn page is relatively static apart from new connections. Most people do not frequently visit their site or those of friends.
LinkedIn does not recruit students and focuses on people looking for a job, business professionals and recruiters. [82]

Stating more than 135 million users (as of November, 2011) [14], the Network fits nicely into the Market of *OSN*, aiming to the needs of professionals and reaching out users over 50 years old, being its use well tolerated on the working place. [82]

### 2.3.5 Foursquare

Foursquare is yet another kind of Online Social Network, namely location-based [76], and it differs from the ones mentioned above for two main reasons: it revolves around the use geo-localization in its everyday use and, given the intrinsic aim of the application (which will be explained in detail in the following paragraphs), it cannot be fully enjoyed without using its mobile client.

It's a newcomer in the market of Online Social Networks, as it was first sketched in fall 2008 by Dennis Crowley and Naveen Selvadurai and officially presented at the SXSW in 2009 [36]. Since then, it rouse to being the market leader in location-based services, reporting 6 million user in January 2011 and more than 15 million users as of December 2011 [76, 36], thus almost increasing threefold its user base in roughly one year.

Foursquare describes their service as a *"[a service that makes] the real world easier to use. We build tools that help you keep up with friends, discover what's nearby, save money and unlock deals. Whether you're setting off on a trip around the world, coordinating a night out with friends, or trying to pick out the best dish at your local restaurant, foursquare is the perfect companion."* [36].

Users can check-in to locations through their mobile clients (checking through computer is available just accessing the mobile site through the browser) to say that they are currently there. When doing a check-in, foursquare examines the user's current location (retrieved by GPS or Network location) and shows a list of nearby places. Users can also register new places, by adding details such as name, address, contacts and, most importantly, a category among the ones present in the application.

When users check in to a place, a notification is by default pushed to their foursquare contacts. People can choose to be notified of all check-ins by their contacts. At the time of the check-in, users can also decide if they want to check-in off-the-grid, in which the check-in is recorded by foursquare but not shared with contacts. This is an important feature to help preserving the privacy of Foursquare's users.

People can also connect their foursquare account to other online services, such as Facebook and Twitter, and have their check-ins be announced on these services. Users who have checked-in to a place can also see who else has recently checked-in (the so called *"Who's here"* functionality). Users can also allow local businesses to view checkins to their location.

The game aspect of foursquare offers virtual and tangible rewards for check-ins. Virtual rewards come in the forms of points, badges, and mayorships visible in one's public profile. Badges are awarded for a variety of reasons, e.g. for starting to use the service, checking-in on a boat, checking-in with 50 people at the same time, or checking-in at a special event and many more that are constantly added by Foursquare's developers.

Mayorships are awarded to a single individual for having the most check-ins in a given place in the past 60 days, where only one check-in per day is counted. Some companies offer discounts for mayors, e.g.: some coffee shops offer discounts on coffee.

Foursquare also enables social recommendations through tips, a small snippet of text associated with a place. Tips are intended to suggest possible activities for that place. Tips can be voted by users, by marking them as "done" when they consider them useful.

Many researches have been published since 2008, dealing with the Foursquare phenomena and location based services, mainly discussing the rise of this kind of services after a partial failure of the first wave of location–based products [5] (Foursquare itself is the second iteration of an idea by Dennis Crowley, called Dodgeball, bought by Google in 2005 and shut down in 2009 [44]) or simply trying to predict the future of location-based services [89].

But, to better understand the usage patterns of Foursquare, some studies focused on what pushes users to overcome the intrinsic fear of privacy loss, historically connected to location-based services, and make them use Foursquare.
The results of [53], show that many of Foursquare's stated design goals were repeatedly listed as reasons to using the application by interviewed Foursquare's users, suggesting that the application is succeeding in achieving its design goals.

Among these reasons, friends' updating and making was mentioned by 80% of the people taking part in the survey, while more than 50% mentioned places discovering, location history, game mechanism (badges and points) and discounts as primary reasons for using Foursquare.

Another strong incentive for checking-in (or better not checking-in) was self representation: one participant stated that *"[I don't check-in to] Fast food.*

*It's embarrassing to be seen there."* while another one said *"Checking in at fast food restaurants too often is embarrassing"*.
We can therefore safely state that people actually care about their self–online–representation, especially in networks that connect them to their friends.

Moreover, even thought the sample used in the aforementioned study was biased (all the participants were already foursquare users) and past researches found that privacy is a barrier to adoption of location sharing services, it emerged that foursquare privacy-protection mechanisms (check-in off the grid and sharing control) make the users comfortable in managing their privacy online [53].

Since those kind of applications are relatively young, a lot has still to be discovered about their potentialities, but what can be seen is a bet placed by the market on the success location-based services will have in future: Twitter recently added the some location based services to their platform [7] and Facebook bought Gowalla [6] (a location-based *OSN*, similar to Foursquare) to move their developers into the teams working on new Facebook features (presumably revolving around geo–location).

At the moment, some directions are being analyzed for using location-based services. Among those, location searches [97], advertising [23] and context-aware searches [4].

Section 2.1 dealt with yet another possibility offered by location-based services, that is, for instance, the one applied to Emergency Management as wished by the Australian government and described in [3].

## 2.4 Enabling Factors

This brief final section, will introduce the main enabling factors that brought to the success the second wave of location-based Online Social Networks, such as Foursquare.

Back in 2008 an exhaustive study was published, with the name *"Location-Based Services* – (from now on LBN) – *: Back to the Future"*. Already the title suggests how the appearance of LBN starting 2005, was more a comeback, as similar services already existed since a 1996 US Government mandate, the E911 (Enhanced 911).

The reasons that made the wind of LBS blowing again in 2005 (this time in the right direction), were both technological and dealing with different applications' design goals.

Among the technological enabling factors, we find the advent of Web 2.0 and of Web Services together the emergence of mobile-devices equipped with broadband 3G internet connection and GPS modules.
Those enhanced mobile-phones quickly became "smartphones" (as opposed to feature phones), and gained more and more popularity reaching more than 50% penetration in developed markets and 20% in emerging markets as of Q3 2011 [33].

The technological progress allowed developers to shift the applications' positioning system from a carrier-centric model to a user-centric one: global positioning was now much more accurate thanks to GPS modules (as opposed to network triangulation present earlier) and this allowed, together with the advent of Web 2.0, the sharing of precise data among users, in a way that made users more confident in sharing personal geo-located data (as they were deciding precisely what to share) [5].
So, while the LBS used until then made the user a passive viewer of data managed by the carrier both in the positioning and in the data provision phase, the new LBSs were more user-centric in a way that made users dependent upon carrier just for data transmission.

Moreover, in the near future, we will witness technologies that will allow positioning with great accuracy (less than 1m) for indoor environments [1]: this result is very important as related to LBS that will need even greater accuracy when operating indoor, for example in a mall or in an airport.
For the moment, even though Google recently launched an indoor mapping service [11], the only usable technology for indoor positioning is a network–WiFi triangulation that uses signal strength, time of flight (measuring how long it takes for the signal to travel from transmitter to device) and angle of arrival. The accuracy with this technology is in the range of 3m, and strongly depends on the algorithms used for triangulation [1].

## 2.5 Conclusions inferred upon Literature Review

The use of Crowdsourcing for Emergency Management is still in its early phase: the technologies that allow basic operations for reporting emergencies, such as geo-location, are becoming popular just lately and new ideas can be successfully tested just when an emergency breaks out, thus greatly slowing down the development of new ideas.

As noticed during the review, most of the researches are focusing upon the

Response phase, achieving extremely positive results and public acknowledgement (as for the Ushahidi project).

The other phases are partly left out from current researches. The current work chooses to focus on the Mitigation phase.

Even if, from a theoretical point of view, Mitigation looks basilar in any Emergency Management lifecycle and past researches show how Emergency Mitigation, in the US, repaid (during the period mid–1993 to mid–2003) the expenses with a 4:1 ratio ($3.5 billion of society cost against gross benefits for $14.0 billion), the high costs, current budget cuts and indefinite duration of the mitigation phase makes it harder and harder for Authorities to implement good Mitigation Plans. [74, 45, 46]

The budget cuts are more and more exposing Emergency Management Authorities worldwide to the lack of knowledge of their territories: this would allow Risks to outburst into Emergencies and Disasters without undergoing an assessment phase that would help the reduction of costs (both in terms of lives and money) in the successive phases of Emergency Management.

Starting from the FEMA definition of the Mitigation Phase, as reported in the new Risk Mapping, Assessment and Planning (Risk MAP [30]), we identify a phase, specifically the Risk Mapping Phase, where the work will give its contribute into reaching the wished collective approach for Emergency Management by giving the populations the power to help themselves while helping the authorities to map possible Hazards.

The scope of the thesis is investigating the possibility of using crowdsourcing in the Emergency Mitigation Phase, especially in the sub-phase of Risk / Hazard mapping, through a location-based social networking mobile application and website, which will help engaging users in reporting geo-located threats to their safety.

Thanks to this approach, we can exploit users' knowledge of the territory and their will of helping their own community for retrieving accurate data over possible Hazards that may outburst into Small-Scale Emergencies.

Moreover, comments and a voting system will help keeping the map and reports up to date, a fundamental requisite all throughout the emergency management cycle.

The innovative approach of this work is supported by multiple findings in literature, together with opinions of a representative of the Ushahidi community and Boston's Citizens' Connect co-chief, reported as an email exchanges in the Annexes B.1, B.2.

This last paragraph, sums up the points upon which the work is based:

- Positive results for the use Crowdsourcing during Emergency Management, especially during the Response phase, are reported in the Literature review
- Authorities and researchers hope for a "revolution" that makes citizens able to help themselves throughout all the phases of an emergency
- Both Technologies and Designs are present for building Citizens' enabled applications for crowdsourcing Emergency information
- Crowdsourcing for Mitigation phase is not yet explored even though, as stated by a representative of the Ushahidi community (cf. Annexes B.1), approaches that exploit geo-located reports are being currently tested
- Local administrations, such as Boston, MA, use web and mobile application to allow citizens' reports on problems (not necessarily hazards) in their jurisdiction (cf. Annexes B.2).
- The indefinite length of the Mitigation phase allows us to use well-established peer review methods, such as voting and commenting, to evaluate the reports, moreover freeing us from the need of having real time elaboration of data
- One study in particular showed empirically how people tend to supply more accurate data when they feel like they're doing something for a good cause [73]
- Last but not least, researches upon existing Online Social Networks showed how people keep on using them for different reasons. Among those, the ability to keep contact with offline friends (Facebook), see where they are (Foursquare), retrieving information (all of them) and also just for entertainment (Foursquare and Facebook).
  Moreover the gaming side of Foursquare (points and mayorships) is a good reason for many users to keep on using the location-based service. Thus we will try and introduce all of these aspects in our application, to engage people using it and obtaining updated hazards maps.

The application's scope and crowdsourcing methodology will be presented, together with a first introduction of its features, in Chapter 3, while the technologies used, the application's architecture and some use cases will be covered in Chapter 4 and 5.

# Chapter 3

# Setting up the Problem Solution

> *"In order to fulfill our mission, we must recognize that the public is an important participant in the emergency management community and that we must work together as one team. The notion of treating the public as a resource rather than a liability is at the heart of our emergency management framework."*
>
> Craig Fugate, Administrator of the Federal Emergency Management Agency (FEMA)

This Chapter covers the set up for the solution to the problem of crowdsourcing information for the Emergency Mitigation phase, in the form of a location-based online social network.

First of all, it will define the scope of the hazards handled by the application, which are going to be extracted from a broad list of common hazards through a filter defined by the analysis of Jul's article [49].

Secondly, it will proceed by defining the approach to the crowdsourcing of data, using the innovative framework outlined in Pongetti's [69]: the resulting definition determines the most important characteristics of the crowdsourcing application.

Finally, Sections 3.3 and 3.4 will present the results of a survey carried out to spy out the willingness of citizens to use an application such as the one presented in the current work, while presenting the benefits to the actors involved in the application's scenario.

Chapter 4 will subsequently introduce a more detailed presentation of the application's technologies and features, together with a set of use cases.

## 3.1 The Hazards' Scope

The aim of the application is to develop a tool to help communities to map local hazards which may cause small-scale emergencies.

We don't want, therefore, to build a complete tool for helping Emergency Mitigation at every level of severity: the focus will be moved just on smaller case emergencies.

During the literature review, no definition of "small-case" emergency (or hazards that may cause them) was found. We will follow a three steps process in order to define the scope of emergencies handled by the application:

1. Define a filter that, according to the work presented in [49], identifies the scale of emergencies we are interested in this work (i.e.: small-scale)
2. Find an exhaustive list of hazards and evaluate the dimension of emergencies that may be caused by such hazards
3. Filter the list found in the previous step with the filter defined in 1., in order to extract an initial list of hazards managed by CroSafe

We will be going through those steps in the subsections 3.1.1 to 3.1.3.

### 3.1.1 Filter definition

The work presented in [49] by Jul is a study that tries and define a systematic description of the design problem space for user interfaces in emergency response technologies. Even though the aim of that work is building a framework for helping the design of EMIS[1] according to the social context it has to be used in, it presents a useful introduction used for defining the dimensions of a disaster/emergency upon which we'll add a dimension for defining users dealing with the hazards, by slightly modifying concepts presented in the aforementioned work.

Jul's analysis is carried on through the application of sociological theories of disaster to the scope at hand. The three dimensions used in the analysis are: **scale** (a measure of the extent of the effects of an event), **kind** (an indicator of the types of effects of an event), and **anticipability** (a description of the

[1] Acronym for Emergency Management Information System, defined as "Information Systems designed to collect, analyze and share information in support of emergency management activities"

possibilities for preparedness for an event).
As stated by Jul, the dimensions are analyzed widely in literature. For a list of works to refer to for deepening knowledge upon the subject, refer to Jul's bibliography. Hereafter, each dimension will be presented in the level of detail needed in the current scope.

### Scale

**Scale** is a measure of the extent of an event's effects and reflects the power of the causal agent(s), the success of mitigative measures, and the effectiveness of the response system. Sociologists commonly discuss three measures of scale: *magnitude*, *scope*, and *duration of impact*.
*Magnitude* indicates *"the severity of social disruption and physical harm"*, i.e. the extent to which the lives of those affected have been interrupted or altered. *Scope* indicates *"the social and geographic boundaries of social disruption and physical harm"*, that is the size of the socio-geographic area affected. *Duration* is *"the time lag between the onset of social disruption and physical harm and when the disaster is no longer defined as producing these effects"*, indicating how long it takes for things to stop breaking.

Thanks to these dimensions, we can define three different categories of **scale**:

- An *Emergency* is a short-lived event whose effects are localized within a single community. The community as a whole and its response infrastructure remain fully functional, and its internal capacity is sufficient to manage the response.
- A *Disaster* is a longer-lived event that affects an entire community, but leaves both community and response infrastructure largely intact. However, because so much of the community is affected, it is not able to manage the response on its own and must rely on aid from neighboring communities (typically through mutual aid agreements).
- A *Catastrophe* is a long-lived event that affects multiple communities, destroying much of their infrastructures, and severely damaging or overwhelming response systems. Communities cannot manage the response on their own and often compete with neighboring communities for external assistance rather than benefiting from mutual aid agreements.

A further step is taken by Jul in defining two sub-categories of Emergencies: the *local emergency* and the *local disaster*. Before stating the differences among the two, we need to introduce yet two more definitions, in the scope of emergency management organizations:

- *Established organizations* engage in response activities and their operational structure is unchanged during responses
- *Expanding organizations* engage in response activities but they must expand their operational structure to do so, typically by recruiting volunteers

Even if every country has a different approach to defining expanding organizations, the aim of this work is to be as general as possible. Thus, we will define expanding organizations also as those where, along with a core of "career" operators, on field operations are mostly impossible without recruiting a base of volunteer workers.
On the other hand, established organizations manage to operate using just their core structure, made up by "career" operators.

Local emergencies and disasters are then defined in the following way:

- *Local Emergencies* are handled entirely by established organizations
- *Local Disasters* require the involvement of an expanding organization, thus requiring some volunteer work in the emergency response itself

### Kind

The second dimension that defines a disaster's characteristics, is the **Kind**. One of its aspects is the *affect*, which is an indication of the diversity of the effects of the event. According to this definition, we identify two different kind of disasters:

- *Community Disasters* that affect a broad range of physical and human resources
- *Sector Disasters* that primarily affect a specialized segment of the community, and may be handled by sector professionals

Another aspect of Kind is *social agenda*, which describes the social context of the response to the event. This aspect allows a distinction between:

- *Consensus-Type Events* in which there is a general agreement on the goals of the response agenda

- *Conflict-Type Events* in which different factions have different agendas (e.g. restoring normalcy versus redefining normality)

### Anticipability

The final dimension of disaster considered by Jul is *Anticipability* and captures event characteristics that determine what preparedness is possible.
It comprises two measures:

- *Predictability* of an event is higher when it is within the realm of imagination of the times and its occurrence is perceived as sufficiently likely as to be believable (e.g.: the bombing of 9/11 was not predictable because, pre 9/11, using airliners as bombs was both unimaginable and beyond credibility, as reported by the National Commission on Terrorist Attacks in 2004)
- *Influenceability* of an event, measures how realistic and implementable are the means of reducing damage caused by the event itself, given the resources and sociopolitical environment of the time and place.

Combining those two measures, results in four classes of events, namely:

- *Conventional*: Easy Influenceability and Easy Predictability
- *Unexpected*: Easy Influenceability and Hard Predictability
- *Intractable*: Hard Influenceability and Easy Predictability
- *Fundamental*: Hard Influenceability and Hard Predictability

### The Scope of the Project

Given the definitions outlined in the previous sections, we are able to specify the characteristics of the events that are managed by our project. As previously stated, this work doesn't claim to provide an all-around solution to Emergency Mitigation (i.e.: for each typology of event that may occur). We are, instead, trying to define a small-scale emergency whose mitigation can be helped by the result of this thesis.
In order to define what are the events that add up to the scope of the project, we will go through the dimensions previously outlined and, for each one of them, we will point out how they adapt into the small-scale definition we are looking for.

Once obtained, we will use this definition to filter an exhaustive list of hazards, in order to find out which ones may lead to small-scale emergencies, thus obtaining a list of hazards that will be handled by our application.

Table 3.1 recaps the dimensions outlined in the previous sections, and marks the levels chosen for our analysis:

<table>
<tr><th>Dimension</th><th>Measures</th><th>Meaning</th><th>Choice</th></tr>
<tr><td rowspan="3">Scale</td><td>Magnitude</td><td>Severity of Social and Physical harm</td><td rowspan="3">Events with low magnitude, localized within community boundaries and solvable in a short time period</td></tr>
<tr><td>Scope</td><td>Social and Geographic boundaries</td></tr>
<tr><td>Duration</td><td>Duration of disaster from onset to conclusion</td></tr>
<tr><td rowspan="2">Kind</td><td>Affect</td><td>Diversity of event effects on society and environment</td><td rowspan="2">Events that affect a limited range of resources, and which have well-established consensus upon response agenda</td></tr>
<tr><td>Social Agenda</td><td>Social context of the response in terms of response agenda</td></tr>
<tr><td rowspan="2">Anticipability</td><td>Predictability</td><td>Degree of predictability of an event, in terms of perceived likelihood for the event to happen</td><td rowspan="2">Events with easy Predictability and Influenceability, i.e. common events with well established methodologies of mitigation</td></tr>
<tr><td>Influenceability</td><td>Degree of how realistic and implementable are the means of reducing damage caused by the event</td></tr>
</table>

*Table 3.1: Emergency related dimensions*

The definitions just stated are enough for specifying the kind of event handled. But we want to add four more dimensions, already found in Jul's work but slightly modified for adapting to our scope, in order to better specify the characteristics of the users that have to identify the Hazard.
These dimensions, each ranked in a Null-Low-Medium-High scale, add Users' characteristics to the previously identified Event's dimension, and are needed to answer a question like: "What kind of users can help in the Emergency Mitigation phase for a given Hazard?".

We present those dimensions alongside with chosen levels for our application, in the table 3.2:

| **Dimension** | **Measures** | **Meaning** | **Choice** |
|---|---|---|---|
| **User** | Hazard Knowledge | User's prior knowledge of specific Hazard | Even users with null to low Hazard and Task Knowledge must be able to help in the scope of chosen Hazards. Levels of External Knowledge can be also null, while Locale Knowledge should be at least low. |
| | Task Knowledge | User's prior knowledge of tasks for Hazard Mitigation | |
| | Locale Knowledge | User's knowledge of local geography and resources | |
| | External Knowledge | User's knowledge of external resources | |

*Table 3.2: User related dimensions*

As shown in the previous table, we want to handle hazards that are easy to spot for every category of users. The characteristic of Locale Knowledge simply states that we want to exploit user's locale knowledge in order to get reliable reports: the low level suggests that users had, at least, a visual contact with the hazard to report, so that they could provide a more reliable judgment on the hazard thanks to an, even partial, evaluation of the surrounding area.

We can now define the *Small-Case* Emergency concept, used for outlining the scope of emergencies handled by our application.
Using the definition pinned in pages 33 to 37, our application will then deal with *Emergencies*, mainly in terms of Local Emergency (but also Local Disaster if we assume that, for instance, many public assistance services are mainly volunteer local services).
Those *Emergencies* must affect a limited range of resources and must be

*Consensus-Type* events, i.e.: a well defined response plan is defined for responding to the event.
Moreover, the emergency itself must be caused by a *Conventional* event, characterized by easy *Predictability* and easy *Influenceability.*

Finally, as far as *Users* are concerned, we want to exploit every user's capability, without restricting to those who have a specific knowledge on the Hazard to identify. A basic knowledge of area surrounding the hazard, maybe simply gained through a superficial visual analysis, should then be sufficient for the user to hand in a valuable report.

### 3.1.2 Hazard Listing

Upon literary review, no complete listing of Hazards was found. This forced us to merge partial lists coming from different publications: this is the approach followed while drafting this section .

We mainly used two UNDP (United Nation Development Program) Disaster Management Training books, namely [72] and [21], together with the already cited introductory book [41] and a WMO (World Meteorological Organization) publication on Natural Hazards [56].
Finally, to get some real insight on how different organizations report emergencies worldwide, we analyzed two reports printed respectively by the FEMA [31] and the SAARC Disaster Management Center[2] [79].

Even if different countries are usually affected by different hazards, most of the literature and publications found, agree on the division into two main categories:

- Natural Hazards: caused by natural phenomena, such as hydrological, meteorological, geologic and other natural processes. Natural hazards are often divided into sub-categories, such as Geological, Climatic and Environmental

- Technological/Man-made Hazards: are a product of technological innovation and human development. Those are usually less understood than their natural counterparts and are increasing in number thus usually enlarging the scope of Technological Hazards over time

[2]SAARC is the South Asian Association for Regional Cooperation, and its Disaster Management Center is the equivalent of the FEMA for 8 south Asian countries, included India, Pakistan, Bangladesh and others, making it the largest regional organization in the world, accounting more than 1.5 billion people altogether

The following paragraphs will cover the main Natural Hazards as presented in literature

### Floods

*Floods* a flood is an overabundance of water that engulfs dry land and property that is normally dry. It is reported to be one of the most frequent and widespread disaster in many countries around the world, including the United States and the South Asian subcontinent.
Flood risk area can be mapped and, according to those map, special insurances can be offered to citizens such as it has been offered through the National Flood Insurance Program [3] in the Unites States, since 1968. Even if mapping of floods is possible, sometimes mitigating those hazards is not economically convenient: that's the case of the catastrophic flood in New Orleans, caused by the Katrina Hurricane in 2005 [17].
Moreover, countries with lower mitigation policies (or at least lower budget spent on floods mitigation) such as the South Asian sub-continent, report numbers of people killed/affected much higher than, for example, Northern America.

### Earthquakes

An earthquake is a sudden, rapid shaking of the earth's crust that is caused by the breaking and shifting of rock beneath the earth's surface. This shaking can cause the collapse of buildings and bridges; cause disruptions in gas, electric, and phone service; and trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis). Structures constructed on unconsolidated landfill, old waterways, or other unstable soil are generally at greatest risk unless seismic mitigation has been utilized.
Earthquakes are sudden, no-notice events despite scientists' and soothsayers' best efforts to predict when they will occur. Seismic sensing technology is effective at measuring and tracking seismic activity, but it has yet to accurately predict a major seismic event with any degree of accuracy.
Seismic tremors usually cause also secondary hazards, such as ground failures, landslides, avalanches but also, if the epicenter of the earthquake is to be found in the sea, tsunamis and seiches.
Given their unpredictability, earthquakes can be mitigated only with a long

[3] In simple terms,when a community joined the NFIP, in exchange for making federally subsidized, low-cost flood insurance available to its citizens, the community had to pass an ordinance restricting future development in its floodplains.

term mitigation plan, that involves seismic-proof building and citizens' training. Both are expensive mitigation solutions that are usually within range just for wealthy countries.

### Hurricanes and Tornadoes

Hurricanes are cyclonic storms that begin as tropical waves and grow in intensity and size. Tropical waves continue to progress in size and intensity to tropical depressions and tropical storms as determined by their maximum sustained wind speed. The warm-core tropical depression becomes a tropical storm when the maximum sustained surface wind speeds range from 63 kilometers per hours (km/h) to 117 km/h. Tropical cyclonic storms are defined by their low barometric pressure, closed-circulation winds originating over tropical waters, and an absence of wind shear.
Hurricanes are fed by warm ocean waters. As these storms make landfall, they often push a wall of ocean water known as a "storm surge" over coastal zones. Once over land, hurricanes cause further destruction by means of torrential rains and high winds.
They are seasonal and usually cities that are known to be at risk, have well defined plans for avoiding major damages to people and structures. Sometimes, anyway, those protections plans are too expensive to become practical, so that are not actually put in practice (cf. New Orleans' pre Katrina warnings [34]).

A tornado, on the other hand, is a rapidly rotating vortex or funnel of air extending groundward from a cumulonimbus cloud, exhibiting wind speeds of up to 480 km/h. Approximately 1,200 tornadoes are spawned by thunderstorms each year in the United States. Most tornadoes remain aloft, but the few that do touch the ground are devastating to everything in their path. The forces of a tornado's winds are capable of lifting and moving huge objects, destroying or moving whole buildings, and siphoning large volumes from bodies of water and ultimately depositing them elsewhere. Because tornadoes typically follow the path of least resistance, people living in valleys have the greatest exposure to damage.
Early warning is a key factor to surviving tornadoes, as warned citizens can protect themselves by moving to structures designed to withstand tornadoes:buildings that are directly in the path of a tornado, have little chance of surviving unless they are specifically built to resist the wind and debris that strike buildings with almost bullet-like speed.

### Mass Movements

The general category of mass movements includes several different hazards caused by the horizontal or lateral movement of large quantities of physical matter. Mass movements cause damage and loss of life through several different processes, including the pushing, crushing, or burying of objects in their path, the damming of rivers and waterways, the subsequent movement of displaced bodies of water, destruction or obstruction of major transportation routes, and alteration of the natural environment in ways in which humans are negatively impacted.
Among this category, we find phenomena like Landslides, Mudflows, Lateral Spreads, Rockfalls and Avalanches.

### Volcanic Eruptions

A volcano is a break in the earth's crust through which molten rock from beneath the earth's surface (magma) erupts. Over time, volcanoes will grow upward and outward, forming mountains, islands, or large, flat plateaus called "shields". Volcanoes cause injuries, death, and destruction through a number of processes, including direct burns, suffocation from ash and other materials, trauma from ejected rocks, floods and mudflows from quickly melted snow and ice, burial under burning hot "pyroclastic" ash flows, and others.

### Winter Storms - Snow and Ice

Severe winter storms occur when extremely cold atmospheric conditions coincide with high airborne moisture content, resulting in rapid and heavy precipitation of snow and/or ice.
Even though it rarely cause of direct deaths, it can strongly damage streets, circulation and everyday's life for communities undergoing frequent Storms.

### Drought

Drought is defined as a prolonged shortage of available water, primarily due to insufficient rain and other precipitation or because exceptionally high temperatures and low humidity cause a drying of agriculture and a loss of stored water resources. They never have clear onset and conclusion, there is no universally accepted drought scale and the effects are usually unclear and spread to larger geographic areas and time.

Therefore, droughts are usually difficult to determine and differ from most of the Natural Hazards.

#### Extreme Temperatures

Both high and low temperatures can cause injuries, fatalities and major economical impacts, especially if they last over a prolonged period.
Heat waves are known to kill thousands of people every year (average of 1500 people a year in the United States) and little can be done, apart buying an air/conditioner and avoiding leaving the house during the hottest hours of the day.
On the other hand, every time temperatures fall below freezing, there is the risk of death from hypothermia to humans and livestock, with the degree to which populations are accustomed to those temperatures a primary factor in resilience. Extreme cold can also lead to serious economic damages from frozen water pipes, the freezing of navigable rivers, which halts commerce and can cause ice dams and the destruction of crops.

This list is only partial and many more Natural Hazards could be added, specifically according to different countries and geographic areas.
The overview just drafted, anyway, offers a pretty much complete listing of natural forces that can (and actually do) cause harm every year around the globe.

Next, we continue with an analysis of the so called Technological Hazards (or Manmade Hazards): the items in this category are much more variegate and difficult to categorize. They exist both as self-sustained hazards and as agents that speed up existing natural hazards. A partial list will be presented in the upcoming paragraphs.

#### Structural Fires

Studies have shown that civilizations have been fighting structural fires (i.e. fires striking human-made structures) using coordinated governmental resources since the first century AD. Structural fires can be triggered or exacerbated by both natural processes, including lightning, high winds, earthquakes, volcanoes, and floods, or by human origins, including accidents and

arson, for example.
Fires bring both to human lives loss, and to economical loss: in 2008, in the United States, 30500 structural fires were arsons and they caused over $866 million damages in property losses.

### Dam Failures

Dams are constructed for many purposes, the most common being flood control and irrigation. When dams retaining large quantities of water fail, there exists the potential for large-scale uncontrolled releases of stored water downstream. Dam failures pose the most extreme flood risk due to the sudden and severe impacts that can result.
Dams most often fail as a result of maintenance neglect, overtopping (as in the case of a flood), poor design, or structural damage caused by a major event such as an earthquake, collision, or blast. Dams are both publicly and privately owned and maintained, so their monitoring can pose a challenge to offices of emergency management charged with assessing associated hazard risk.

### Epidemics

Epidemics include Viral Infectious Diseases (Meningitis, Measles, Dengue, Polio, etc) and Bacterial Infectious Diseases (Cholera, Diarrhea etc.). The main causes of occurrence of epidemics are non-availability of clean and hygienic drinking water, fecal contamination of drinking water sources, lack of awareness about sanitation, eating substandard and unhygienic food, inadequate facilities for the displaced people, poor living conditions, overcrowding, economic conditions (lack of sufficient funds to prevent epidemic ), biological conditions (organism may mutate, increasing pathogenic etc) in addition to ecological factors.
Even though epidemics can be hardly predicted, the conditions leading to epidemics (like the ones stated above as listed in the South Asian Report [79]) can be spotted and much can be done to be protected against risks.

### Road Hazards

Even countries with low vehicle density can be prone to many accidents, mainly because of poor condition of the roads, of signals and of vehicles.

Road maintenance is usually delegated to authorities, but a complete mapping of road conditions, especially in countries with a large road network, can be too expensive and some problems can remain completely unrecognized.

#### Violence and Crime

Those hazard fall under the same category, as they all build up upon human behaviors. They are not sure to cause (at least immediately) an emergency but they can certainly do if left uncontrolled.
For example, neighborhood where Crime and Violence are more common, can be related to poverty zones [43], and poverty is one of the reasons for higher vulnerability to Hazards, therefore rising the risk of that geographical area.

#### Building Collapse

Man-made buildings can collapse due to different reasons: absence of maintenance, poorly constructed and aged structures, but also mixture of these reasons, together with natural hazards such as heavy snow and rainfalls.
Situations that may lead to building collapse, can be easily spotted, but it may not be economically possible to mitigate the hazard or even the risk may be underestimated both by authorities and the community itself.

#### Power Outage

A power outage is an interruption of normal sources of electrical power. Short-term power outages (up to a few hours) are common and have minor adverse effect, since most businesses and health facilities are prepared to deal with them.
Extended power outages, however, can disrupt personal and business activities as well as medical and rescue services, leading to business losses and medical emergencies. Extended loss of power can lead to civil disorder and major economical losses, as in the New York City blackout of 1977 [85].

As in the case of the Natural Disasters list, the one concerning Manmade Hazards is not complete. Moreover, new technologies appear every year, and an assessment over their categorization as hazards usually requires years.

Moreover, we decided to exclude from the list some Technological Hazards, such as the Chemical, Nuclear and Industrial related one: their coverage may have been extremely wide and long, as well as extremely specialized. We can firmly state, even now, that they would fall out from the scope of our application, since people dealing with such risks must be sector specialists, and very little people own this kind of expertise.

The following section will illustrate which Hazards can fall into the scope of our application, filtering the list just presented with the scope definition given in Section 3.1.1.

### 3.1.3 Hazards in the Scope of Application

Now that we have a list of Hazards, and the definition of the typology of events we want our application to handle, we can finally define a list of hazards that fall in the scope of CroSafe.

To extract this from the broader hazard list, we will examine those hazards and decide if, based upon reports, an hazard can cause an emergency that falls into the *small-scale* definition we outlined in Section 3.1.1.

We begin our analysis from *Natural Hazards*.

Given the characteristics of non-locality, typical for the phenomena that are the root of Natural Hazards, this kind of Hazards seldom affects a single community therefore falling outside the definition of small-scale emergency. For instance, Earthquakes, Hurricanes, Tornadoes, Volcanic Eruptions and Extreme Temperatures struck a single community only if the community is metropolis-sized or even larger.
Mass Movements, even if can be localized to single communities, are difficult to spot for the inexpert eye, and require a specific knowledge in Hazard evaluation and Emergency response.
All these Hazards, therefore, fall outside the scope of CroSafe's hazards list.

On the other hand phenomena like Floods, Winter Storms and Drought can assume a local form.

For example Floods can take place in cities and other man-modified environments because of lack of maintenance on draining pipes and manholes but also because of unawareness of floodplains bounds that may lead to constructions in risk-prone areas.

Winter Storms and Drought, too, can be localized to a single community: some neighborhood of a city can be less served by public services such as snow plowing and salt spreading, thus being more vulnerable to Winter Storms Hazard while some suburban areas can suffer more from Drought because of errors in hydric distribution.

The response to these localized problems is always of Consensus type and their Predictability and Influenceability are easy, being common events caused by well known reasons.

Intuitively, *Technological Hazards* are more prone to a certain level of locality: finding their roots in human-made structures or interventions, wherever those intervention do not take take place, there won't be any Technological Hazard.

That said, we can certainly state that Structural Fires, Road Hazards, Building Collapse, Power Outage, Violence and Crime can be small-scale Emergencies: they are easy to recognize, usually have impact on small communities and, given their conventionality, are always associated with a consensus-type response.

Dam Failures, on the other hand, cannot be interpreted as small-scale, since events that cause a failure are not easily predictable (e.g.: earthquakes) and the knowledge to spot such hazard is not commonplace.
Epidemics too are, by definition, a widespread occurrence of an infectious disease and thus cannot be small-scale: they usually aren't short lived, are difficult to predict and the response may not be Consensus-Type (e.g.: who to give the vaccine first in case of epidemics for which there is no vaccine for everyone?)

#### The Final Hazards List

Given the considerations exposed in 3.1.1 to 3.1.3, we can now define the Hazards that fall inside the scope chosen for this work. The following list lays the foundations for CroSafe:

- **Floods**
- **Winter Storm - Snow and Ice**
- **Drought**

- **Structural Fires**
- **Road Hazards**
- **Building Collapse**
- **Power Outage**
- **Violence and Crime**

## 3.2 CroSafe's Crowdsourcing Model

This section uses Pongetti's [69] *Descriptive Framework* to classify CroSafe under the dimensions pinned by his work, subsequently completing the analysis by means of comparison with results obtained through the *Prescriptive Framework*'s analysis on a wide sample of real crowdsourcing applications.

### 3.2.1 Introduction to the Descriptive Framework

The descriptive framework proposed by the author, is a novel systematic approach that helps analyzing crowdsourcing applications through dimensions coming from a broad inquiry of previous academic work in the fields of Web 2.0, Psychology, Online Communities, Knowledge Management and Sharing, etc.
The resulting dimensions are often an adaptation from similar concepts existing in domains sometimes distant from the Crowdsourcing scope; other dimensions, on the other hand, are not present in any previous research, and come out from new considerations.

We present the dimensions in table 3.3, leaving the description of every dimension to following subsections.

| Dimension Name | Metric |
|---|---|
| **Categorization** | Collective Knowledge, Knowledge Sharing, Collective Creativity, Cloud Labor, Knowledge Acquisition, Crowdfunding, Open Innovation, Problem Solving |
| **Crowdsourcing Type** | Integrative, Selective |
| **Required Knowledge** | Low, Medium, High |

| | |
|---|---|
| **Community Size (Quantitative)** | $\geq$0, N.A. |
| **Community Size (Qualitative)** | Small, Medium, Big, N.A. |
| **User Type** | Amateur, Professional |
| **Task Type** | Simple, Complex, Game |
| **Main Reward** | Enjoyment-based, Opportunistic, Prestige-oriented |
| **Minor Reward** | Enjoyment-based, Opportunistic, Prestige-oriented, None |
| **Remuneration (Quantitative)** | Numeric Range, N.A. |
| **Remuneration (Qualitative)** | Low, Medium, High |
| **Incentive** | Sharing of the result, Sharing of the goal, User ranking and voting systems, Position inside community and user power scaling, Money, Competition |
| **Data Quality Mechanism** | Group Evaluation [Voting], Group Evaluation [Averaging], Group Evaluation [Consensus], Reward Accuracy, Competition, Surveillance, None |

*Table 3.3: Descriptive Framework Dimensions*

We present in the following paragraph, a brief introduction for every dimension and category, without going in too deep. For a broader coverage and complete bibliography, refer to the original work [69].

### Categorization

The categorization of a crowdsourcing application is a key step, since it significantly influences the values of the remaining dimensions.
Possible values are:

- **Collective Knowledge**: an application that acquires and/or shares knowledge and information from and to the crowd (e.g.: Wikipedia)
- **Knowledge Sharing**: a Collective Knowledge application that acquires knowledge from the crowd and shares it back to the crowd

(e.g.: Wikipedia)

- **Knowledge Acquisition**: a Collective Knowledge application that acquires knowledge from the crowd and shares it with another agent, leaving out the crowd (e.g.: Get A Slogan[4])

- **Cloud Labor**: an application that uses a distributed virtual labor pool to fulfill, on demand, a range of tasks from simple to complex (e.g.: Amazon Mechanical Turk)

- **Problem Solving**: a Cloud Labor application where the labor pool is required to fulfill Problem Solving tasks (e.g.: CrowdSpirit[5])

- **Collective Creativity**: an application that taps into a creative talent pool to design and develop original art, media or content (e.g.: iStockphoto)

- **Open Innovation**: an application that uses the crowdsourcing paradigm to address sources outside an entity or a group in order to generate, develop and implement new ideas (e.g.: InnoCentive)

- **Crowdfunding**: an application that aims to the raising of monetary capital for new projects and activities following several models (e.g.: Kickstarter)

### Crowdsourcing Type

It defined two different situations in which the crowdsourcing paradigm is used:

- **Integrative**: Crowdsourcing is used to accumulate multiple and complementary information or data. User contributions are aggregated to form a collective database of information

- **Selective**: Only a subset of the information coming from the crowd is kept. Usually this involves a set of criteria to select the best or most suitable data (a Winner-takes all kind of model)

[4]Get A Slogan is a crowd-sourced slogan development service. [www.getaslogan.com]

[5]CrowdSpirit is a crowdsourcing community built around designing electronic products. Users submit ideas for innovative electronic products that the community votes on. The best ideas rise to the top where investors provide financing. [http://www.crowdspirit.com]

#### Required Knowledge

It defines the knowledge required to the user for collaborating with the community. The metric for the dimension is an High-Medium-Low scale where, for instance, High required knowledge is the one needed for writing a new article on the Wikipedia, Medium is software testing while low is rate a movie or provide traffic information.

#### Community Size (Quantitative and Qualitative)

Represents the number of active contributors to the community and a qualitative interpretation of that number (Small: less than 283000 users, Medium: between 283000 and 1132000 users, Big: bigger than 1132000).

#### User Type

This dimension distinguishes among two types of users belonging to the crowd:

- **Amateur**: an user currently performing tasks in the community without specific professional training/education
- **Professional**: an user currently performing tasks in the community using his prior knowledge, coming from professional education or schooling.

#### Task Type

The answer to the question "What kind of task can be crowd-sourced?" may be answered using a three-category taxonomy:

- **Simple Tasks**: whose completion requires a relatively low involvement from the individuals, few steps and a short amount of time
- **Complex Tasks**: whose completion requires intensive activities, many steps and a consistent amount of time
- **Game Tasks**: whose completion requires playing a computer game

### Rewards (Main and Minor)

This dimension, presented in table 3.4, defines the reasons that move the users in the crowd to take part in collaborative projects.

| Main of Minor Reward | Description |
|---|---|
| **Opportunistic** | Not Monetary:<br>– Receiving a fair share of the result<br>– Career related<br>– Skills improvement<br>Monetary:<br>– Direct monetary compensation<br>– Indirect future earnings |
| **Enjoyment Based** | Desire to do something different<br>Desire to express oneself<br>Curiosity and desire to test if it works<br>Values and ideology:<br>– Volunteerism<br>– Mutual help<br>Desire to establish networks<br>Fun |
| **Prestige-Oriented** | Desire to influence other people<br>Increasing online reputation<br>Desire of power and control |

*Table 3.4: Reward dimension in the Descriptive Framework*

### Remuneration (Qualitative and Quantitative)

Describes the remuneration for task completed inside the crowdsourcing application.
While the quantitative implementation clearly states the value of this remuneration, the quantitative scale detects Low remuneration (between few cents and 100$), Medium ones (between 100 and 1000 dollars) and High Remunerations (rising above 1000$).
Obviously, also no remuneration is possible.

### Incentive

A crowdsourcing implementation should leverage on the motivations that move people to join the community, in order to make people behave like active users as long as possible.
The Incentive dimension provides a description of the mechanisms that a crowdsourcing platform can use in order to effectively leverage the rewards discussed previously.

The Incentive types are introduced in table 3.5:

| Incentive | Reward | Description | Examples |
|---|---|---|---|
| **Money** | **Opportunistic** | Offering money to the users in exchange of their contributions | Amazon Machine Turk |
| **User ranking and voting system** | **Enjoyment-based, Prestige-Oriented** | Implementing user-ranking systems according to contribution<br><br>Implementing voting mechanism to express on others' contributions | Yahoo! Answers |
| **Competition and Gaming** | **Enjoyment-based** | Introducing competition among the users to stimulate participation | Threadless |

| | | | |
|---|---|---|---|
| **Position inside the community** | **Prestige-oriented** | Implementing hierarchies of users with different powers and status in the community | Wikipedia |
| **Sharing of results** | **Enjoyment-based** | Allowing the users to access and enjoy the others' contributions | Waze |
| **Sharing of the goals** | **Enjoyment-based** | Making the users aware of the goals of the project | Wikipedia |

*Table 3.5: Incentive dimension in the Descriptive Framework*

### Data Quality Mechanism

Crowdsourcing applications relies on individuals to gather data, whose quality must be somehow validated. The validation can be based upon different mechanism. The exhaustive list is reported in table 3.6:

| Data Quality Mechanism | Description | Examples |
|---|---|---|
| **Group Evaluation (Voting)** | The user-base itself selects and elicits the best data, through voting and rating systems | Digg |
| **Group Evaluation (Averaging)** | According to this paradigm all the information coming from the crowd are weighted and mixed together to produce an output according to some formula | Foldit |
| **Group Evaluation (Consensus)** | Users' contributions are subject to continuous review by the community and the quality is ensured by the collective process of reviewing and correcting | Wikipedia |

| | | |
|---|---|---|
| **Reward Accuracy** | Only one solution among the many proposed by the crowd is selected and rewarded by some mean | Amazon Machine Turk |
| **Competition** | Introducing competition among the users, can provide a mechanism to ensure data quality | InnoCentive |
| **Surveillance** | Surveillance can be implemented through automatic algorithms that check the information or by selecting a group of agents for this purpose | Amazon Machine Turk |
| **None** | No data quality mechanism applied: highly discouraged | Amazon Machine Turk |

*Table 3.6: Incentive dimension in the Descriptive Framework*

### 3.2.2 Using the Prescriptive Framework to define CroSafe

Before continuing, we categorize the dimensions of the Descriptive Framework in Fixed Set and Variable Set: the first includes those dimensions which are part of the application's tasks and cannot, therefore, be modified by the system designer, while the second set contains dimension that can be adapted to the application's needs.

Fixed Dimensions are:

- Categorization
- Crowdsourcing Type
- Required Knowledge
- Community Size (Qualitative)
- User Type
- Task Type

while the Variable Dimension Set includes:

- Main Reward
- Minor Reward
- Remuneration
- Incentive
- Data Quality Mechanism

The definition of the main crowdsourcing characteristics of CroSafe will be a two step process:

1. Set the Fixed Dimensions that are intrinsic to the application's task itself
2. Choose the proper Variable Dimensions in a way that finds comfort from the data of the Prescriptive Framework

As mentioned previously, the application that results from this thesis will be an application to crowdsource data for Hazard Mapping. The crowdsourced data will be managed by the application, saved on a Database, and crowdfed back to other users in order to increase the social awareness of local hazards and eventually used by authorities that can mitigate those hazards.

According to the Descriptive framework, CroSafe is then ***Categorized*** as a ***Knowledge Sharing*** application.

As far as the ***Crowdsourcing Type*** is concerned, the application clearly uses an ***Integrative*** approach, since all the reports are going to be aggregated to form a collective database of information: there is no "right" solution to Hazard mapping.

As discussed throughout Section 3.1, the application scope has been built in order to allow the whole community's involvement to the crowdsourcing of data, so that no entrance barrier to the community has been set.
***Required Knowledge*** is then ***Low***.

Moreover, CroSafe's tasks are not time-consuming and don't require any a-priori knowledge, apart the one given from a visual analysis of the hazard itself. The steps taken for reporting one hazard (opening application, waiting for GPS signal to localize the user, selecting a category, writing a short description and sending), are few and fast, making the ***Task Type*** clearly ***Simple***.

For the same reasons just stated, the ***Users*** can be both ***Amateurs*** and ***Professionals***, where the second category may have a different role in the application (i.e.: hazard validation, assessment, etc.).

The analysis on ***Community Size*** is not possible, but that's hoped to be as ***Big*** as possible: based on past analysis, such as [73], and reports from similar applications (see Annexes B.2) we tend to believe users are going to provide accurate reports so that more users will bring more data with the same level of accuracy.

According to these Fixed Dimensions, we are carrying on our investigation using the best practices outlined by the Prescriptive Framework which highlights relationships among Fixed and Variable Dimensions through an analysis of existing Crowdsourcing applications.

We begin with setting the ***Main Reward*** for our crowdsourcing application. Data analysis shows how applications with a Low *Required Knowledge*, Amateur *User Type*, and Simple *Tasks* tend to have an ***Enjoyment-Based*** *Main Reward*.
The choice is also suggested by the literature review, that showed how people working for voluntarily helping each others tend to provide better results than people working for monetary-only reasons [73]. Moreover, given the characteristic of the project, which is completely independent from any authority, a monetary compensation wouldn't have been possible.
The only *Opportunistic* reward that could be possible, is for users to receive a fair share of the results: in this case, seeing one's report being promptly mitigated by the authorities can surely be considered as a reward, but this is not possible until some kind of agreements are struck up with local authorities.

This ***Opportunistic*** reward can then be seen as a possible ***Minor Reward***, influenced by externals factors (agreements, promptness of local authorities, etc).
A ***Prestige-Oriented*** reason can also be accounted as *Minor Reward*: people using location-based social network, upon which they can connect with their offline-friends, are reported to care more about their online reputation [53], which can be greatly boosted by doing good for their communities. This result is confirmed by the Prescriptive Framework that shows how application with an *Enjoyment-Based* main reward have, if any, both *Prestige-Oriented* and *Opportunistic Minor Rewards*.

The ***Incentive*** dimension is indeed related both to the *Main* and the *Minor Rewards*, but also to the *Required Knowledge* and the *User Type*. The range

of *Incentives* is intentionally as broad as possible, so that users are widely stimulated into a long-term and profitable relationship with the crowdsourcing system.
The easiest *Incentives* are the ***Sharing of Goals*** and ***Results***, so that users will feel like an integral part of the whole project. Moreover, being this a Social Volunteer project, we can still leverage on the will of users to provide reliable data by sharing the goals of CroSafe.
***User Ranking and Voting Systems*** are indeed a good *Incentive* for keeping the community alive over time, thanks to the ***Competition*** that may arise from ranking both against all the users, but especially against own friends (both online and offline). This can be achieved by gaining points over each correct report, and comparing one's own score to other's.
Finally the ***Position Inside the Community***, with eventual *Power Scaling* can also increase the fun perceived by users: after a certain number of correct reports, or by reporting a certain amount of hazard per category, the user may reach different levels inside the application, thus gaining virtual badges to show everyone the result achieved and boosting own's online self-representation.
Moreover, different levels can be associated to different *Powers* inside the application itself: an expert user (or super-user as it's defined in some crowdsourcing applications) may have definitive voting capabilities, with the chance of setting a report as "confirmed", or mark it as "fake" or even "fixed" after mitigation.
The choice is actually both suggested and confirmed by the Prescriptive Framework that empirically shows how Crowdsourcing applications tend to use more than one *Incentive* method (average is 4 incentives per application), and how applications with CroSafe's Fixed Dimensions values use all of the stated methods.

The ***Data Quality Mechanism*** is related both to the ***Community Size*** and the ***Task Type***. Community Size strongly influences the *Data Quality Mechanism*: CroSafe's community will indeed be small in the beginning, so we cannot simply rely on ***Group Evaluation*** through ***Voting***, at least initially. Votes could be easily biased or even too few initially to retain any kind of Quality Assurance meaning.
We are, therefore, leveraging once more on the fact that volunteers who feel like they're acting for the common good, usually provide more reliable data (as empirically proven by [73] and reported by Boston's Citizens Connect team cf. Annexes B.2), and on the ***Competition*** deriving from the *Incentives* chosen for the application, which can indeed be a methodology for

ensuring data quality.
This choice is indeed confirmed by the Prescriptive Framework, both for CorSafe's Task Type and Community Size.

Finally, we proceed with the analysis that crosses the *Categorization* of an application, with its *Incentives*, and with the *Main* and *Minor Rewards*, to have the final validation of our choices.
For *Knowledge Sharing* applications, though, all kind of incentives are used, but *Competition*: we decided to use this *Incentive* inside our list anyway even if it's never reported to be used by real crowdsourcing applications. A *Competition* based on rankings among users, alongside with the will of users to help the community (achieved also through the application's *Sharing of the Goals*), allows us to think that this *Competition* will become a positive boost for the users' community to *"do more and do better"*.
Moreover, comparison among *Categorization* and *Rewards* (both *Main* and *Minor*), indeed confirms our choices in all the three dimensions, since our choices build up to the second most used paradigm among the analyzed real-life crowdsourcing systems.

## 3.3 How potential users perceive CroSafe

This section will present the results of a survey carried out to spy out the willingness of citizens to use an application such as CroSafe, thus becoming active actors in the scenario of local Emergency Management.

To test whether people would be willing to use an application such as the one just outlined, we decided to use the survey presented in Annexes B.3.

This survey was made available only online: we can therefore deduce that all the interviewees are computer users.
Moreover, out of the 121 people from 8 different countries who completed the survey, only 9 on them don't use any Online Social Network.

The survey is divided into three main parts:

- The first part tries and categorize the user, asking questions about his personal details, definition of their current place of residence and usage of OSNs

- The second part tries and understand which are the most important Hazards that each user feels like an application for Emergency Management should handle

- The third part tries and figure out the most important characteristics of the application itself, according to every user

The questionnaire was completely anonymous. In this way, we ensured a higher quality of the experiment's outcome. All the questions, apart the ones in a fourth - optional - section that worked as a "suggestion box", were mandatory.

After presenting the sample, we will identify some macro-groups according to two dimensions (age and living environment), therefore analyzing aggregated and per macro-group results.

### Introducing the sample

The final sample comprised of 64 Males (52.9%) and 57 Females(47.1%) and can be therefore considered heterogeneous according to the gender.

| Gender | Number | Percentage |
|---|---|---|
| Male | 64 | $\approx 52.9\%$ |
| Female | 57 | $\approx 47.1\%$ |

*Table 3.7: Gender distribution*

The users come mainly from Italy (109 $\approx$ 90%) but also from Latvia (6 $\approx$ 5%), Bulgaria, Germany, Morocco, Luxembourg, Jordan and Benin (1 user each $\approx$ 0.8%).

| Nation | Number | Percentage |
|---|---|---|
| Italy | 109 | $\approx 90\%$ |
| Latvia | 6 | $\approx 5\%$ |
| Bulgaria | 1 | $\approx 0.8\%$ |
| Germany | 1 | $\approx 0.8\%$ |
| Morocco | 1 | $\approx 0.8\%$ |
| Luxembourg | 1 | $\approx 0.8\%$ |
| Jordan | 1 | $\approx 0.8\%$ |
| Benin | 1 | $\approx 0.8\%$ |

*Table 3.8: Nationality distribution*

The survey will then be mostly meaningful for Italy, but can also carry some insights from other countries.

The ages have a wide range (from 18 to 70 years), with an average of 31,97 years and partitioned as it follows:

| **Range** | **Number** | **Percentage** |
|---|---|---|
| age < 20 years | 6 | ≈ 4.96% |
| 20≤age<30 | 72 | ≈ 59.5% |
| 30≤age<40 | 12 | ≈ 9.92% |
| 40≤age<50 | 15 | ≈ 12.4% |
| age≥50 | 16 | ≈ 13.22% |

*Table 3.9: Ages distribution*

The wide range actually helps us trying to figure out how the whole population would respond to the application itself since, as stated before, we will try and involve most of the population.

The average education is shifted to an high level and, even if we didn't manage to have an equal number of people representing every category, we have representatives from every category according to the following distribution:

| **Education Level** | **Number** | **Percentage** |
|---|---|---|
| High School Diploma | 25 | ≈ 20.66% |
| Bachelor Degree | 26 | ≈ 21.49% |
| Master Degree | 60 | ≈ 49.59% |
| PhD | 7 | ≈ 5.78% |
| Other | 3 | ≈ 2.48% |

*Table 3.10: Education distribution*

Every interviewee can use a computer (we don't actually care how good, since we want every typology of user to be able to approach the community) since the invitations to complete the survey were received by Facebook or email.

The OSNs used are, Facebook, Twitter, Google+, Foursquare, LinkedIn, Draugiem.lv, MySpace, CouchSurfing and Flickr according to the following distribution:

| **Online Social Network** | **Number** | **Percentage** |
|---|---|---|
| Facebook | 102 | ≈ 84.3% |
| Twitter | 33 | ≈ 27.27% |
| LinkedIn | 29 | ≈ 23.97% |

| | | |
|---|---|---|
| Google+ | 26 | ≈ 21.49% |
| Foursquare | 12 | ≈ 9.92% |
| Flickr | 8 | ≈ 6.61% |
| MySpace | 6 | ≈ 4.96% |
| Draugiem | 5 | ≈ 4.13% |
| CouchSurfing | 4 | ≈ 3.3% |

*Table 3.11: OSNs used*

While 9 users (≈ 7.5%) state they are not using any Online Social Network, among all the users, we have the following reported usage time of OSN.

| **Time Range** | **Number** | **Percentage** |
|---|---|---|
| No Use | 9 | ≈ 7.5% |
| Less than 1 hour | 52 | ≈ 42.1% |
| Between 1 and 3 hours | 46 | ≈ 38% |
| More than 3 hours | 15 | ≈ 12.4% |

*Table 3.12: OSN time usage distribution*

We asked users to define the environment they live in (Metropolis, Big City, City, Town or Village) and to describe it (Urban, Sub-urban, Countryside, Seaside, River-lakeside or Mountainous). Most of the people live in an Urban Metropolis, but here too we have representatives from every category, according to the following distributions:

| **Environment - Definition** | **Number** | **Percentage** |
|---|---|---|
| Metropolis | 57 | ≈ 47.1% |
| Big City | 20 | ≈ 16.53% |
| City | 21 | ≈ 17.36% |
| Town | 21 | ≈ 17.36% |
| Village | 2 | ≈ 1.65% |

*Table 3.13: Environment Definition*

| **Environment - Description** | **Number** | **Percentage** |
|---|---|---|
| Urban | 89 | ≈ 73.55% |
| Sub-urban | 18 | ≈ 14.87% |
| Countryside | 6 | ≈ 4.96% |

| | | |
|---|---|---|
| Seaside | 6 | $\approx 4.96\%$ |
| River-lakeside | 1 | $\approx 0.83\%$ |
| Mountainous | 1 | $\approx 0.83\%$ |

*Table 3.14: Environment Description*

The last question of the survey was a question to understand whether the person, before knowing how the application would operate, would be willing to join an online social network for mapping risks and making the world a safer place.
As expected after the literature review, people are usually pleased to helping when they feel like they're acting for the common good. We received in fact the following answers:

| **Willing to Join** | **Number** | **Percentage** | **Aggregate** |
|---|---|---|---|
| Strongly Agree | 27 | $\approx 22.31\%$ | **Positive**: 67.76% |
| Agree | 55 | $\approx 45.45\%$ | |
| Neutral | 35 | $\approx 28.93\%$ | **Neutral**: 28.93% |
| Disagree | 3 | $\approx 2.48\%$ | **Negative**: 3.31% |
| Strongly Disagree | 1 | $\approx 0.83\%$ | |

*Table 3.15: Willingness to join the OSN*

The same question will be later analyzed according to the macro-group defined by the age and environment, in order to see whether those dimensions influence the answer.

### Defining the macro-groups

We will be carrying the remaining part of the analysis, comparing the aggregated responses to the ones narrowed to some macro groups we spotted according to the age and environment dimensions.

We will therefore focus our attention to the age groups already used for sample analysis:

- **Age $<$ 20**
- **20$\leq$Age$<$30**
- **30$\leq$Age$<$40**

- **40≤Age<50**

Moreover, we are trying to define groups according to the environment the users live in. Unfortunately, though, the data presented in Table 3.14 shows that most of the interviewee live in an urban environment (which shouldn't amaze, given the actual distribution of citizens upon the Italian territory).

We are therefore defining those groups:

- **Urban Environment**
- **Urban Environment in a Metropolis**
- **Sub-urban**
- **Countryside**
- **Seaside**
- **Any Not-Urban Environment**

The river-lakeside and mountainous environment, will be just included in the non-urban group, since they have a single interviewee each.

#### Analyzing the data

The following report upon the results of the survey, will present the aggregated results for every question therefore pointing out different behaviors recorded by the groups outlined above.

**Q9: Willingness to join a risk OSN** The question already reported earlier, asks the interviewee if he or she would be willing to join an OSN for risk reporting. The overall results are reported in Table 3.15.
No relevant differences are to be noted among the macro-groups, even though we note as people living in sub-urban areas have an higher percentage of indifference toward such an OSN ($\approx 44.4\%$).

**Q10: Risk ordering** The question asks the interviewee to rank the hazards according to the importance they feel they should have inside the application.
The overall ranking for risk importance is the following:

1. **Violence and Crime**

2. **Road Hazards**
3. **Building Collapse**
4. **Fires**
5. **Floods**
5. **Winter Storm - Snow and Ice**
6. **Power Outage**
7. **Drought**

Ordering according to the age is less significant, even though we note how, for people over 50 years, Road Hazards are to be found just in fifth position, this being probably due to the fact this category is using the car less than younger interviewee.

If we check ordering according to environment, we notice how, in a sub-urban environment, Fires jump to second position, and Floods to the third while in the countryside, floods are found in second position and drought leaves the last position, as it's to be expected in such an environment.

**Q11: Report Accuracy** The question asks the interviewee whether he or she will create reports as accurate as possible.
The answers were extremely positive, and this agrees with the literature analysis that showed how people working for the common good, tend to provide more accurate data.

Overall results are reported in the following table:

| Accurate reports? | Number | Percentage | Aggregate |
|---|---|---|---|
| Strongly Agree | 38 | $\approx 31.4\%$ | **Positive**: 85.95% |
| Agree | 66 | $\approx 54.55\%$ | |
| Neutral | 16 | $\approx 13.22\%$ | **Neutral**: 13.22% |
| Disagree | 1 | $\approx 0.83\%$ | **Negative**: 0.83% |
| Strongly Disagree | 0 | $\approx 0\%$ | |

*Table 3.16: Willingness to create accurate reports*

Analysis by age, shows how people over 50 tend to have a higher willingness of completing extremely accurate reports (50% of them replied *strongly agree* to the question) while no significant differences emerge during the environment analysis.

**Q12: Scoring system as Incentive** The question asked users if they would use the application more willingly thanks to a scoring system on the reports, that allows competing with friends.
The results were pretty positive even if we noticed how some people were neutral to the matter. Just 12 people, though, didn't agree with the feature.

Overall results are reported in this table:

| **Scoring system?** | **Number** | **Percentage** | **Aggregate** |
|---|---|---|---|
| Strongly Agree | 22 | $\approx$ 18.18% | **Positive**: 59.5% |
| Agree | 50 | $\approx$ 41.32% | |
| Neutral | 37 | $\approx$ 30.58% | **Neutral**: 30.58% |
| Disagree | 9 | $\approx$ 7.44% | **Negative**: 9.92% |
| Strongly Disagree | 3 | $\approx$ 2.48% | |

*Table 3.17: Agreement on scoring system*

The scoring system would be more appreciated by people over 30 (29 positive responses out of 43 interviewee $\approx$ 67.44%), which may indicate that this category pays more attention to this kind of issues.

**Q12: Virtual Badges as Incentive** The question asked users if they would use the application more willingly thanks to virtual badges to be awarded upon the completion of some tasks inside the application.
The results to this question were mostly neutral, indicating that people don't sense it as a major incentive to using the application. Negative responses, though, were still low enough, so that this feature will probably not bother users.

Overall results are reported in this table:

| **Badges system?** | **Number** | **Percentage** | **Aggregate** |
|---|---|---|---|
| Strongly Agree | 4 | $\approx$ 3.3% | **Positive**: 27.27% |
| Agree | 29 | $\approx$ 23.97% | |
| Neutral | 70 | $\approx$ 57.85% | **Neutral**: 57.85% |
| Disagree | 12 | $\approx$ 9.92% | **Negative**: 14.88% |
| Strongly Disagree | 6 | $\approx$ 4.96% | |

*Table 3.18: Agreement on badges system*

**Q14: The application must be quick** The question asked users if they agree with the fact that reporting an issue, especially through the mobile application, must be as quick as possible.
The results scored the highest positive score in the survey, underlining how the use of the application must be quick and easy.

Overall results are reported in this table:

| Quick application? | Number | Percentage | Aggregate |
|---|---|---|---|
| Strongly Agree | 89 | $\approx$ 73.55% | **Positive**: 97.52% |
| Agree | 29 | $\approx$ 23.97% | |
| Neutral | 3 | $\approx$ 2.48% | **Neutral**: 2.48% |
| Disagree | 0 | $\approx$ 0% | **Negative**: 0% |
| Strongly Disagree | 0 | $\approx$ 0% | |

*Table 3.19: Agreement on quick application*

No significant fluctuations were spotted among the macro-groups identified.

**Q15: Spread the word!** The question asked users if they would try and involve friends and acquaintances into using the OSN, in order to make their voices heard.
The level of agreement upon this question was still high, so that we hope the application may have a good success among citizens. Moreover, as pointed out in Section 3.2.2, data from the OSN will gather relevance especially when the community will become Big. Replies to this question are therefore even more important under these circumstances.

Overall results are reported in this table:

| Involve others? | Number | Percentage | Aggregate |
|---|---|---|---|
| Strongly Agree | 42 | $\approx$ 34.71% | **Positive**: 81.82% |
| Agree | 57 | $\approx$ 47.11% | |
| Neutral | 22 | $\approx$ 18.18% | **Neutral**: 18.18% |
| Disagree | 0 | $\approx$ 0% | **Negative**: 0% |
| Strongly Disagree | 0 | $\approx$ 0% | |

*Table 3.20: Willingness to involve other people*

For this question, it' people over the age of 50 that seemed more enthusiast: 15 people ($\approx$ 93.75%) had a positive reply.

**Q16-Q17: Share results on other OSNs** Those questions asked users if they would like to share results obtained on CroSafe with other OSNs and, if so, which ones they would like to share with.
Most of the people were indifferent but, as for question 12, the negative votes were low enough to allow us adding this feature as an optional choice, without bothering any user.

Overall results are reported in this table:

| Share on OSNs? | Number | Percentage | Aggregate |
|---|---|---|---|
| Strongly Agree | 18 | ≈ 14.88% | **Positive**: 43.81% |
| Agree | 35 | ≈ 28.93% | |
| Neutral | 55 | ≈ 45.45% | **Neutral**: 45.45% |
| Disagree | 9 | ≈ 7.44% | **Negative**: 10.74% |
| Strongly Disagree | 4 | ≈ 3.30% | |

*Table 3.21: Willingness to share results*

Moreover, users are willing to share their results especially with Facebook and Twitter, but also with other OSNs they use.

Also for this question, it' people over the age of 50 that seemed more enthusiast: 13 people (≈ 81.25%) had a positive reply to sharing with other OSNs (Facebook is the first choice).

**Q18 and Q20: Communication with authorities** Those questions asked users how they would like the application to communicate the reports to the competent authorities.
We proposed four different communication methods:

- **Manual communication**: every citizen personally notifies the authorities of the hazard(s) spotted, eventually taking the results gathered through this application as evidence
- **Automated communication**: the application itself sends a periodic report of spotted hazards to the authorities
- Communicating with authorities is **not important**: I'd use the application even just for increasing community awareness
- It'd make sense just if the authorities were **directly involved**

The interviewees created the following ranking:

1. **Automated Communication**
2. **Manual Communication**
3. **Direct Involvement Only**
4. **Communication not Important**

The order doesn't change according to the macro-groups identified, so we can state users would love the application to automatically take care of communicating the data gathered to the authorities.

Moreover, we asked interviewee whether or not they would like to receive replies from the authorities upon reports automatically sent.

Most replies were positive, and the overall results are reported in this table:

| Receive Replies? | Number | Percentage | Aggregate |
|---|---|---|---|
| Strongly Agree | 36 | $\approx$ 29.75% | **Positive**: 88.43% |
| Agree | 71 | $\approx$ 58.68% | |
| Neutral | 12 | $\approx$ 9.92% | **Neutral**: 9.92% |
| Disagree | 2 | $\approx$ 1.65% | **Negative**: 1.65% |
| Strongly Disagree | 0 | $\approx$ 0% | |

*Table 3.22: Willingness to receive replies*

According to this question, people living in a sub-urban area that agree more on receiving the authorities' replies (100% of 18 interviewee had positive replies).

**Q19: Using the application even if the authorities don't solve problems** This question asked interviewee if they would keep on using the application even if the authorities didn't actively participate in mitigating the risks spotted.

Surprisingly enough, most of the users would keep on using it even just for increasing the social awareness of problems around them: they evidently consider the tool also as a source of information from the crowd to the crowd, without considering necessary for the authorities to actually operate on the risks spotted.

The results are reported in the following table:

| Use w/o authorities? | Number | Percentage | Aggregate |
|---|---|---|---|
| Strongly Agree | 30 | ≈ 24.79% | **Positive**: 81.81% |
| Agree | 69 | ≈ 57.02% | |
| Neutral | 14 | ≈ 11.57% | **Neutral**: 11.57% |
| Disagree | 7 | ≈ 5.79% | **Negative**: 6.62% |
| Strongly Disagree | 1 | ≈ 0.83% | |

*Table 3.23: Willingness to use the application without authorities' involvement*

The people who replied negatively to the question, mostly (6 out of 8) live in a urban environment. This may indicate that this category feels that risks around them are, more often than not, ignored by the competent authorities.

### Comments upon results

Even though the survey doesn't claim to carry an incontrovertible evidence on the positive response upon the idea of the work at hand, it indeed carries some interesting insights.

Most of the people, living different environments, would be interested in a tool to map risks around them: risk ranking, on the other hand, is influenced by the territory where the user lives, but the categories identified cover most of the problems felt by the users.
As suggested by some of the interviewee, we will add a *Generic Hazard* category to the existing ones, in order to make people able to add risks that do not fall into any of the aforementioned categories.

The hypothesis of building CroSafe, inspired by results found during literature review, is reinforced by the results of the survey: we therefore think that the creation of an application with the characteristics outlined thus far lays on foundations strong enough to allow its development.

## 3.4 The benefits of using CroSafe

This section tries and answer the following question: *"Who and How will get benefits from using CroSafe?"*.

As far as the "who" part of the question is involved, we can identify two main actors: the Crowd (i.e.: the whole community of CroSafe's users) and the Authorities that decide to interact with the system.

We will show in the upcoming paragraphs, how both actors will enjoy benefits from joining the application's social network.

Moreover, in order to specify the modalities used to deliver such benefits, we must refer once more to the Mitigation cycle introduced in Section 2.1.1.

As stated in Section 2.5, CroSafe has been thought for helping the subphase of *Risk Mapping*, inside the *Emergency Mitigation* cycle as presented in Figure 2.3 and reported once more hereafter for your convenience.


*Figure 3.1: The Mitigation Cycle*

Risks are mapped by users through the application, saved in the application database and made visible on a map dynamically created from the reports. This base reporting functionality of CroSafe helps the phase of *Risk Mapping*.
Both the Authorities and the Crowd will benefit from accessing this map:

- The Authorities will have valuable data about risks in their territories, upon which they may base the following mitigation steps
- The Crowd will gain *awareness* upon the situation in the territory the live in or simply they happen to be momentarily

Carrying on with the step-by-step benefit analysis of CroSafe, we come across the second step in the Mitigation Cycle: *Risk Assessment*.
Even though it's usually assessment specialists who cover this phase, the local hazards which are covered by CroSafe, deliberately share the characteristic of not requiring any specific knowledge for their assessment.

Everyday users, then, can contribute to this phase thanks to the voting system of CroSafe: reports with an higher number of positive votes can be regarded as *"Assessed by the Community"*, with a risk level proportional to the number of votes, according to the definition of risk itself:

$$\textbf{Risk} = \textbf{Hazard} \times \textbf{Exposure}$$

In fact, if many people vote for a report, we assume that the hazard has big exposure therefore a potential higher level of risk.

The voting system allows us to rank hazards, in a way that may be useful both for Authorities, in order to prioritize the hazards to assess and mitigate, but also for the Crowd to know where the "hot" spots are around them (therefore possibly avoiding them).

Finally, phases 3 and 4 (*Risk Communication* and *Risk Mitigation*) are mostly managed by the authorities.
In spite of this, CroSafe could help, especially in the phase of *Risk Communication*: carrying information about users who voted for a specific Hazard (in this way showing the user's interest to the hazard itself), the system can also notify them (through email or through a notification system implemented in the application itself) when it receives official replies regarding the mapped hazard.

This user "tracking" will therefore be useful to the Crowd, in order to be updated on the hazards of interest, but also to the Authorities, since they may use CroSafe as a reliable way of communicating to citizens both in the Mitigation (e.g.: by sending updates on the status of mitigation operations) but also in the Preparedness phase (e.g.: by sending useful hints on how to behave in the case of an escalating hazard to citizens who want to be updated on the status of an hazard).

According to us, then, CroSafe would take multiple benefits to all the actors involved.

The analysis carried on thus far, though, omits one fundamental topic: without communicating to authorities, CroSafe would create a Mitigation Cycle parallel to the one followed by the competent offices, which are gonna use their own methods for risk mapping, assessing and mitigation.

The best interaction would be for the competent offices to directly interface their own risks with the ones reported through CroSafe. This methodology, though, would require some specific agreement and some common data exchange format. The analysis on the chances of stipulating such contracts, falls outside the scope of this work.

Before this is made possible, though, we suggest a different approach to be undertaken: most of the city halls, nowadays, have an online way for contacting the competent offices and reporting problems or simply asking questions. Our suggestion is to automatically contact authorities through this communication mean.

For example, Milan's City Hall has an online service managed by the Communal Civil Protection, called *Sistema Milano*.

As the act published upon the creation of the service [24] states, the service *"...operates 365 days a year, both during emergencies and ordinary periods [...] to acquire quickly, continuously and thoroughly data and news about everything that concerns critical situations upon Milan's territory"*.

To achieve this aim, the system uses both a phone number (active 24/7) and an email address: through this, CroSafe may write a periodic report carrying the reports that will be (hopefully) evaluated and merged with the "official" risks managed by the Milan's City Hall Emergency Management cycle.

## 3.5 Conclusions

Upon an extended analysis of existing material in the fields of *Emergency Mitigation*, *Hazard Mapping* and *Crowdsourcing* we are therefore able to outline the main characteristics of CroSafe, giving the application both with a good theoretical and empirical background.
Moreover, these characteristics have been double-checked thanks to the good feedback reported by a survey, specifically created with the aim of evaluating people's response to the idea of an application such as CroSafe.

We defined, first of all, the scope of Hazards handled by the application. The list here presented comes from the analysis carried out throughout Section 3.1:

- **Floods**
- **Winter Storm - Snow and Ice**
- **Drought**
- **Structural Fires**
- **Road Hazards**

- **Building Collapse**
- **Power Outage**
- **Violence and Crime**

The category of **Generic Hazard** has been added subsequently, listening to the suggestions collected through the survey, in order to cover the Hazards which didn't fall in any of the aforementioned categories.

Section 3.2, on the other hand, outlines the application's characteristics, as far as the Crowdsourcing Model is concerned. Final results are summed up in the following table:

| Dimension | Choice | Description |
|---|---|---|
| **Category** | **Knowledge Sharing** | The crowdsourced data will be managed by the application, saved on a Database, and crowdfed back to other users in order to increase the social awareness of local hazards and eventually used by authorities that can mitigate those hazards |
| **Crowd-sourcing Type** | **Integrative** | All the reports are going to be aggregated to form a collective database of information: there is no "right" solution to Hazard mapping |
| **Required Knowledge** | **Low** | The application scope has been built in order to allow the whole community's involvement to the crowdsourcing of data, so that no entrance barrier to the community has been set |
| **Task Type** | **Simple Task** | The steps taken for reporting one hazard (opening application, waiting for GPS signal to localize the user, selecting a category, writing a short description and sending), are few and fast |
| **Users Type** | **Amateurs and Professionals** | The Low Required Knowledge and the simplicity of Tasks, makes it possible for both Amateurs and Professionals to collaborate with the application |

| | | |
|---|---|---|
| **Community Size** | **N.A. (as Big as possible)** | Based on past analysis and reports from similar applications we tend to believe users are going to provide accurate reports so that more users will bring more data with the same level of accuracy |
| **Main Reward** | **Enjoyment-Based** | Data analysis shows how applications with a Low Required Knowledge, Amateur User Type, and Simple Tasks tend to have this kind of Main Reward. Moreover no Opportunistic Reward could have been possible, and no Application with a Prestige-Oriented Main Reward exists |
| **Minor Reward** | **Prestige-Oriented and Opportunistic** | Opportunistic reward could be possible: users may receive a fair share of the results by seeing one's report being promptly mitigated by the authorities (but it depends on agreement with authorities). A Prestige-Oriented reason can also be accounted as Minor Reward: users tend to care about their online representation and doing good for their community may definitely boost their digital-ego |
| **Incentives** | **Share Goals-Results, User Ranking-Voting, Competition and Position in Community** | The range of Incentives is intentionally as broad as possible, so that users are widely stimulated into a long-term and profitable relationship with the crowdsourcing system. The choice is actually both suggested and confirmed by the Prescriptive Framework. The only incentive used against literature analysis, is Competition: we believe, instead, that it may take to a "do more, do better" behavior among users |

| | | |
|---|---|---|
| **Data Quality Mechanism** | **Group Evaluation (Voting), Competition and Volunteers' Accuracy** | CroSafe's community will indeed be small in the beginning, so we cannot simply rely on Group Evaluation through Voting, at least initially. As shown empirically in literature, Volunteers that act for common good, tend to provide more accurate data. Moreover Competition among users, may help data quality assurance |

*Table 3.24: CroSafe according to the Descriptive Framework*

Finally, after validating the application's features through a survey, introduced in 3.3, we gave an overview of the application potential in section 3.4, by showing what CroSafe would be able to achieve, once all the features presented thus far will be implemented.

The prototype requirements, the technologies used and a set of use cases will be presented in Chapter 4, where we will pin which are the features actually implemented in our prototype, and which should be implemented in future development of the application.

Moreover Chapter 5 will introduce the architecture and the design of the system, while Chapter 6 sums up the current work, analyzes the results and points out directions for future work.

# Chapter 4

# CroSafe Technology, Functionalities and Use Cases

> *"The hardest single part of building a software system is deciding precisely what to build. No other part of the conceptual work is as difficult as establishing the detailed technical requirements, including all the interfaces to people, to machines, and to other software systems. No other part of the work so cripples the resulting system if done wrong.*
> *No other part is more difficult to rectify later"*
>
> Brooks Jr, F. P. [12]

This chapter introduces the technologies used for the prototypal implementation of CroSafe, therefore systematically specifies the project's requirements and finally enters into the details of CroSafe at different levels.

Chapter 5 will therefore introduce the system architecture and design, while Chapter 6 presents the implementation of CroSafe and a user's manual to better understand the prototype functioning.

## 4.1 Technology Overview

### 4.1.1 Vaadin

In order to speed up the development of the application, we used the Vaadin [1] framework, which allows to build server-side AJAX application by writing

[1] `http://vaadin.com/home`

just JAVA code, both for the server and the presentation layer.

Without going further into the details of a Vaadin Application architecture, we can say that an application made with Vaadin runs as a Java Servlet in a container.

The entry-point to the application itself, is the application class, which creates and manages all necessary interface components.
User interaction is handled with event listeners and visual appearance is defined in themes as CSS files. Icons, other images, and downloadable files are handled as resources, which can be external or served by the application server or the application itself.

The Vaadin Application Architecture is reported in Figure 4.1, taken from "The Book of Vaadin" [39].

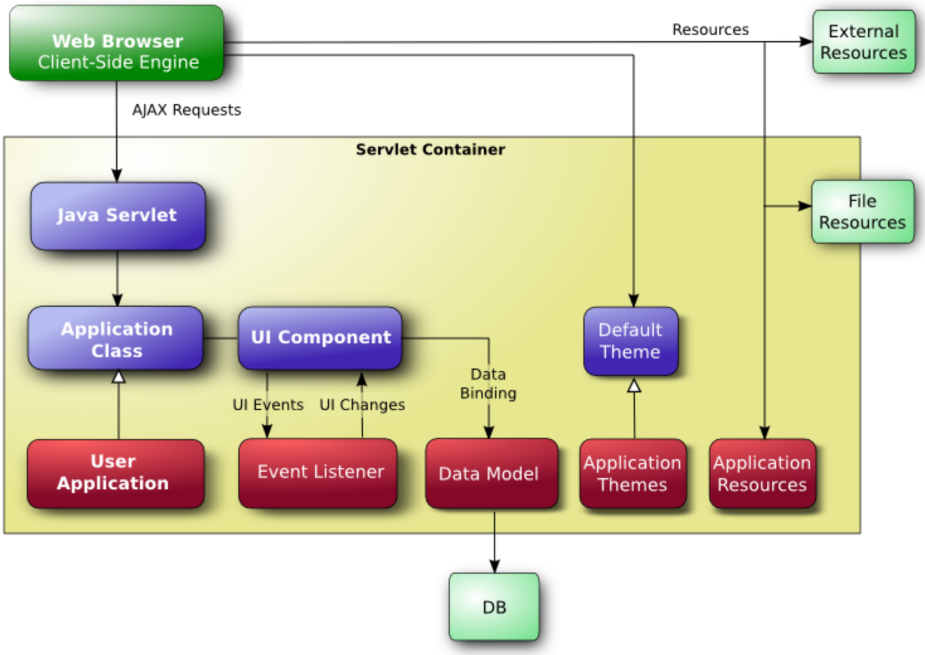


*Figure 4.1: Architecture of a Vaadin Application*

The framework offers plenty of components ready to use and many more are offered as add-ons in the shape of jar libraries.

The user interaction is rendered by the presentation layer, built on GWT, that communicates with the servlet according to the User Interface Definition Language (UIDL), through JSON strings sent over HTTP(S) connections.

For example, the interaction of a button click is shown in Figure 4.2.

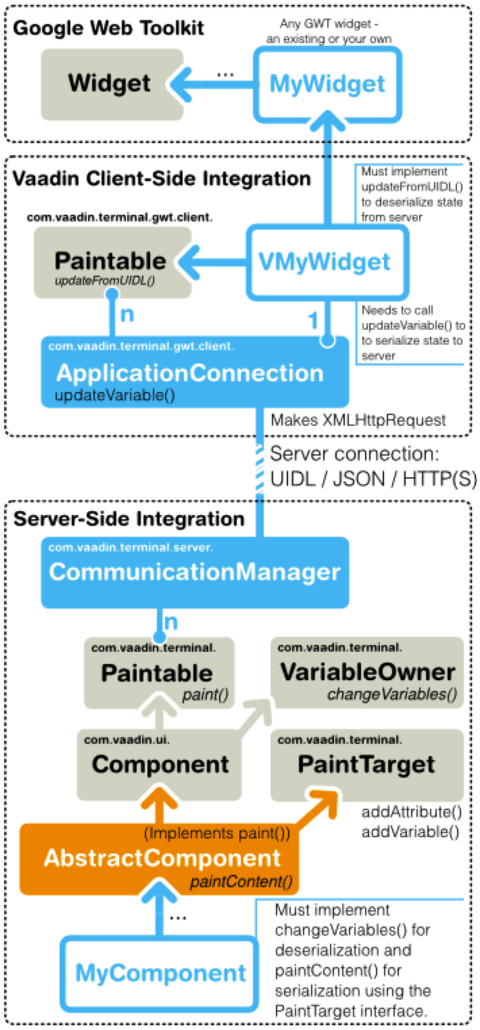


*Figure 4.2: Button click interaction in Vaadin*

This architecture, on one hand makes any application much more secure, since it doesn't publish any part of the application logic outside the server, on the other, though, forces (almost) every user interaction to be passed back to the server, therefore heavily depending on server latency for most of the interactions.

In spite of this, the Vaadin framework has been chosen for multiple reasons:

- the ease of programming entirely in Java and the possibility of using most of its libraries, since we operate server-side

- the flexibility of the framework, that allows a cross-browser experience out of the box
- the presence of an active community
- the integration with Eclipse
- the presence of a good amount of constantly updated add-ons

Among the add-ons used, two deserve a mention, since they take care of two of the most important aspects of the application:

- **Appfoundation** - provides a lightweight foundation to any Vaadin project. Among the many modules it offers, we find an implementation of JPA, the Java Persistence API.
  JPA is a framework that implements the CRUD functions necessary for managing data persistence on a Data Storage; it maps entities in the database to Entity Classes, which are java classes that allow a seamless object-oriented integration with the database. Moreover, Appfoundation, offers modules for session management, internationalization of strings (i18n service), user registration and login.
- **Google Maps Add-on** - built on the Google GWT library (which, unfortunately, still hasn't been updated to the v.3 API), creates an interface to the many APIs supported by the mapping service. This add-on ports most of the functionalities offered by the famous mapping service inside the Vaadin framework, thus allowing us to implement the core functionality of CroSafe, i.e. hazard mapping.

Other add-ons used, allow us to easily retrieve the geographical location of a user, managing browser cookies, resize images, refresh the map status periodically (we opted for polling instead of server push, since the second choice is much more difficult to implement in a Vaadin application) and geocode an address inserted by a user into geographical coordinates.

### 4.1.2 JSON

JSON (JavaScript Object Notation) is a subset of the JavaScript scripting language, although is commonly used for language-independent and human-readable data exchange among applications.
It is made up of easy structure and it is easily parsed by virtually every programming language.

The language grammar is based on two structures:

1. **Object**: is an unordered set of name/value pairs. An object begins with { (left brace) and ends with } (right brace). Each name is followed by *:* (colon) and the name/value pairs are separated by *,* (comma), as shown in Figure 4.3.

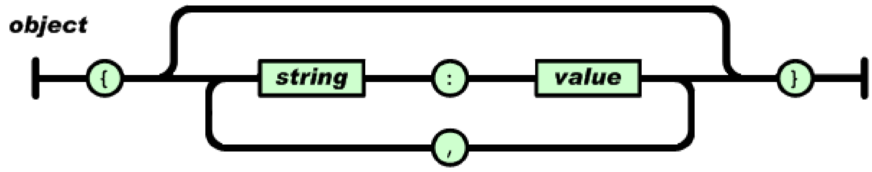


*Figure 4.3: JSON Object*

2. **Array**: is an ordered collection of values. An array begins with *[* (left bracket) and ends with *]* (right bracket). Values are separated by *,* (comma), as shown in Figure 4.4.

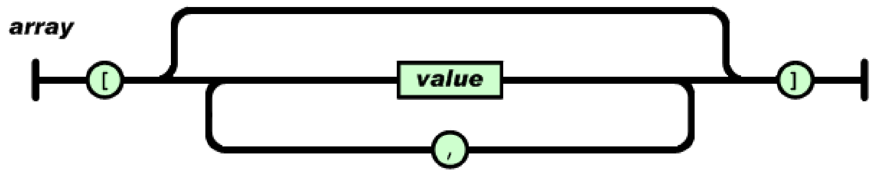


*Figure 4.4: JSON Array*

Moreover, a value is represented by a string in double quotes, a number, true, false, null, an object or an array as shown in Figure 4.5.

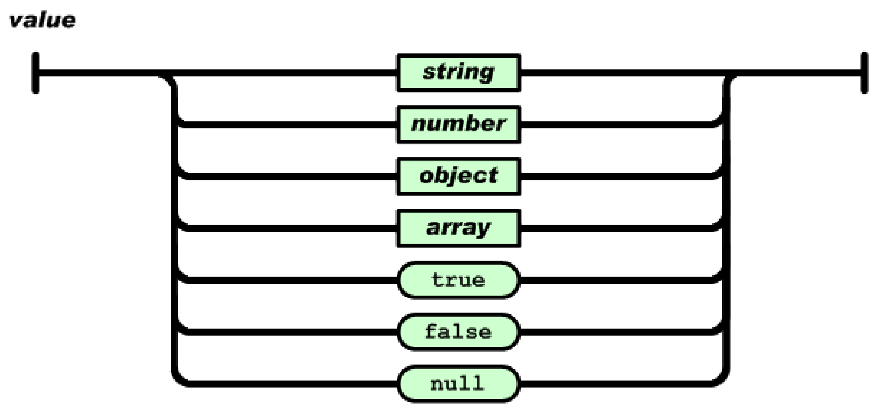


*Figure 4.5: JSON Value*

The representation of strings and numbers follow the format used commonly by Java or C, and won't be represented hereafter.

With the exception of a few encoding details, this completely describes the language.

JSON is be used in CroSafe both inside the Vaadin framework and in the interaction with external services (e.g.: Facebook and Twitter). Moreover, the public APIs that allow the mobile application to interface with the application service, also make use of the JSON format for data exchange.

### 4.1.3 External Services

The application uses three external services for enriching user experience: the user will be able to interface directly to his Facebook account and connect his Twitter identity in order to let CroSafe tweet on his behalf.

Moreover, in order to better specify reports, we will add geographical information (such as country, state, city and street name) retrieved through Yahoo's PlaceFinder Web Service.

#### Facebook

To ease CroSafe's user experience, we allowed the login through one's own Facebook's account. This allows the user to login without remembering yet one more account, thus simplifying the approach to the community.

Once we register our application with our Facebook developer account, the authentication is easily achieved thanks to the Facebook's oAuth 2.0 Authentication protocol, which is a three step process:

1. **User authentication** - authenticates the user in the Facebook domain

2. **Application authorization** - the authenticated user authorizes the application the access to specific data and grants it some capabilities (CroSafe asks for email address and posting permission)

3. **Application authentication** - ensures that the user is giving their information to your app and not someone else

Once the three steps are completed, the application is granted with a user access token (with a duration of roughly two months), which allows the application to behave on the user's behalf.
The whole protocol is implemented strictly in a server-side flow, as the one reported in Figure 4.6;

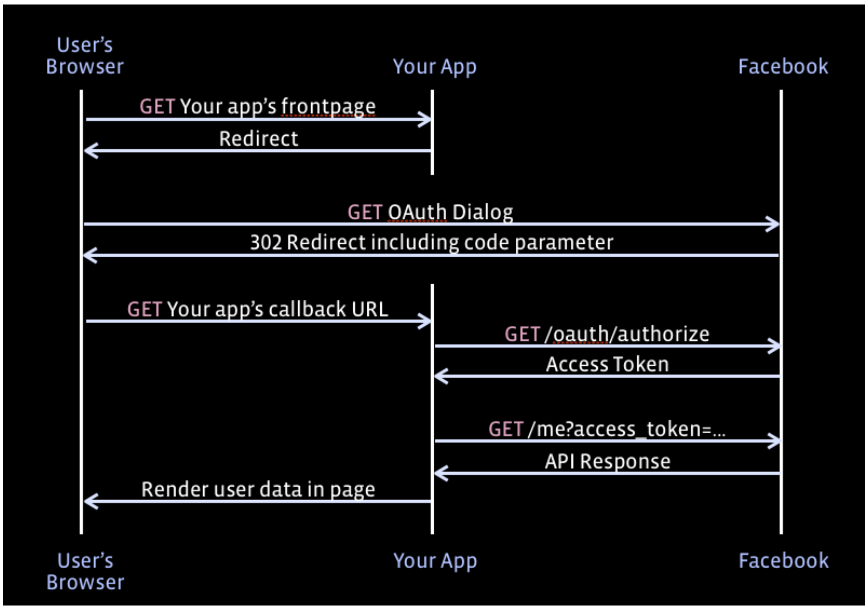


*Figure 4.6: Facebook server-side Authentication flow*

The whole flow was implemented by manually handling the GET requests, since no specific Vaadin add-on was found.

Once the application has the user's access token, we can store it in CroSafe's database and access the user's information and, through Facebook's Graph API, post on user's wall/timeline.

### Twitter

Connecting a user's CroSafe account with his or her twitter identity is similar to the three-legged Facebook authentication process.

The only difference is that Twitter uses oAuth 1.0 authorization: the resulting flow is a little different, but we used a java library called Scribe [2] that takes care of the request signing for us.

After the authentication and authorization process is done, CroSafe obtains an access token to be saved on the application database and successively used for accessing Twitter APIs.

[2] https://github.com/fernandezpablo85/scribe-java

### Yahoo! PlaceFinder

When a user creates a report, its geographical location is retrieved in a Latitude, Longitude format. This is useful for placing a report on the Google Map widget, but not really useful for retrieving information in a human-friendly format.

We are therefore using Yahoo's *http://where.yahooapis.com/geocode?* GET endpoint, with three parameters:

- **location** - specifies the latitude,longitude position we query
- **glfags** - sets some flags on the query; we use the *R* flag that asks for reverse geocode coordinates for each result (i.e.: given coordinates, returns address information)
- **flags** - sets options on the request format; we use the *J* flag to ask for a reply in JSON format

Once the reply is received, we parse it using a JSON Java library, and extract information about the *Country* of the report, its *State*, *City* and *Street Name*.

## 4.1.4 RESTful Web Services

REST is an acronym for REpresentational State Transfer and represent a paradigm that uses a client-server stateless architecture for accessing web services identified by their URL.

The interaction between the mobile application and the application itself, is managed according to the REST paradigm: the application uses specific URLs for accessing, adding and modifying resources saved on the server.

In order to access web resources, the application can uses the GET, POST, PUT and DELETE methods of the HTTP protocol which are easily integrated in the Vaadin framework as *HttpServlet*.

The REST paradigm was first conceived by Roy Fielding, one of the founding fathers of HTTP protocol, who identified REST as a system to describe and identify web resources, according to two main elements:

- **Resources** - every resource on the web is univocally identified by a URL

- **Methods** - resources can be accessed through the Get, Post, Put and Delete HTTP methods

The main characteristics of a RESTful web service are:

- **Architecture** – strictly client-server
- **Interaction** – must be *stateless*, in a way that every request/response cycle is a separate interaction that doesn't store any user-session information, therefore minimizing server memory usage and complexity
- **Accessibility** – uniform, since every resource must be identified by a unique URL and must present the same interface identified by the HTTP protocol (and implemented by the HTTPServlet class in Java, for instance)

## 4.2 Defining CroSafe requirements

This section is going to identify, using a systematic approach, the system's requirements through the introduction of some use cases.

We will first overview the main functionalities of the application, underlining which will be actually implemented in the application prototype.

The following subsections move the focus inside the application and, through the description of some use cases, gather and analyze the system's requirements.

While the first part will be carried with the help of textual descriptions, subsequent paragraphs will make wide use of the UML modeling language to better specify the system.

### 4.2.1 CroSafe Functionalities

We first list the functionalities currently implemented in the prototype, leaving to a second list the features that should be implemented in future development.

#### User registration and login

This is the basic functionality of any Online Social Network. Since we need to track the users of our application, in order to give a better service, we have to ask users to register or to login through Facebook.

We decided to ask the minimum amount of information, in order to minimize the user's abandonment rate during the registration phase. Another information is automatically added to the user's profile by CroSafe, i.e. the date of registration which can be useful while defining users' roles inside the application.

Moreover, if the user logs-in through his/her Facebook account, we will automatically save his user access token, in order to let CroSafe impersonate the user while using Facebook's Graph API.

The overview of this functionality is trivial, and will be omitted. Its implementation will be further analyzed in the following sections.

#### User position retrieval

Since the most important feature of CroSafe is geotagging every report, it's important to easily find one user's geographical position (specifically in a latitude, longitude format), as quickly as possible.

The application uses two methods for position retrieval:

- **Geo Location Add-on**: it wraps the Geolocation API, as drafted by W3C [70], in order to retrieve the user's position by precise sources, such as GPS, or by inferring it from network signals, such as IP address, WiFi and Bluetooth MACs or even GSM cell IDs. The position is returned together with an accuracy range that may differ according to the network and browser used

- **Reverse Geo Location**: it uses Yahoo's web services in order to retrieve the geographical location of an address inputted by a user

Both methods return the result in the format requested (*latitude, longitude*), and users can increase the report's precision by visually refining its position by dragging the marker on the map.
In addition to this, a long lasting cookie will be saved in the browser, in order to remember user's last visited position on the map.

#### Language selection

Since the application vows to being a world-wide online social network, one important step though internationalization is the implementation of an i18n servlet.

We decided to use the module present in the Appfoundation add-on, which allows to start a servlet on CroSafe startup. The module will therefore read all the strings from a .tmx file (an XML, human readable file format for string internationalization) and update the User Interface accordingly to the language selected.

Moreover, a long lasting cookie will be saved in the browser, to remember user's language selection upon following logins.

From a user's point of view, language selection simply consists of one selection from a drop-down menu, so that the overview of the functionality can be omitted.

#### Report creation

The creation of an hazard report, is the base functionality of CroSafe.

Its functioning has been made as simple as possible, and consists in just few steps:

1. The user localize him/herself on the map, by using the position retrieval feature or by simply moving the map to his/her position
2. After clicking the add report mode in the side menu, he/she clicks on the map, where the report must be added. A temporary marker is added on the map.
3. After refining the position of the marker by dragging it on the map, he/she can click on it to open the add-report callout. The report can be thus specified with a mandatory title and category (to be picked from a drop-down menu) and an optional description, picture and tags.
4. Clicking the save button will, persist the report in CroSafe and make it available to the community

The overview of the feature is shown in Figure 4.7.

#### Report voting

Report voting is used both to assess reports, in a way that reports with many negative votes will more likely not be commonly perceived as hazardous, and to rank them: a report with a high number of positive votes, would probably

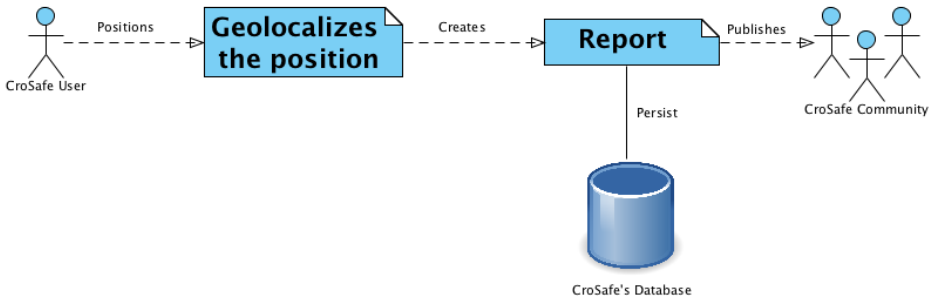


*Figure 4.7: Overview of Report creation from user's perspective*

indicate an hazard with high exposure, which is perceived as threatening by many users.

The voting feature is implemented in a really simple way, and requires just few step for the user to vote:

1. The user opens a report he or she's interested in, simply by clicking on its map marker
2. If the user wants to vote, he or she can simply click on the "plus" or "minus" button on the report callout
3. Once the vote is casted and saved on CroSafe's database, the whole community can see it while the user who casted it can later decide to cancel it

Votes will be used to rank hazards in order of popularity and, since risk is proportional to the exposure of an hazard, the ranking will be proportional also to the potential risk of each report, inside its own category.
Moreover, users who vote for a report are tracked by CroSafe, so that they can choose to receive updates on the report.

The overview of the voting feature is shown in Figure 4.8.

### Report filtering

The filtering feature is used both by the Crowd and the Authorities to show only reports whose categories they're interested in. The functionality usage is triggered by 9 toggle buttons, one for each category, present on application's side menu.
Its functioning is intuitive and the overview of the functionality can be omitted.

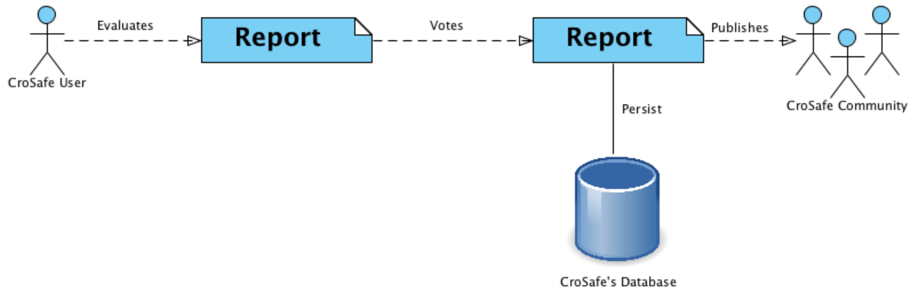


*Figure 4.8: Overview of Report voting from user's perspective*

### Friends management

This functionality is fundamental both for making the community grow and for creating a Social Network among users, since the common way of creating such a structure in a virtual environment, is through friends invitation and friendship requests.

While the prototype of the application never reached the production stage, where the creation of OSNs would become possible as well as meaningful, the methods and the data structure responsible for its management (a bilateral many-to-many reflective relationship between CroSafe users) are already implemented and operational in the prototype.
Friendship requests and invitations are sent specifying the email of the user, and notified both inside the application and through email.

Moreover, once the size of the community will become meaningful, competing with friends on the number of reports and their perceived value, will be made possible with minimum programming effort.

The overview of the functionality is shown in Figure 4.9

### Access through a Mobile Application

As stated in the previous chapters, mobile technologies allow, nowadays, the creation of applications that have all the features requested, specifically, by CroSafe.

The mobile applications access the RESTful Services published by CroSafe through specific APIs that interface external users with the core logic of the application.
The APIs should be reachable on HTTPS connection and, upon every standard HTTP request, should reply in JSON format.

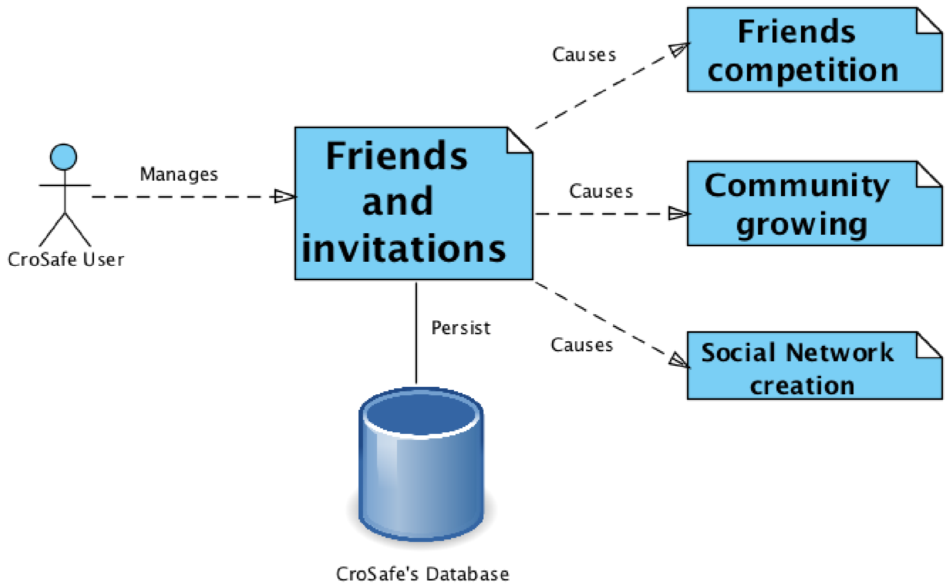


*Figure 4.9: Overview friend management both for user and system*

For the sake of testing the prototype, an Android application has been created with reduced features: the user will be able to login and, after localizing him/herself on the map (through the device GPS module and/or network position), will submit a report with the same data requested by the application's website.

Given the simplicity of updating an android application through versioning, the application itself has a module for checking if updates are available, so that adding new features and propagating them to the users will be easy even if the application is not present on the Android Market.

The overview of the functionality, from the mobile user's point of view, is shown in Figure 4.10.

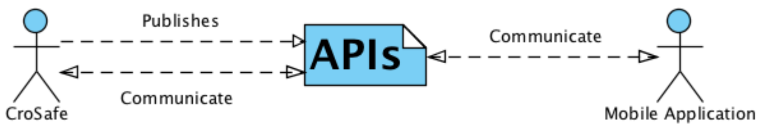


*Figure 4.10: Mobile application interacting with CroSafe*

### Publishing on Facebook and Twitter

This functionality allows users to share reports in CroSafe, both on Facebook and on Twitter. The user can decide whether to share a report on the moment of creation or to share a report's information while viewing it.
Both interactions are managed by the click of two buttons on the respective callouts.

In order to allow this feature, the user has to retrieve an access token from the Facebook and/or Twitter APIs.
While Facebook uses oAuth 2.0, and its simple get calls are managed simply using Java methods, Twitter uses oAuth 1.0 which needs a not-so-easy requests signing process. We therefore used a Java library, called Scribe, to manage Twitter's API calls.

Both connections are managed in a pop-up window and need the user to log out and back in, to register the changes. This is due to the fact that we couldn't embed the authentication dialogs in an *iframe*, that would have allowed the application to track its close event, therefore refreshing the logged user's properties.
Both Twitter and Facebook, in fact, don't allow to embed their dialogs in an *iframe*, for security reasons.

The functionality overview is presented in Figure 4.11. We added also the sharing of Achievements, even if they're not yet implemented in the application: they would use exactly the same interactions used for report sharing.

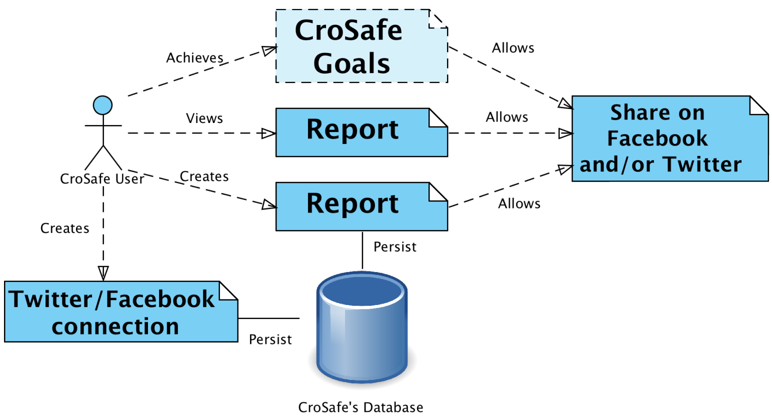


*Figure 4.11: Sharing achievements and reports on Facebook and/or Twitter*

On the other hand, here is a list of features to be implemented in future developments in order to adhere to the functionalities listed and validated thus far.

#### User Roles

Roles inside the application can be useful, once the community has reached a certain size, for reasons such as community control, report assessment, voting termination and community notification.

Basically two different roles would exist inside the application:

- **User**: any citizen that decides to join CroSafe community would start like this
- **Authority**: any authority that decides to actively join the community has this role. This would allow them to notify users about the report being taken in charge, closing the voting system on a report and interacting with the users subscribed to the report through notifications and emails.

Moreover we can decide to promote Users to being Super-Users (both automatically or manually, upon request of the user itself, if he/she meets some requirements), so that they gain more powers in order to help managing the community.

#### Authorities Communication

This functionality allows the interaction of CroSafe with the competent offices which are notified, according to some rules to be yet specified, about reports in their jurisdiction through emails.

Moreover, replies received can be analyzed by CroSafe and automatically forwarded to users who subscribed to reports (through voting).

Obviously, the best interaction between authorities and CroSafe, would be a direct involvement of the competent offices into the application itself, through “Authority” accounts or event through direct access to CroSafe’s database.

This would require some deals which may be difficult to achieve, especially for a new-born community.

We are therefore deferring the implementation of this feature to a point where the application itself has been tested carefully and the reports have been proven to be reliable enough.

After an initial analysis, the functionality overview is presented in Figure 4.12.

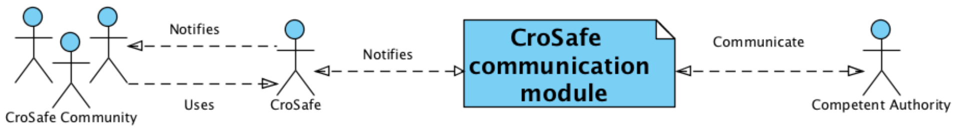


*Figure 4.12: Interaction with Authorities*

### 4.2.2 CroSafe Requirements and Use Cases

This section analyzes the requirements for the most important functionalities of the application, from the users' point of view, while introducing some Use Cases to better elicit requirements.

We begin with the introduction of a use case model, that represent the interaction of users with the whole system. The model is presented in Figure 4.13.

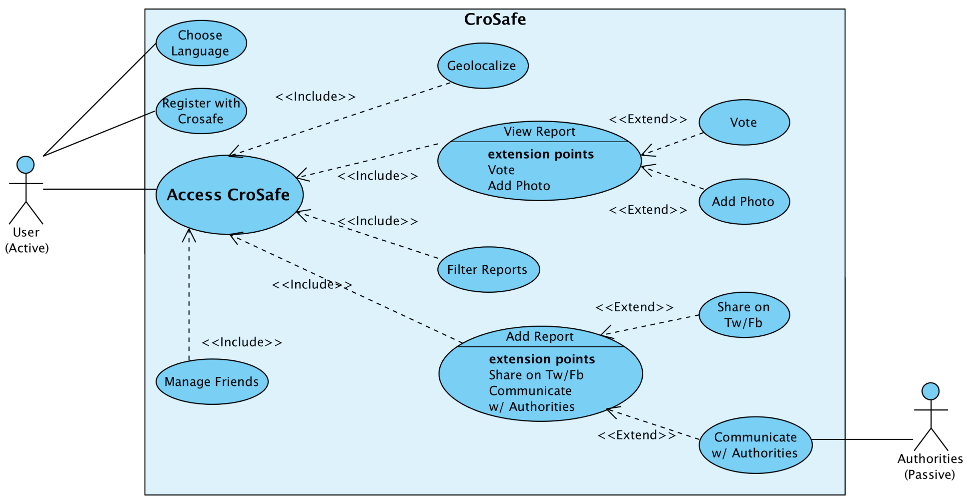


*Figure 4.13: CroSafe's Use Cases Model*

The only functionality that has been omitted from the model, for the sake of a clear representation, is the one regarding users roles.
Active Authorities and Super users are grouped into another actor (i.e.: active super-user) and the only use case added to the current model, is called *Modify/Update Report*.

The interaction of the Passive Authorities with CroSafe, on the other hand, is as simple as replying to an email, and won't be therefore represented.

The following paragraphs analyze some of the most important use cases just introduced, therefore eliciting CroSafe's requirements.

Since CroSafe is a web application that can be reached exclusively online, two requirements of CroSafe are easily spotted right away:

- The system must be online, up and running
- The user must have an internet connection

Moreover, when we say *access* CroSafe or any of its features, we ideally mean both through a web browser and the mobile client.

**Register with CroSafe**

| **Actor** | User |
|---|---|
| **Precondition** | – |
| **Postcondition** | The user is registered within the CroSafe system. |
| **Flow: New User** | 1. User accesses the registration page (through mobile client or web browser)<br>2. User fills in the required registration data and click *Register*<br>3. The system persists registration data on the Database, adding the day of registration<br>4. The user is registered within CroSafe |

| | |
|---|---|
| **Flow: FB User** | 1. User accesses the registration page (through mobile client or web browser)<br>2. User clicks on *Register with Facebook*<br>3. User grants CroSafe access to his/her Facebook profile<br>4. The system persists registration data on the Database, adding the day of registration and Facebook's access token<br>5. The user is registered within CroSafe |

The only requirement deriving from this use case, if the user wants to use the Facebook login, is for him/her to *own a Facebook account*.
Moreover, since the prototype hasn't implemented a secure connection to communicate with the mobile client (since we used Amazon's free tiers for its EC2 cloud service, which doesn't assign a securable domain), we decided not to allow mobile user's registration, since we would have needed to exchange Facebook tokens over an insecure connection.

**Access CroSafe**

| **Actor** | User |
|---|---|
| **Precondition** | The user is registered with CroSafe |
| **Postcondition** | The user accesses the CroSafe system. |
| **Flow** | 1. User accesses the login page<br>2. User inserts the login data or simply clicks *Login with FB*<br>3. The system validates the login and, if the validation succeeds, the user has accessed CroSafe |

The only requirement deriving from this use case, is that the *user must be registered*, whether through a CroSafe or a Facebook account.

**Geolocalize**

| Actor | User |
|---|---|
| **Precondition** | The user has accessed CroSafe, and his browser/mobile device supports geolocation |
| **Postcondition** | The user retrieves his/her current Geographical location |
| **Flow** | 1. User accesses CroSafe<br>2. User clicks on the *Get your position button* or simply waits for the device to get a GPS fix<br>3. User eventually allows the browser to monitor his/her position<br>4. After a while the position is received and pinned on CroSafe map |

The only requirement deriving from this use case, is that the user's browser/device must *support the geolocation feature* and user must allow the monitoring of his/her position.
Moreover, the Android client, automatically starts the geolocalization process once the application is started, so that steps 2 and 3 are not necessary.

**Add Report**

| Actor | User - Authorities |
|---|---|
| **Precondition** | The user has accessed CroSafe |
| **Postcondition** | The report is added to the CroSafe's Database and Authorities are, eventually, notified |

| | |
|---|---|
| **Flow** | 1. User accesses CroSafe<br>2. User clicks on the map, in the position he/she wants to add the report<br>3. The user fills in the report's detail<br>4. He eventually agrees to share the report on his social networks<br>5. The report is persisted on the system<br>6. Periodically, or when the report reaches some characteristics (i.e.: number of positive votes), the authorities are notified of the report, through email |

The only requirement deriving from this use case, is that the competent local authorities must have an *active email contact* and users must connect their Facebook/Twitter account in order to share their reports.

**View Report**

| **Actor** | User |
|---|---|
| **Precondition** | The user has accessed CroSafe |
| **Postcondition** | The user has gained knowledge about hazards around him, and/or has voted and added a picture |
| **Flow: Standard** | 1. User accesses CroSafe<br>2. User clicks on report to view<br>3. User reads data thus raising his/her awareness |
| **Extended Flow: Add Photo** | 1. User accesses CroSafe<br>2. User clicks on report to view<br>3. User reads data raising his/her awareness, and adds a photo to add information on the report |

| | |
|---|---|
| **Extended Flow: Voting** | 1. User accesses CroSafe<br>2. User clicks on report to view<br>3. User reads data and evaluates the report<br>4. If the user hasn't already voted for the report and evaluation is positive, clicks "+" otherwise clicks "–"<br>5. Vote is persisted on the Database |

The only requirement elicited from this use case, is that users have to be *allowed to vote just once.*

**Communicate with Authorities**

| **Actor** | Authority |
|---|---|
| **Precondition** | The authority must have an email contact. |
| **Postcondition** | The authority receives updates from CroSafe and its replies are forwarded to the subscribed users |
| **Flow** | 1. The authority email is imported into CroSafe's database (reported by users and validated by administrators), with an indication of its jurisdiction (hazard category(ies) + territory)<br>2. Periodically, CroSafe sends an email to the authorities, filtering the reports of interest (according to hazard category, territory and number of positive votes) |
| **Flow** | 3. The authorities (hopefully) reply to the CroSafe address, which will map a reply (parsed and recognized thanks to its unique report ID) to the users who voted it<br>4. The subscribed users receive the reply from the authority. |

This flow is still tentative since, as we already stated, before interacting with authorities we need to evaluate the system's performance and report's quality. Moreover, we really hope for authorities to actively take part to the functioning of CroSafe, so that they can interface directly with its database.

Anyway, this use case has few requirements:

- The competent office must have a contact email.
- The office's email address must be inserted in the database: this can be done with the help of users who report addresses of their territory offices, together with their jurisdiction.
- Since those addresses should be validated, this data should be entered by an administrator.
- The text of the exchanged email should be formatted in a way that makes automatic redirection possible though parsing.

The use cases omitted don't add any requirement, and their simplicity allows us to leave them outside the analysis.

We have therefore identified the main requirements for the application as a whole. Moreover, the technologies chosen for the project have the major advantage of working seamlessly on every browser, so we won't have to add any external interface for dealing with different platforms that access CroSafe.

Chapter 5 will move on toward the system's Architecture and Design specification.

# Chapter 5

# CroSafe Architecture and Design

*"The 1990s, we believe, will be the decade of software architecture. We use the term "architecture", in contrast to "design", to evoke notions of codification, of abstraction, of standards, of formal training (of software architects), and of style."*

Perry, D.E. and Wolf, A.L. [66]

Chapter 5 will try and specify the Architecture and the Design of CroSafe, both at different levels of specification.

We will begin with an high level architectural representation of the application, therefore we will try and specify the most important modules and their class representation.

Moreover, since Data structure is one fundamental part of the application, we will present the ER data diagram.

## 5.1 CroSafe Architecture and Modules

Figure 5.1 shows, at an high level of abstraction, the architecture of the system.

Already at this level we may spot the most important interactions in the system:

- The login/registration module

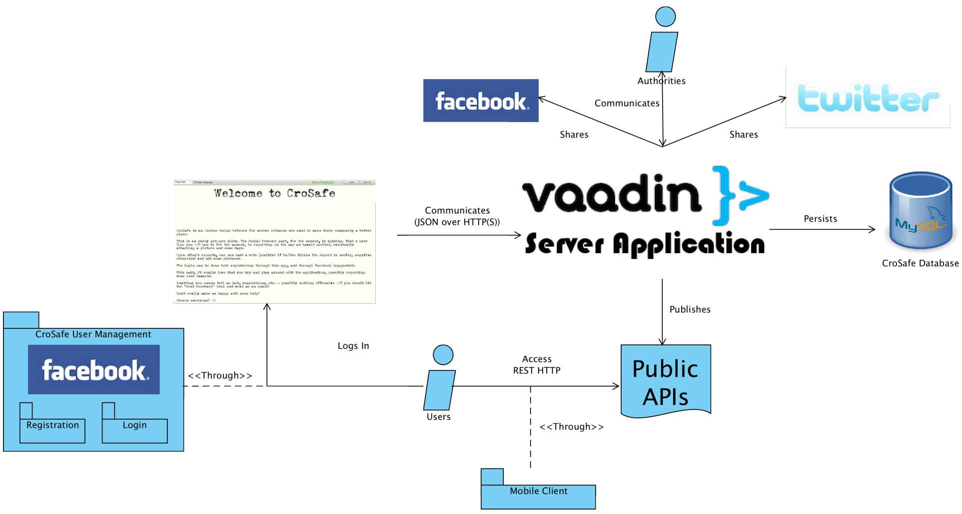


*Figure 5.1: High level CroSafe architecture*

- The persistence module
- The public APIs
- The authorities interaction module
- The Facebook/Twitter interaction module

The following subsections will analyze those interactions, together with some of the ones outlined in the use cases introduced in Section 4.2.2, trying to define the main functioning of the system.

Moreover, when data persistence will be part of the module, we will try and identify the attributes of the entity to be persisted.

### 5.1.1 The login/registration module

The module allows any user to register and subsequently log into CroSafe. Moreover, a user can decide whether to register new credentials, or simply use his/her own Facebook account.

To allow this, we extended the *User* class implemented in the *Appfoundation* add-on with the *CrosafeUser* class, that adds some CroSafe-related data (among the others, the registration date, a Report list and a Friends list). Moreover, to identify users who log in through Facebook, we extended *CrosafeUser* with *CrosafeUserFB*, which adds the Facebook *accessToken* property.

Finally, to allow the multiple-provider login schema, we also had to modify *Appfoundation*'s login utility methods, so that we can easily differentiate which typology of user is logging in, thus raising the security level of the application.

The classes inheritance and the sequence diagram of the registration/login phase are shown in Figures 5.2 and 5.3.

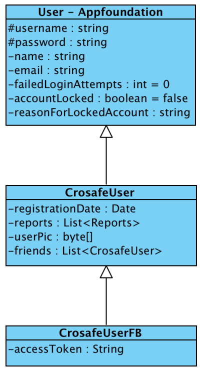


*Figure 5.2: The User class generalization*

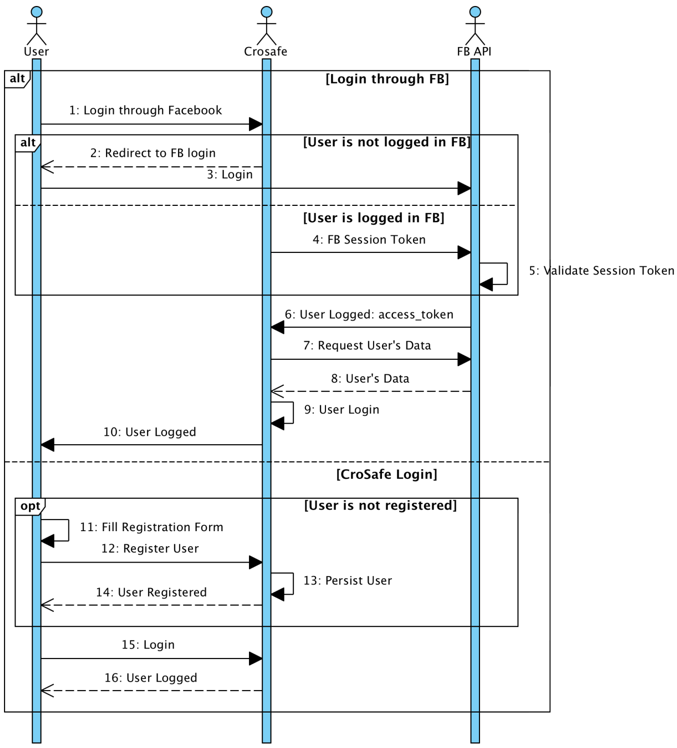


*Figure 5.3: The login/registration sequence diagram*

### 5.1.2 The persistence module

CroSafe uses the Appfoundation implementation of JPA in order to handle Entities persistence. The module depends on EclipseLink and adds useful session management tools, in order to simplify the mapping between the MySql database and the entity beans in CroSafe.

The database creation and management is, therefore, made a lot easier by this useful add-on that makes available a good amount of tools commonly needed by the applications.

What we do, while programming, is simply setting some specific annotations over the classes and properties and the module will automatically create the relative structures in the database.
The resulting ER diagram, shown in Figure 5.4, illustrates the structure of the application's database, automatically created upon the annotations on the Java classes.

We can notice, for instance, the automatic creation of a table called *"CrosafeUser_has_Friend"*, created in order to make a *Many to Many* reflexive friendship relationship among the application's users.

Moreover, in the *CrosafeUser* class, we notice an attribute called *"DTYPE"*, which carries the user's typology, whether *CrosafeUser* or *CrosafeUserFB*.

### 5.1.3 The public APIs

The public APIs allow the mobile application to interface with the services offered by CroSafe.

In order to test the prototype, we implemented two fundamental APIs:

- Login: used to login a mobile user and retrieve a token used to identify the requests
- Add Report: used to add a report to the application, using a multipart Form POST

Moreover, we implemented two APIs for accepting and declining friendship requests which can be eventually used to manage requests through a simple GET request sent, for instance, as a link through email.

The implementation of the APIs was simplified by the nature of the application (i.e. server side) and leverages the HttpServlet Java class.
Parsing the Form POST request has been the trickiest part since, running

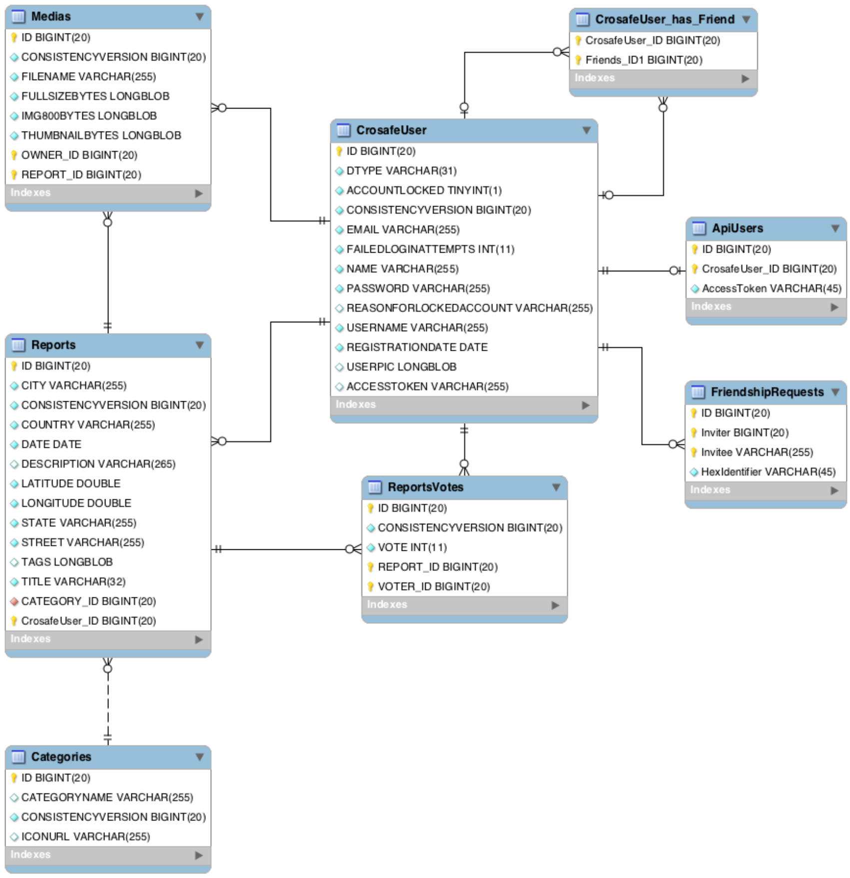


*Figure 5.4: CroSafe's database ER schema, as generated by the Persistence module*

on a servlet version lower than 3.0, we don't have native methods to get its parts. We therefore had to use an Apache library to parse the request.

The connection, established through a "fake" secure connection (i.e. HTTPS with self signed certificates which makes the connection cyphered but open to MITM attacks), begins with the user's login that validates his/her credentials. Once the credentials are validated, the server persists an access token (i.e.: a unique randomly generated hex string) in its database, thus replying to the user with the same token which will be used in order to identify the subsequent requests.

Moreover, to secure the APIs we add a unique application id (i.e.: an id that identifies the mobile application) so that requests can be served only if they carry a registered ID, hard coded inside the mobile client and saved in CroSafe Database.

Even though the implementation results not completely secure (it would be advisable to use an expiring token, or to implement the oAuth 2.0 authorization mechanism server-side) it is indeed enough to allow the testing of the mobile application, with one main restriction: the user won't be able to register through the mobile client to avoid the transmission of sensitive data (e.g.: Facebook's access token).

Figure 5.5 illustrates the sequence of events to access the public APIs.

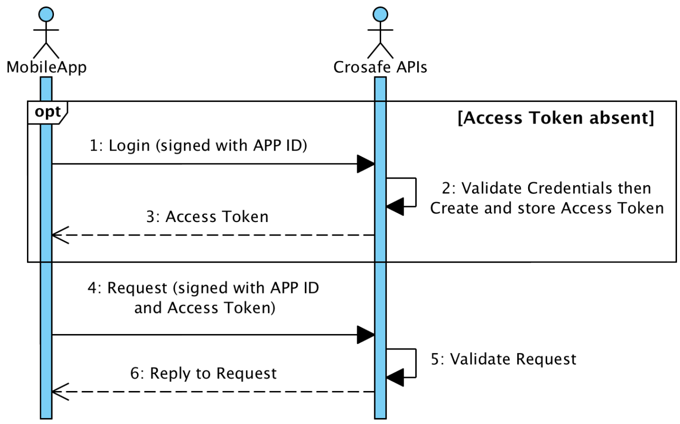


*Figure 5.5: APIs interaction with the mobile application*

As of this moment, another API is under development, which allows the users to view reports around them also on the mobile application.

### 5.1.4 The authorities interaction module

The module to handle the interaction with the authorities should take care of two main tasks:

- Periodically communicate to the competent offices a record of the reports in their jurisdiction
- Map the authorities' replies with the users who voted for that report, therefore forwarding the replies

We therefore need a table in the database that contains the data for the competent offices, carrying the following information:

- **Email Address**
- **Jurisdiction on Hazard categories**: mapping the *Categories* table

- **Jurisdiction on Territory**: reporting the city - state/region - country

We can then map virtually any report to a competent office (if it exists).

The laws that regulate the dispatch of emails are not decided yet, but the main idea may be to send an email once a report reaches enough positive votes. This would mean that enough people feel endangered by the hazard reported so that the risk tied to it is potentially higher than the others.

The sequence diagram of the interaction for the module is presented in Figure 5.6.

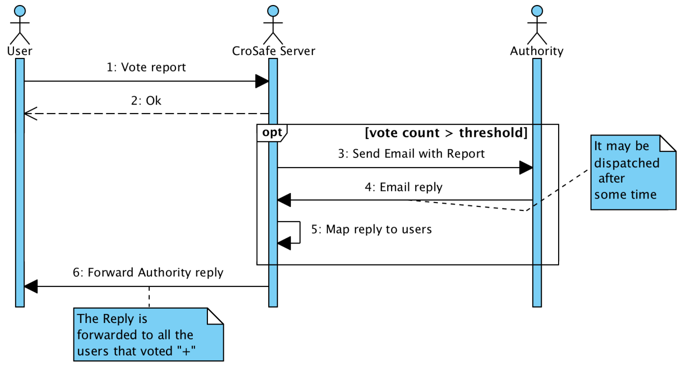


*Figure 5.6: Communication with the Authorities*

### 5.1.5 The Facebook/Twitter interaction module

The module allows users to publish data on the most important social networks. Given the results of the survey, presented in 3.3, we think that the most important connections should be the ones with Facebook and Twitter.

Both the social networks have authenticated APIs that accept requests signed with an access token. In order to obtain the access token, Facebook uses the authentication protocol called oAuth 2.0, presented in 4.1.3, while Twitter uses the older oAuth 1.0 (even though it's planning to move to oAuth 2.0).

CroSafe already obtains the Facebook token when a user logs in through his/her account, while Twitter's authentication hasn't been implemented yet.
Its implementation was made easy thanks to a Java library called Scribe, which takes care of the most complicated aspect of the protocol, i.e. requests signing.

Users will be able to choose what kind of data they want to share on the other OSNs (reports, achievements, badges, etc.) and, once obtained and stored the tokens, the interaction with the services will be pretty straightforward: we will just send a POST request to the appropriate API.

### 5.1.6 The friends management module

The data structures and methods for holding a friendship relation are already present in the system (cf. the table CrosafeUser_has_Friends in Figure 5.4), while the friendship network hasn't been used yet to implement the competition features presented thus far.

Searches are carried on using email address and, obviously, a friendship request must be accepted before the relationship is established.
In order to achieve this, we used a table in the database that carries three properties:

- **The inviter ID**
- **The invitee ID**
- **Invitation hex ID**: an hexadecimal unique random string associated with the request

The friend acceptance/refusal is managed by two methods (one for the accepting requests, the other for refusing them), which identify requests through their hex ID. We also implemented two serlvets that process GET requests carrying out the same tasks. This approach allows us manage the request management both in-app and through email.

The friendship management diagram is presented in Figure 5.7.

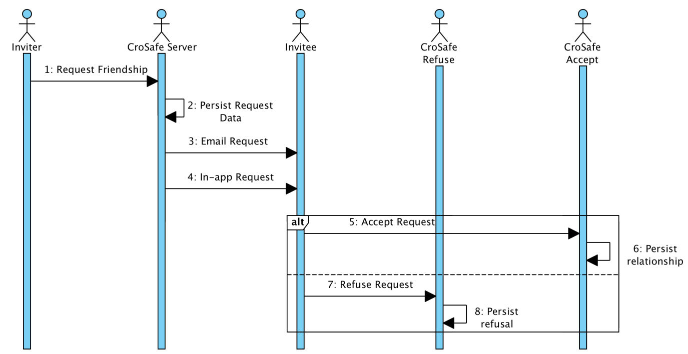


*Figure 5.7: Friendship requests in CroSafe*

### 5.1.7 The add report module

The *add report* module, is the central element of the application. It is extended by the possibility of adding a photo to the report at the moment of creation and its functioning is shown in Figure 5.8.

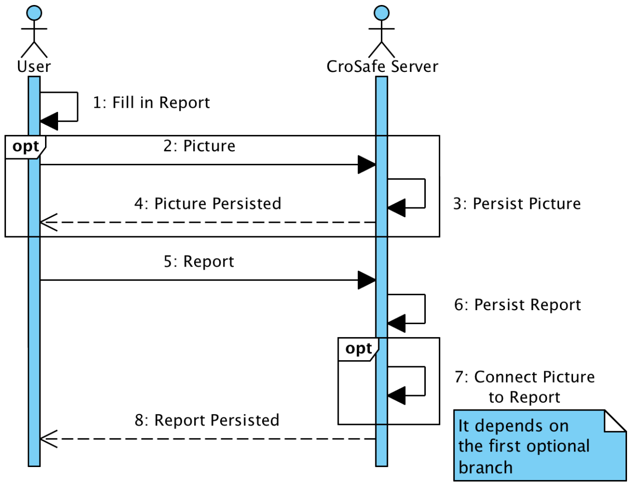


*Figure 5.8: Adding a report in CroSafe*

Moreover, we present here two other fundamental interactions that take place on a Report once it's saved: adding a picture and voting for the report. The straightforward interactions are presented in Figure 5.9 and 5.10.

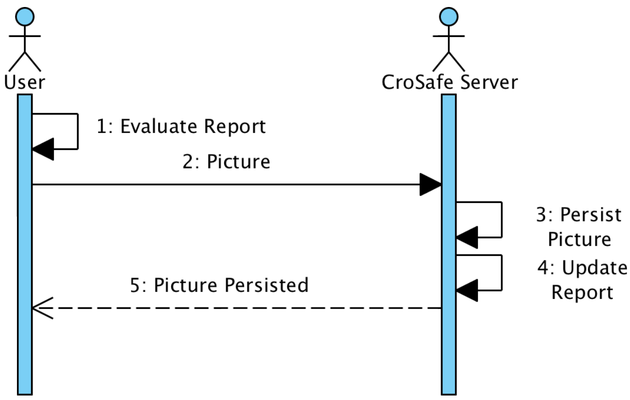


*Figure 5.9: Adding a picture in CroSafe, to an already existing Report*

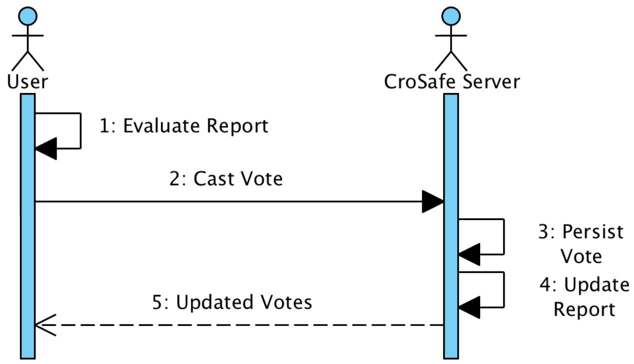


*Figure 5.10: Casting a vote for a Report in CroSafe*

## 5.2 CroSafe Final Overview

Throughout Section 5.1 we introduced both the current prototype modules and the ones to be implemented for further development.

We therefore enrich the ER model presented in Figure 5.4 thus obtaining the final representation for the CroSafe's database, presented in Figure 5.11.

This representation follows the model automatically created upon the annotations in the data classes of the application and follows all the requirements found throughout Section 4.2.2.

Further refinement will be probably needed during actual implementation of the new characteristics, but the schema may be indeed useful also during the implementation of yet unexplored features.

While the EER schema helps understanding the structure behind the application, the implementation of JPA is done by extending the Appfoundation *Abstract Pojo* class, which carries methods for verifying the object consistency, and using the *JPAFacade* class for persistence and querying.
Figure 5.12 represent the two classes, used by the data module of the system to manage entities.

Figure 5.13 illustrates the main packages inside the application, as seen from the initialization package *com.vaadin.crosafe*. The complete representation of package dependencies would be less readable in the its printed format, and is therefore omitted.

We indeed notice how the application is managed by the classes inside the central *com.vaadin.crosafe* package, instantiated on the application startup, while the APIs proceed with the same initialization thus functioning as a second entry point to the system as a whole.

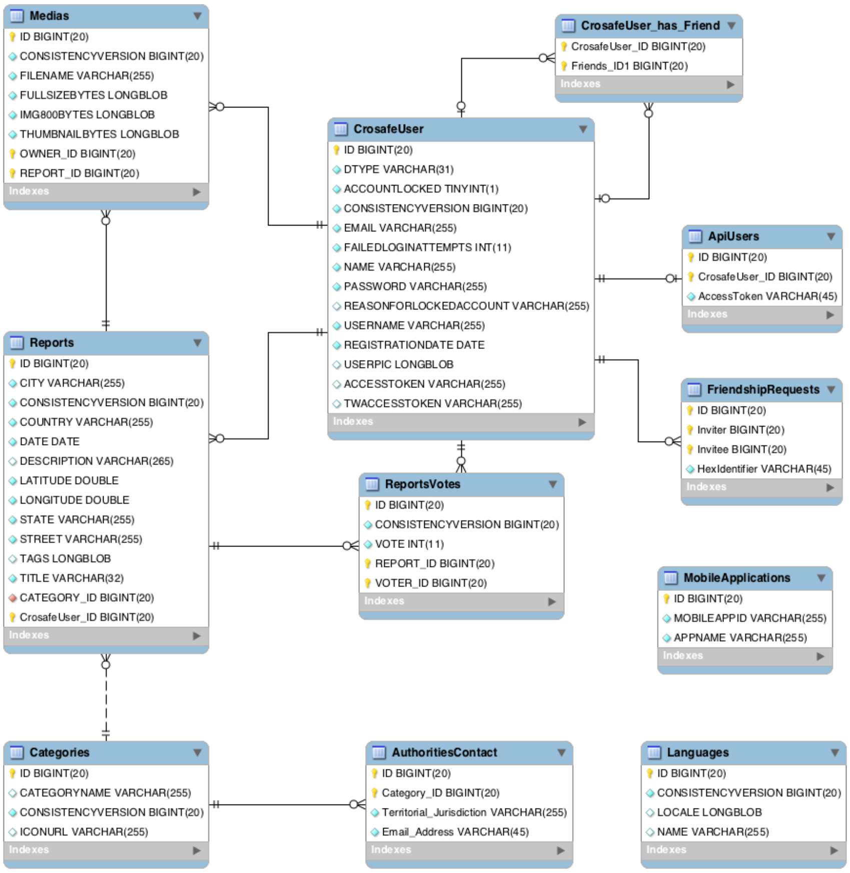


*Figure 5.11: CroSafe's final ER schema*


*Figure 5.12: Appfoundation's classes for Persistence*

The *appfoundation.authentication* package contains the classes for authentication, while the *data* package has the classes implementing the objects that map the Database entities.

*Json* and *utils* packages contain system utilities that are used by the system

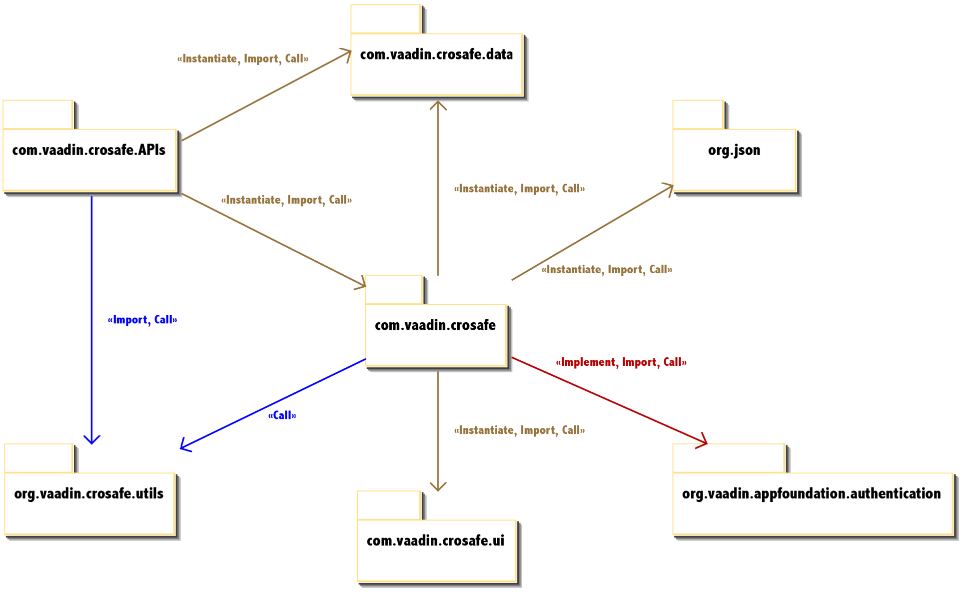


*Figure 5.13: CroSafe's Implemented Package Dependency schema*

in its functioning.

Figures 5.15 and 5.14 show the implementation of the Users classes and the RESTful APIs.

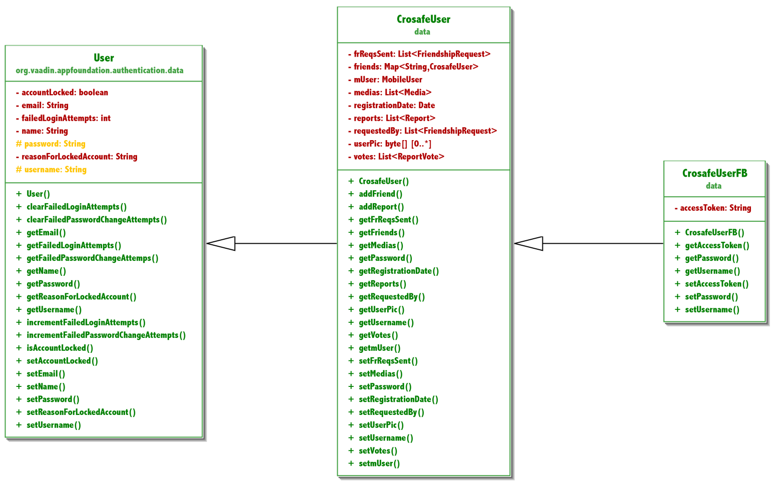


*Figure 5.14: CroSafe's Users Classes*

Figures 5.16, instead, shows the implementation of the user's interface. As we can see from the class diagram, the various classes are managed by a central object, used to map the current session with the main UI objects, so that we won't have to carry references to each class.

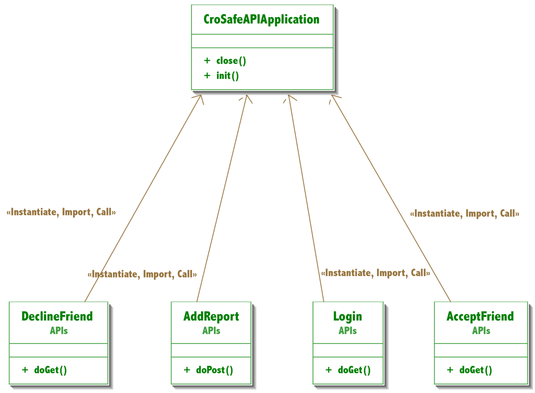


*Figure 5.15: CroSafe's Implemented APIs*

Using this approach we use a singleton (*CommonObjectContainer*) that maps the UI objects to their main application instance, which can be easily found using the *getApplication()* method, available in every Vaadin class.

The final classes presented, are the ones concerning the users authentication. The two utility classes are modified from the Appfoundation library, in order to manage the login for two different users category (Facebook user and "standard" user), which proceed with login using two different flows.

Figure 5.17 shows the two different authentication methods: Facebook users log in through the main class, which implements the *HttpServletRequestListener* class (Vaadin *Application* classes are, in fact, servlets that communicate with the UI through JSON strings), while "standard" users authenticate through the login window.
Both flows use, though, the methods present in the *crosafe.utils* package.

The application involves, obviously, more classes and packages. For the sake of a clear representation, we introduced only the most meaningful classes, leaving out secondary interactions in order not to overcrowd the class diagrams.

While the final Section 6 deals with the conclusions and future developments of the work, we refer the reader to Section A in order to find a brief User's Manual and a usage example, thus getting a clearer idea of the prototype implemented.

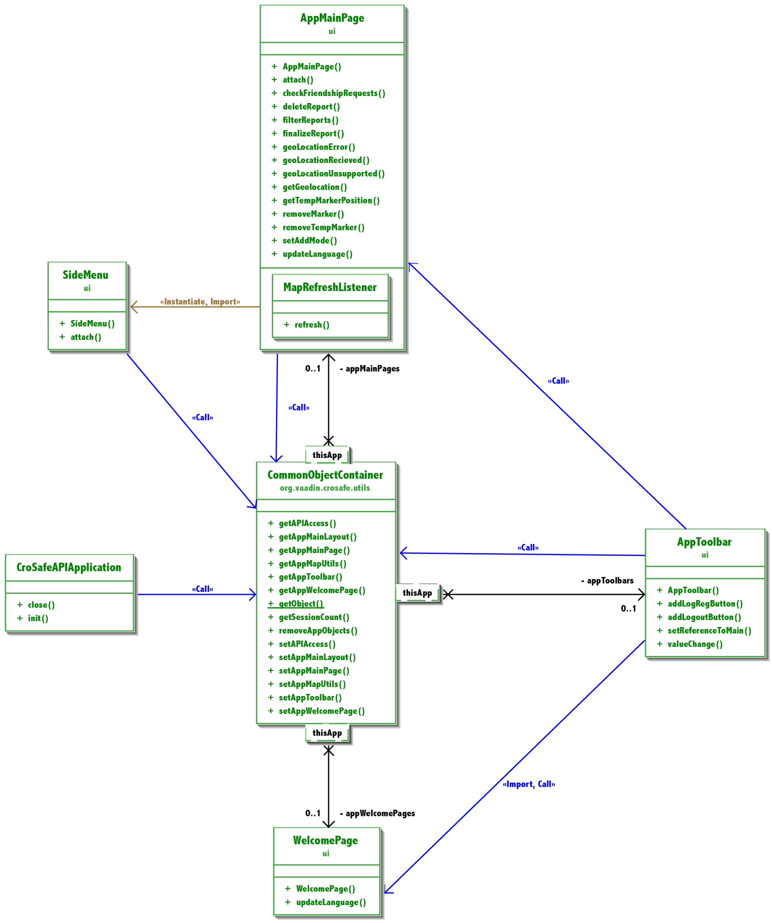


*Figure 5.16: CroSafe's User Interface Classes*

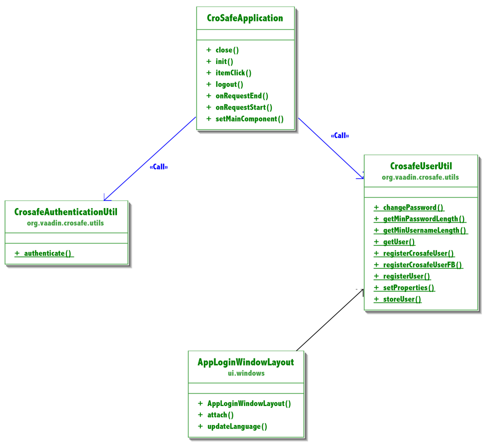


*Figure 5.17: CroSafe's Authentication Classes*

# Chapter 6

# Conclusions and Future Developments

*"Prediction is very difficult, especially about the future."*

Bohr, N.

The aim of this work was to evaluate the possibility of using an Online Social Network for mapping local hazards through crowdsourcing, in order to help the Emergency Management cycle, specifically in its Mitigation phase.

Using common technologies, such as RESTful web services, smartphones and online mapping services, we can create such an Online Social Network that would lead to the creation of an updated map of local risks.
Those will be validated by the users themselves, who can vote for reports therefore ranking them in order of exposure and perceived danger.

The map can then be used both by citizens, who will witness an upraise in their awareness regarding local problems, and by authorities who will have updated and ranked data regarding dangers under their jurisdiction.

The starting idea was validated through literature analysis, where the interaction between social media and and emergencies is nowadays a central topic, but also through a survey that was taken by 121 people.

While the analysis brought evidences that such an approach is being studied by others (cf. Ushahidi and Citizen's Connect), we also saw how there is no such product like CroSafe, that aims to use the models taught by existing OSN on the crowdsourcing of emergency-related data.

The people who took the survey supported the idea upon which CroSafe is built and, once decided which crowdsourcing model to adopt, we began building the CroSafe application.

Using the Vaadin framework, we built the backbone structure of the system upon which a user can interact with the community as a whole. Moreover, we enriched user's experience with an Android mobile application that, as the moment of writing, can be used just to report hazards.
Even though the community would greatly enjoy the benefits of a mobile application (in order to report hazards immediately), we had to build a web application first, in order to support data persistence, allow better data overview and drive more users to join the community.

At the moment of writing, the community has been online for 20 days, and it has barely reached the public outside a group of the author's acquaintances. 51 users subscribed to CroSafe, from whom we gathered 52 reports: 47 from Milan and surrounding areas, 2 from Turin , 1 from Moggio (Lecco), 1 from Castel San Giovanni (Piacenza) and 1 from Sevilla, Spain.

Even though it may be a little early to draw conclusions on the available data, we may infer some interesting insights:

- **Users prefer to log in through Facebook**: out of the 51 users who registered at the moment of writing, 38 are the ones who logged in using their Facebook account.

- **Users in Milan mostly report road issues**: out of the 47 reports in the city of Milan and suburbs (coming from 18 different users) 30 deal with road hazards (mostly roads condition and car accidents). This agrees with the results of the survey, where people ranked road hazards in second position.

- **Still no *Drought* reports**: all the reports come from users who live in an urban environment, and the absence of drought reports is thus explained: as the survey pointed out, this kind of hazard was ranked last by this category of users.

- **Still no *Power outage* reports**: power outages in cities are extraordinary events, and usually come during periods of heavy rainfall or extreme cold. The time during which the data was gathered, is usually calm under this point of view, thus such events weren't reported yet.

- **Just one *Violence and crime* report**: even though people who took the survey suggested the category as the most important inside CroSafe, we just have one report dealing with it, coming from a town 20 minutes drive away from Milan. Reasons for this result may be multiple: the community is still small and most of the users live in risk-free areas, people want to know where crimes are but aren't willing to report them but, also, we may think that the perceived threat of crime in Milan is actually higher than its real presence.

- **The community needs some incentive for growing**: while the users where asked to invite some friends to join, just few of them did. In order to have more users joining, the application should fully implement the features identified thus far and use some social advertisement technique together with user's word of mouth. We tried creating a Facebook Group and Page for the application, but this approach didn't manage to attract people outside acquaintances of the author.

- **A mobile application is needed for the main platforms**: we had the time of developing a mobile application just for the Android platform. It now accounts 12 users. In order to reach out more people, we would need to develop a version at least for the Apple iOs platform and, eventually, for Symbian and Windows Phone.

- **Problems with password**: users who didn't log-in through Facebook, have problems remembering their password (5 cases). While, for the moment, the registration process doesn't check the user's email, we should modify it to do so, in order to be able to reset user's password in case of need. The process must be completed manually by the author for the moment and discourages a user that forgot his/her credentials.

The development of the application will continue following the guidelines outlined by this work, and will hopefully provide more data with time. Moreover, we will continue implementing the features present in the online application on the mobile client, so that it will offer the same functionalities to the end user.

Table 6.1 carries a quick overview on the reports gathered thus far. Updated results will be presented on the day of the final presentation.

| Report Category | Count | Considerations |
|---|---|---|
| **Road Hazard** | 34 | Users reported road works (10), car accidents (10), potholes (6), new parking toll areas (3), viability issues (3), uneven street (1) and dangerous crossroads (1). One report specifies how the pothole may be very dangerous for cyclists: they may be a specific category of application's users. |
| **Building Collapse** | 6 | Users reported four abandoned buildings (a factory, a farmstead and two former shops, one with asbestos roof) inside the city, a construction site and a dismissed area on a collapsed building site. |
| **Fires** | 2 | Users reported a car burning in center Milan and a burnt clothing shop's warehouse. |
| **Floods** | 2 | User reported a leaking pipe and a blocked drain. |
| **Ice and Snow** | 2 | Users reported street with snow residuals and frozen sidewalk. |
| **Violence and Crime** | 1 | User reported a stabbed egyptian citizen. |
| **Generic Danger** | 5 | Users reported a club that was too crowded, debris on the road, illegal camping in a city park, abandoned animals in a bin and generic neighborhood degradation. |

*Table 6.1: Reports Overview after 20 Days of usage*

Finally, we must say that building the community for a new OSN will not be easy but, according to our researches, we think that the application, over time, has the potential for growing and turning out useful both for citizens and administration for moving towards a safer environment.

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# Appendix A

# Manual and Presentation of the Prototype

This Appendix introduces the implemented applications through a user's manual enriched by some screenshot to illustrate the most important interactions of the user with the system in an hypothetical flow of actions into CroSafe.

We will first illustrate the features available on the main website and finally introduce the Android client, used for reporting hazards through one's mobile device.

## A.1 The Web Application

### A.1.1 Registration and Login

Once landed on the home page (Fig. A.1 of the application[1], the user needs whether to register a new account (Fig.A.2 and only subsequently log in (Fig. A.3) or log in directly through his/her Facebook Account.

The login through Facebook doesn't need a registration (or better, the registration is automatic using Facebook's data), and is fired by a click on the "Login with FB" button.
The user will therefore login on Facebook (Fig. A.4) and then allow the CroSafe to access his/her Facebook data (Fig. A.5).

Clicking on "Go to App" will register the user inside CroSafe and redirect him/her to the CroSafe main page (Fig. A.6).

[1] `http://ec2-50-16-120-222.compute-1.amazonaws.com:8080/CroSafe`

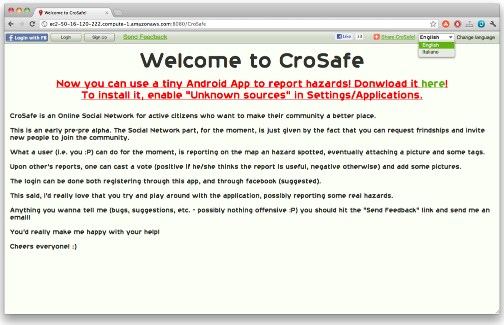


*Figure A.1: CroSafe Home Page and Language Selection*

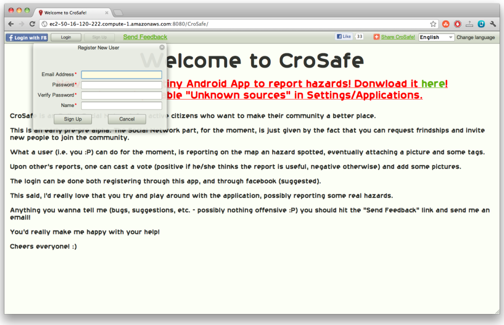


*Figure A.2: Registration Window*

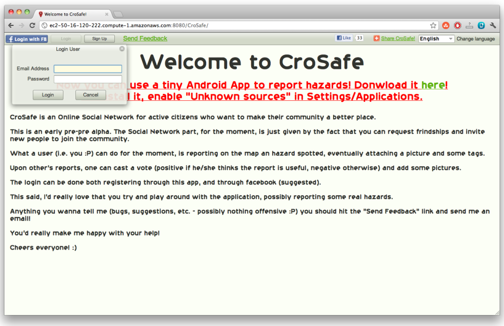


*Figure A.3: Login Window*

The Facebook authorization and registration phase, is needed only on the first login. Following logins, will simply require that the user is logged with his/her Facebook account.

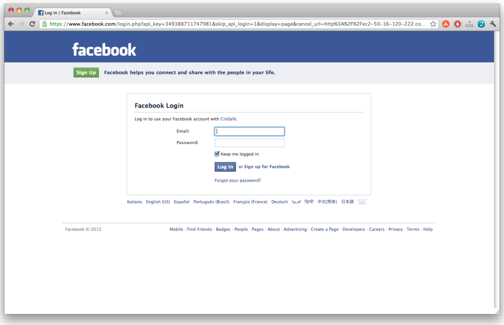


*Figure A.4: CroSafe Facebook Login*

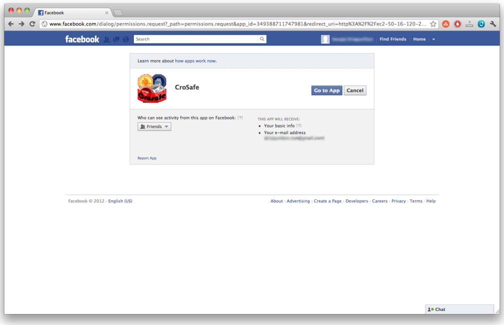


*Figure A.5: Facebook Permission for CroSafe*

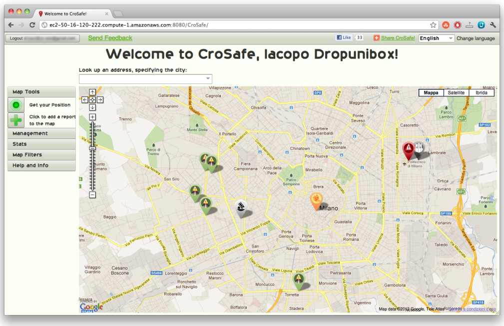


*Figure A.6: CroSafe Main Page*

### A.1.2 Getting Help

The user can get help inside the application, both holding the mouse pointer over an area and opening the help window inside the application (Fig. A.7). The framework allows the user to keep on using CroSafe with the windows open, so that he/she can easily learn how to use the application.


*Figure A.7: Help Window*

### A.1.3 Finding the Position

Once the user is logged, he/she can easily find a position on the map using the Address Lookup (Fig. A.8) or the browsers' geolocalization module, activated by clicking on the *"Get your Position"* button (Fig. A.9).
Both interactions are extremely simple and immediate.

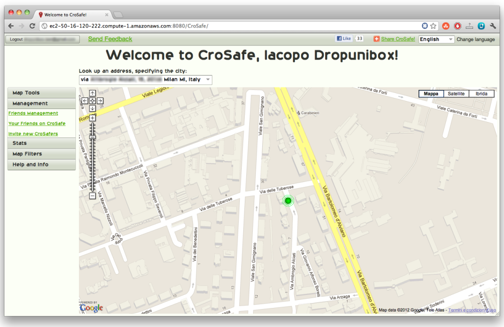


*Figure A.8: Address Lookup*

### A.1.4 Filtering the Map

The user can easily filter out the categories of interests on the map. This is done simply by clicking on the toggle buttons in the side menu: the categories faded out will not be visible on the map (Fig. A.10).

### A.1.5 Users invitation and Friendship Requests

In order to make the community grow, the user can invite new users to join CroSafe by simply sending them an email through the application

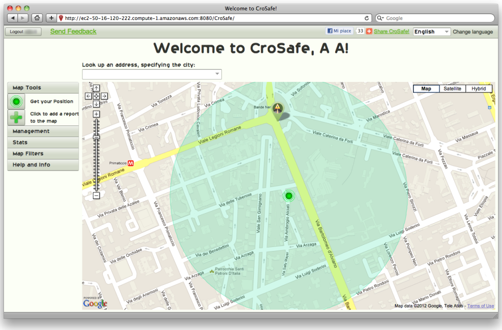


*Figure A.9: Geolocalization*

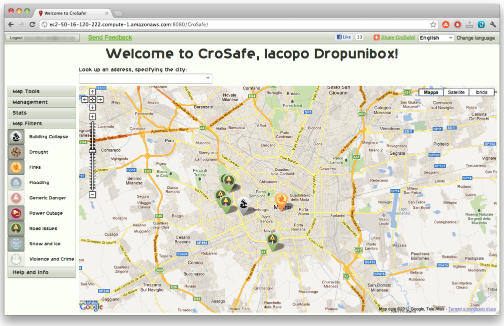


*Figure A.10: Map Filters*

(Fig. A.11). More emails can be sent at once, separating them with commas.

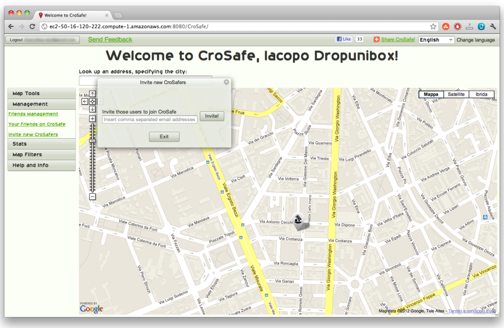


*Figure A.11: Invite new Users to join CroSafe*

Moreover, in order to build a network of friends to compete with, we implemented a window for requesting and managing friendship requests among users. The window pops up by clicking on the "Friends Management" in the “Management” menu.

Invitations are carried out by specifying a user’s email address (Fig. A.12) and hitting the “Invite!” button.

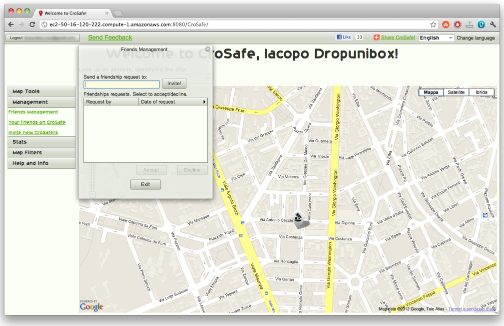


*Figure A.12: Friendship request*

When a user receives a request, a notification pops up (Fig. A.13) and the user can therefore decide whether to Accept or Reject the request, simply by navigating to the same “Friends Management” window, selecting the request and clicking on “Accept” or “Decline” (Fig. A.14).

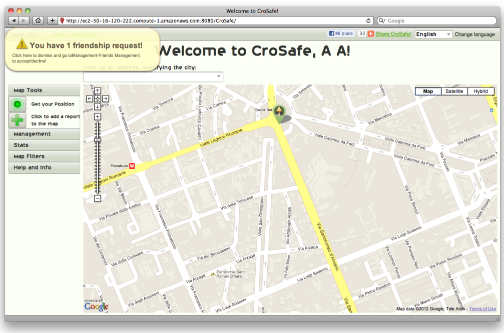


*Figure A.13: Friendship request Notification*

The user can check all of his/her friends from the “Your Friends on CroSafe” menu, in the “Management” section (Fig. A.15).
Ideally, every friend will have his/her own page with information and statistics. This feature hasn’t been implemented yet at the moment of writing, even though the data is already available in the System.

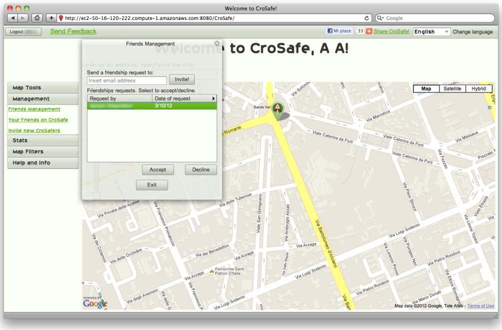


*Figure A.14: Accepting or Rejecting a Friendship Request*

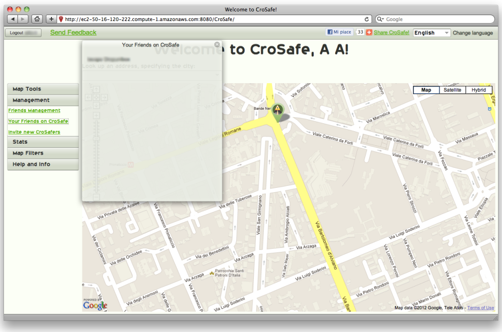


*Figure A.15: Friends list*

### A.1.6 Facebook and Twitter Connection

Connecting with Facebook and Twitter is very similar and the flow presented is valid for both services.
Obviously, if the user logged in through Facebook, the “Connect to FB” button will not be available, since the connection was already established upon login.

In order to establish the connection, we click on the corresponding button in the *Management* section of the side menu (Fig. A.16) and the Twitter's/Facebook's log-in–authorization window immediately pops up.

After authorizing the application, the pop up closes and we're back to the application main page. A notification asks the user to log out (Fig. A.17), in order to register the changes to its entity on the database. This glitch is due to the fact that neither online social network allows their authentication window to be embedded in an iframe, so that we could have listened to the event of window close, therefore refreshing the user's object.

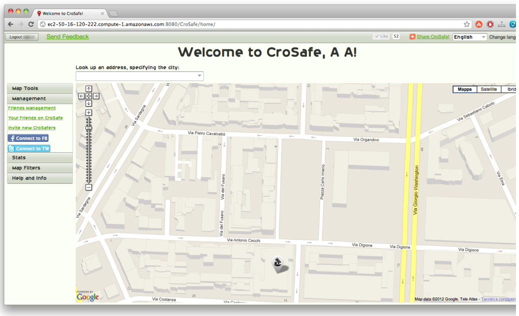


*Figure A.16: The connection buttons*

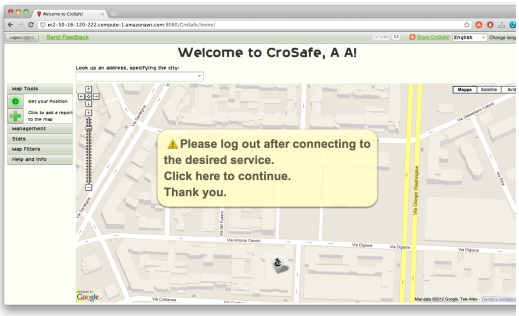


*Figure A.17: The Logout Notification*

When the user logs back in, he will see the menu button grayed out: the connection has been successful and the access token is now saved on the database (Fig. A.18).

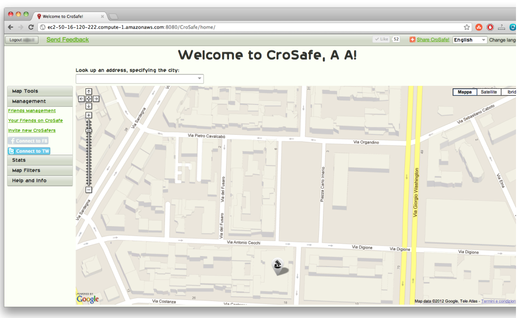


*Figure A.18: Connection success: grayed out button*

### A.1.7 Report Creation and Voting

The core functionalities of CroSafe are, indeed, Report Creation and Voting.

In order to add a report, a user has to click on the "Add Report" button in the "Map Tools" menu and click on the map to position the report: a temporary marker is therefore added to the map. By clicking on it, the report callout will pop up (Fig. A.19).

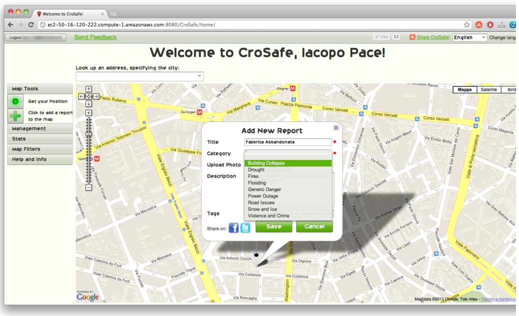


*Figure A.19: Adding a report*

After filling in the requested data (the sections marked with a red star are required) and eventually adding a picture, the user can persist the report by clicking on the "Save" button.
If the users has the Facebook and/or Twitter toggle button selected, the report data will be shared on the corresponding service.

A saved report can be viewed simply by clicking on its marker: this action pops up a callout with the report Data (Fig. A.20) and buttons to delete the report (if the user created it), add another picture, vote for it and share it on Facebook and Twitter.


*Figure A.20: Viewing a report*

Moreover, the user who voted for a report can later on decide to cancel the vote casted but also delete a picture he or she uploaded to the report (Fig. A.21).

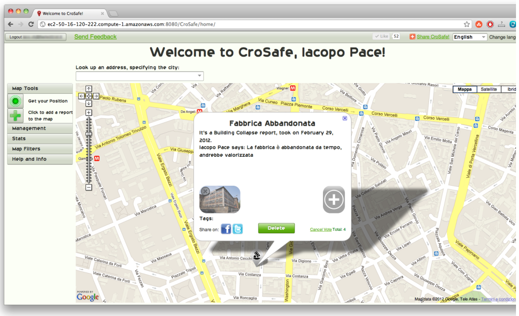


*Figure A.21: Managing a Report and Votes*

## A.2 The Android Client

The Android client's functionality are pretty bare-bone.
The user has to register (or log in from Facebook) once before using the mobile application, since we weren't able to obtain a certificate to secure the connection for data exchange with the mobile application and didn't want to send data such as the Facebook access token over an insecure connection.

Once this first step is done, the user can log with his/her data, which are sent over a connection secured with a self-signed certificate (connection is therefore cyphered but unprotected against MITM attacks) or through his Facebook account (Fig. A.22).

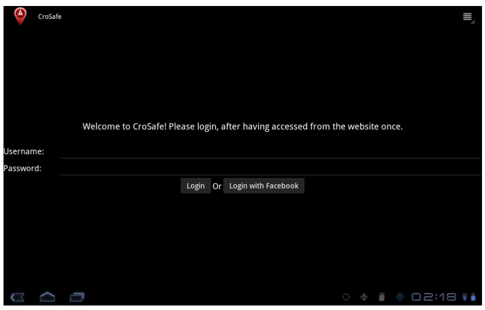


*Figure A.22: Login from the Android Application*

Once he/she is logged in, the application shows a map with a temporary marker (the last user's position as saved by the O.S.) and starts getting a

GPS fix in order to obtain a more precise position.
The user can also drag the marker and drop it to precisely locate the report (Fig. A.23). After filling in the report details and eventually adding a picture (taken from the device camera or selected from the gallery – Fig. A.24), the user can submit the report to CroSafe.

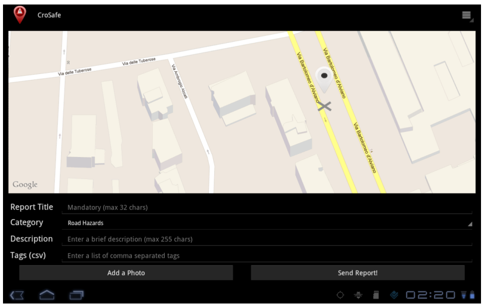


*Figure A.23: Dragging the report marker*

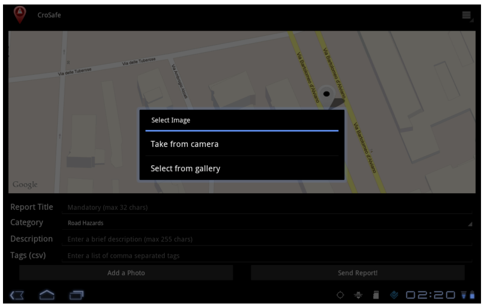


*Figure A.24: Adding a picture to the Report*

Once this is done, the application is ready to report another hazard! (Fig. A.25)

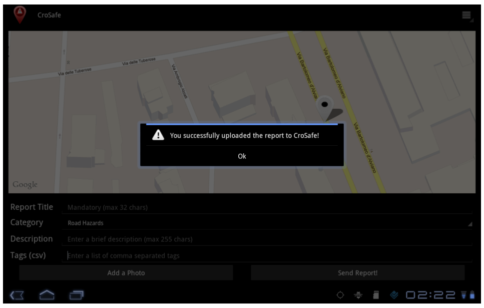


*Figure A.25: Report uploaded to CroSafe!*

We also implemented a system for checking if a new version of the client is present on the download server (Fig. A.26). The check is run every two hours, and fired from the application menu (Fig. A.27) or when the application is restarted.

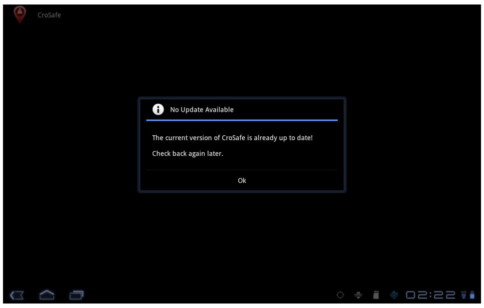


*Figure A.26: Result of Updates Check*

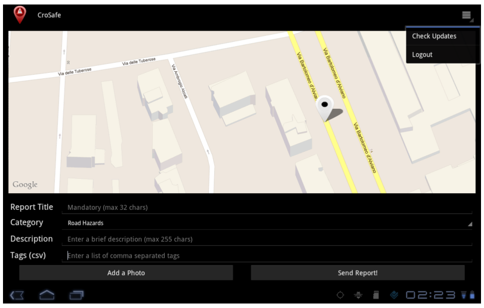


*Figure A.27: The application menu in Android 3.2*

Moreover, the user can decide to logout, always proceeding from the menu, thus deleting tokens saved on the device and proceed with another login.

At the moment of writing, the implementation of the "Report Viewing" functionality on the Android client, is underway.

# Appendix B

# Annexes

## B.1 Email Exchange with Ushahidi

In this section is reported part of the email exchange with Heather Leason, Director of Community Engagement in Ushahidi.
The conversation may be found online here.

### Iacopo Pace wrote on November 29, 2011 @ 10:39 AM

Hi, thanks for the reply! :)
I went more into deep, in the topic of crisis management, and decided, together with my professors, to move the focus of my thesis to the mitigation phase: my idea would be to build a web app, with at least one mobile application that, through checkins, will give users the possibility of reporting possible future dangers they can spot in their territory. This way we can both use the knowledge of people living their cities/towns to spot possible dangers (from rough street conditions to unsafe buildings, deteriorated neighbors, dangerous crossroads and many others) that can be mapped, and also use visitor's feelings when visiting a city, in a way that may be useful to report issues that may have not being spotted by people living there all the time.

I got the idea after reading the literature where i found lot of articles saying that crowdsourcing may be useful in all the phases of emergency management, but found remarkably little information over crowdsourcing in mitigation phase.

In this scenario, i was planning also to allow users to share their reports on Twitter (using hashtags) and Facebook. Thanks to the hashtags on Twitter, Ushahidi would be able to crawl the reports, then mapping all the reports inside Ushahidi (and it may be useful to check, during response/recovery, how some reported problems may have been already spotted during mitigation).

I would really love to get some feedback from you guys in Ushahidi: i already sent an email to Patrick Meier (who wrote me after i contacted Ushahidi), but i guess he's super busy to reply right now ;)

Anyway, i already begun implementing the application, since i got positive feedback from my professors. :)

Thanks once more,
Cheers
Iacopo

**Heather Leason wrote on December 04, 2011 @ 04:37 AM**

HI Iacopo,

I agree that software and planning for mitigation is core to some future applications. At this very moment, I am attending a global hackathon (brainstorming) called Random Hacks of Kindness (rhok.org). The type of research that you talk about it is something that RhoK is very much about - trying things out and building solutions to test.

Here is an example of an Ushahidi instance doing community mitigation planning - http://www.cic.mx/tehuan/ As you can see, it is exactly the type of mapping you refer.

I hope that this helps you along your research. Truly, I hope that the academic research group is useful for you.

If you have further questions, please email me at the address below.

Thanks,
Heather L.
Director of Community Engagement
Ushahidi

## B.2 Email Exchange with Boston's Citizens Connect

In this section is reported the email exchange with Chris Osgood, Co-Chair of Boston's, MA Mayor's office of new Urban Mechanics.

**Chris Osgood wrote on January 04, 2012 @ 3:25 PM**

While we don't formally track the number of "service misuses", I can tell you that the number is extremely low. There are occasions where an address provided is wrong or too vague, or a constituent requests a service that the City cannot provide. I cannot, however, recall a single time when a constituent has reported something where there was absolutely nothing.

And, yes, you can certainly use those stats in your thesis.

Chris

**Iacopo Pace wrote on January 04, 2012 @ 8:30 AM**

Chris,

thanks a lot for your email and data. I will certainly make use of them in my work.

I was wondering if you could tell me one more thing about Citizens' Connect: do you have any numbers (or even impressions) regarding the percentage of verified reports?
Like, has there been any cases where you got a report (e.g. a pothole, or a sidewalk repair) and, when the repair team got there, there was actually nothing to repair? Something like a number of service misuses.

By the way, am i allowed to attach the data you just sent me as an annex to my thesis?

And sure, I will send you a link to my work once it will be handed in: it will be available through our university website.

Best, Iacopo

**Chris Osgood wrote on January 03, 2012 @ 5:34 PM**

Iacopo,

Thank you for your email and interest in our work.

A few facts that might be helpful:

Citizens Connect is the source of roughly 14% of all constituent reports that come into the City. The remainder come in through the telephone hotline (roughly 66%) and the website (20%)

The breakdown of case types reported via Citizens Connect is below, covering the period since the app's launching on October 22, 2009 through yesterday. Of note, four of the case types have been more recently added: unshoveled sidewalks, sidewalk repair, snow plowing, missing signs.

Type of Case (Number of Requests)
General Request (11511)
Pothole (3592)
Street Light Outages (2258)
Graffiti Removal (3757)
Unshoveled Sidewalk (754)
Snow Plow (310)
Sidewalk Repair (563)
Missing Sign (437)
Totals: 23182

Additionally, we provide a site for constituents to map and download stats on neighborhood issues. This covers issues reported through Citizens Connect, the City's website and the hotline. You may find additional stats of interest there: http://hubmaps1.cityofboston.gov/datahub/

We would love to see a copy of your thesis when it is done.

Best,

Chris

**Iacopo Pace wrote on December 31, 2011 @ 10:30 AM**

Dear CitizensConnect team,

I'll briefly introduce myself: I'm a student in Computer Science Engineering at the Politecnico di Milano (Italy), and I'm writing my M.Sc. thesis upon information crowdsourcing for emergency mitigation.

Checking online I came across the citizen's connect application which, in some way, helps mapping hazards by the Boston community.

I was wondering if you had some data and/or statistics upon the use of the application (something like percentage of correct reports, reports per genre, spikes and things like this) that you could send me and that I could, maybe, mention in my work.

Thanks a lot.

Best Regards and happy new year,
Iacopo Pace

## B.3 Survey

### Introduction

If you got to this survey, you probably know me, or at least know someone who knows me. Anyway, I'm a 25 year old student of Engineering of Computer Systems in Milan's Polytechnic University. This survey will be of great help for my Master's Thesis, which tries to add a Social dimension to the gathering of information for Emergency Management, specifically in its Mitigation phase.

In a nutshell, my aim is to create an Online Social Network for reporting hazards that users spot in their local community (e.g.: their neighborhood, town, city, etc.). Both a mobile and a web application will be available for quickly reporting hazards, using geo-localized data.

With few click, you'll be able to add a report, with a title, a category and eventually a description, some tags and a photo: the report will be validated by the community itself, through voting and commenting. The results will be then made visible on a map which can be inspected online or through the mobile application. Few minutes of your time, can make a difference!

The social network will be created by inviting friends through email or, if you want to connect your Facebook account, by inviting them among your Facebook friends.

A scoring system will create a healthy competition for being the best hazard reporter, and badges will be awarded to you upon completion of different tasks (e.g.: reports for different categories, validated reports, number of reports, etc.). Your accomplishments in the social network may then be shared on Facebook and/or twitter, to show everyone how good a citizen you are!

In a preliminary study, I identified some categories of Hazards that may be tracked by my application, and the aim of this survey is to understand whether this social application is perceived to be potentially useful by citizens (you all ;)), therefore I'll be asking you some data to know what you think about this idea!

Thanks a lot for your collaboration! :D

To begin the survey go to the next page. It is 22 questions long, won't take more than 10 minutes, and you'll make me happy by submitting your answers! :)

**A little about yourself**
First of all, I'd like to know a little more about yourself and your use of the Internet and social media.

1. **Select your gender**
   - Male
   - Female
2. **Enter your age (I won't disclose it to anyone ;))**
3. **Select your country of residence (the country you lived in longer)**
4. **Define the environment you live in (if you have multiple residences, the one where you lived in longer).**
   - Metropolis ($\geq$1,000,000 inhabitants)
   - Big City ($<$ 1,000,000 $\geq$100,000 inhabitants)
   - City ($<$100,000 $\geq$50,000 inhabitants)
   - Town ($<$50,000 $\geq$2,000 inhabitants)
   - Village ($<$2,000 inhabitants)
5. **Describe the environment you live in (if you have multiple residences, the one you lived in longer).**
   - Urban
   - Sub-urban
   - Countryside
   - Seaside

- River-lakeside
- Mountainous

6. **Please enter your education level (the one you are currently pursuing if you are a student)**
    - High school diploma
    - Bachelor Degree
    - Master Degree
    - PhD
    - Other
7. **Which Online Social Networks (OSNs) do you currently use?**
   **(Max 5 choices, the ones you use the most)**
    - None
    - Facebook
    - Twitter
    - Google+
    - Foursquare
    - LinkedIn
    - Draugiem
    - Vkontakte
    - Orkut
    - MySpace
    - Couch Surfing
    - Flickr
    - Qzone
8. **How many hours a day you spend on your Online Social Networks (OSN)?**
    - I don't use any OSN
    - Less than 1 hour
    - Between 1 and 3 hours

- More than 3 hours

9. **Would you like to join an online community that allows to map the hazards and risks around you, thus making the world a better place to live in?**

    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

**The role of Social Media in Emergency Mitigation**
Upon a review of existing hazards, I created a list of hazards that can be easily reported through a Social Application, by every user who is willing to dedicate one minute for filling in report details.

The hazards identified are:

- Floods (localized to buildings, streets, etc)
- Winter Storm - Snow and Ice (e.g.: snow plowing issues, icy sidewalks, etc)
- Drought (e.g.: irrigation problems, missing water, etc)
- Structural Fires (i.e.: fires in man-made structures)
- Roads Hazards (e.g.: potholes, dangerous junctions, missing road-signs, etc)
- Building Collapse (i.e.: evident structural issues, man-made buildings collapse)
- Power Outage
- Violence and Crime (e.g.: fights, gunshots, robbery, drug dealing, etc.)

10. **Given the hazards identified, which of them the application should be able to report? Please rank them (from the most to the least important).**

    **Leave any comment, such as suggestions about categories to add**

**The functionalities of the Application in Emergency Mitigation**

Here I'd like to know what you think of the application concept, specifically if you agree or not with some of its (possible) features.

11. **I would create reports as precise as possible in order to help my community.**
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
12. **I would use the application more merrily, thanks to the scoring system that allows me to compete with my friends.**
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
13. **I would use the application more merrily, if I were to receive badges for my reports.**
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
14. **Reporting a hazard, especially through the mobile application, must be as quick as possible.**
    - Strongly Agree
    - Agree
    - Neutral

- Disagree
- Strongly Disagree

15. **I would try and involve my friends and acquaintances into using the application, in order to make our voices heard.**

    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

16. **I would like my friends on other OSNs (e.g.: Facebook, Twitter, etc.) to know when i achieve some results that help making my community a better and safer place to live in.**

    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

17. **Which of the OSNs you use would you like to share your achievements with? Please rank them (from the most to the least important).**
    **(Reply only if you are interested in sharing achievements with other OSNs)**

    - None
    - Facebook
    - Twitter
    - Google+
    - Foursquare
    - LinkedIn
    - Draugiem

- Vkontakte
- Orkut
- MySpace
- Couch Surfing
- Flickr
- Qzone

18. **Even though the best connection between authorities and the application would be for them to directly interact with citizens through the application itself, this requires to reach some kind of cooperation agreement which may not be easy to achieve.**
    **I am therefore evaluating other methods of communication with the appropriate offices of local authorities.**
    **For example:**

    - **Manual communication**: every citizen personally notifies the authorities of the hazard(s) spotted, eventually taking the results gathered through this application as evidence
    - **Automated communication**: the application itself sends a periodic report of spotted hazards to the authorities
    - Communicating with authorities is **not important**: I'd use the application even just for increasing community awareness
    - It'd make sense just if the authorities were **directly involved**

    **Please rank the communication methods from best to worst.**

19. **I would keep on using the application even if the local authorities choose not to actively take part in mitigating the hazards the community points out, so that i can increase the community's awareness of problems around them.**

    - Strongly Agree
    - Agree
    - Neutral

- Disagree
- Strongly Disagree

20. **I would like to automatically receive replies from local authorities if the application was to send automated reports to the proper offices.**
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

**One final word!**
In these optional last questions, I'll be asking you suggestions for the application. If you have any brilliant ideas, why don't you drop me a line?
Moreover, I'd love to know if you were interested in testing the (eventual) Android demo mobile application. If so, I kindly ask you to leave me your email (it won't be disclosed!).

21. **Leave a suggestion for the application (even more than one, if you want!).**

22. **If were ever to get to the point of creating a working demo for the Android mobile application, would you be interested in testing it? If so, please leave us your email address so we can contact you!**

**Thanks a lot for completing the survey!**
**You contributed to make the world a better place! :)**