

SAFE (Safety for Families in Emergency)

A Citizen-Centric Approach for Risk Management

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Abstract. In the field of Civil Protection, there is a growing awareness that the involvement of citizens has an immediate impact on decisions and actions to be taken, thanks to the distributed knowledge they hold about their territory. In this paper we describe SAFE (SAfety for Families in Emergency), an information system conceived to improve the certified emergency response procedures which may benefit from user-generated contents deriving from existing intelligent community networks. SAFE design follows the trend of the current research, namely to identify hybrid solutions that let citizens and experts work together to collect and redistribute the information, once properly processed.

Keywords: Volunteered Geographic Information · Citizen-centric design · Risk management · Mobile applications · GeoVisual summary

1 Introduction

In the last decade, in the field of Civil Protection, as in other domains, there has been a growing awareness that the involvement of citizens has an immediate impact on decisions and actions to be taken, as they hold distributed knowledge about their own territory. The timeliness of data they provide through a direct participation increases indeed the reliability of information, thus allowing operating on a territory in an efficient and effective way.

Some usages of the so-called Volunteered Geographic Information (VGI) can be found in the field of the *early warning* [1]. *Ushahidi* is the best-known platform that offers local observers an open source software for collecting, visualizing and geolocating information through smartphones and the Internet, thus creating sharable spatio-temporal databases [5].

The rationale behind *Ushahidi* is the concept of social activism entrusted by public responsibility. *Ushahidi* adopts the model known as 'activist mapping', which is the combination of social activism, citizen journalism and geospatial information. It was first used to collect and disseminate on a Google map the eyewitness accounts of violence occurred in Kenya in 2007.

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In similar scenarios, citizens play the role of observers, who are geographically distributed on the ground. Moreover, as stated in [1], humans themselves represent a sensor network (of more than 6 billion of components), thanks to their capability of interpreting what they capture by their senses. This is a founding approach for experts and represents the basis from which every action on a territory should start.

Despite this awareness, however, existing methods and tools addressed to support general-purposes monitoring tasks are not satisfactory, yet. They face, indeed, each issue from a unique perspective and, although they represent innovative solutions, they may be limited by the lack of a real involvement of ultimate users by experts and decision makers during the design phase.

The direction that current research is following along this line is then to identify hybrid solutions that let citizens and experts work together to collect and redistribute the information, once properly processed [9, 11].

In this paper we describe SAFE (**SA**fety for **F**amilies in **E**mergency), an information system conceived to pursue this goal, i.e., to improve the certified procedures which, based on the need of a continuous monitoring of a territory, can benefit from the user-generated content deriving from existing intelligent community networks. In SAFE, the involvement of families is relevant to enhance those emergency procedures that are activated in case of an event, such as an earthquake and a landslide. In such cases, the timely communication by citizens allows decision makers to address aids where needed, thus optimizing the available resources.

SAFE is part of a wider initiative, namely *Comune Sicuro*, whose goal is to align the actions performed by Public Administration to the Open Government's ones through methods and tools that enhance the citizens' engagement. In particular, *Comune Sicuro* aims to facilitate and automate most of the tasks in charge of the civil protection professionals, such as the identification of risks on a territory and the planning of needs according to them.

The paper is organized as follows. Section 2 briefly describes the new paradigm underlying *Comune Sicuro*, Civil Protection 2.0. In Sect. 3 the integration of actions performed by citizens with procedures certified by professionals is described. In particular, three goals are presented and the associated results are discussed. Section 4 embeds the obtained results in SAFE and describes both components, SAFE Mobile and SAFE Web. Some conclusions are drawn in Sect. 5.

2 Civil Protection 2.0

The goal of the research we are carrying out is to catch foundation of the systemic process started by the Open Government paradigm, namely transparency, participation and collaboration, and let citizens play a different and more aware role in the evolving scenarios that concern them.

The initiative *Comune Sicuro* stems from a collaboration between the Laboratory of Geographic Information Systems (*LabGIS*) at the Department of Computer Science (University of Salerno) and the research group *geoSDI* at the Institute of Methodologies for Environmental Analysis of the National Council of Research (CNR IMAA).

Research in this domain has been stimulated by the awareness that although each municipality is required to draw up and manage an emergency plan for the possible risks associated with its territory, many of them are defaulting. Reasons are different. Lack of funds to be allocated to that activity, lack of expertise in this field, lack of a continuous monitoring of resources and information, are only some possible causes.

The focus of *Comune Sicuro* is the identification of the risks of a territory, the census of available resources, the planning of the needs according to the risks, the dissemination of the emergency plan to citizens, and the establishment of itself as a geo-social service. In order to reach these goals, *Comune Sicuro* adopts a paradigm that aims to put Civil Protection activities [8] into practice thanks to the use of new methods and tools, including ICT-based solutions. The basic idea is to converge the amount of data managed in the Civil Protection field within a cloud platform to allow a correct and perfect exchange of data and information. The goal is to optimize the available resources management and guarantee the correct involvement and coordination of the various actors present in the various procedures for implementing the municipal plan. To allow that, the project offers a set of features that every day, 24 h a day, makes citizens participate to the execution and management of the procedures.

The whole process scheduled in *Comune Sicuro* starts by acquiring and storing data through an intelligent census based on a Web of data approach [6]. An ontology of the Civil Protection domain is under construction [7]. It allows modelling and validating resources in terms of metadata, state and behavior. Moreover, the ontology can be used also to aggregate subsets of resources to build units to which a composite state and a behavior can be associated. Inference algorithms can be used to derive additional relationships among validated resources. The requirement is to have a system that dynamically generates new cards for the data entry tasks and populates the available dataset, through procedures that are based on an effective territorial knowledge, where instrumental and human resources, rules, behaviors and interactions converge.

A fundamental feature of the whole system, which should be simple and intuitive to use, is the “dynamism of data”, meant as a continuous updating of resources and their possible interactions. A high quality standard has also to be guaranteed in order to avoid duplications, inconsistencies, incompleteness and unreliability.

A scenario where the research activities are applied relates in particular to the development of a monitoring and decision support system that allows for activating alert or rescue procedures when events occur that require civil protection actions. Procedures that activate this system are realized by different typologies of users, each operating through a different type of application. End users, citizens, experts and professionals can participate by using mobile applications that are intended to support their *prosumerism* and enable various geo-social processes that in general allow increasing the knowledge of a territory. The following Section describes how SAFE supports this approach towards the collaboration of different actors involved into civil protection actions.

3 Integrating Social Activism and Certified Procedures

The Civil Protection field represents a public sector where the integration of activist mappers and certified data managers could contribute to the enhancement of its efficacy.

Besides the role played by experts and professionals, the citizens' involvement is extremely important. The reason is twofold. Engaging citizens into a decision making process implies to build more efficient solutions because they can contribute to the requirement analysis as active stakeholders, thus focusing attention on real needs. Moreover, contributing to the development of a solution by citizens also guarantees a more convincing adoption of it. These assumptions mean that citizens can acquire awareness about territory and its phenomena and produce collective intelligence.

Researchers from *LabGIS* pursue the goal of designing and developing innovative tools to facilitate citizens' interaction conceived to provide data (the citizen as a producer) and acquire information (the citizen as a consumer) [10].

In order to reach this goal, three specific research topics have been addressed and discussed, namely,

1. diversification of users,
2. visual summary and
3. quantification of risk parameters.

In the following subsections, the results obtained for each topic are discussed and their integration in SAFE is presented.

3.1 The User *Family*

In SAFE, the citizen-centric design and the previous requirements led to the definition of the *Family* (nucleo familiare) user. A *Family* is a sociological unit that represents an aggregation of people belonging to the same core from a fiscal, legal and economic point of view, and sharing the same accommodation. The metadata that characterize a *Family* unit are both quantitative, like the number of components, and qualitative, and in this case, we refer to the components expressed as a hierarchy of family ties between them.

3.2 The Geometaphor *Neighborhood*

As part of SAFE, a fundamental requirement concerns the visualization of data referring to a bound space like a map. In this case, the constraint of a precise geographic reference limits the capability of locating aggregated data in the best position in terms of visualization. The usual visualization techniques may in fact prove ineffective for georeferenced data since these are associated with precise coordinates (geographical or Cartesian) and cannot be arranged in different positions even if contained in areas of respect. On the other hand, leaving the atomic data always visible can lead to misinterpretations of a scenario by a decision maker.

It is then necessary to use a technique that allows both positioning an exact reference for each SAFE user and at the same time visually aggregate users georeferenced in the same space.

The solution proposed in SAFE is a visual summary technique that allows having, under certain conditions, a visual synthesis of data present on a thematism. The idea is based on the Shneiderman mantra [2] and the Keim method [4]. Shneiderman's formulation "first overview, zoom and filter, then details on demand" represents a well-known visualization paradigm, which consists in the visualization, during the supervision phase, of all data contained in the dataset to obtain a complete view of the situation that characterizes a domain of interest. This type of visualization allows the user to have a global vision of information, ensuring a more accurate management.

Keim's formulation "Analyze First - Show the important" states that it is not appropriate to use only visual and interactive methods for displaying large amounts of data. It is reasonable to first apply a series of computational analyzes and then provide an overview of the information that is relevant to the user. In this way, the user can interact with components that represent the synthesis of data without running the risk of losing data that make up the dataset.

By taking account both paradigms, in SAFE a visual geometaphor is introduced that arises as a hybrid solution and adapts to the requirement of georeferencing [3].

The visual geometaphor defines the concept of *Neighborhood* (Vicinato) that visually groups families associated to the same space. This is the case, for example, of families in the same building, then with the same planimetric coordinates, or families present in an area defined by a buffering threshold. Figure 1 shows the components of the *Neighborhood* geometaphor. It consists of a physical component or Geometry, in this case a point geometry, and of a logical component or Icon, expressed as a pair (physical representation and meaning) and a state.

***Neighborhood* geometaphor**		
Geometry		●
Icon	physical representation	
	meaning	aggregation of Family users
	state	• safe • unsafe / danger • unknown

Fig. 1. The *Neighborhood* geometaphor.

As in SAFE the geometaphor is associated with a map, it has been drawn as a usual ballon to which a user navigating a map is accustomed. Its size implicitly includes the concept of one or more *Family* users who are located in a unique spatial reference or in an area defined by a specific threshold. Finally, to manage the state of the geometaphor, its physical representation can be associated with a different well-defined coloration (Fig. 2).



Fig. 2. The *Neighborhood* state representation.

The geometaphor has also a zoom scale associated with it that has an impact on its spatial destruction. This mechanism makes the project scalable and capable of handling large amounts of data in a clear and efficient manner. Figure 3 shows the Family users associated to the geometaphor. They are displayed once the scale value is appropriate for their display.

Spatial operators can be applied to the *Neighborhood* geometaphor, in line with the operations allowed on a point geometry with respect to the geometries present in the other themes. In particular, topological operators (*containment* and *adjacency*), directional operators and metric operators (*distance*) can be applied.

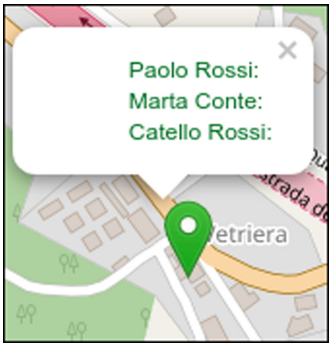

Fig. 3. *Family* users associated to a *Neighborhood* geometaphor.

3.3 Dynamically Quantifying Risk Parameters

The Risk is defined by the formula [12]:

$$R = P \times V \times E,$$

where variables correspond to:

P = Hazard: it is the probability that a phenomenon of a certain intensity occurs in a certain interval of time and in a given area.
V = Vulnerability: the vulnerability of an element (people, buildings, infrastructures, economic activities) is the propensity to suffer damage as a result of the stresses induced by an event of a certain intensity.
E = Exposure or Exposed Value: is the number of units (or "value") of each of the risk elements present in a given area, such as human lives or settlements.

In this formula, the variable E represents the most sensitive data because it is linked to the human component. Usually, when it is processed, the Risk refers to the value obtained from data present in the official registry. However, it is known in literature that this value is the most susceptible to changes, and a value acquired in real time with respect to an estimated or static value can make the difference in emergencies.

In SAFE, it is relevant to make the variables, coming into play during the Risk calculation, visible to the decision maker and at the same time that their values are as realistic as possible. The proposed solution is based on the use of the *Neighborhood* geometaphor and in particular on the value assumed by the component that expresses its state. Then, a value associated with the *quiet* state matches the global value estimated or acquired through the municipal plans. Otherwise, the feedback due to the change of state (*unsafe*, *unknown*) directly influences the calculation of the variable E allowing real-time monitoring of the population distribution. Thus, through SAFE graphical systems for displaying the values of variables updated in real time, the decision maker can have a complete view of all variables involved during rescue operations and make the best decision easier.

4 Acting in *SAFE*

SAFE has been designed as a geo-social application that provides *Family* users with functionality of daily use. As an example, a notification is automatically sent to a mum when the school bus is entering into an area at a given distance from her house (Fig. 4). A citizen can send an alert to a target office in order to report an environmental problem. This daily practice is important because it guarantees that SAFE is used also in case of emergency where stress conditions can complicate the usage of an unfamiliar application.

Figure 5 shows the interface to register the members of a family along with some personal data, such as age, telephone number, possible pathologies and allergies.

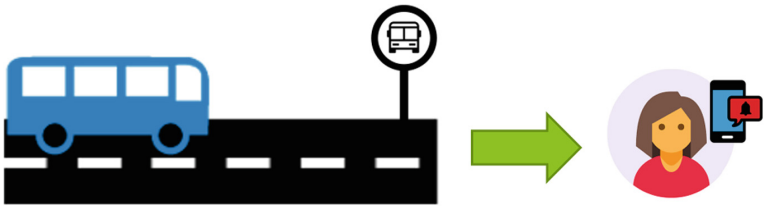

Fig. 4. Geo-social services in SAFE



Fig. 5. Registering family members

Each registered *Family* user is then visualized in a QGIS environment where a map of their geographic distribution is displayed, as shown in Fig. 6. A Python script can be used by the emergency manager to select data about them.

Figure 7 illustrates the architecture of the system, which consists of a Web application, a mobile application and a PostGIS database. Different users interacting with the systems are also displayed, namely a citizen (cittadino), a civil protection professional (operatore protezione civile), and a decision maker (decisore).

In case of an emergency, a decision maker or an emergency manager interacts with the SAFE Web application illustrated in Fig. 8. It shows the environment with a legend (legenda) with two differently-sized geometaphors, namely *Family* (nucleo familiare) and *Neighborhood* (edificio/vicinato), and an icon for the risk areas (aree di rischio). On the right, it also contains both the *Hazard scenario* conceived to define the area of the event and (de)activate an alarm, and the *Exposure scenario* that visually summarizes the global distribution of the *Family* users' state in terms of *safe* (sicuro), *unsafe* (pericolo) and *unknown* (ignoto). Once an alarm is launched, balloons representing both *Family* and *Neighborhood* users are red to indicate that, until SAFE receive feedbacks, citizens are in an *unknown* state.

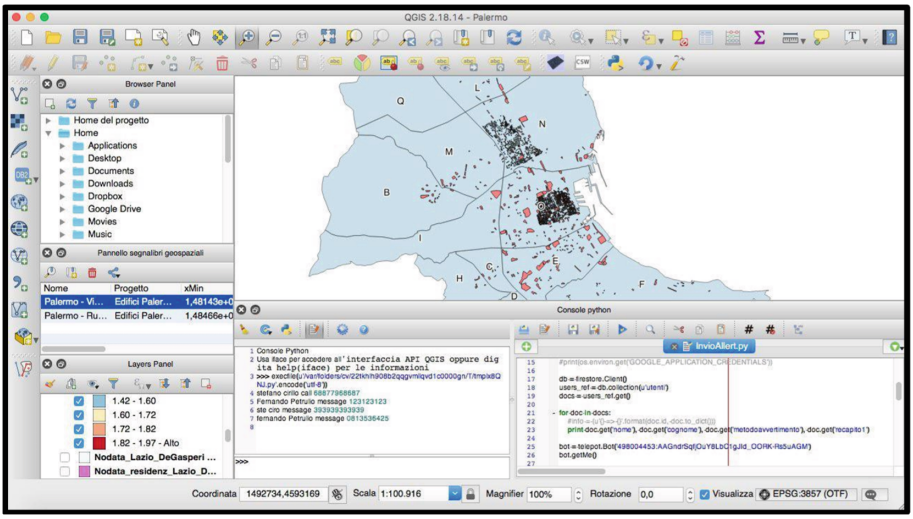

Fig. 6. The environment visualizing the users' distribution

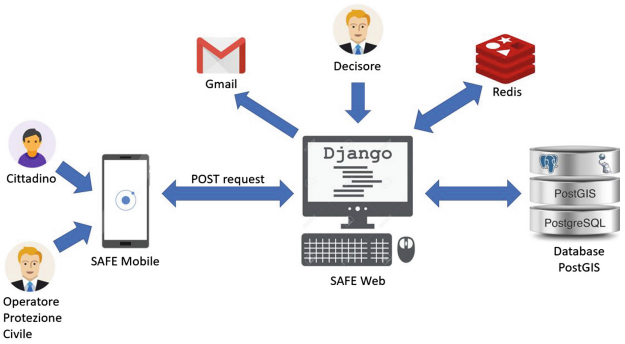

Fig. 7. The SAFE architecture.

From a user point of view, the citizens' involvement is prominent. Once they received an alert on their mobile device, the head of family can communicate the necessary information about the state of each family member. The timeliness of this action makes the difference both in terms of human lives and in terms of optimizing the distribution of rescue interviewees. Figure 9(a) shows the mobile interface through which a citizen is alerted about an occurred event or a possible risk (the detail explains the situation), while Fig. 9(b) illustrates the module the citizen can use to communicate the whole family state, member after member.

As the users' notifications arrive, the color of the balloons can change accordingly. It becomes green when the *Family/Neighborhood* user notifies that each person associated to it is in a *safe* state. Differently, it remains red if even one person is in an *unknown* state, while it becomes yellow if even one person needs aid. Figures 10 show

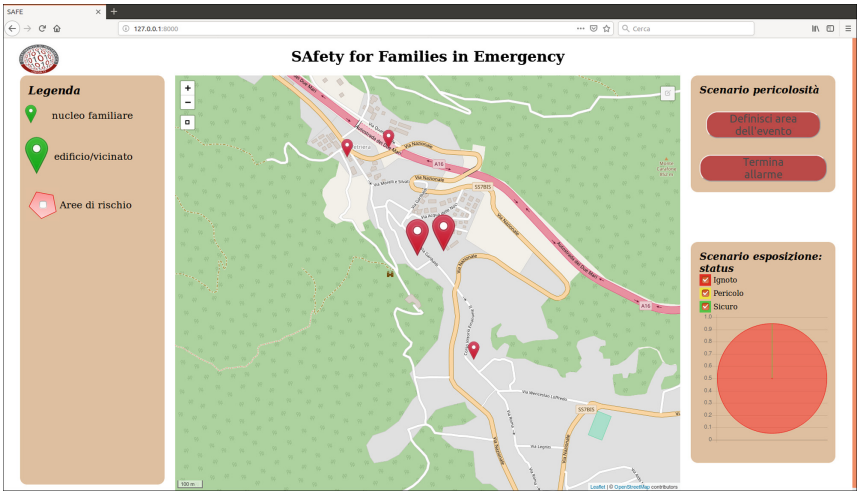

Fig. 8. Launching an alarm.

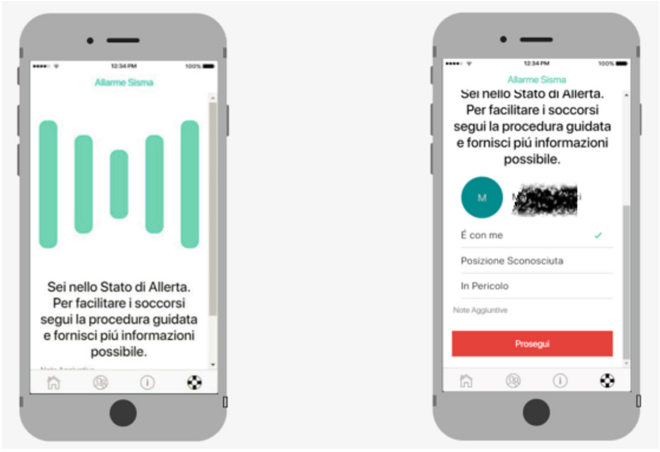

Fig. 9. (a) An alert sent to a user. (b) The family state communication

a red balloon associated to a *Neighborhood* user. When selected, the former lists the *Family* users associated to it and their state (Fig. 10(a)). The latter displays the state of each person belonging to a selected *Family* user (Fig. 10(b)).

The information that can be derived from the users' notifications also refer to the possibility of optimizing aids distribution. Figures 11(a) ÷ (c) show the interface available for the operators on the field. They can control both their zones of competence (aree di competenza) in general, and scenarios evolving inside them, thus reaching areas where their intervention is extremely important. In particular, Fig. 11(b) lists users who need aids (Soccorsi), while Fig. 11(c) shows the path to reach them.

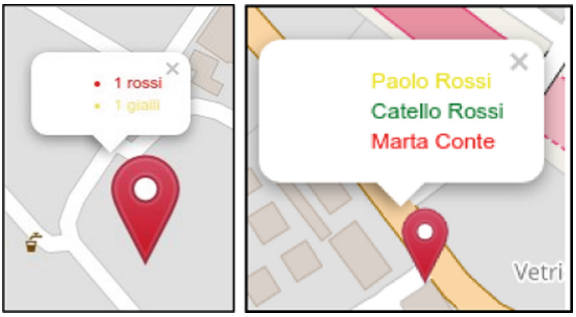

Fig. 10. (a) A *Neighborhood* user in an *unknown* state. (b) A *Family* user in an *unknown* state

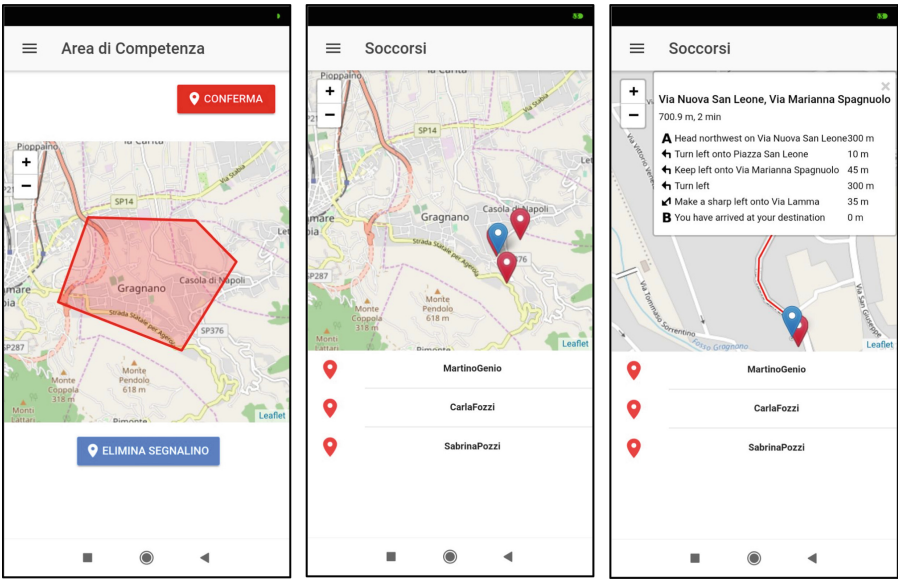

Fig. 11. (a) A zone associated to an operator on the field. (b) Users and operator's position. (c) Details about users.

Finally, as for the Exposure parameter, Fig. 12 shows a detail of the interface, namely the graphic representing the *exposure* scenario in two different moments.

Values associated to them fill in the formula to calculate the risk parameters in real time. This functionality allows performing a real time analysis of risk distribution, as shown in Fig. 13. Besides red balloons that identify the *Family* and the *Neighborhood* users in an *unsafe* location, the environment lists the risk codes that represent the impact levels derived from the risk matrix defined by the basin authority plan (PSAI) *Liri – Garigliano e Volturno* and *Campania Centrale* (Central Campania), Italy.

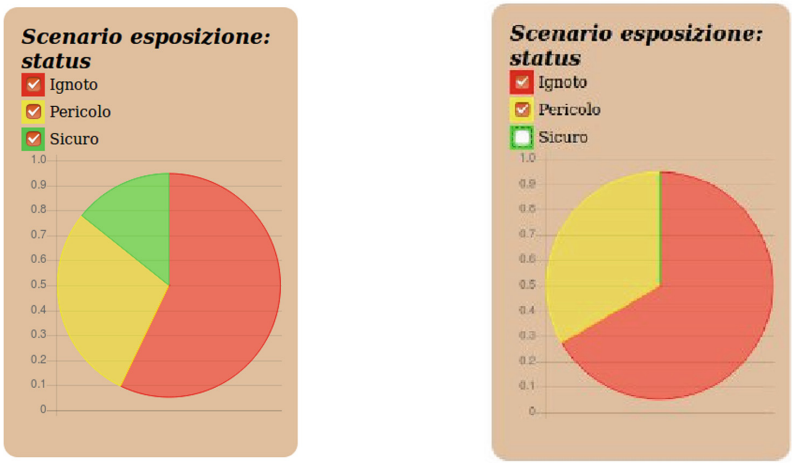

Fig. 12. The evolution of an *exposure* scenario.

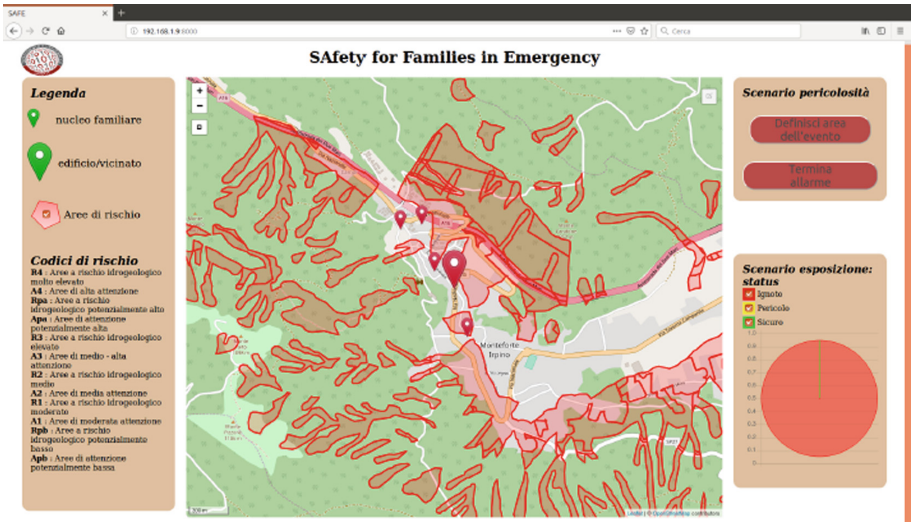

Fig. 13. Risk codes and *Family* users located in the high hazard level areas.

5 Final Remarks

SAFE satisfies the initially set objectives. The SAFE Mobile component is a simple and agile tool for citizens who want to contribute to support operations on a territory. The SAFE Web component plays a twofold role. It aims optimizing the available resources management and guaranteeing the correct involvement and coordination of the different actors present in the various procedures for implementing a municipal plan. Moreover, it carries out syntheses of data collected and builds dynamic maps of risk scenarios useful to decision makers for acting on a given area in case of emergency.

SAFE is a very ambitious project and as such it can reach its goal if each user, citizens, professionals and decision makers, participates in the design task from the very initial phase. This approach has been indeed followed while defining both SAFE functional and non-functional requirements. Moreover, during the development of SAFE basic functionality, several events have been simulated in order to test the system performances also through the users' feedbacks. In particular, a memorandum of understanding has been signed by the LabGIS director and a manager of a municipality in the Campania region though which a SAFE prototype for multi-platform devices has been distributed. Currently, the analysis of data collected from users is an ongoing activity and some preliminary investigations have been performed in terms of interface evaluation and comprehensiveness of information displayed for the emergency managers and decision makers.

As for the planned future work, an improvement to SAFE has been scheduled in terms of functionality addressed to the dissemination of information concerning both the behavior to be taken in case of a natural event, and in general the perception of risk itself by people, independently from the role they can play.

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